AGSE 2012 – FOSS4G-SEA

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Geoinformation – Catalyst for planning, development and good governance

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Geoinformation – Catalyst for planning, development and good governance

Applied Geoinformatics for Society and Environment

AGSE 2012

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Preface

'A rolling stone gathers no moss' goes the adage and it applies very well to the globe-trotting *Applied Geoinformatics for Society and Environment* (AGSE) series of conferences and summer workshops. What started off in 2008 in Asia, in the Indian sub-continent on a small scale has come full circle and after five years now returns to Asia, to the Universiti Teknologi Malaysia. The conference has over the years moved from Asia (Trivandrum, 2008) to Europe (Stuttgart, 2009), to South America (Arequipa, 2010), to Africa (Nairobi, 2011) and back to Asia (Malaysia, 2012).

The humble objective of the conference is to 'take the benefits of geographic information technologies to a wide canvas of applicable areas, particularly in the realms of development, environment and social well-being'. AGSE2012 therefore pledges itself to align with the aims of the United Nations Millennium Development Goals and has taken up the motto 'Geoinformation – Catalyst for Planning, Development and Good Governance' for this year's deliberations. It also aims at internationalization of education and has become a venue where academicians, researchers, students, scientists and technologists from across the globe can come together in a very open environment of scientific debate and come out enriched from such encounters. The affiliations of the authors in AGSE2012 cover 21 nations from Germany, India, USA, Malaysia, Sri Lanka, Indonesia, Austria, Philippines, Italy, Nepal, Egypt, Bolivia, Bangladesh, Pakistan, Tanzania, Sudan, Kenya, Zambia, Lithuania, to Somalia and Romania.

A significant development of AGSE2012 is that it now collaborates with OSGeo, the Open Source Geospatial Foundation to establish the FOSS4G-Southeast Asia conference. Synergistic initiatives like this has been the hallmark of AGSE, establishing it as not just an academic endeavour, but also as a facilitator of inclusive, socially-relevant and technologically-advanced geospatial research and activism. The AGSE gives space to alternate thinking, stresses empowerment across genders and nations. The thematic areas of this edition of AGSE cover a wide spectrum ranging from Earth Observation Systems, Information Extraction, and Photogrammetry to Advances in GIScience, Internet-based Applications and Open Source Solutions, SDI & Land Management, Environmental Issues and Sustainable Development, Disaster and Risk Management and GIS in Health and Education, Urban and Regional Planning. The workshops on Orthophoto Mosaic Generation; Implementing OGC conformable Web services; gvSIG and SEXTANTE; Interoperability in Disaster Management; Strategic process management for introducing GIS; Networking Implications; Fuzzy Logic Analysis using MapWindow, and 3D modelling will enable the delegates to get a hands-on experience on the latest techniques and philosophies of geospatial thinking.

It's apt that AGSE now comes to Malaysia, a country aptly lauded as being *'Truly Asia'*. One of the economic powerhouses of SE Asia and an emerging destination for high-quality but affordable world-class education, Malaysia has always encouraged learning and has truly internalized the spirit of internationalization of education. Its public expenditure on education as percentage of GDP was 5.8 in 2009 compared to USA's 5.4.

The editors express their gratitude to the UTM Malaysia, in its 37th year of existence as a university, for being a gracious host through its Faculty of Geoinformation and Real Estate.

On behalf of the editors

Dr. A. P. Pradeepkumar

12 August 2012

Preface, 1st edition

First of all, I would like to thank the Stuttgart University of Applied Sciences, Germany for giving the Universiti Teknologi Malaysia (UTM) an opportunity to host this year's Applied Geoinformatics for Society and Environment (AGSE 2012) conference and summer school. I am very sure this conference will result in many academic collaborations and other research initiatives being forged amongst the alumni and other professionals.

This year, for the first time in its five-year history, AGSE collaborates with OSGeo, the Open Source Geospatial Foundation to establish the FOSS4G Southeast Asia conference. This kind of synergy takes the initiatives of the AGSE to a more socially-relevant and technologically advanced realm. It also provides for an excellent learning platform for participants, with experts discussing their papers either in technical or workshop sessions from 16 – 19 July 2012.

The proceedings contain more than 60 papers and the majority could be considered as application-based papers and presentations.

Finally, I hope all of us would come out enriched through participation in this year's conference and summer school.

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6 July 2012

Earth Observation Systems, Information Extraction, and Photogrammetry

We resolve … to intensify our collective efforts
for the management, conservation and
sustainable development of all types of forests

United Nations Millennium Declaration, 2000

Characterizing Forest Fire in Eastern Zambia using Guided Clustering and the Normalized Burn Ratio

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ABSTRACT:

Several approaches have been used to map burned areas from satellite imagery employing single-date, bi-temporal, or time series data. Features such as the color, texture, and spectral response of the burned area are normally used in traditional image classification methods. Also, spectral indices such as the Normalized Difference Vegetation Index (NDVI), the Normalized Burn Ratio (NBR) and the Burned Area Index have commonly been used to discriminate burned from unburned areas. We evaluated two methods to map burn areas in eastern Zambia: Guided clustering using a single Landsat TM image and NBR method using bi-temporal Landsat TM data. We assessed the accuracy using 701 random ground truth points of which guided clustering scored an average accuracy of 86.59% with a 0.7018 kappa statistic while the NBR method scored 74.61% with a kappa of 0.4124. The high accuracy obtained using guided clustering is attributable to the stringent way spectral classes are defined and the higher number of spectral features used. The NBR method works well but suffers from high omission and commission errors.

1   Introduction

Fire, both natural and human induced, impact ecosystem resources and the environment (Lentile 2006). Millions of hectares are burned worldwide resulting in air pollution, loss and degradation of forested land, loss of wildlife habitat, weakening of soil structure and loss of surface cover leading to increased surface runoff and soil erosion (DeBano, Neary et al. 1998). In Eastern Zambia, fire is commonly used in the dry season (May to November) to clear undergrowth for safety from wild animals, to clear fields of residue in preparation for planting, to open forest land for new cultivation, to flush animals for hunting, and to assist in harvesting wild honey (Frost 1999; Eriksen 2007; COMACO 2011). But fires often burn out of control with devastating impact on the native forests and wildlife. To the local population, the annual fire season is part of life, and there is little understanding of the broader ecosystem impact and spatial extent of the damage. This is further compounded by the lack of reliable information on the spatial and temporal distribution of these forest fires at the government or institutional level caused mainly by the high cost associated with the creation of such data.

Local burned area information does not exist in Zambia. The only available data are global datasets such as the MODIS burned area (BA) product (Boschetti, Roy et al. 2009). However, the utility of such products is limited owing to lack of local validation and their coarse resolution. The coarse resolution precludes the detection of small fires and tends to overestimate burn areas as large pixels cover a combination of burned and unburned pixels (Loboda, O'Neal et al. 2007). However, the availability of free satellite imagery such as Landsat data now offers a great opportunity to generate maps of burned areas in a cost-effective and time-efficient manner at a scale that is meaningful for local (community, chiefdom, district) application.

Several approaches have been used to map burned areas from satellite imagery. Features such as the color, texture, and spectral response of the burned area together with traditional image classification methods are normally used. Spectral indices such as the Normalized Difference Vegetation Index (NDVI) (Fraser, Li et al. 2000) which is used to highlight green vegetation, the NBR (Miller, Knapp et al. 2009), and the Burned Area

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Index (Dubinin, Potapov et al. 2010) have commonly been used to discriminate burned from unburned areas. Each has been applied with varying levels of accuracy. We compare two methods of mapping burned area in the semi-arid environment of eastern Zambia: guided clustering with maximum likelihood classification, and the normalized burn ratio (NBR). We used a 258 km2 study area (12°0'S, 32°58'E) in the Lundazi district of Eastern Province, Zambia. The landscape is mainly crop fields, abandoned fields, native forests, and wetlands (Her and Heatwole 2008). There is rampant burning of forests and cropland throughout the dry season of May to November.

2   Overview of the classification methods

Guided Clustering is a hybrid classification procedure which seeks to maximize benefits of unsupervised clustering for identification of spectral classes with some (supervised) mechanism for identification of the informational class to which each spectral class belongs. The first of such approaches was developed by Bauer et al (1994) for mapping Minnesota forest resources, and later adapted for use in the Midwest GAP Image Processing Protocol (Wynne 2011). With this procedure, the analyst delineates training regions on the image. Each of these polygons would represent a single spectral signature in traditional supervised classification. But in guided clustering, all regions for a given class are further divided into 10-20 spectral classes by an unsupervised clustering method enabling definition of purer spectral classes. This is the repeated for each information class and the final classification is based on the full set of spectral classes1. Normally, separability analysis within and between information classes is assessed using measures such as the transformed divergence or the Jeffries Matusita distance, and any two poorly separable classes are merged into one or deleted. Because of the heterogeneity of burned areas in the study area this approach presented a good option.

The normalized burn ratio (NBR) is an index used to highlight burned areas using Landsat imagery. It is calculated as (B4-B7)/(B4+B7), where B4 and B7 are Landsat TM bands 4 (near-infrared) and 7 (mid-infrared) respectively (Key and Benson 2003). The NBR ratio method relies on the change of the NBR index from the pre-fire scene to the post-fire scene to differentiate burned from unburned areas. The difference between pre-fire and post-fire NBR, dNBR, is then classified into burned and unburned classes by applying a threshold. Burn thresholds are normally chosen empirically by exploring false-color images, comparing with high resolution imagery (USGS 2004) or using ground truth if available. The strength of the NBR method lies in its simplicity and has been reported to give good results (Lentile 2006; Miller and Thode 2007). However, like NDVI, the NBR approach is affected by background soil color, vegetation regrowth, time period of the pre- and post-fire images (Zhang and Kondragunta 2008) and surface moisture (Loboda, O'Neal et al. 2007).

3   Methods

1.1   Data and Preprocessing

Landsat 5 TM data path 169, row 68 for the study area was acquired through the USGS' Global Visualization Viewer (GloVis2) for 20th April (pre-fire) and 26th August (post-fire) 2010. In addition, we procured high spatial resolution GeoEye-1 imagery (2m multispectral and 0.5m panchromatic) for September 10 2010 as a validation dataset.

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[1] http://dartgeoblog.wordpress.com/2009/07/22/guided-clustering-an-overview/

[2] http://glovis.usgs.gov/

| Landsat TM 20/04/2010 | Landsat TM 26/08/2010 | GeoEye-1 10/09/2010 |
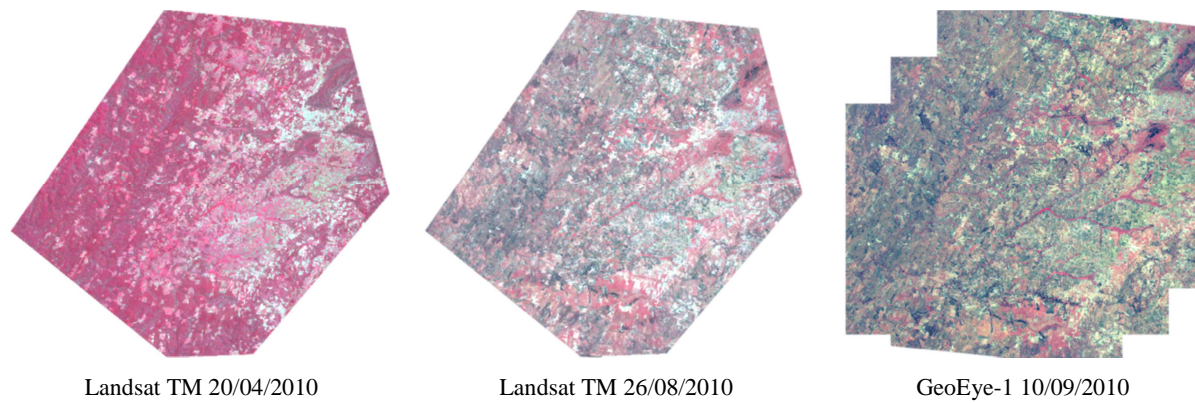
Figure 1: Satellite imagery used in the analysis. (North-South distance is approx. 18km)

The Landsat data were converted to Top of Atmosphere (ToA) reflectance using NASA's Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS, http://ledaps.nascom.nasa.gov/) software. The output (HD4 format) was converted to TIFF using ERDAS Imagine 2010 for easier handling in subsequent processes and then clipped to the study area extent.

1.2 Classification using guided clustering

Guided clustering uses only the post-fire Landsat data. Three broad classes were defined: Burned Areas (all burned landscape), Open areas (cropland, settlements, roads) and Forest (all vegetated areas). Several areas of interest (aoi) per class were defined using ERDAS Imagine software. All areas of interest for a given class were then divided into 10 spectral classes using the ISODATA clustering algorithm. Separability analysis was done using the transformed divergence at the class level and repeated when all the spectral signatures were combined to form full set signatures for classification. We set to achieve a minimum intra-class divergence of 1500 and inter-class divergence of 1800. Any class not meeting these thresholds was either merged with the closest neighbor or deleted.

1.3 Classification using NBR method

NBR was calculated for the two Landsat images using band operators in ERDAS. Differenced NBR was then calculated by subtracting the August NBR from the April NBR. The NBR method only allows the classification of the landscape into two classes i.e. burned or unburned. A burn threshold was determined empirically by exploring Landsat false-color images (4-3-2 band combination) which shows burned areas as shades of gray. The GeoEye-1 image was used to identify burned areas, and from evaluation of several sites a burn threshold of 500 was selected. Figure 2 shows the calculated NBR images and the difference NBR. The differenced NBR is shown color coded with burned areas corresponding to yellow to red shades. The dNBR image was then classified by applying the selected threshold.

| NBR April 20 2010 | NBR August 26 2010 | dNBR (color-coded) |
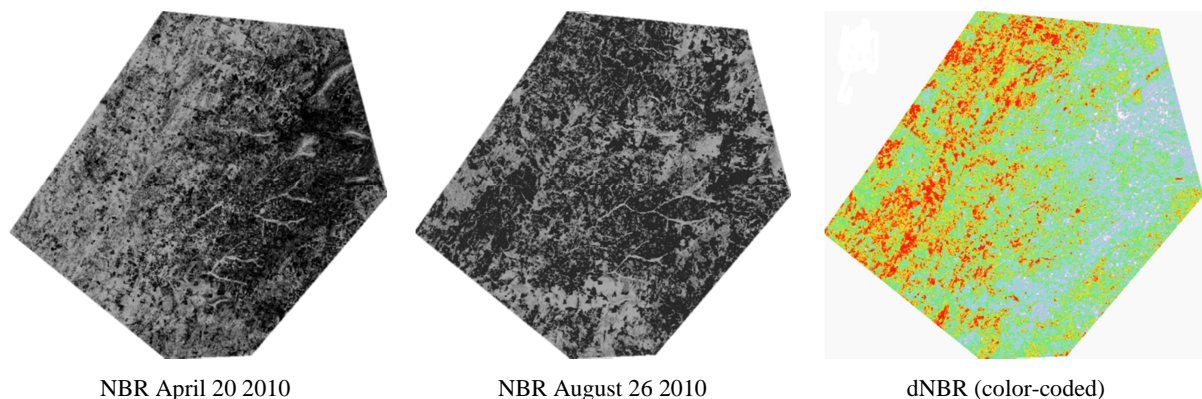
Figure 2: NBR images for the pre-fire and post-fire Landsat images and differenced NBR (dNBR)

1.4   Accuracy Assessment

The accuracies of the two methods were assessed with 701 random points (See Figure 3d) manually classified using the high resolution GeoEye-1 image. ERDAS accuracy assessment tools were then used to generate the desired assessment statistics.

2   Results

Figure 3 shows the classification results of the two methods. The result from guided clustering (Fig 3a) was recoded to two classes to facilitate comparison with the NBR method. The two results are consistent in overall pattern although the NBR result shows less burned areas in the northeast part of the study area. Accuracy statistics for the two results assessed with 701 random points are given in table 1. The overall classification accuracy for the guided clustering output was 86.59% with an overall kappa statistic of 0.7018. For the NBR, overall accuracy was 74.61% with kappa of 0.4124. The guided clustering result was better even on a per class level. The area estimates for burned area in the study area is given in table 2.

Table 1. Accuracy assessment for the two methods

Class name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Kappa Statistic	Omission error	Commission error
Guided clustering accuracy								
Burned	231	247	192	83.12%	77.73%	0.6679	16.9%	22.3%
Unburned	470	454	415	88.30%	91.41%	0.7393	11.7%	8.6%
Normalized burn ratio accuracy								
Burned	231	211	132	57.14%	62.56%	0.4416	42.9%	37.4%
Unburned	470	490	391	83.19%	79.80%	0.3869	16.8%	20.2%

Table 2. Percent area burned estimated for the study area.

Class name	Guided Clustering			NBR method		
	Total Pixels	Area (sq.km)	% Area	Pixel Totals	Area (sq.km)	% Area
Burned	100710	90.6	35.2	90617	81.6	31.7
Unburned	185425	166.9	64.8	195518	176.0	68.3
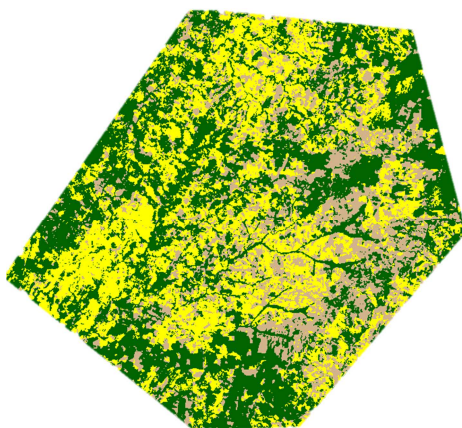
a)   Guided clustering
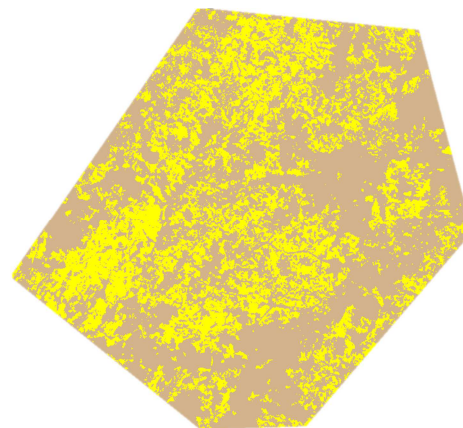
b) Recoded guided clustering

c)   Differenced NBR (dNBR)   d)   Accuracy assessment points
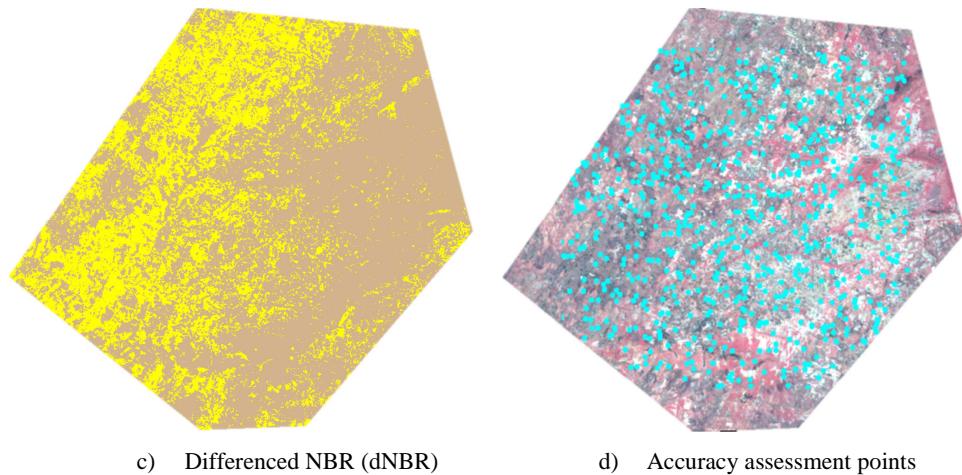
Figure 3: Comparison of classification results. (Yellow is burned areas,
brown is unburned and green unburned forests.)

3   Discussion and Conclusion

We evaluated the utility of Landsat data to map burning in upland landscapes of Eastern Zambia using guided clustering and the normalized burn ratio. Based on the two results 86.1 sq.km of the 260.5 sq.km study area had burned by 26th August 2010. This figure obviously rose by the end of the dry season showing the rampant nature of forest burning in the area. We did not assess the size of individual fires because of the lack of good data for the May-July. But from our field visit in November 2011, fires in the study area are more fragmented and cover much smaller areas. So Landsat is better suited for mapping them than coarse resolution imagery such as MODIS.

The two methods used provided some useful insights on classification of burned areas. Burn classification by guided clustering had higher accuracy than the NBR method. This should be expected going by the stringent process of defining spectral classes. It also used more features (all bands of the image) for the classification which increased its power to discriminate between burned and unburned areas. The heterogeneity of burned areas was well captured using this method. A high kappa statistic (0.7018) shows better agreement with the reference data. The NBR method is attractive because of its simplicity but it suffers from high omission/commission errors (table 1) for both the burned and unburned classes. These errors are attributable to the single global threshold used which fails to capture some local variation in NBR. Also, NBR method has been reported to work well for a single large burned area (Cocke, Fule et al. 2005) but the study area had small fragmented burned areas.

Lastly, there is room for improvement in NBR method. One improvement we are working on is replacing the global threshold with a more adaptive local threshold. We are also modeling factors such as soil background, soil moisture, percent tree cover, vegetation regrowth that have been reported to affect the NBR index so we can develop better methods of mapping fires in environments like our study area.

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A brief Note on a GPS-aided IMU Drive through Stuttgart

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ABSTRACT:

Data acquisition from a moving sensor platform with cameras and/or laser systems requires monitoring the position and orientation of the sensor platform whenever images are captured or laser measurements are carried out. The progress in the field of MEMS technology has led to greater availability of Inertial Navigation Systems at lower cost. At the same time the accuracy of the determination of position and orientation of MEMS based INS has been improved steadily.

This paper evaluates the performance of two MEMS based GPS/INS systems with a navigation grade GPS/IMU in an urban environment. Most attention is given to the positional accuracy. All three IMUs were mounted on a vehicle platform while driving in the city centre of Stuttgart. The performance of the MEMS based systems is evaluated by comparing the results to the more precise reference solution. The paper describes the equipment, one low-cost unit from Xsens (MTi-G), a mid-range unit from OXTS RT3002 and as reference the LV420 system from Applanix.

The analysis of the test drive focuses on mainly three different conditions: with good GPS reception in both open sky and urban area, with partially disrupted GPS coverage and with complete GPS outages in tunnels. Results are obtained in real-time from all systems. For the OXTS and the Applanix system there is the possibility to improve the accuracy by post processing. While the MTi-G uses the satellite based augmentation system EGNOS for differential corrections the RT3002 employ the satellite reference service ascos and the LV420 solution is corrected by calculating GPS-baselines to a geodetic reference station.

1 Introduction

In Geomatics, position and orientation of a moving sensor platform equipped with cameras and/or laser systems is often acquired with integrated INS/GPS systems. In the project GyroTIR we have got the opportunity to evaluate three different integrated INS/GPS systems with respect to their position and orientation performance. The understanding of pros and cons of the performance these systems in particular while driving in urban areas helps to be aware of the limitation of each device and provides knowledge on how to use them most efficiently.

In this paper we will give an overview of the utilized hardware, evaluate the limitation of the systems regarding to different environments and examine the potential of additional post processing in order to improve the results.

Godha & Cannon (2005) have investigated the integration of DGPS with a low cost MEMS - based inertial measurement unit (IMU) for land vehicle navigation applications. Their research focused on the analysis of positional accuracy. They have used a closed loop decentralized GPS/INS integration design and investigated two different methods to lower the error accumulation in the Inertial Navigation System during the absence of GPS. In first method constrained motion attributes of a land vehicle are utilized to control the drift in the INS solution, which can be performed in real-time applications. The method is based on a Rauch Tung Streibel (RTS) smoother suitable for post processing of the data. One of their findings for their MEMS-based IMU was that with a primary filter configuration it was possible to maintain a horizontal accuracy a maximum error within 10 m (2D) for about 13 to 17 seconds during the GPS outage (Godha & Cannon 2005).

2   System components

Three different GPS/INS systems were simultaneously used in the experiment. Figure 1 shows the mounting of the devices for the experimental investigations. Table 1 lists details about the used GPS/INS systems and manufacturer specifications. A brief characterization is given in the following:

Xsens MTi-G: The MTi-G provides position and orientation from the integration of a L1 GPS receiver, a low-cost consumer grade MEMS inertial sensor, magnetometer and barometer sensors. Due to its small size and low weight, the sensor is used in a lot of different types of applications (Xsens 2010). It is normally used with an active patch antenna and is calibrated by the manufacturer.

OXTS 3002: The OXTS device delivers position, orientation, accuracy estimates and some more information in real-time. The core of the modular system consists of an IMU with tactical grade MEMS inertial sensors, calibrated by the manufacturer. The selection of the GPS unit mainly defines the achievable position accuracy and this results in a wide range of available products. In our experiments we used the OXTS 3002 which is equipped with a L1/L2 code and phase GPS receiver and a RTK module. The additional use of an odometer and a second GPS antenna is possible but not realized in our experiments. Routinely an active patch antenna supports L1/L2 code. Post-processing of the data is provided by the OXTS post processing software (OXTS 2011a,b).

Applanix POS LV 420: The Applanix POS LV V4 is an integrated position and orientation system, which is commonly designed to be used in land-based vehicles. It is composed of a tactical grade IMU with MEMS accelerometers, fiber optic gyros (FOG), L1/L2 code, phase GPS receiver and an odometer. It is possible to use RTK corrections via a serial port. The system is equipped with two L1/L2 Trimble zephyr (TRM39105) antennas. Post-processing is required to achieve the best results (Applanix 2007). The odometer is not used in our experimental investigations.

Figure 1: Overview of Applanix IMU (lower right), OXTS (lower left), Xsens MTi-G (upper left) and GPS power splitter

Company	Xsens	OXTS	Applanix
Product	MTi-G 28A53G35	RT 3002	POS LV V4 420
GPS	L1 C/A SPS + SBAS	L1/ L2 + RTK	two L1/ L2 (+ RTK)
Additional devices	(Magnetometer),	(Odometer)	Odometer
RT KF methods	EKF, Loosely coupled, Selectable scenario	EKF, Loosely coupled	EKF, Loosely coupled
RT Output format	Xsens API	NMEA, NCOM, RT, CAN, PPS	NMEA, RS232, PPS
Data rate (Hz)	120	150 or 250	200
Accelerometer	consumer grade MEMS	tactical grade MEMS	tactical grade
Gyroscope	consumer grade MEMS	tactical grade MEMS	Fiber Optic Gyro
RT Pos Accuracy X,Y [m]	2.5 (2 with SBAS)	0.02	(0.035)
RT Pos Accuracy Z [m]	2.5 (2 with SBAS)	0.02	(0.05)
RT Roll & Pitch Accuracy	1	0.03	(0.015)
RT Heading Accuracy [°]	1	0.1	(0.02)
PP Pos Accuracy X,Y [m]	not provided	not specified	0.02
PP Pos Accuracy Z [m]	not provided	not specified	0.05

PP Roll & Pitch Accuracy	not provided	not specified	0.015
PP Heading Accuracy [°]	not provided	not specified	0.02

Table 1. Characteristics of utilized GPS/INS devices and manufacturer specifications

3   State of technology

Xsens MTi-G: The position is based on GPS L1 single point positioning service (SPS) with additional usage of the satellite based augmentation system (SBAS) if it is available. The positions are combined with the inertial observations using an Extended Kalman Filter (EKF). Selection of different EKF scenarios will affect the usage of additional information such as: pressure observations, magnetic observations or holonomic constraints (Xsens 2009). We have used the "General" scenario which includes the static pressure observations in order to provide better altitude data. Position, velocity and orientation are calculated in real-time, but if there are some GPS outages longer than ten seconds, only orientation will be estimated. No specific maneuver has to be performed for initialization.

OXTS 3002: After turning on the device, the GPS receiver calculates the position with accuracy depending on the availability of RTK corrections. Inertial raw data will be recorded, but the EKF only starts after an initialization, which requires driving straight on faster than a certain velocity threshold (in our experimental investigation the threshold was put to 5 m/s). Position, velocity and orientation can be output in various data formats, i.e. National Marine Electronics Association (NMEA) or Controller Area Network (CAN) bus. Two possibilities are available for post-processing. The "simulated" post-processing allows the user to change the settings and recalculate with the same filter used for the real-time calculation. The "combined" processing combines a forward and backward filtered solution. For backward filtering, the initialization is required; the filter starts only if the initialization speed is reached. There is also the possibility to feed the OXTS software with a post-processed GPS solution, which has to be calculated externally.

Applanix LV 420: In real-time (RT) mode, Applanix LV 420 uses a loosely coupled EKF to combine the GPS coordinates and velocities with inertial measurements, odometer measurements and additional azimuth from the GPS azimuth measuring system (GAMS). GAMS consists of GPS antennas and receivers forming a moving baseline at the vehicle. The GAMS baseline needs to be measured in advance or is can be determined in a free sky environment by the system itself and then set for further use by the operator. All data is saved for the post-processing where a GPS reference station can be used to increase positioning accuracy and tightly coupled EKF to improve the overall reliability. The accuracy is improved by additional backward filtering and smoothing.

In the experimental investigations we use the backward filtered and smoothed results of Applanix as reference data. The results provided by Xsens, OXTS real-time (OXTS_RT) and OXTS post processing (OXTS_PP) are compared to the reference data and categorized according to different environmental conditions (with good GPS reception in both open sky and urban area, with partially disrupted GPS coverage and with complete GPS outages in tunnels.).

4   Experimental investigation, results and analysis

4.1   Description of the field experiment

The three systems have been installed in a vehicle in such a way that their local x-axes are parallel to the vehicle's forward axis, see Figure 1. Only one GPS antenna (Trimble zephyr TRM39105) was used via an active power splitter to give the same signal to all of the devices. For the GAMS of the Applanix system, a second Trimble zephyr antenna was used forming a 2.61 m baseline. The lever-arms were measured and entered into the processing software of each device (Table 2).

The experiment started at the former air-field in Malmsheim. The driving route contains four different environment-related situations: free space, interurban area, urban area and GPS outage areas in tunnels. It ends at the city center of Stuttgart.

Post-processing was performed for Applanix and OXTS data using the software provided by the manufacturers. In order to make a comparison, all data was output with 100 Hz in UTC time. Because Xsens uses a different local coordinate frame definition, the orientation had to be adjusted to be comparable with the output of the other systems. All positions were transformed into UTM coordinates.

Lever-arms	Forward [m]	Right [m]	Down [m]
OXTS->Antenna 1	1.85	1.23	-1.18
APP->Antenna 1	1.72	1.19	-1.09
Xsens->Antenna 1	1.93	1.33	-1.12

Table 2. Lever-arms to GPS antenna

4.2 Results and analysis

Figure 2 shows the track of ca. 30 km length which includes two tunnels indicted by (a) and (b) in the graphic. As expected, the behavior of the systems during GPS outage within the tunnels is most different. The first tunnel is a short one and the second tunnel is relatively long. In the short tunnel the Xsens track starts deviating quickly from the tracks of OXTS and Applanix. In the long tunnel there are no recorded locations by Xsens for a large region of the tunnel. The improvement of post- processed OXTS data with respect to the real-time OXTS data is nicely visible in Figure 2b. While the real-time data show a significant deviation towards the end of the tunnel, the post-processed (forward and backward filtered) OXTS locations follow reasonably close the Applanix track.
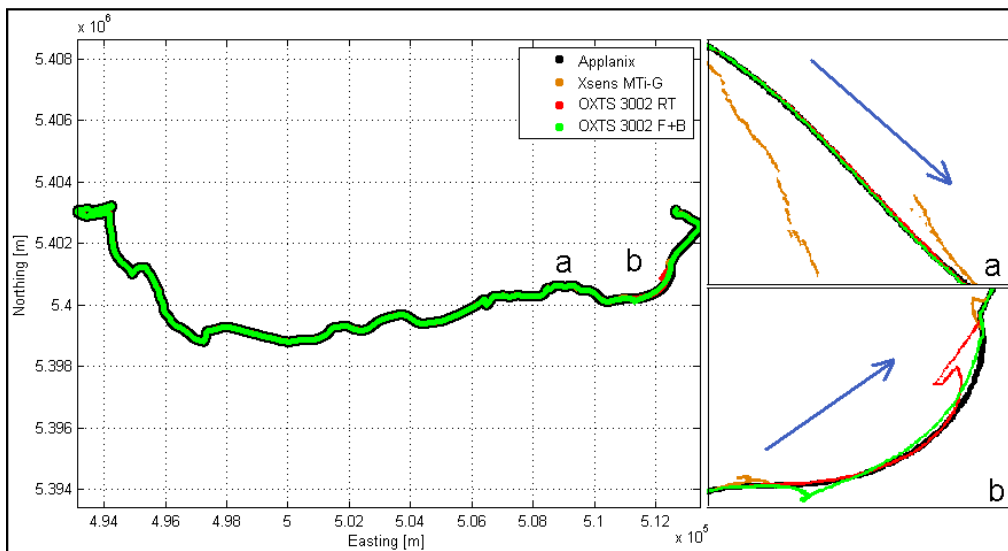
Figure 2: Monitoring the track based on 2D UTM coordinates, blue arrows in sub-figures (a) and (b) show the track direction

Figure 3 shows roll, pitch and heading estimated by the three GPS aided IMUs (left column) and the estimated accuracies of the three orientation angles for the Applanix and OXTS system (left column). The datasets are plotted over time. In the beginning the one antenna systems (Xsens and OXTS) start with varying values,
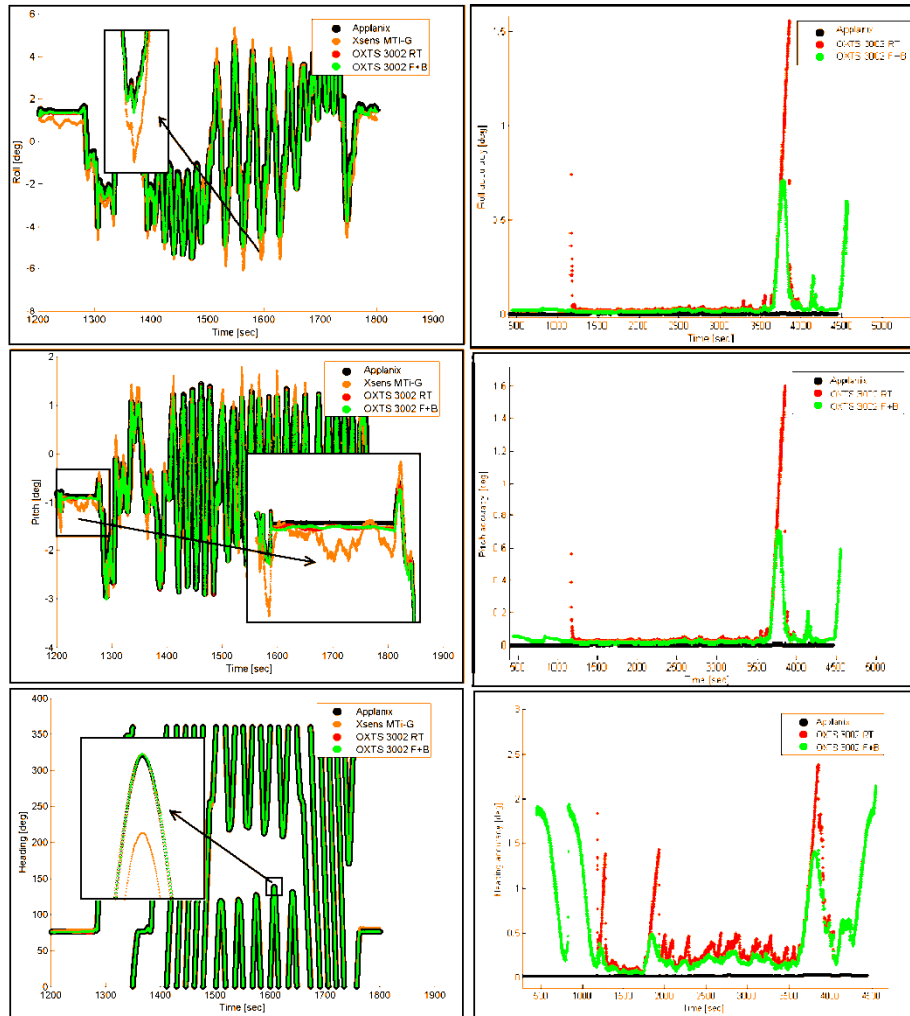
Figure 3: Roll, pitch and heading of Applanix, OXTS before and after post-processing and Xsens (left column) and accuracies of roll, pitch and yaw estimated by Applanix (black) and OXTS (red and green) (right column)

although the vehicle was not moving at that time. After a warming up phase, the orientation of OXTS is very close to that estimated by the Applanix system. The Xsens values show larger variations especially for sudden changes in roll, see Figure 3 top left. In the bottom left part of Figure 3, a change in heading is magnified during two turns. The difference in heading between Xsens and the other two systems is up to 1.5 degrees. The estimates of Applanix for the accuracies of all three angles indicate high precision even in the tunnels. The real-time OXTS accuracy estimates indicate a lower accuracy level with significant differences in the long tunnel. Further the improvement achieved by post-processing the OXTS data is visible in the figure.

The post-processed data of OXTS is a combination of a forward filtered result and a backward filtered result. The filter gives results only after the initialization, which requires driving faster than the initialization speed. This leads to epochs in the beginning of the experiment (t < 1200 s), where the forward filter has not been initialized, but there are results from the backward filter. At the end, the same effect happens. For the backward filter, the direction of the time will be inverted. So the epochs at the end (t > 4000 s) are before of the initialization and have no result from backward filter, but from the forward filter. The combination of both filters is the result of the post-processing. Between the initializations of the forward and backward filter (1200 s < t < 4000 s) the advantage is clearly visible compared to the RT result. Before initialization (t < 1200 s), the PP result is just from the backward filter. In this part, there was only a very short movement. For static conditions, the OXTS one antenna system cannot support the heading estimation and the heading relies only on integration of the gyroscope data, which is drifting. At the end of the experiment (t > 4000 s), the car was static again and RT and forward filter producing the same error behavior, which can be seen in Figure 3.

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Some more details on the estimated accuracies are shown in Figures 4 and 5 for the Y and the height coordinates of Applanix (black), OXTS before (red) and after post-processing (green). The forward velocity is added to the graph (cyan color) with the idea to enable comparison of the coordinates when the vehicle is moving with a certain speed. It is noticeable that the estimate accuracy of post-processing solution of OXTS in the free spaces is higher than the accuracy of Applanix. This can be observed in the detailed views of Figures 4 and 5 for the Y coordinate and the height. The superiority of Applanix is observed within the long tunnel as shown in the other two detailed views.
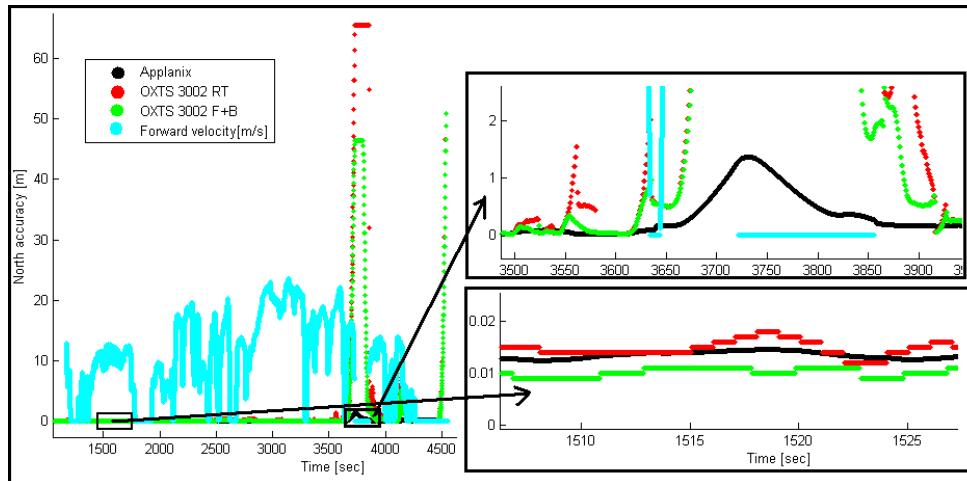
Figure 4: Estimated accuracies for the Y coordinates related to Applanix, OXTS before and after post processing
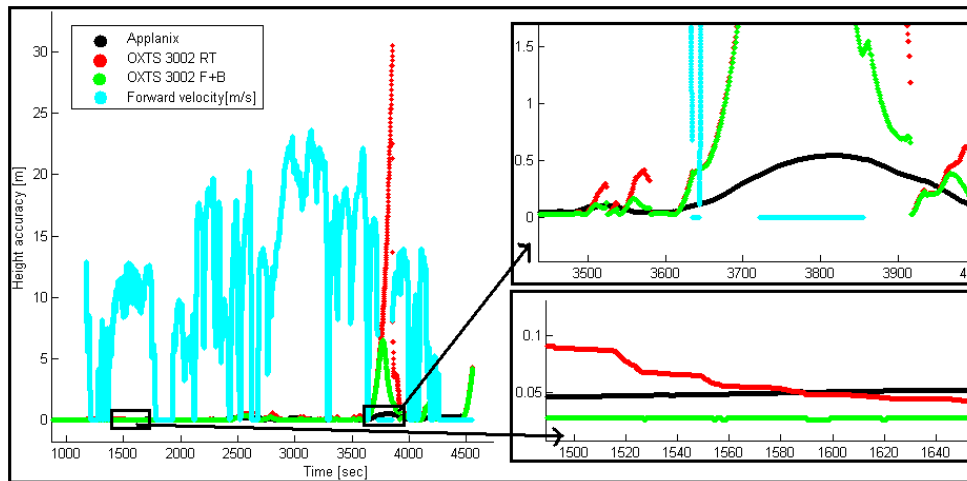
Figure 5: Estimated accuracies for the height related to Applanix, OXTS before and after post processing

Next we have calculated the differences for the estimated positions of Xsens, OXTS RT (real-time) and OXTS PP (post processed) by taking the Applanix data as reference. In the analysis absolute values for the residuals in the X and Y coordinates are taken into account. Figure 5, shows the residuals in the Y direction for the different INS/GPS systems. The big differences in tunnel and the remarkable similarity of OXTS RT and OXTS PP with Applanix (detailed view) are visible in Figure 6.
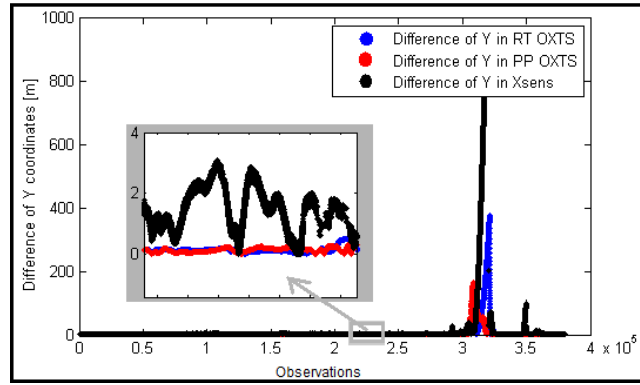
Figure 6: Residuals of Y coordinates of OXTS RT, OXTS PP and Xsens data with respect to the Applanix reference data

For the quantitative analysis the mean absolute differences (MAD) and the root mean square (RMS) values are calculated from the residuals obtained by subtracting Applanix coordinates from those determined by Xsens, OXTS RT and OXTS PP. The tracks are divided into tiles with 36.000 measured locations. This means each tile is representing a segment recorded within 6 minutes of driving.

In the following table MAD and RMS values are listed for the total of 10 tiles. Tiles 1, 2, 3 and 4 represent free space areas, tiles 5, 6, 7 and 8 interurban areas, tile 9 GPS outage areas in tunnels and tiles 10 urban areas containing a small tunnel in the city of Stuttgart.

Unit [m]	Tile 1	Tile 2	Tile 3	Tile 4	Tile 5	Tile 6	Tile 7	Tile 8	Tile 9	Tile 10
MAD Xsens_X	2.61	1.59	2.21	1.86	0.97	0.79	1.75	1.06	507.0	7.18
RMS Xsens_X	3.02	1.73	2.60	2.01	1.19	0.94	1.81	1.20	801.9	24.3
MAD Xsens_Y	0.78	0.47	1.69	0.51	1.68	1.78	1.41	1.47	170.0	5.75
RMS Xsens_Y	0.94	0.62	1.99	0.83	2.09	2.07	1.70	1.96	341.16	14.33
MAD RT_X	NaN	NaN	0.03	0.01	0.03	0.44	0.19	0.06	35.3	0.47
RMS RT_X	NaN	NaN	0.04	0.02	0.04	0.56	0.25	0.08	80.14	1.06
MAD RT_Y	NaN	NaN	0.04	0.04	0.05	0.59	0.21	0.20	39.8	0.97
RMS RT_Y	NaN	NaN	0.05	0.06	0.09	0.84	0.33	0.33	90.79	2.21
MAD PP_X	0.07	0.08	0.07	0.03	0.08	0.29	0.20	0.08	60.3	0.53
RMS PP_X	0.07	0.09	0.09	0.04	0.10	0.36	0.26	0.12	114.87	0.86
MAD PP_Y	0.19	0.15	0.08	0.13	0.09	0.35	0.20	0.22	27.0	0.70
RMS PP_Y	0.19	0.16	0.10	0.14	0.12	0.55	0.25	0.27	49.00	1.06

Table 3: Mean absolute differences (MAD) and the root mean square (RMS) values of Xsens, OXTS RT and OXTS PP with respect to Applanix

The missing numbers of OXTS RT for tile 1 and 2 are a consequence of the not successfully considered warming up phase, because this is before the initialization of the RT filter.

From this table we can see that for the free space areas we have a very good agreement of OXTS RT, OXTS PP with Applanix. MAD values are in the order of 1 to 19 cm, RMS values between 2 and 19 cm. In the interurban areas, in most of the tiles, we have a similar situation. In some tiles MAD and RMS values are higher. In the urban area MAD values are between 47 and 97 cm and RMS values go up to 2.21 m. GPS outage areas in tunnels lead to significant differences which indicate that OXTS certainly needs further stabilization e.g. from odometers.

5   Conclusions

We demonstrated the performance of three integrated navigation systems in a test drive with different GPS conditions. The low cost system Xsens MTi-G works well within its specifications. It cannot handle GPS outages longer than 10 seconds; this protects the user from working with unreliable data. After the outages, it recovers quickly when the GPS signals are available again.

The OXTS systems benefit from their capability to reprocess the RT data again after a possible change of settings. The requirements of backward initialization must be considered and evaluated carefully for post-processing. The analysis of the post-processed data requires some knowledge of the special features of the OXTS software. In short tunnels and static conditions, the OXTS PP solution works better than the RT solution. But for longer tunnels, even the post-processed data becomes unreliable compared to the results of Applanix. Applanix has the best accuracy for orientation due to its better IMU. The estimated accuracy of the positioning filter of the OXTS system indicates higher accuracy as the one of Applanix. In our analysis, we considered the Applanix to be the reference system, so no independent conclusion about its accuracy can be drawn from our work.

Some possible improvements and future work are the usage of RTK corrections also for the Applanix, possible feed of OXTS and Applanix with RTK corrections from the same source simultaneously, an evaluation of the improvement of GPS post-processing of the OXTS data using additionally software like GrafNav, GAMIT, or rtklib, and reading out of the performance metric of Xsens MTi-G (horizontal accuracy, vertical accuracy) for evaluation with tailored software.

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Acknowledgement

Characterisation of Urban Heat Islands in one of the Most Urbanised Corridors of India from Space Based Multi-Sensor, Spatio -Temporal Data

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ABSTRACT:

Urbanization is the process through which the population of urban area increases, and is usually expressed relative to the total population. Urbanization mainly causes the replacement of vegetated areas by non-evaporating and impervious surfaces like asphalt and concrete, which changes the physical characteristics of the surface, such as albedo, thermal capacity and heat conductivity. As a result of this, the urban areas are warmer than the surrounding rural areas, especially during night. This is called Urban Heat Island (UHI). Currently available space based multi-sensor, Spatio - Temporal Remote Sensing data from Indian Remote Sensing Satellites (IRS), Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER), Moderate-Resolution Imaging Spectroradiometer (MODIS) sensors can be excellent source to investigate the Land Surface Temperature (LST) with reference to urban land use dynamics. LST combines the results of all surface–atmosphere interactions and energy fluxes between the atmosphere and the ground. The paper presents the characterisation of UHI for two cities coming under the Pune to Gandhinagar urban corridor. The data used for the study is MODIS/Terra Land Surface Temperature 8-Day L3 Global 1km SIN Grid. The result shows an increasing trend in the intensity of UHI and the extent of UHI in the cities as well as the nearby small towns and in the rural villages.

1   Introduction

Urbanization is the process through which the population of urban area increases, and is usually expressed relative to the total population (Pieter et al, 2003). In urban areas, the natural surfaces are replaced with heat trapping impervious surfaces which directly change the local climate in urban areas and leading to high near surface air temperature than the rural areas especially during night. This is referred to as Urban Heat Island (UHI). According to Oke 1982, the most significant reasons for the UHI is the differences in the thermal properties of the radiating surfaces and a decreased rate of evapotranspiration in the urban environment. In addition to this, the contributions due to urban topography include the "canyon effect" which increases absorption of shortwave radiation, a decreased sky view which reduces outgoing longwave radiation, and increased surface roughness which reduces boundary layer winds as well as hinders sensible heat loss. The high levels of pollution can also increase the urban albedo and reradiate longwave radiation. Hung et al. 2006 explains the two different ways of conducting the urban heat island studies. One is measuring air temperature through the use of automobile transects and weather station network, and the other is measuring surface (or skin) temperature through the use of airborne or satellite remote sensing . The advantage of remotely sensed temperature measurement from satellites is the higher spatial coverage repeatability. The advantage of satellite thermal data is that it can effectively depict the patterns of the thermal environment of extensive urban areas. Streutker 2002 also emphasizes the advent of satellite remote sensing for the study of urban heat island on continental or global scale.   In this day and age of satellites, the satellite science data products are far easier to obtain through a number of programmes such as the National Aeronautics and space administration's (NASA's) Earth Observing System (EOS) programme and Defence Meteorological Satellites Program (DMSP). Moderate Resolution Imaging Spectroradiometer (MODIS) instrument is on board the NASA's Aqua (EOS-PM1) or Terra (EOS -AM1) satellites. MODIS LST Products have already been used for surface UHI investigations in many countries and cities across the globe. Some of the notable studies include Hung et. al. (2006), Pongracz et al. (2006), Cheval and Dumitrescu (2009), Tomlinson et al. (2012). According to Mannstein (1987) & Sellers et al. (1988). LST combines the interaction and the energy exchange between the Earth-atmosphere.

2 Methodology

2.1 Study Area

The study area selected is Gandhinagar and Ahmadabad, the cities coming under Pune to Gandhinagar Urban corridor. This corridor is one of the most urbanized and economic corridors of India. Present study area is selected based on the drastic changes in the Urbanization. Based on CPR studies on future corridors Sivaramakrishnan and Singh emphasised that by 2021, 72% of Gujarat state's urban population will be in Mehsana-Gandhinagar-Ahmedabad-Vadodara-Bharuch-Surat-Valsad corridor. Presently Gandhinagar is the national capital of Gujarat and Ahmadabad is the largest city in the whole state of Gujarat. Even though Gandhinagar is smaller city, it has undergone a rapid urbanisation within a short period of time.

2.2 Data used

The data used for the study is MODIS/Terra Land Surface Temperature 8-Day L3 Global 1km SIN Grid version 5(MOD11A2). The LST over eight days is the averaged LSTs of the daily LST product (MOD11A1) over eight days. The MODIS LST product uses split window algorithms and techniques (Wan and Dozier, 1996) that are corrected for atmospheric effects (including absorption and emission) and surface emissivity (inferred from MODIS land-cover calculations) by utilizing multiple bands from the 36 available on the MODIS sensor. A number of studies have tested the accuracy of the MODIS LST product with favorable results (Wan, 2002; Wan et al., 2004; Coll et al., 2005; Wan, 2008). Though the MODIS sensor is carried on both NASA's Aqua and Terra satellites, the images from Terra is used for the present study which gives the night time image at 10.30 PM. According to Oke and Maxwell 1975, the maximum heat island intensity is best observed at three to five hours after sunset and a rapid decay of the heat island occurs after sunrise. That is why Terra night mode has chosen for the present study. In addition to this a night image allows a more precise LST calculation as there is no incoming solar radiation to change the surface radiation balance, and nighttime MODIS LST accuracy has been found to be better than day time (Rigo et al., 2006)

The data were obtained for the summer seasons (May 17-24) for a period of 11 years from 2000 to 2011 since the heat island is prominent in summer (Oke 1982). The data were downloaded freely from the NASA's online database called WIST (Warehouse Inventory Search Tool). The data were tiles with HDF-EOS format. HDF-EOS applies standards for attaching geolocation and temporal information to scientific data (Larry Klein,2003). Since the HDF-EOS is not generally usable in common GIS application tools such as Arc Info, ENVI and ERDAS, the HDF-EOS to GeoTIFF Conversion Tool (HEG) has been used to convert that data from HDF-EOS to GeoTIFF format for use in GIS application tools. This data is further mosaicked (if necessary), and subsetted. These processing ultimately resulted in a raster file of each image, geo-referenced and clipped to the study area, with each pixel representing LST in Kelvin. Here we are using only three years data (2000,2007,2011) for understanding the trend in UHI.

2.3 Algorithm description

The algorithm developed by the MODIS team is described here in order to understand how the radiance values are converted to Land surface temperature (LST).

The emitted spectral radiance L at wavelength λ from a surface at thermodynamic temperature Ts is given by multiplying the Planck function by spectral emissivity (Lillesand et.al 2007)

$$L\ (\lambda,\ T) = \varepsilon\ (\lambda)\ B\ (\lambda,\ Ts)$$

In thermal Infrared Remote sensing, thermal scanners are used and these scanners sense the thermal portion of the spectrum. The wavelength range used in thermal remote sensing is typically between 3-14 μm (Thermal Infra Red) preferably 8-14 μm. This range is important because the atmosphere is reasonably transparent to radiation in this range (atmospheric window) and the peak emissions from object occur within this range. In thermal scanning the sensors sense only the emitted energy from the objects. In MODIS the bands 31 & 32 range from 10.780 - 11.280 μm and 11770 - 12270 μm respectively.

There are several techniques to derive LST from satellite TIR bands. But the main difficulty is the accurate measurement of emissivity, which varies with materials. Emissivity is a factor that describes how efficiently an object radiate energy compared to a blackbody (Lillesand et.al 2007). Several techniques such as thermal log

residuals and alpha residuals have been developed to extract emissivity from multispectral thermal infrared data (Hook et al., 1992). Based on these techniques and an empirical relationship between the minimum emissivity and the spectral contrast in band emissivities, a temperature emissivity separation (TES) method has been developed for calculating LST (Gillespie et.al). In addition, three types of methods have been developed to estimate LST from space: the single infrared channel method, the split window method which is used in various multi-channel sea-surface temperature (SST) algorithms, and a new day/night MODIS LST method which is designed to take advantage of the unique capability of the MODIS instrument. The day/night MODIS LST method the day- and night-time data of 7 channels of MODIS and inverses LST and channel average emissivity, and don't need high-resolution atmospheric temperature and water-vapour profile. MODIS LST algorithm utilizes the stability of emissivity of certain ground object in thermal infrared band (generalized split-window algorithm) and tiny change of radiance of solar wave band on TOA (day/night LST algorithm) to inverse LST.

Generalized split-window algorithm (Wan & Dozier 1996): This algorithm is applicable to the surface which has relative stable emissivity of band 31 and 32.

$$T_{S=} \left(A_1 + A_2 \frac{1-\varepsilon}{\varepsilon} + A_3 \frac{\Delta\epsilon}{2} \right) \frac{T_{31}+T_{32}}{2} + \left(B1 + B2 \frac{1-\varepsilon}{\varepsilon} + B3 \frac{\Delta\varepsilon}{\varepsilon^2} \right) (T_{31} - T_{32}) + C \qquad (1)$$

Where ε =0.5(ε31+ ε32) and $\Delta\varepsilon$ = ε31- ε32. T31 & T32 are brightness temperature of band 31 and 32. C, Ai and Bi is given by a series of look up tables and which are got by linear regression of multiple surface and atmosphere conditions.

Day/night LST algorithm (Wan &Li 1997) is applicable to all surface with variable and unknown emissivity.

$$L(j) = t_1(j)\varepsilon(j)B_j(T_s) + L_a(j) + L_s(j) + \frac{1-\varepsilon(j)}{\pi}\left[t_2(j)\alpha_\gamma\mu_0 E_0(j) \right] + t_3(j)E_d(j) + t_4(j)E_\tau(J) \qquad (2)$$

Where all items are channel average values. ε(j) is channel emissivity, Bj (Ts) is black body emissivity with land surface temperature Ts, La(j) is path thermal radiation, Ls(j) is scattering solar radiation, E0(j) is solar radiance of TOA, Ed(j) and Et(j) are the average diffuse radiation arrived surface and the down heat emission from atmosphere, ti(j), i=1,2,3,4 is channel effective transfer function. This equation can be solved with statistical regression or least square methods.

3   Results and Discussion

3.1   Preparation and analysis of Land Surface Temperature (LST) Map

LST maps of the two cities for the years 2000, 2007, 2010 have prepared and analyzed. It can be inferred from the maps (Fig1,Fig 2, Fig 3) that the Urban Heat Islands are clearly noticeable in all the three years in both cities. It shows an increase in temperature from the outskirts to the core urban area. This may be attributed by the increase in urban densification and reduction in open spaces.
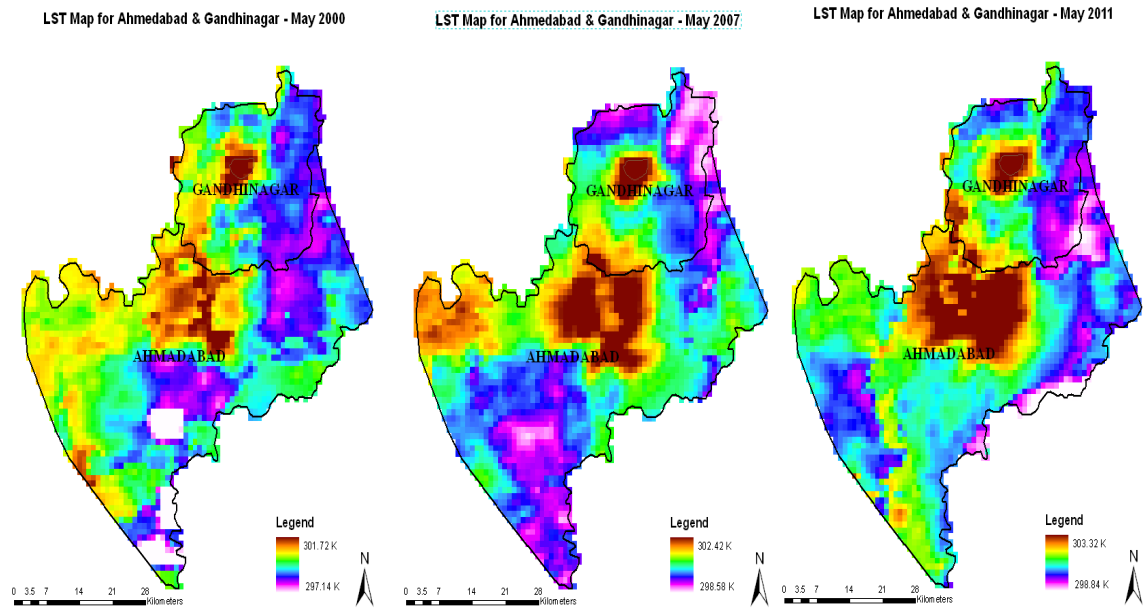
Figure 1

Figure 2

Figure 3

3.2   Multi temporal analysis of Temperature

Multi temporal temperature data from 2000 to 2010 have been taken. The temperature profile for the two cities have been created and analyzed (Fig. 4&5). The profile contains two bells having higher temperature. The wide bell corresponds to Ahmadabad and narrow one corresponds to Gandhinagar. Some anomalies may be there in the data because the 8 day composite products are much easier to be affected by climatic conditions (Tomlinson et al. 2012). In general the average temperature is showing an increasing trend from 2000-2010.

Figure 5 Temperature Profile

Figure 4 Stacked LST data for 2001,2004,2007,2008,2010

Year	Temperature	
	Mean(K)	SD
2001	299.84	0.80
2004	300.33	0.91
2007	300.99	0.81
2008	301.42	1.22
2010	302.34	1.52

Table 3 Mean Variation of LST

3.3 Relationship between urbanization and extent of Urban Heat Island (UHI)

Urbanization and the extent of Urban Heat Island (UHI) is showing a positive correlation. The temperature data is overlaid above the optical data (IRS 1C PAN for 1997 & Cartosat-1 for 2011) to understand spatial variation of Land surface Temperature and the change in urbanization. UHI intensity of higher than 1°K indicates significant thermal modification and, here the extension of the area characterised by this temperature differential is relatively large. In short as the urbanization increases the extent of UHI also increases (figure 6,7,8 and 9).

3.4 Calculation of Urban Heat Island Intensity (UHII)

In order to calculate the UHI Intensity, 10 sample location from urban area and 10 sample location from rural area are identified and fixed for the three years (2000,2007 &2011) using the optical data. From each of the sample location the average temperature of urban and rural locations are calculated and analyzed separately . The analysis (Table 2), shows that the UHI Intensity is showing an upward trend. In rural area the increase in the LST is not much more notable whereas in urban areas it shows a notable change in temperature in all the three years, that result in the increase in trend of UHI Intensity.

Figure 6 IRS 1C PAN-1997

Figure 7 Cartosat 1- 2011
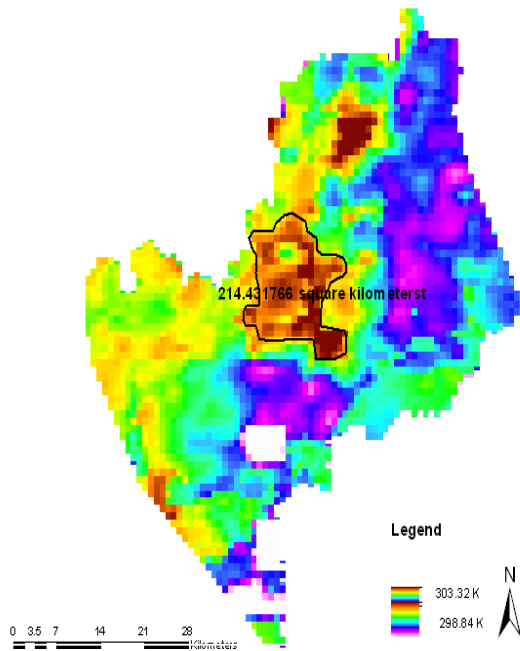
Figure 8 LST Map for 2000 -Extent of UHI city centre
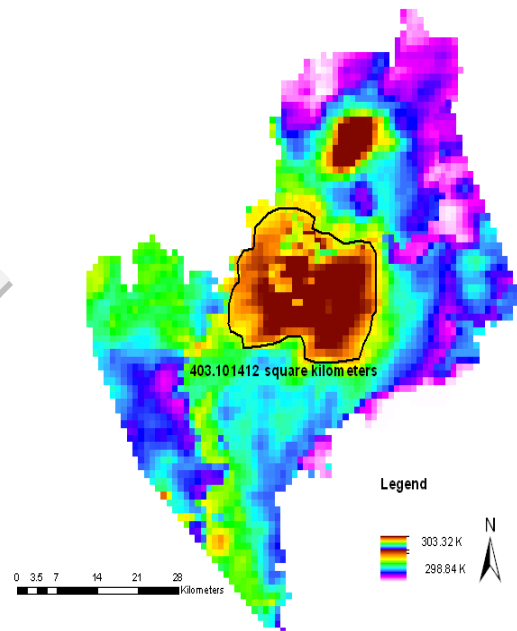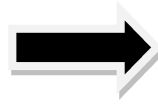
Figure 9 LST Map for 2011 -Extent of UHI city

Year	UHI Intensity
2000	1.51
2007	1.62
2011	1.95

Table 4 Variation of UHI Intensity

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Acknowledgements

Digital Elevation Model (DEM) Extraction from Google Earth: a Study in Sungai Muar Watershed

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ABSTRACT:

Topographic data and DEMs are commonly perceived as providing loaded information for hydrological modelling. However, this information is severely limited, and most users rely on published topographic maps or DEMs produced by government agencies. This paper proposes an alternative method of generating DEM by using online source of elevation data which is easier and free. The result shows that, the difference in percent of the watershed boundary is 0.19% by using Google Earth's elevation data as it compared with the same watershed area which is delineated using 20 meter interval contour data obtained from JUPEM (Department of Survey and Mapping Malaysia). Firstly, the location of the study area identified in Google Earth, was divided into thirty-six areas and marked using provided mark functions in Google Earth. The coordinates were exported to an online application tool named Terrain Zonum Solutions for extracting 5000 elevation points for each thirty-six areas. These points were uploaded and processed in ArcGIS software (version 9.3.1) to generate the DEM. As to compare the reliability of the elevation values that extracted from Google Earth, the DEM was utilized and integrated with river line data to delineate Sungai Muar's watershed boundary using ArcHydro version 1.4 tool. Based on the results, this study proposes an alternative method in obtaining a DEM data for a wide area which is traditionally time consuming and costly.

1   Introduction

In hydrologic studies, it is vital to obtain topographic information for many purposes such as to delineate watershed boundary and to identify the flow direction. Generally, there are several of methods to extract elevation data such as topography map, on-site measurement or data application from government agencies. However, the existing methods are traditionally tedious, time consuming and costly especially for wider area. In Malaysia, it is common for lacking of accessible data for free and accurate. Fortunately, by the extensive development of information technology there are many free source tools that can be manipulated to gather the topographic information and later processed into DEM (Digital Elevation Model). The DEMs commonly perceived as providing a means for encoding the spatial distribution of the hydrological process (Abbot et al., 1986; Moore et al., 1990). In real practice, the topographic information normally gathered from those topographic maps which can be bought from government agency; JUPEM (Department of Survey and Mapping Malaysia). Then, the map scanned and digitized its contour lines to extract the elevation values. Later, these values are used and processed to generate the DEM. Due to extremely tedious work, the digitizing process becomes unpractical and produces less accurate results if it is implemented in wider area. Human error factor may contribute to an action to simplify the contour line while digitizing process. Another option is by downloading DEM SRTM (Shuttle Radar Topography Mission) data which is available for free, provided by USGS (U.S Geological Survey) with the vertical accuracy of 30 m in US and 90 m worldwide. However, for a small area, the accuracy provided by the SRTM may not suitable for some hydrological modelling process because they require more accurate DEM. Therefore, this paper presents an alternative method to extract elevation data using online free web tool and to generate it into DEM by the aid of GIS application tools.

2   Data and Methods

1.1   DEM Extraction from Google Earth

Sungai Muar's watershed area has been selected in this study to be extracted the elevation data. The basic principle for determining the watershed boundary is by identifying the main river (Sungai Muar) and its tributaries. As the limited source of data in this study, the river line for Sungai Muar was digitized using ArcGIS 9.3.1 from existing river map published by the Department of Irrigation and Drainage of Malaysia. These lines then converted to .kml (Keyhole Markup Language) file and viewed in Google Earth to identify the approximate area of the Sungai Muar's watershed. The conversion process can be conducted using Shape2Earth extension in Map Window GIS tool. Sungai Muar flows in Muar, Segamat, Gemas and Gemencheh in Negeri Sembilan to Seri Menanti and Batu Kikir, Negeri Sembilan. The extent of Sungai Muar watershed area are from 1.926702°N, 102.056472°E in lower left corner and 2.972698° N, 103.222606°E in upper right corner. Then, these areas were divided into thirty-six areas using a marking tool provided in Google Earth. Each of these marks contained latitude and longitude values which are in WGS84 (World Geodetic System) projection. Next, these coordinates were exported to extract elevation data in an online tool named Terrain Zonum Solution that can be accessed for free in http://www.zonums.com/gmaps/terrain.php. This tool is easy to understand and to use as it only required some basic information such as the location (latitude, longitude) and numbers of points sampling. The maximum points would be 5000 points for both type of sampling either randomly or uniform grid. The tool automatically marks the elevations points which depend on the desired requirement of the detail for the data. Reduce the extent area but increase the number of sampling points to obtained detail elevation data. The output of the extraction process are the coordinates (x,y) values (WGS84 projection) including the elevation (z) in meters. These values are then imported into a text file for further process in ArcGIS 9.3.1. Figure 1 shows the overall process of extracting the elevation data in Google Earth.
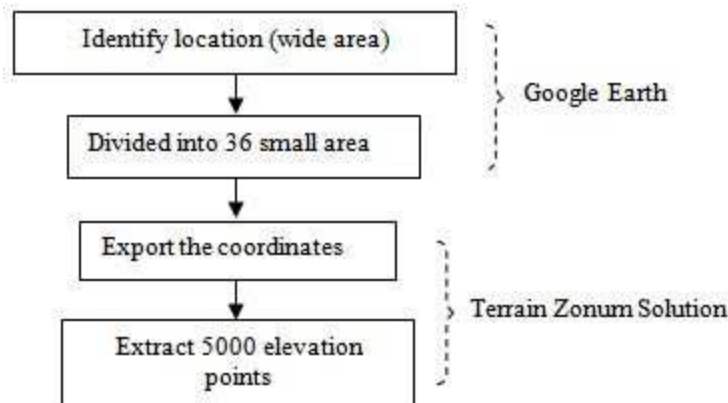
Figure 1: The flow of extracting processs

1.2   Watershed Delineation

This section explains the process to delineate Sungai Muar's watershed boundary by using the previous elevation data extracted from Google Earth (later, GE elevation data will be used in this paper).

The elevation points are then exported to ArcGIS 9.3.1 and converted into shapefiles (.shp). Before conducting the next process, the elevation value should be checked. Google Earth gives -32768 m value for any points obtained from water area such as sea. Therefore, these values should be eliminated as they become outliers for the data and disturb the accuracy for the next process. As the data cleaned from the outliers, the TIN (Triangulated Irregular Network) was then generated using 3D Analyst tool in ArcGIS 9.3.1. According to Peucker et al., (1978) and Mark (1975), TINs usually the samples of surface specific-points, such as peaks, ridges and break in slope and form an irregular network of points store as a set of x,y, and z coordinates together with pointers to their neighbours in the net. From TIN, it then converted to raster as it becomes the DEM data which is the most widely used terrain model for drainage delineation. A DEM is a grid of square cell; and each cell value represents the elevation of the land surface. By determining how water flows from cells to cells, the set of cells whose drainage flows through the cells at the outlet point location can be identified and thus the watershed area determined (Maidment, 2002). The ArcHydro version 1.4 was utilized to delineate Sungai Muar's watershed boundary. It is an extension tool for water resource management in ArcGIS and this version

is compatible with ArcGIS 9 or 9.3.1. The depression in the DEM data firstly 'filled' by increasing the cells value in depression to depression's spill point value. The next process is to compute the flow direction for each cell in the 'filled' DEM. After that, the next step is followed by the computation of the flow accumulation value for each cell. This is simply the count for each cell of how many upstream cells would contribute based on their flow directions. After these pre-processing phases, the datasets can be further processed to delineate watersheds. This process is simple by integrating flow direction data with digitized Sungai Muar river line that have been converted into raster. The overall process of manipulating the extraction of elevation points until the watershed delineated. The processed displayed in Figure 2.
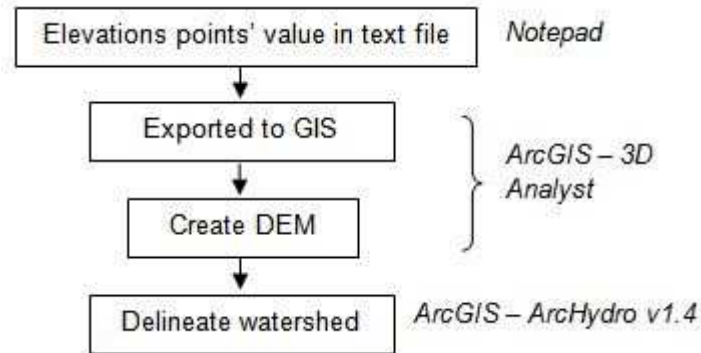
Figure 2: The brief process of watershed delineation

2   Results and Analysis

In this section, the height comparison between GE's elevation and 20 metres interval contour will be discussed using a normal distribution statistical comparison. Later, the delineated boundaries from both data were compared and analyzed.

2.1   GE Compare with 20m Interval Contour

To analyze the reliability of GE's elevation data, approximately, 6521 hectares of flat area and hilly area were extracted their height values. These GE's elevation points then overlapped with 20 metres of contour interval data and analyzed using normal distribution statistical method. Based on the results, the difference of mean and standard deviation value for GE's elevation data is close to 20 metres of contour interval data (see Table 1).

Area	Source	Mean	Stand. Dev
Flat	Google Earth	12.87	6.41
	20 m interval	14.18	7.36
Hilly	Google Earth	62.54	13.15
	20 m interval	61.94	12.30

Table 1 Height comparisons for three sources elevation data

Later, the mean and standard deviation values, used to calculate the normal distribution of both data and displays in Figure 3. According to the bell shape formed, the GE's elevation data fell in the range of 20 metres contour interval data for its normal distribution in hilly and flat area.

2.2   Further GE Comparison

There was a hydrologic study conducted by NAHRIM (National Hydraulic Research Institute of Malaysia) in Sungai Muar watershed area (San & Selamat, 2010) which involved 20 meter interval contour of data for watershed delineation. Hence, their boundary area was digitized and compared with the results of watershed delineation using GE's elevation data. Based on the results (see Table 2), the watershed boundary delineated from GE's elevation data produced an (i) area difference as it compared to NAHRIM's delineated boundary. The finding is really interesting due to the source of NAHRIM's elevation data by using 20 meter interval of

contour data. Additionally, a (ii) ratio measurement also conducted to compare the boundary shape of GE with 20 m interval of contour data. This calculation conducted by divided boundary's perimeter over area. In addition, the GE boundary also compared the (iii) percentage of overlay area with NAHRIM'S boundary by intersecting both boundaries in ArcGIS. Lastly, these boundaries are also compared with their location of mean centre which is 2.1 km difference in distance between two mean points (see Figure 4).
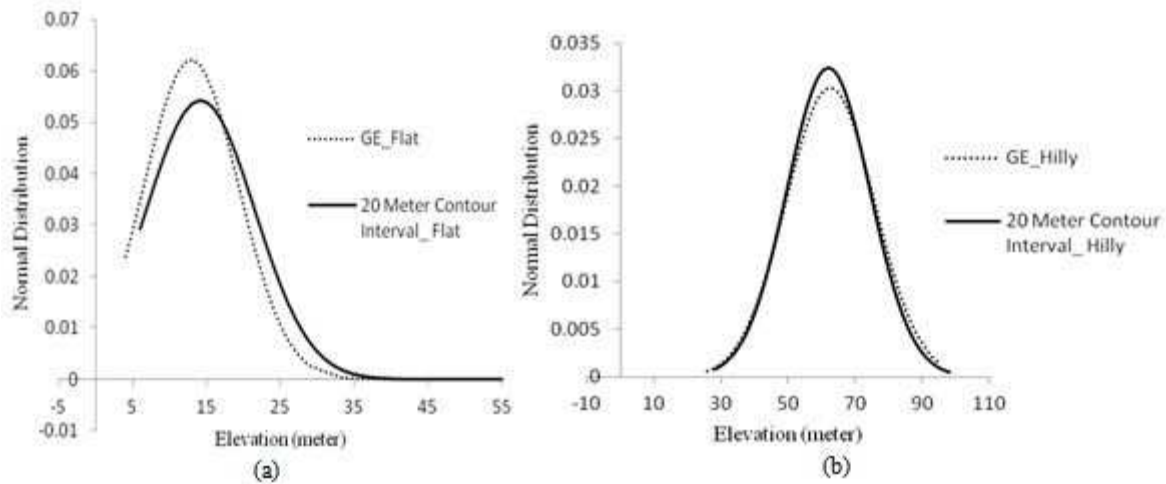
Figure 3(a): Normal distribution graph in flat area, (b) Normal distribution graph in hilly area

Data Source	Area (km^2)	Perimeter (m)	(i) % Difference	(ii) Ratio (Perimeter/Area)	(iii) % Overlay	(iv) Mean centre distance
20 m interval	6149.00	590.15	0.19%	0.09	76 %	2.1km
Google Earth	6137.46	614.20		0.10		

Table 2 Comparison results of both
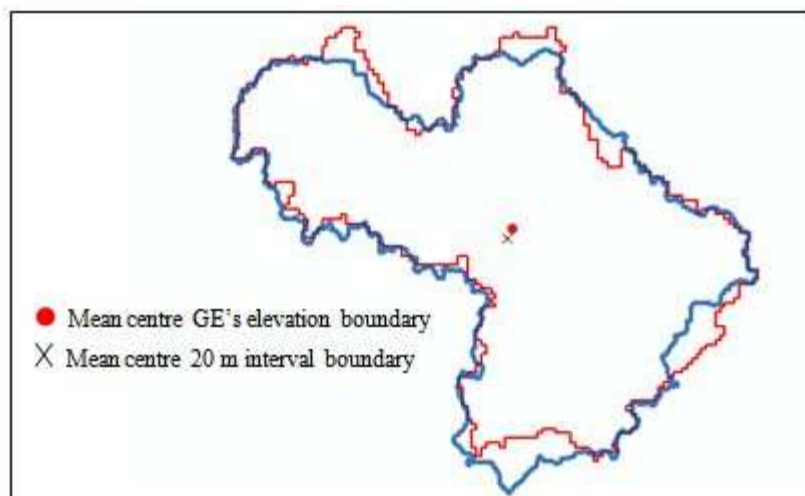
Figure 4 Mean centre location for both boundaries

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There are wide online forum discussions on the accuracy of elevation data in Google Earth. However, there is no official statement from Google on their elevation source of data including its accuracy. The early reliable information from Google Earth's personnel, that the elevation provided by GE is originated from ten (10) different sources of elevation data. However, they do not mention about the sources. Among the GE's user, they speculated that one of the elevation source in GE is from SRTM data which its resolution vertically 30 metres in US and 90 metres worldwide. However, starting from June 2009, NASA and Japan both released ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) satellite data on the internet for free. The data covers 99% of the entire Earth's landmass terrain compared to SRTM which is only 80% coverage. In addition, ASTER's data providing better resolution compared to SRTM. It has a base resolution of 30 metres, and can be extended to 7m-10m. Therefore, there is a probability that GE is utilizing this free data as one of their elevation source. In fact, the GE's users had tested the accuracy of elevation data by comparing the site measurement. Many of them agree that GE's elevation is more accurate in flat area with error range less than 5m and some findings less than 1m. However, in mountainous terrain, the data is less accurate due to GE's elevation where the data appears to be an average elevation data for an area centred over the desired point.

3   Conclusions

The results from the watershed's delineation process have indicated that the elevation data extracted from GE is usable. Moreover, this finding has given some hopes to the researchers that are having difficulties in collecting elevation data for their studies. In fact, researches do not need to spend money to conduct extremely tedious processing of data collection if the same accuracy can be easily obtained from Google Earth.

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Acknowledgements

Mapping the Condition of Asphalt Roads using HyMap Imagery

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ABSTRACT

For many years now, traditional field survey methods have been successfully used for the mapping of road conditions. This has proved to be effective and convenient if the area to be surveyed is small. However, the time required for capturing field data as well as costs incurred increase with the length of the road network. Therefore, there is a high demand for efficient methods for mapping the condition of road materials, in particular for large areas.

Hyperspectral remote sensing has the potential to become a key approach for mapping urban, semi-natural and natural environments. Previous research carried out by the authors with HyMap imagery has shown that hyperspectral data has a significant capability for automatic identification and mapping of road materials and conditions.

This study aims at a detailed analysis of hyperspectral data in order to map the condition of asphalt roads. It is based on an urban area in Ludwigsburg, Germany using a HyMap dataset recorded during the HyEurope campaign in August 2010. The dataset has a spatial resolution of 4 m and comprises 125 bands in the range 0.45 – 2.49μm. Vector data of roads is combined with the HyMap data to limit the analysis to roads. The goal is to classify the asphalt roads of the study area into four different conditions of asphalt, namely new, good, intermediate and bad. For this purpose training regions are defined using in-situ surveys of road segments. The geometry of each segment is captured by differential GPS measurements. In order to determine features (band combinations) which are suitable for the distinction of target classes, the discriminant analysis feature extraction (DAFE) is applied to the hyperspectral data. The classification is based on the extracted features and is performed with spectral angle mapper (SAM). A confusion matrix is employed to assess the classification accuracy of mapped asphalt conditions.

1   Introduction and related research

Hyperspectral data consists of numerous, narrow and adjacent spectral bands. This provides for every pixel in the hyperspectral image a unique spectral signature, i.e. a wavelength dependent reflectivity progression. Therefore, hyperspectral data has a good capability for automatic identification and mapping of the condition of road materials. However, exploiting the high spectral information content of hyperspectral data requires an understanding of ground material properties and their relation with hyperspectral measurements.

(Herold et al., 2004) explore the capabilities of hyperspectral data in mapping road conditions in California, USA. Information about the road condition is acquired by experts based on extensive field measurements and used to create a pavement condition index (PCI). A spectral library of the road surfaces and distress (e.g. cracks) is compiled using an ASD hand-held spectrometer in order to study the generic spectral characteristics of road conditions. The investigation shows that different road conditions (asphalt material) can be distinguished based on their spectral characteristics. The information derived from the spectral characteristics about the road conditions agrees to a higher extent with that based on field measurements. Research by (Mohammadi, 2011) shows that supervised classification using regions of interest with few or no outliers can enhance the classification of target materials in an image. The research also shows that some materials belonging to different classes have similar spectral characteristics. These materials mostly can be distinguished by using spectral

features, i.e. specific spectral behavior within two wavelength positions in the reflective part of the electromagnetic spectrum (Heiden et al., 2007).

In this study, regions for evaluation and training are defined by field inspection using differential GPS to capture the geometry. The discriminant analysis feature extraction (DAFE) proposed by (Landgrebe, 1999) is applied to the hyperspectral data. The goal is to determine and use only features suitable for the distinction of the target materials. It can be expected that this will help to enhance the separability of the material classes of interest and also reduce the dimensionality of the hyperspectral data (thus reducing the processing time). DAFE is based on the within-class and between-class scatter matrices defined by the training samples. It attempts to find a transformation matrix which when applied to the hyperspectral data, maximizes the class separability. The resulting features are used to create a new image and this image is classified with SAM. The classification results of road surface materials and different conditions of asphalt are presented in chapter 4 and 5, respectively.

2   Study area and data

The analysis of hyperspectral data to support road surface material classification is done for a case study in the city of Ludwigsburg. This city is situated in Baden-Württemberg, Germany, particularly in the north of Stuttgart, near the river Neckar. The image data covers the urban area extending approximately 9.6 km x 9 km of this city. The hyperspectral data was acquired during the HyMap campaign on 20th August, 2010 by German Aerospace Center (DLR) and consists of six strips. The data consists of 125 bands (ranging from 0.45 µm to 2.49 µm) and has a ground sample distance of 4 m. Amtliche Liegenschaftskarte (ALK) vector data of roads is provided by Fachbereich Stadtplanung und Vermessung der Stadt Ludwigsburg. The vector data is used for limiting the analysis to roads and thus reduce confusion between roads and surrounding objects. GPS data of regions for evaluation and training is obtained from field measurements.

3   Defining regions for training and evaluation

Regions for training and evaluation are defined in the field with a GeoXH differential GPS with a measurement accuracy of 30cm. These regions represent four different materials, namely concrete, gravel, asphalt and cobblestone. Besides, some training regions are introduced for vegetation in order to exclude vegetation from the further analysis. In addition, regions are defined for the different conditions of asphalt, that is, new, good, intermediate and bad. It is challenging to define regions that are predominantly bad or intermediate. Most of these regions are on narrow roads which are usually bordered by trees or tall buildings. A total of 22 training regions and 16 evaluation regions are defined. The GPS data for the regions is converted to polygons. Figure 1 shows an example of the different conditions of asphalt.

4   Classification of road surface materials

Before classification, the ALK vector data of roads is used to subdivide the hyperspectral data into segments, in particular to mask the roads. The resulting road image is used for further analysis. DAFE is applied to the road image in order to determine suitable bands or features for the differentiation of surface materials, namely asphalt, concrete, gravel and cobblestone. Evaluation of the weight of the resulting features shows that the first five features (with the highest eigenvalues) are sufficient for the differentiation of the target materials. The features are used to create a new image with a reduced dimensionality. The new image is classified with the SAM similarity measure. The overall result of material classification is shown in figure 2. It is observed that some road segments are classified as vegetation. Ground truth information confirms that these road segments are truly covered by vegetation, in particular by overhanging trees which are located within the road segments created from vector data.
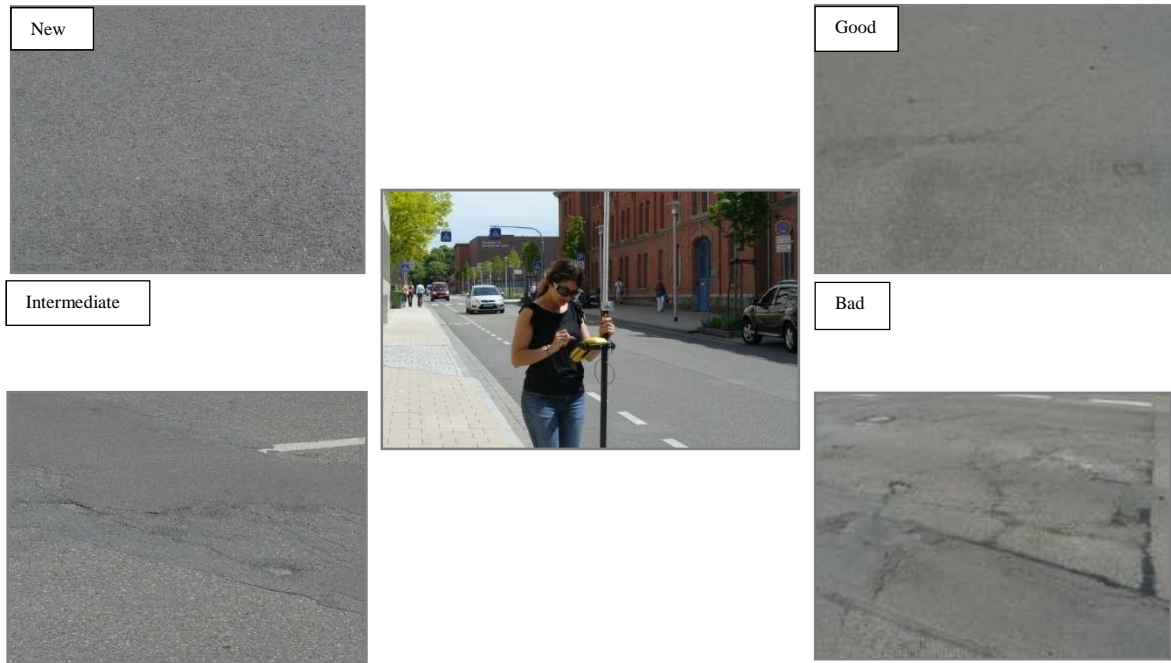
Figure 1: Defining regions for various asphalt conditions with differential GPS.
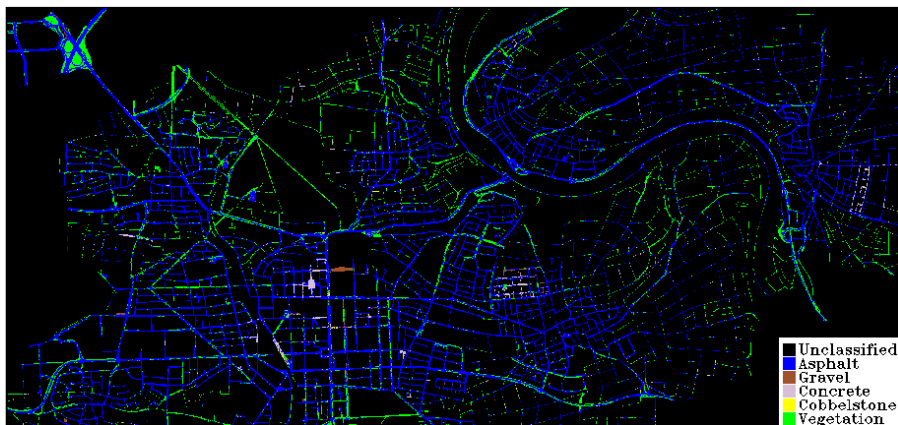
Figure 2: Classification map for different road surface materials.

Figure 3 shows some of the evaluation regions for the different materials in the orthophoto and classification map. Unlike the other evaluation regions shown in figure 3, the evaluation region for cobblestone is also a training region since it was hard to find an area which was mostly cobblestone not mix with other types of materials. It is observed that the evaluation regions are classified correctly.

In order to obtain detailed information about the accuracy of the classification result, a confusion matrix is calculated for the different road surface materials using 15 material training regions and 10 additional regions based on field measurements. Two measures, namely the overall accuracy and kappa coefficient are considered important in the confusion matrix calculation. The overall accuracy gives the ratio between correctly classified pixels and the total number of pixels. In this study, the overall accuracy achieved is 98.5%. The kappa coefficient shows the proportion of agreement obtained after removing the proportion of agreement that could be expected to occur randomly (Foody, 1992). It takes into account all elements of the confusion matrix. The values of the kappa coefficient are classified in three main classes for interpretation: A value between 0.8 and 1 shows strong agreement, a value between 0.4 and 0.8 shows moderate agreement, and a value between 0 and 0.40 shows poor agreement (Congalton, 1996). In this study, the kappa coefficient is 0.98 (strong agreement).
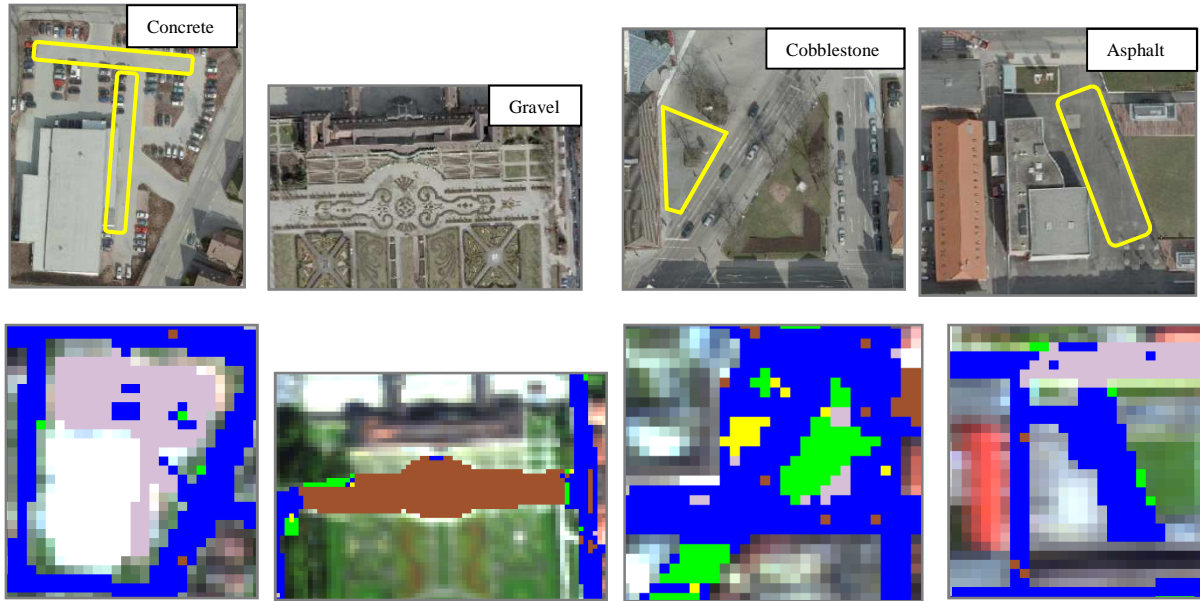
Figure 3: Classification of road surface materials: evaluation regions.

5   Classification of asphalt road conditions

In this part of the investigation, focus is on the different conditions of asphalt. In particular, the asphalt region mapped in the previous material classification is used to extract asphalt road regions within the original hyperspectral image. All other regions consisting of other materials are eliminated. This is done in order to avoid confusion between asphalt and other road surface materials in further analysis (asphalt condition investigation). DAFE is applied to the hyperspectral image consisting of asphalt material. The feature extraction is performed with training regions for new, good, intermediate and bad asphalt conditions. However, it should be noted that some of the regions defined by field inspection could not be used in the road conditions investigation because the associated roads in the hyperspectral image were covered by shadows cast by buildings or trees. The first five resulting features (with the highest eigenvalues) are used to create a new image and it is classified using the SAM similarity measure. The overall result of the asphalt condition classification is shown in figure 4.
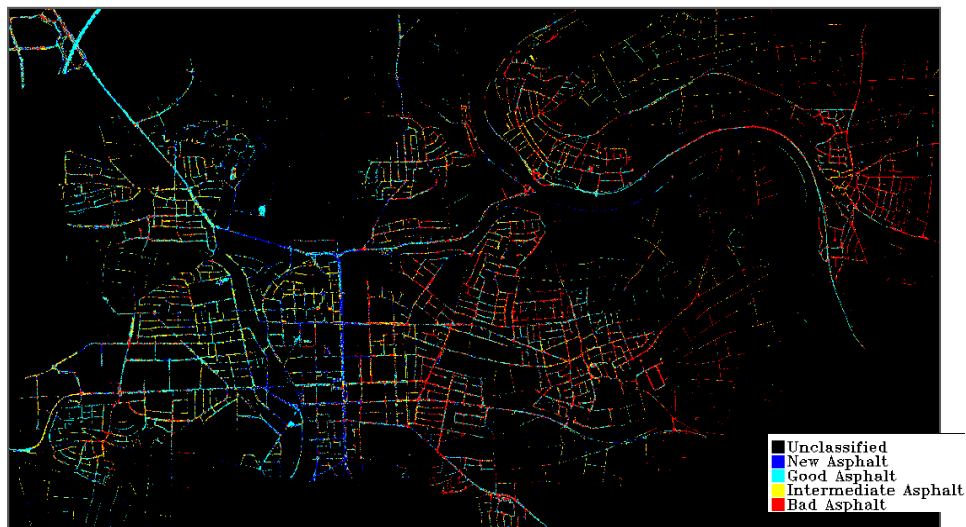
Figure 4: Classification map for different asphalt conditions.

The class statistics computation based on the classification of asphalt road conditions reveals that 11 % of the pixels are identified as new asphalt, 32% as good asphalt, 22% as intermediate asphalt and 35% of the pixels as bad asphalt. Figure 5 shows how some of the evaluation areas are classified. These areas are exclusively used for evaluation purposes. Inspection of these areas shows that they are predominantly classified correctly. For instance, the upper image in figure 5 shows that a part of the area around the "film academy" consists of new asphalt and this is confirmed by field information. It is observed that most of the pixels within this region are classified as new asphalt (blue) as expected. The lower classification image shows that "Ditzinger-Strasse" consists of good asphalt which is also confirmed by field inspection.

Figure 5: New (upper) and good (lower) asphalt condition classification.

Figure 6 shows examples of intermediate (upper) and bad (lower) asphalt conditions. The intermediate asphalt condition region is mapped along "Christoph-Strasse" and the bad asphalt condition region is mapped along "Karl-Haussmann-Strasse". The evaluation regions in yellow and red confirm the classification results.
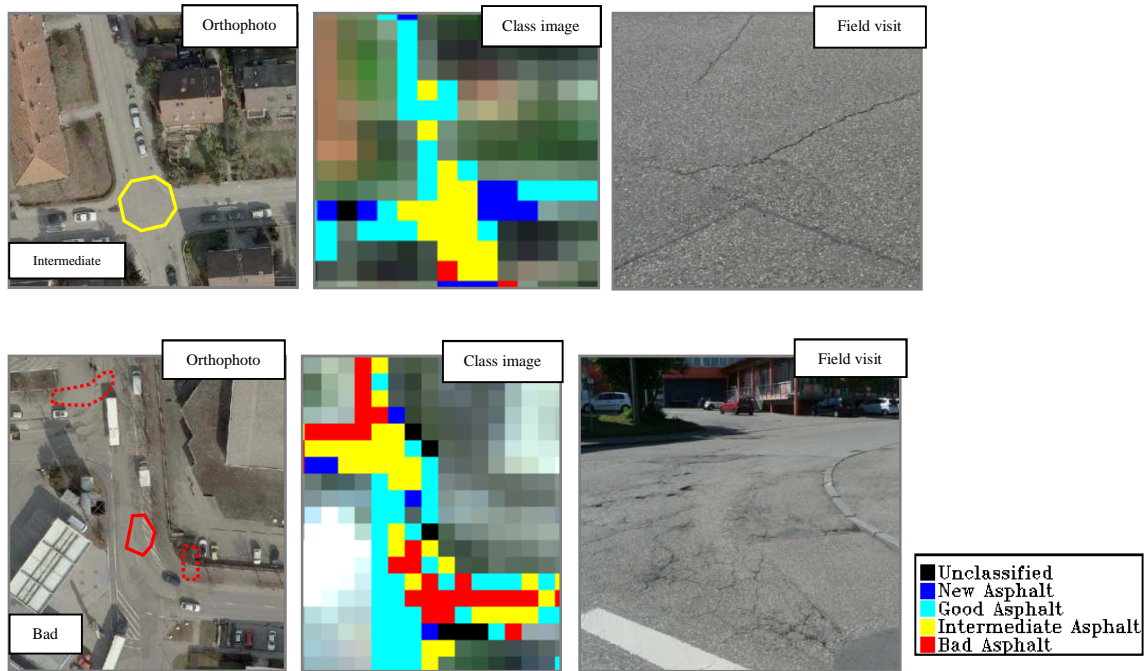
Figure 6: Intermediate (upper) and bad (lower) asphalt condition classification.

A confusion matrix is also calculated for the different asphalt condition classes. A total of 17 training regions plus 14 additional regions are used for this purpose. An overall accuracy and kappa coefficient of 75.4% and 0.65, respectively are obtained. The achieved kappa value indicates a moderate agreement. Details of the confusion matrix are provided in table 3.

Class	Ground truth (pixels)						
	New Asphalt (Pixels)	Good Asphalt (Pixels)	Intermediate Asphalt (Pixels)	Bad Asphalt (Pixels)	Total	Producer Acc. (Percent)	User Acc. (Percent)
New Asphalt	39	2	0	0	41	73.58	95.12
Good Asphalt	1	41	0	7	49	75.93	83.67
Intermediate Asphalt	3	7	10	1	21	100.00	47.62
Bad Asphalt	10	4	0	17	31	68.00	54.84
Total	53	54	10	25	142		

Table 1: Confusion matrix for the classification results.

The producer's accuracy is a measure indicating how much of a class on the ground is classified correctly. For instance, in table 3 the intermediate class has a total of 10 ground truth pixels and all the 10 pixels are classified correctly. Therefore, the producer accuracy is given by the ratio (10/10) multiplied by 100%. The user accuracy is a measure indicating the probability that a pixel labeled as a certain class in the image really belongs to this class. For example, the total number of pixels classified as intermediate asphalt is 21. However, only 10 pixels are classified correctly. The user accuracy is given by the ratio (10/21) multiplied by 100%. Table 3 shows that new and good asphalt have high user accuracies (very good). However, intermediate and bad asphalt have relatively low user accuracies. This may be due to the fact that some of the regions defined during field measurements for intermediate and bad asphalt were more generalized (usually a mix) in the sense that some areas belonging to either good or new asphalt road segments were included.

6 Conclusion

In this study, a detailed analysis of hyperspectral data is performed in order to map different road surface materials and conditions of asphalt. Defining the geometry of training and evaluation regions using differential GPS is helpful in determining the corresponding locations of the regions in the associated image. The classification process is an extrapolation of the training regions in the image and thus it is affected by the quality of these regions.

The discriminant analysis feature extraction helps to identify band combinations that are very essential for distinguishing target materials. Moreover, vector data of roads helps to limit the analysis to objects of interest (road surface) and avoid confusion with surrounding objects. The classification accuracies of the mapped road surface materials and asphalt conditions are assessed by calculating a confusion matrix. In both cases, the kappa coefficient value and the overall accuracy indicate that the classification results are reasonable. It is also noticed from the investigation that the asphalt condition of narrow roads especially those which are bordered by buildings and trees is still a challenge to map accurately. The classification results can be improved for such roads by either using hyperspectral data with a better spatial resolution or improving the spatial resolution of the already existing hyperspectral data. This can be done by fusing the hyperspectral data with high spatial resolution panchromatic data. However, the fusion technique used should preserve the spectral information of the original hyperspectral data.

7 References

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Pansharpening of Hyperspectral Data: An Investigation focused on Mapping of Building Roofs

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ABSTRACT:

Hyperspectral data is acquired by sensors with a fine spectral resolution and thus has a significant capability for automatic identification of materials. However, there is usually a tradeoff between the spectral and spatial resolution of a sensor. Therefore, it is common to find that a sensor with a high spatial resolution has limited spectral bands (spectral resolution) and the converse is also true. For multispectral imagery, in particular those recorded by new commercial earth observation satellites, it is common practice to enhance the multispectral information with that obtained from high resolution panchromatic data. Many methods have proved to be effective for enhancing the spatial resolution of multispectral images which can be explained by the fact that the spectral range of the panchromatic band of those sensors covers essentially the whole spectral range of its multispectral bands. Little work has been done so far for extending the procedures to hyperspectral imagery. The challenge is developing methods that enhance the resolution of the material borders (in the image) and preserve the spectral information of the original hyperspectral data as much as possible.

Pansharpening is an image enhancement technique in which a low spatial resolution multiband image is fused with a high spatial resolution panchromatic image. The resulting pansharpened image should adopt the spectral and spatial characteristics of the multiband and panchromatic data, respectively. In this study, building roofs are classified using pansharpened hyperspectral data. Amtliche Liegenschaftskarte (ALK) vector data of buildings and roads is combined with the hyperspectral data to limit the analysis and reduce confusion between roofs and surrounding objects. The hyperspectral data is pansharpened using different techniques such as Principal Component Fusion and Gram-Schmidt transform. A new sharpening technique based on segmentation of a high resolution panchromatic image derived from an RGB-orthophoto is proposed. The pansharpened images are classified with spectral angle mapper (SAM) similarity measure. In this study, the best results of the classification of building roofs are discussed and presented.

1   Introduction and related research

Pansharpening can be applied to hyperspectral data in order to improve the spatial resolution of the data. However, care should be exercised when selecting a pansharpening method for hyperspectral data. The pixel values of calibrated hyperspectral data represent absolute reflectivity values of the material surface to which the pixels belong. Therefore, the surface materials can be identified and distinguished on the basis of these reflectivity values or spectral information. This means that a good method for pansharpening hyperspectral data should not only improve the visual quality but should also preserve as much as possible the spectral information of the original hyperspectral data. Therefore, it is necessary to compare the performance of pansharpening methods in order to determine a suitable approach.

Several research publications have compared the performance of some pansharpening methods. (Vijayaraj, 2004) compares multiband imagery sharpened using the Intensity-Hue-Saturation Transform, Principal Component Analysis, Wavelet Transform and Brovey Sharpening. The evaluation is based on statistical measures such as Root Mean Square Error and Correlation Coefficients. The results of the investigation show that the Wavelet Transform sharpened image is spectrally and spatially close to the original image at the same resolution. (Moeller et al., 2009) propose a variational approach for sharpening high dimensional images. In

particular, two approaches are presented, namely the variational wavelet pansharpening (VWP) and the alternate energy (AVWP). These approaches are applied on a four band multispectral image (Quickbird satellite data) with a spatial resolution of 2.4 m. A panchromatic image with a spatial resolution of 0.6m is used for this purpose. In order to evaluate the proposed approaches, the pansharpened multispectral image obtained using each approach is compared to the multispectral data pansharpened using the Intensity-Hue-Saturation (IHS) Transform, Principal Component Analysis (PCA), Brovey, Wavelet Fusion (stationary) and the P + XS image fusion proposed by (Ballester et al., 2006). The evaluation is based on image quality metrics, namely the Relative Dimensionless Global Error in Synthesis (ERGAS), Spectral Angle Mapper (SAM), Spectral Information Divergence (SID), Universal Image Quality Index (Q-average), Root Mean Squared Error (RMSE), relative Average Spectral Error (RASE), Correlation Coefficients (CC) and Filtered Correlation Coefficients (FCC). The results indicate that the highest spectral distortion is in the PCA, IHS and Brovey pansharpened data. This data also has the highest spatial quality. The VWP and AVWP pansharpened data is not as sharp as the pansharpened data resulting from the other methods. However, most of the spectral information is preserved in this data and this is confirmed by the ERGAS, RASE, RMSE and CC values. The best values are obtained for VWP and AVWP pansharpened data.

The research discussed above like most of the available studies by other authors compares the performance of pansharpening techniques based on statistical measures such as Root Mean Square Error and Correlation Coefficients. However, this study compares pansharpening techniques by focusing on the effect of these techniques on material classifications. Some of the common pansharpening techniques are compared, namely Principal Component Analysis, Wavelet Fusion and Gram-Schmidt Transform. In addition, an alternative pansharpening method which is based on an initial segmentation of high resolution panchromatic data with an additional use of map vector data is proposed.

2   Study area, data and preprocessing

The hyperspectral data used in this study was acquired by German Aerospace Center (DLR) on 20th August, 2010 in the course of its annual HyEurope campaign. The data covers the city of Ludwigsburg, Germany, which is located close to Stuttgart in the Neckar basin and consists of 125 bands (ranging from 0.4 µm to 2.5 µm). It has a ground sample distance of 4 m. The scene consists of 6 strips with an overall extension of $9.6{\times}9.0$ km^2. The RGB-orthophoto was registered in the spring of 2010. The ground resolution of the orthophoto was originally 25 cm; it was degraded to 1m in order to keep the pansharpening factor moderate. ALK vector data of buildings and roads is provided by Fachbereich Stadtplanung und Vermessung der Stadt Ludwigsburg. This vector data of buildings is used for limiting the analysis to roofs. The preprocessing of the hyperspectral data was done by DLR; in particular the data was corrected for radiometric, geometric and atmospheric effects. A high resolution LiDAR surface model of Ludwigsburg with 2 m raster size was made available for this purpose.

3   Segmentation-Based Pansharpening Method

The goal of this paper is to introduce a pansharpening method which preserves as much as possible the spectral characteristics of the original hyperspectral data. In the first stage of the investigation, segmentation of a high resolution panchromatic image is performed. The segmentation is carried out with eCognition software using a multiresolution segmentation approach. Pixels with similar grey values are grouped together to form segments. In particular, three parameters mainly affect the segmentation process, that is, scale, colour and shape. The scale determines the maximum allowed heterogeneity for the resulting image objects. Colour and shape are competing weight parameters, which favour either similarity of grey values or a simple form of the resulting objects. Shape is defined by two competing parameters, that is, smoothness and compactness. These parameters provide either smooth object boundaries or optimal compactness of the object areas. The segmentation of the panchromatic image is performed using the following scale, shape and compactness values: scale = 100, shape = 0.2 and compactness = 0.9. Vector data of buildings and roads is incorporated in the segmentation process. The vector data serves as the first level of the segmentation and thus each polygon of the vector data represents a segment. This segmentation is refined by additional splitting of the high resolution image, i.e. the borders defined by the vector data are not changed but only additional borders are introduced. Figure 1 shows the segmentation result for a small portion of the research area.

Figure 1: Segmentation of panchromatic image

In the second stage of the investigation, the hyperspectral data is interpolated by means of an inverse distance method on the finer grid. The interpolation is performed with MATLAB software. Only pixels of the original hyperspectral image which are located completely in the same segment as the interpolation position are used. The pixel centers of the hyperspectral image are considered as data points, whereas the pixel centers of the panchromatic grid are considered as interpolation points. In order to evaluate the resulting pansharpened image, it is compared with hyperspectral data pansharpened with the Principal Component Fusion, Gram-Schmidt Transform and Wavelet Fusion. Figures 2 – 7 show the original HyMap data, RGB orthophoto and the pansharpened data achieved with four different methods, for a small region within the city of Ludwigsburg.
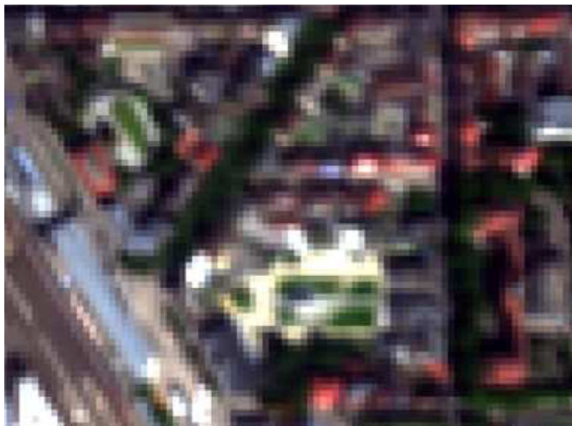
Figure 2: RGB channels of original HyMap image

Figure 3: Original RGB- image

Figure 4: RGB channels of Segmentation-based

Figure 5: RGB channels of Gram-Schmit fusion

Figure 6: RGB channels of Principal Component fusion image
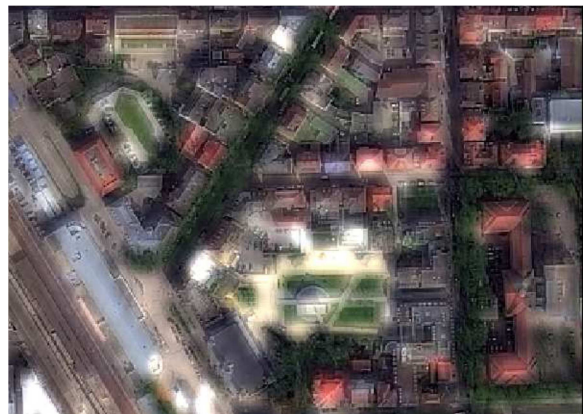
Figure 7: RGB channels of Wavelet Fusion image

Visual inspection of the figures 2 to 7 reveals that the Gram Schmidt and the principal component fusion images have high visual quality (good). The Wavelet Fusion shows some undesired artefacts. By careful inspection of the segmentation-based fusion image, it is observed that the edges in this image reflect the segmentation borders. This is because only the data points within the respective segment for interpolation on the finer grid were taken into account. Therefore, the well-defined edges in the Segmentation-based fusion image may be very essential when it comes to classification.

4   Classification

In order to evaluate the pansharpening techniques, the hyperspectral images pansharpened by different techniques are classified using a supervised classification approach. Before classifying the different pansharpened images, training regions for different surface materials are defined. In particular, 16 training regions for 12 roof materials plus vegetation are defined. The classification of the different images is performed with the spectral angle mapper similarity measure. Figures 8 - 10 give an impression of the classification results. Field inspection confirms that the building roof enclosed by a white continuous circular boundary in Figure 8 is made out of Zinc. It is also known that the building roof in the dotted white boundary is made out of roof material 4. The best classification of each of these building roofs is achieved with the segmentation based-fusion image, that is, the building roofs are correctly classified and the classification is more homogeneous.

(c)   Segmentation based - fusion
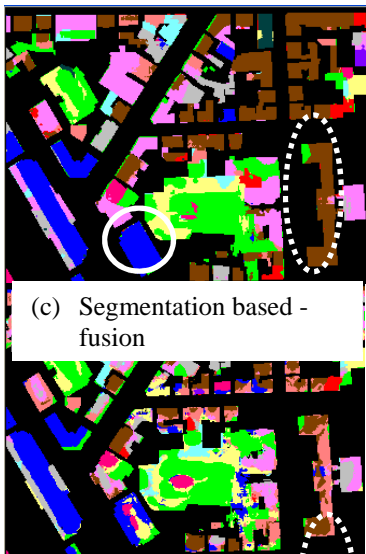
(a)   PCA fusion

(b)   Gram-Schmidt fusion

(e) Wavelet fusion	(d) RGB image
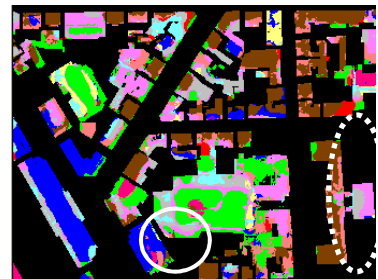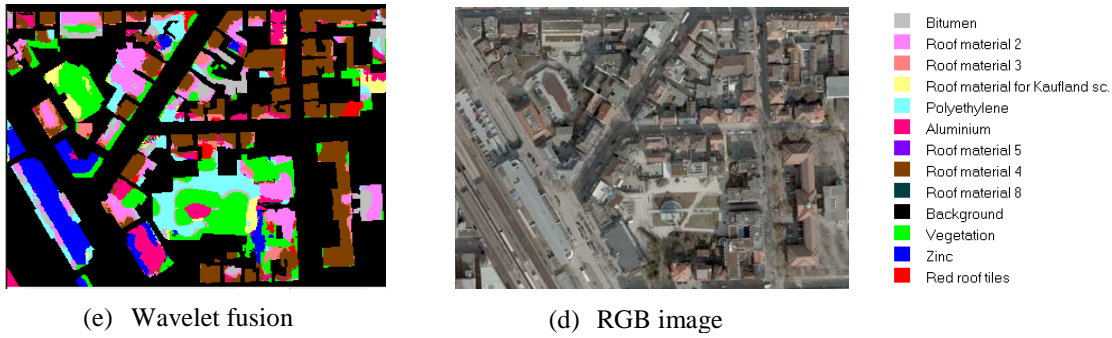
Figure 8: Classification Example I

It is also known from field inspection that the building roof enclosed by the dotted white rectangular boundary in Figure 9 is made out roof material 2. The best classification of this roof is achieved with the segmentation based-fusion image. Field inspection also confirms that the roof segments classified as aluminium in the segmentation based-fusion image in Figure 9 are correctly classified. The classification of these segments in the PCA fusion image is relatively good.

(a) Segmentation based-fusion	(b) PCA fusion	(f) Gram-Schmidt fusion
(h) Wavelet fusion	(g) RGB image	
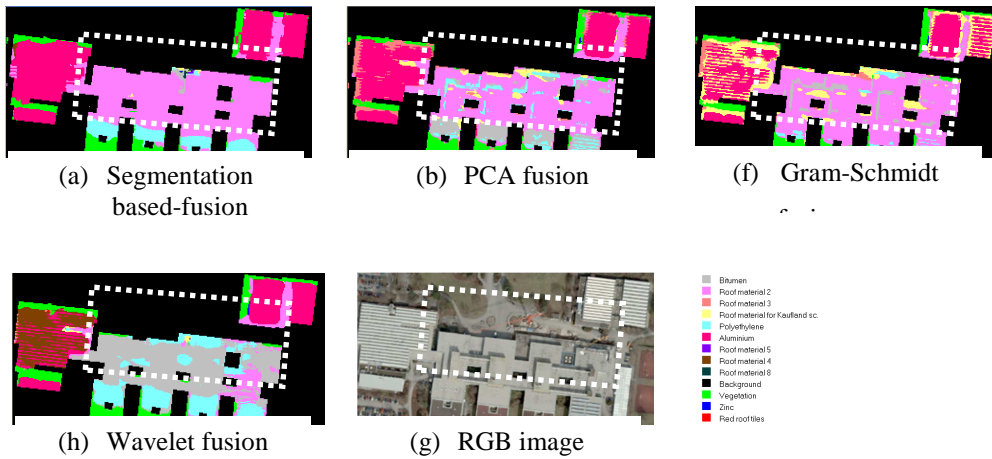
Figure 9: Classification Example II

The classification of the two building roofs in Figure 10 is more accurate in the segmentation based-fusion image. Field information confirms that the left building is made out of zinc while the right building is made out of bitumen.

a) Segmentation based-fusion

b) PCA fusion

C) Gram-Schmidt fusion

Wavelet fusion

- Bitumen
- Roof material 2
- Roof material 3
- Roof material for Kaufland sc.
- Polyethylene
- Aluminium
- Roof material 5
- Roof material 4
- Roof material 8
- Background
- Vegetation
- Zinc
- Red roof tiles

e) RGB image
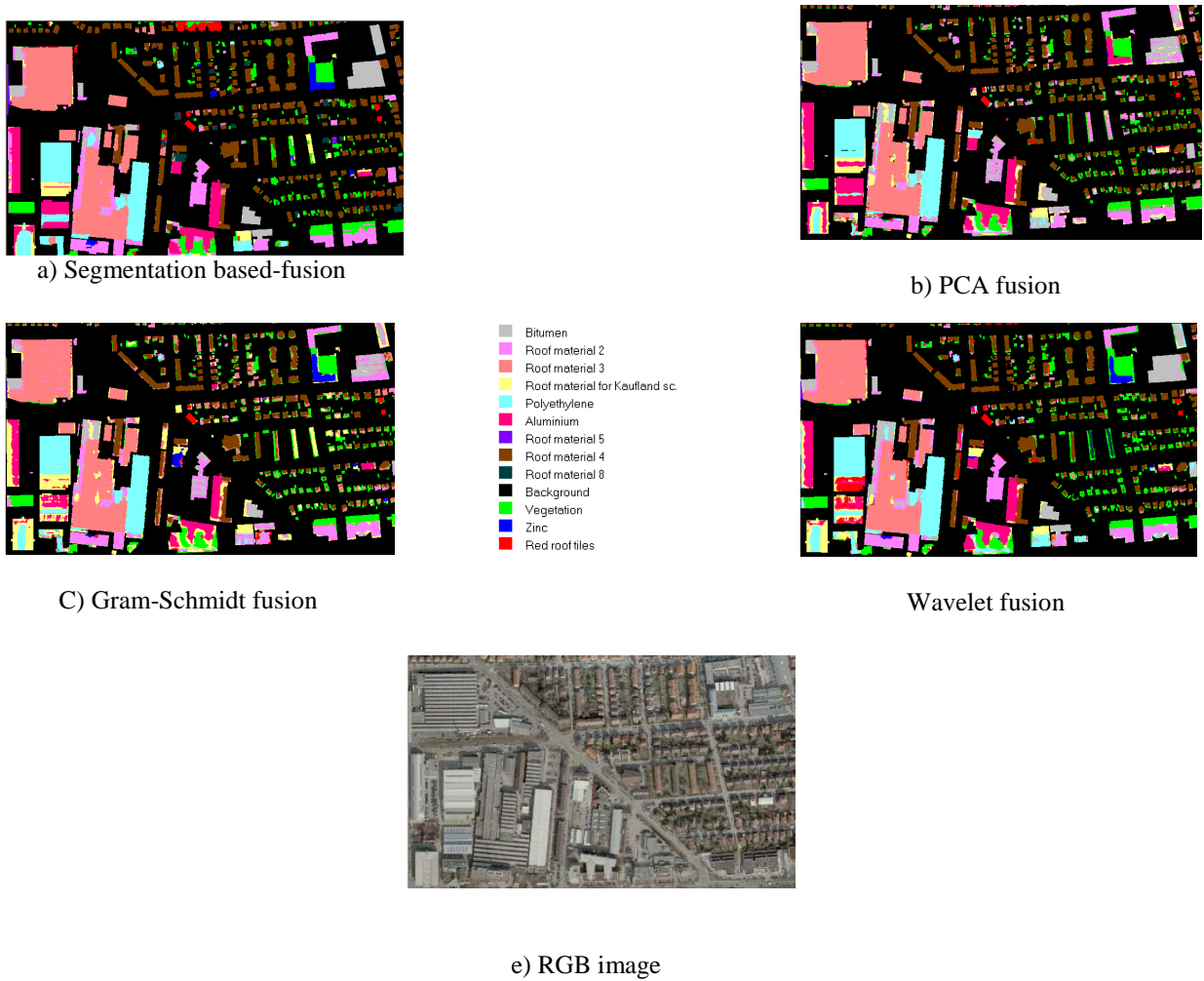
Figure 10: Classification Example III

In order to obtain more detailed information about the accuracy of the classification results, confusion matrices are computed. For this purpose, all the 16 training regions plus 49 additional regions are used as ground truth. More emphasis is placed on two items of the calculated confusion matrices, namely the overall accuracy and kappa coefficient. The overall accuracy gives the ratio between correctly classified pixels and the total number of pixels. The kappa coefficient is a measure of reliability which indicates the proportion of agreement corrected for chance (Cohen, 1960). Table 1 shows the overall accuracy and kappa coefficient for each of the classification results. The highest classification accuracy is achieved with the segmentation based-fusion image. Details of the confusion matrix for the segmentation-based fusion image classification are provided in table 2.

Image	Overall Accuracy (%)	Kappa Coefficient
Segmentation-based fusion	98.6	0.983
PCA fusion	95.7	0.947
Wavelet fusion	95.2	0.942
Gram-Schmidt fusion	95.0	0.937

Table 1: Accuracy measures of the classification results based on different fusion methods.

The overall accuracies and kappa coefficients achieved in table 1 are very good. Table 2 also shows that the pixels for roof material 5 (RM5) and red roof tiles (RRT) are not confused with pixels from other roof material classes. This may be due to the fact that the training regions for RM5 and RRT are also the evaluation regions (one region for RM5 and the other region for RRT). In addition, the training region defined for roof material 8 (RM8) is also used as an evaluation region. This may have contributed to the high values in the overall accuracies and kappa coefficients. A more comprehensive classification accuracy assessment should include more ground truth regions for each of the roof material classes.

Ground truth (Pixels)

class	Bit.	RM2	RM3	RMK	Poly.	Alum.	RM5	RM4	RM8	Zinc	RRT	Total	P.A%	U.A%
Bit.	28766	0	0	0	0	0	0	0	0	2	0	28768	99.86	99.99
RM2	8	19712	119	0	0	158	0	0	0	0	0	19997	99.91	98.57
RM3	0	0	17866	0	0	4	0	269	0	0	0	18139	99.28	98.49
RMK	1	0	10	1530	0	311	0	0	0	0	0	1852	100	82.61
Poly.	32	0	0	0	8224	431	0	0	0	0	0	8687	100	94.67
Alum.	0	17	0	0	0	12822	0	0	0	4	0	12843	93.41	99.84
RM5	0	0	0	0	0	0	3337	0	0	0	0	3337	100	100
RM4	0	0	0	0	0	0	0	3907	0	0	0	3907	93.56	100
RM8	0	0	0	0	0	0	0	0	809	1	0	810	100	99.88
Zinc	0	0	0	0	0	0	0	0	0	1936	0	1936	99.64	100
RRT	0	0	0	0	0	0	0	0	0	0	724	724	100	100
Total	28807	19729	17995	1530	8224	13726	3337	4176	809	1943	724	101000		

Table 2: Confusion matrix for the classification of the segmentation-based fusion image.

This is based on training regions of bitumen (bit.), roof material 2 (RM2), roof material 3 (RM3), roof material for kaufland shopping centre (RMK), Polyethylene (poly.), aluminium (Alum.), roof material 5 (RM5), roof material 4 (RM4), roof material 8 (RM8), zinc and red roof tiles (RRT). Here P.A% is Producer Accuracy (Percent) and U.A% is User Accuracy (Percent).

The producer accuracy is a measure indicating how much of a class on the ground is classified correctly. For instance, in table 2 the Bitumen (Bitu.) class has a total of 28807 ground truth pixels and only 28766 of these pixels are classified correctly. Therefore, the producer accuracy is given by the ratio between the number of correctly classified pixels and the total number of ground truth pixels, i.e. (28766/28807) multiplied by 100%. The user accuracy is a measure indicating the probability that a pixel labeled as a certain class in the image is truly this class. Table 2 shows that the total number of pixels classified as bitumen (Bit.) are 28768. However, only 28766 of these pixels are classified correctly. Therefore, the user accuracy is given by the ratio (28766/28768) multiplied by 100%.

5 Conclusion

Pansharpening has an effect on the overall brightness and form of the spectral signatures of hyperspectral data. Therefore, pansharpening techniques may have an influence on the accuracy of material classifications. In the investigation, it is observed that the highest classification accuracy is achieved with the segmentation based-fusion image. This could also mean that the proposed pansharpening technique distorts the spectral information of the original hyperspectral data the least. However, further investigations involving advanced classification methods and sufficient ground truth regions are required.

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Application of linear features in close range photogrammetry

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KEYWORDS:
Exterior Orientation Parameters (EOP), linear features, condition number, close range photogrammetry, single photo resection.

ABSTRACT

This research addresses the utilization of linear features in close range photogrammetry. Spatial resection of a single image has been performed by using the optimal 4-parametric representation of 3D straight lines. The computation was based upon the simulated data by the collinearity model.

Successful implementation of 4-parametric model to solve the standard problems in photogrammetry for aerial images could be found in recent literature. Defining 3D straight lines in the object space can be done physically or by using available spatial databases. A minimum of three lines with two points per line are enough to solve the single photo resection in contrast to the three full control points configuration in the point based computation. Providing 3D control lines for spatial resection of aerial images is comparatively difficult than control points in traditional practice though the linear features prove stable results.

Most of close range images are rich with 3D straight lines than in aerial images and easier to define in the object space due to close proximity of the space concerned. Known structures, similar to artificial ground controls, can also be used to provide such lines in the image. In this research the Exterior Orientation Parameters (EOPs) of a simulated close range image has successfully been determined for the various geometrical line configurations. The numerical stability of each computation has also been determined with the condition number of corresponding normal matrices in the least squares solution.

Multi-temporal LiDAR change detection for landslide analysis using slope-based automatic co-registration

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ABSTRACT

Multi-temporal LiDAR data have provided the opportunity to detect changes in the topography and landscape at fine-scale resolutions previously not possible. Multi-temporal LiDAR change detection analysis requires data sets to be spatially co-registered. Co-registration is ideally performed using the LiDAR 3-D point clouds for each flightline rather than LiDAR-derived rasters to avoid propagation of flightline co-registration errors. A slope-based surface matching of the LiDAR point cloud was previously used to improve the relative accuracy of overlapping flightlines. We have adopted the slope-based matching technique to improve the co-registration of multi-temporal LiDAR data to an accuracy that is applicable for fine-scale change detection. The slope-based matching method employs the slope of the elevation data to determine the spatial offset between the overlapping surfaces. We evaluate our results using multi-temporal LiDAR data sets from Salmon Falls Creek in south-central Idaho, USA. Initial relative accuracy before the co-registration was compared with final accuracy after co-registration, and the improvement in relative horizontal and vertical accuracies across the multi-temporal data was observed to be as much as 40 cm and 10 cm, respectively. Co-registration among multi-temporal data should be a precursor to multi-temporal surface analysis using LiDAR data, especially when the datasets are collected with different sensors and different point densities and levels of accuracy.

Orthorectification of Very High Resolution Satellite Imagery in the Context of Detail Spatial Planning Purposes

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KEY WORDS: Orthorectification, DEM, QuickBird, GCP, RPC

ABSTRACT:

In order to perform detailed spatial planning activities, the topographic map as one of fundamental geospatial information is a mandatory input. At this point, the 1:5000 large scale topographical mapping will be performed to achieve accurate geospatial planning analysis.

Since the geospatial data acquisition platform for the large scale mapping is still limited and consequently needs high effort and budget, it is better to apply step by step milestone for handling. First step is the planimetric component and the latter is hypsographic component. This paper will only deal with the first component which should be produced efficiently.

Nowadays there are a lot of very high resolution satellite imageries on the market which offer good visualization of the earth's surface in a natural interesting color. However, the high resolution is not always correlating with good geometric accuracy.

Ortho-rectification arises as one solution to achieve better accuracy by considering the land terrain for geometric correction. Basically, this approach needs two major components namely Ground Control Points (GCPs) and a Digital Elevation Model (DEM). This paper will identify the proper requirements of those two components by using an empirical approach.

Supporting detailed spatial planning purposes in the National Strategic Region of Borobudur Temple as one of the world heritages, it is necessary to perform accuracy assessment of Very High Resolution Satellite Imagery. By assessing this kind of geospatial data source, further standard operating procedure can be defined in order to fulfill the accuracy requirement.

1   Introduction

1.1   Background

In the next three years ahead BAKOSURTANAL, Malaysia's National Coordination Agency for Surveys and Mapping, will be changed into Board of Geospatial Information (BIG) based on the Act ratified on March 2011. Not only the name itself, but the role of BIG is becoming more important in the context of spatial data acquisition and production.

By above mentioned regulation only the incoming BIG will be responsible for the production of fundamental / base geospatial information e.g. Horizontal Geodetic Network, Vertical Geodetic Network and Topographic Maps in Indonesia. Consequently, the expected spatial data accuracy needs to be increased since the public will only use single official topographic map produced by BIG.

Based on the latest national act in Indonesia both concerning detailed spatial planning purposes and geospatial information, it is necessary to provide large scale topographical map as a framework. This fundamental geospatial dataset in a large scale of 1:5.000 will be used as primary geospatial input for spatial planning. In principal, there are two major components contained in the topographical map. The first one is the planimetric component relating with 2 dimensional form of the object (features) while the second one is the hypsographic component relating with 3 dimensional form of the object (features).

For the time being, the data acquisition technology which could provide those components in a large scale topographical mapping is still limited and therefore needs relatively high production cost. Commonly the combination of Light Detection and Ranging (LiDAR) systems and Digital Aerial Metric Cameras will be utilized by using airborne platform. Consequently, the problem is not only deal with the technology itself but also with bureaucratic problems such as security clearance. Especially in Indonesia, security clearance needs a lot of administrative terms and conditions both from defense ministry and air force institutions.

Moreover, since the large scale topographical mapping is usually aimed only for small area of interest, from project perspective the minimum size of an area of interest (AOI) will be defined in order to gain realistic financial benefit. It means the unit price usually in $/km^2 for small size AOI will be increased significantly. In common, many private mapping companies apply 100 km^2 as minimum AOI, while the detail spatial planning activity usually is just concentrated in sub district (kecamatan) size with approximately less than 50 km^2 only.

On the other hand, the development of geospatial data acquisition by using space borne platform is proliferated rapidly following the sensor improvement from time to time. It has been shown that the data resolution of optical geosatellite imagery is improving dramatically. This phenomenon triggers the massive utilization of Very High resolution Satellite (VHS) imageries around the globe as it shows on web-based imageries application. People tend to use this kind of interesting geospatial data source to answer their geospatial awareness demand.

In that sense, there is a chance to use VHS imageries as an alternative geospatial data source to support large scale mapping i.e. 1:5,000 map scale. In principal, VHS imageries use what so called Rational Polynomial Coefficient (RPC) in an automated way for geo-referencing purposes. Therefore it is necessary to conduct further planimetric accuracy investigation of QuickBird Imagery in the context of large scale topographical mapping. At the end, the evaluation will also yield some recommended solutions to increase the planimetric accuracy of VHS imagery by incorporating other data sources and equipments.

1.2   Research Objectives

The objectives of this research can be grouped into three major parts as follows:

- Identification of QuickBird VHS imagery (RPC-Orthorectified) accuracy by performing independent GCP measurements using Rapid Static GNSS positioning or Continuous Operating Reference System (CORS) Real Time Kinematic (RTK);

- The basic requirements of GCPs and DEM needed for orthorectification purpose of very high resolution satellite imagery by investigating the geospatial data accuracyin order to fulfill large scale topographical mapping i.e.1:5,000 map scale;

- Standard operating procedure for orthorectification of very high resolution imagery in term of topographical mapping requirements.

1.3   Data and software used

Very high resolution satellite imagery used for this research is QuickBird Orthorectified Imagery Product (Table) which has geospatial accuracy depending on the map scale as published by Digital Globe, Inc. (2006). This product can be delivered in Area-based scheme by using square kilometer as a unit price.

The software used to support this research can be classified into the following purposes:

1.   Accuracy assessment investigation and GIS analysis by using ArcGIS 9.3.1;

2.   Image processing and Softcopy Photogrammetry by using PCI Geomatics ver.7.0.

Product Level	Processing	Absolute Accuracy		Geographic Availability
		CE90%	RMSE	
Basic Imagery	Sensor Corrected (Raw)	23-meters[3]	14-meters3	Worldwide
Standard Imagery	Georectified	23-meters[4]	14-meters[2]	Worldwide
Ortho 1:50,000	Orthorectified	25.4-meters	15.4-meters	Worldwide
Ortho 1:12,000	Orthorectified	10.2-meters	6.2-meters	US and Canada
Ortho 1:5,000	Orthorectified	4.23-meters	2.6-meters	Worldwide
Ortho 1:4,800	Orthorectified	4.1-meters	2.5-meters	US and Canada
Custom Ortho	Orthorectified	variable[5]	Variable[3]	Worldwide
DG DOQQ	Orthorectified	10.2-meters	6.2-meters	Continental US

Table 1: QuickBird Product Level

1.4 Methodology

This research is conducted by combining theoretical and empirical approach in order to achieve proper geospatial data quality in an efficient way (Figure). At the first place, the QuickBird imagery(RPC-Orthorectified) is used as a benchmark for 38 GCP measurements planning purpose. Following this GCP planning network, Rapid Static or RTK GPS positioning can be proceeded as well as GCP pricking over the image for being used in the orthorectification process subsequently.
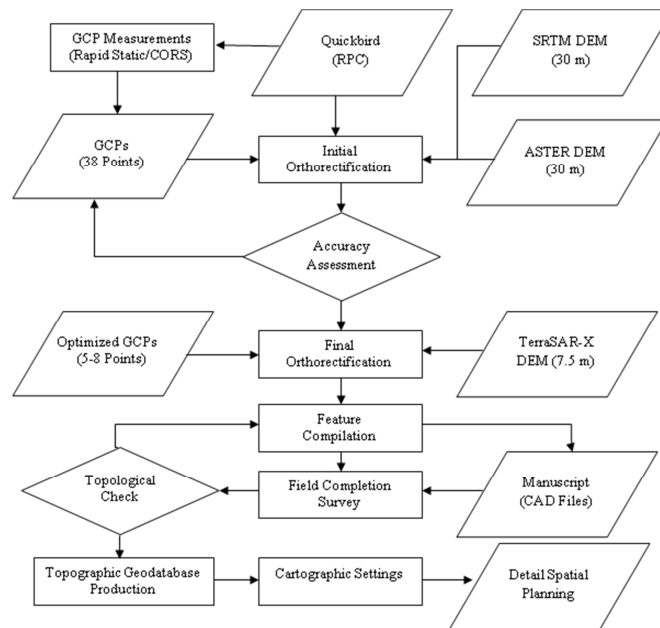
Figure 1: Research workflow

At the first place, the investigation will identify the real planimetric accuracy of QuickBird imagery (RPC-Orthorectified) against GCP measurements using GNSS survey with a cm level accuracy. This investigation will also verify the claimed accuracy in the QuickBird product level (Table) by the image vendor.

By using both free downloadable DEM/DSM in a medium resolution of 1 arc second (30 m) and measured GCPs, first initial orthorectification is proceeding subsequently to produce QuickBird Orthorectified Imagery

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[3] Attained using supplied Image Support Data files and a user supplied DEM, excluding sensor and viewing geometry and Topographic displacement

[4] Excluding viewing geometry and topographic displacement

[5] Accuracy of the Custom Ortho is determined by the accuracy and quality of customer supplied support data.

for further accuracy assessment. In this case, accuracy assessment shall be performed in order to obtain planimetric component characteristic.

Next step of orthorectification is following iteratively by using different numbers of GCP until it saturates within specified accuracy tolerance by using both National Standard for Spatial Data Accuracy (NSSDA) and National Mapping Accuracy Standard (NMAS). From this point, the number of optimized GCP can be identified for further efficient improvement in the standard operating procedure of orthorectification in the future.

Continuously by using DSM with a better resolution (7.5 m) from TerraSAR-X, the final orthorectification will provide the reliable geospatial data source to be used in feature compilation by using GIS Desktop Software. Topographical Geodatabase will be used as a geospatial data warehouse with necessary cartographic setting afterwards. Finally the detail spatial planning in 1:5,000 map scale will be prepared to govern the National Strategic Area in a proper way.

1.5   Research Area

Borobudur temple, the biggest temple in Indonesia is located in southern part of Central Java Island, well known as one of the preserved UNESCO's world heritage (http://whc.unesco.org/en/list/592). Therefore it is prioritized by the stakeholders to accomplish the detail spatial planning over that National Strategic Area.

National Strategic Area of Borobudur temple includes some villages in a North East – South West direction which covers approximately 2,700 hectares broad. Basically the terrain condition of the study site is classified as medium undulated without any steep slope feature object.

2   Field Survey

2.1   Planning

Field survey planning is aimed for providing the representative GCP network with good distribution over the National Strategic Region of Borobudur Temple. In principal, GCP measurements will cover two main purposes of field survey. The first one is to check the quality of Quickbird imagery geo-corrected by using RPC and the latter one is to establish accurate GCPs for orthorectification purpose. At a first glance, total number of 38 GCPs has been designed with good distribution covering the Area of Interest.

GCP selection has been performed in the Quickbird (RPC) by defining 38 points which can be identified clearly. The point selection shall be done by extracting point from regular form features within the minimum size of 2 times Quickbird imagery spatial resolution i.e. 1.2 m. The good examples of this regular form feature are the building corner, statue, and road delimiter (Figure 2).

Figure 2: GCP network planning around Borobudur Temple

2.2   GCP Measurement

Considering the spatial resolution of Quickbird imagery i.e. 60 cm, it is necessary to perform high accuracy GNSS survey. The proper GNSS measurement for that purpose is conducted by using either Rapid Static

Positioning or Real Time Kinematic GNSS Positioning. Rapid static positioning uses at least one pair of measurement which is usually more time consuming with higher accuracy in centimeter level of accuracy.

Since the object planned as a GCP is selected currently from recently available VHS imagery, it is often called post-marking GCP. The drawback of this post-marking method is relating with the nature of geospatial object which is dynamically changing over time. In this case, the time stamp is an issue which should be taken into account.It is necessary to make sure that every selected object is less dynamic and therefore some changing in actual selected GCP object within a given tolerance is allowed. The GNSS measurement should be supported by picking reliable and fixed object in the field otherwise it will not worth with the centimeter level of accuracy. The real instances will be explained in 3.1Orthorectification.

Using SOUTH STAR S86T Integrated RTK GNSS dual frequency receiver, every planned GCP was measured accurately to reach centimeter level accuracy. In rapid static positioning the minimum static measurement was about 30 minutes per-GCP while with RTK was only less than 5 minutes to get fixed positioning.

In addition to the GNSS measurements, it is also important to take some pictures of GCP location from at least 4 different angles. This task should support the GCP identification with the highest level of confidence. Supporting this aim, additional measurements are necessary e.g. the diametrical size of the object, distance to other objects, etc.

3   Technical Implementation

3.1   Orthorectification

Orthorectification has been implemented over the National Strategic Region of Borobudur Temple by using provided GCP coordinates from the field and proper DEM as 3D frameworks. First initial orthorectification proceed by picking all of 38 measured GCPs with the extracted elevation from SRTM DEM. Using PCI Geomatics ver.7, all of the measured GCPs are taken into account for orthorectification process to provide first initial orthorectified QuickBird imagery by using both SRTM DEM and ASTER DEM as DEM input.

Regarding RMSE which is usually using less than cell size as a threshold, in this research there is no minimum applicable threshold to be considered. As an example, the provided RMSE using 38 GCPs was 0.96 m with RMSx = 0.74 m and RMSy = 0.62 m. This approach was selected because there will be accuracy assessment as the final adjustment afterward.

Iteratively by using "Near" functionality in ArcGIS, the statistical analysis will provide the sort of posteriori RMSE which could detect the wrong GCP pricking over the VHS imagery. The first initial orthorectification plays important role to detect blunder error which often occurs because of inconsistency between GCP measurement and GCP pricking. Findings from GCP02 and GCP27 as described in Figure 3 show incorrect GCP pricking (wrong street corner identification (GCP02); wrong building corner identification (GCP27)).

Figure 3: Blunder error detection (+: before orthorectification, x: after orthorectification)

Subsequently, the number of GCPs used will be decreased followed by corresponding orthorectification process. Thus there are some orthorectified imageries produced for further investigation. Using four different schemes of GCP network will be useful to identify the proper GCP requirements for 1:5,000 level of accuracy. The

investigation has been concentrated on the number of optimized GCPs used to fulfill the requirements by using different GCP amount.

3.2 Accuracy Assessment

Considering spatial accuracy, a method called National Standard for Spatial Data Accuracy (NSSDA) has been applied for geospatial consistency checking (FGDC, 1998). The basic functionality of this method is the blunder detection (vector inconsistency) from a given data set and the derivation of a statistical model. Data resolution (similar to image pyramids) can be applied to generate a corresponding model in a coarse to fine approach using 4 different GCP schemes. This method is based on linear prediction to detect the smallest object. The NSSDA uses Root Mean Square Error (RMSE) to estimate positional accuracy. The RMSE can be calculated by the following equation (FGDC, 1998):

$$RMSE_r = \sqrt{RMSE_X^2 + RMSE_Y^2}$$

(Eq. 1)

$$Accuracy_r = 1.7308 * RMSE_r$$

(Eq. 2)

Where RMSE$_{x/y}$ = Root Mean Square Error in x/y axis direction, RMSEr = Horizontal (2D) Root Mean Square Error

Accuracy is reported in ground distances at the 95% confidence level. The reported accuracy value reflects all uncertainties, including those introduced by geodetic control coordinates, compilation, and final computation of ground coordinate values in the product. Based on National Mapping Accuracy Standard (NMAS), the horizontal tolerance accuracy can be seen in Table 2. Differently to NSSDA accuracy, NMAS introduced circular error in 90 % level of confidence which is more moderate than NSSDA in what so called Circular Map Accuracy (CMAS) as put in Eq. 3.

$$CMAS_r = 1.5175 * RMSE_r$$

(Eq. 3)

Map Scale	Tolerance at Publication Scale	Tolerance at Ground Distance
1:1,000	1/30 inch = 0.85 mm	0.85 m
1:5,000	1/30 inch = 0.85 mm	4.25 m
1:10,000	1/30 inch = 0.85 mm	8.5 m
1:25,000	1/50 inch = 0.5 mm	12.5 m
1:50,000	1/50 inch = 0.5 mm	25 m

Table 2: NMAS Horizontal Accuracy Tolerance

In order to obtain proper statistical analysis and avoid misleading in the accuracy assessment, the following assumption has been used in this research:

1. Rapid static positioning for GCP measurements will provide coordinates in centimeter level accuracy;

2. Operator ability to prick the GCP points in the VHS image will be 2 times image resolution = 1.2 m.

Based on previous assumption, the accuracy assessment has been done as includes in Table 3.

No	GCP amount	RMSE (m)		NSSDA (m)		NMAS (m)		Tolerance (m)
		SRTM (30 m)	TSX-DSM (7.5 m)	SRTM (30 m)	TSX-DSM (7.5 m)	SRTM (30 m)	TSX-DSM (7.5 m)	
1	RPC (0 GCP)	7.199		12.266		10.925		4.25
2	5	1.947	1.897	3.317	3.232	2.954	2.879	4.25
3	8	1.762	1.764	3.003	3.006	2.674	2.677	4.25
4	15	1.801	1.658	3.068	2.824	2.733	2.516	4.25
5	38 (Full GCP)	1.499	1.416	2.555	2.413	2.275	2.149	4.25

Table 3: Accuracy Assessment of QuickBird Orthorectified Imagery

4   Closing Statement

4.1   Conclusion

Finally this research has proved the significant geometrical improvement of VHS imagery by implementing orthorectification mechanism. In fact, the real calculated accuracy of VHS imagery orthorectified by RPC within a range of 10.93 - 12.27 m is not adequate enough to fulfill the large scale topographical mapping tolerance accuracy either defined by NSSDA or NMAS. VHS Imagery can be used as a reliable geospatial data source for 1:5.000 large scale topographical mapping within the range of 2.15 – 3.32 m by performing orthorectification under certain aspect as follows:

- GCP measurement is still considered as the best solution to establish the reference network both for orthorectification and spatial data accuracy measurements;

- GNSS Rapid Static Positioning or RTK (CORS) can be considered as the necessary solution to establish GCP network requirement even though it needs heavier effort viewing from time and resources perspective;

- The medium resolution DEM/DSM such as from ASTER, SRTM in 30 m resolution is sufficient enough to provide 3 dimensional factor of object features, however Space borne DSM RADAR such as TerraSAR-X in 7.5 m resolution is classified as the best solution for better accuracy.

Recommendation

The orthorectification task for very high resolution satellite imagery yields some necessary recommendation as follows:

1. The number of GCP as mentioned in subsection 4.1 can be reduced into the amount of 5-8 GCPs pro-scene of VHS imagery respectively.

2. Space borne DEM RADAR such as TerraSAR-X DSM can be sufficiently used to orthorectify VHS imageries in order to achieve planimetric (2 D) accuracy for the large scale map i.e. 1:5,000.

3. To overcome the budgetary problem in the detail spatial planning purpose, step by step geospatial data production can be implemented in this case by performing planimetric compilation at the first place and hypsographic geospatial data derivation at the end.

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Geospatial Analyses of Vegetation Cover Trend using NOAA-AVHRR NDVI in Eastern Africa

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KEY WORDS: NDVI Trend, Vegetation, East Africa

ABSTRACT:

The study analysed seasonal trend of vegetation cover using Normalizes Difference vegetation Index (NDVI) from Advanced Very High Resolution Radiometer (AVHRR) between 1982 and 2008 (27 years). During the first half of the period the overall vegetation cover was in constant decline in most parts of east Africa with the exception of Sudan were relative stability was observed. During the second half the overall vegetation trend is better than the first half. Though relatively stable, there are areas with fast decline particularly in western escarpment of the Ethiopian rift valley, southern Kenya and western Uganda. The trend also shows higher decline during summer and spring seasons.

1 Introduction

Normalized Difference Vegetation Index (NDVI) maps allow comparisons of the spatial and temporal variability in the amount and condition of vegetation. These can be used to asses agricultural production and trends in desertification in areas that rely on rainfed agriculture. To meet the Millennium Development goal of eradicating extreme poverty and hunger, proper planning based on the knowledge of the system is paramount.

The number of undernourished people in eastern and southern Africa since 1980 has more than doubled (Funk 2005). In the 90s, rural development stalled and rural poverty expanded. Population growth remains very high, and declining per-capita agricultural capacity retards progress toward Millennium Development goals.

2 Vegetation Cover Trend Analyses:

NDVI is valuable for studying annual phenology and trends of vegetation. However the regression between e.g. yield-NDVI is site and crop specific and as the NOAA pixel is 8*8 km a spectral mixture of the pixel is unavoidable. But studying the trend through the same pixel an increase in NDVI through time could either be caused by a land use change, change in vegetation cover for the pixel as well an actual change in biological production of natural vegetation. When studying trends through a time series of years it is essential to first explore the behaviour of the annual vegetation cycle. Integrating NDVI around peak seasons would approximate the biological production or yield each year providing a time series to study.

Rainfall variability and long-term changes in both rainfall amount and distribution has affected many countries over recent decades. While rainfall is only one factor in a complex tableau of factors that are influenced by the global climate, it plays an important role in regulating the growth and vegetation cover dynamics of Eastern and Southern Africa significantly. Fig 1 shows satellite-observed Mean Annual rainfall distribution of East Africa. Rainfall amount vary significantly in the region.

East African Vegetation cover shows seasonal variation. There are areas that show less seasonal variation like the forest areas as well as permanently arid areas. In general the vegetation cover in autumn and summer is relatively higher (See Fig. 2). Uganda, Western tip of Kenya and southern western Ethiopia are under higher vegetation cover through out the year. There is thin or no vegetation cover in areas near the red sea coast and Indian Ocean as well as northern part of Sudan, north eastern Ethiopia and north western Kenya.

Summer vegetation in western Ethiopia is abundant since there is enough moisture in the soil caused by summer rain. Summer rainfall results good vegetation cover for most parts of western and central Ethiopia. The

vegetation cover is higher during autumn. The vegetation cover in parts such as around Turkana in North Western Kenya, Afar triangle in north eastern Ethiopia, northern Sudan and Somalia is almost non existent.

All in all the vegetation cover reduces during winter time. For example in winter the Ethiopian natural forests located in the central & western parts are clearly identifiable since the seasonal vegetation cover greenness is relatively low in other parts of the country. Applying same procedure the forest cover in the southern Uganda and western Kenya near Lake Victoria are clearly identifiable.
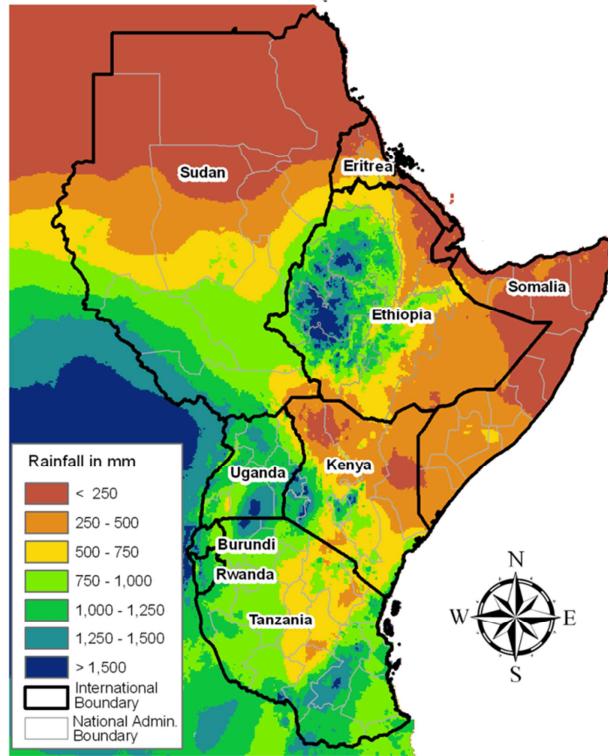
Figure 1. Mean Annual rainfall distribution of East Africa (Basic Data source: NOAA RFE)

Some areas like southern Uganda and south western part of Ethiopia the annual rainfall is more than 1500 mm per year and it also exceeds 2000 mm are some areas. Elevation remains to be very important actor to determine the amount of rainfall in most part of east Africa. Ethiopian highlands are highly dominated by orographic effects particularly by moisture bearing trade winds coming from Atlantic Ocean during boreal summer. Northern Sudan, Eastern Ethiopia, Somalia and northern half of Kenya are generally arid area with rainfall less 500 mm of rain and in the drier parts is less than 250mm of rainfall which qualifies the definition of desert.
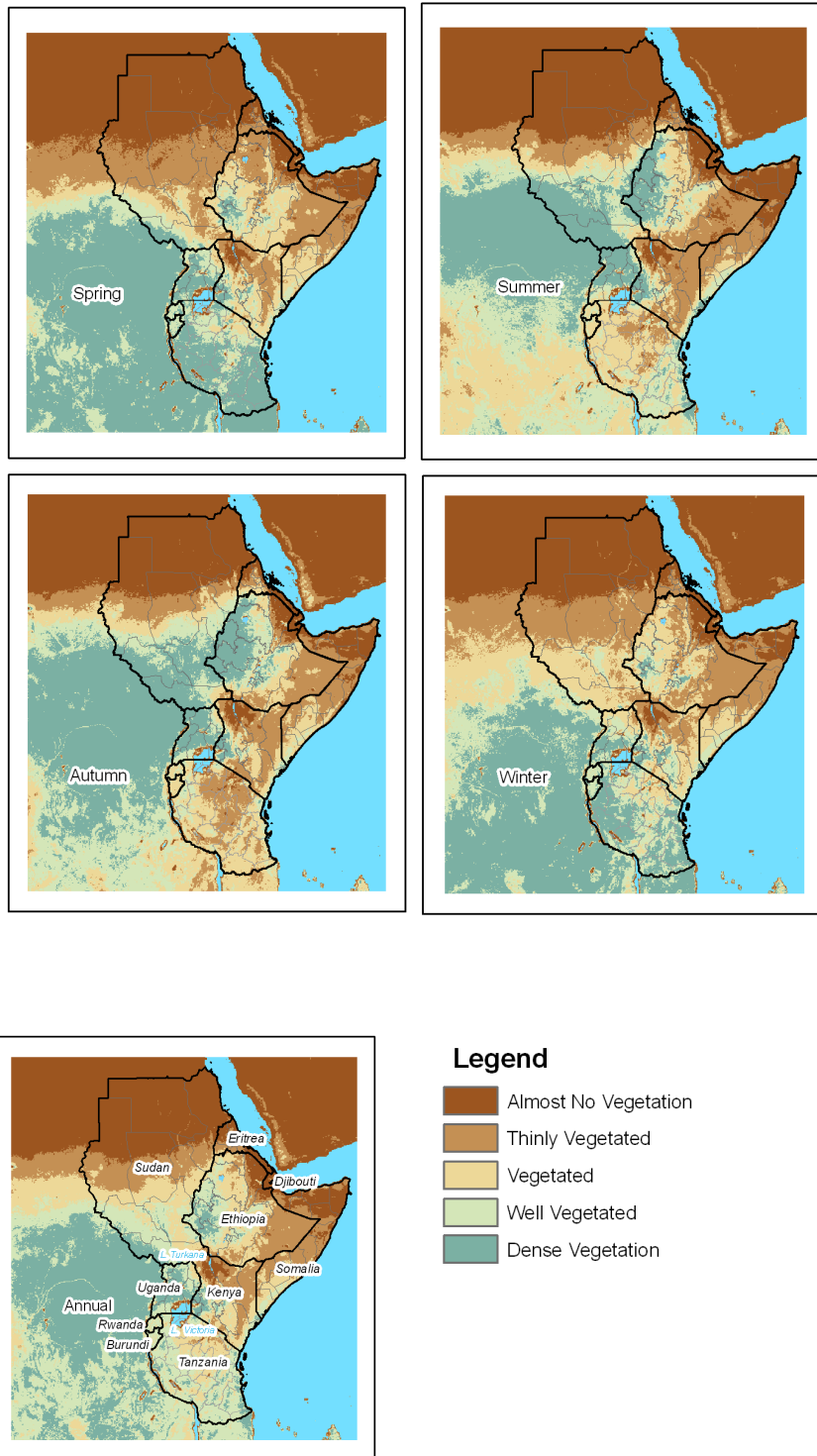
Figure 2. Seasonal distribution of vegetation cover map based on NOAA NDVI

Time series of satellite images can be used to study and assess trends in environmental, land use change large areas that are not easily accessible. Changes in NDVI in regions that rely on rainfed agriculture are likely to be driven by climate changes. Calculating the gain coefficient for each pixel through the time series would provide a map of the spatial change and its gain.

The linear trend line equation is called the simple linear regression and can be calculated by most statistical programs. However there is yet no function in ArcGIS to calculate the trend of pixels for time series of sequential satellite images.

The simple linear regression formula is given as:

55

$$y = \alpha + \beta x$$

where:

α is the offset, where the regression lines cut the y-axis at x = 0

β is the gain coefficient, showing how much the y value is changing for each x step.

To explore biomass change expressed as NDVI for the study area you will only focus on calculating the gain coefficient.

According to statistical references the following is a formula to calculate trend (Draper, 98).

$$\beta = \frac{S_{xy}}{S_{xx}}$$

$$S_{xy} = \sum_{i=1}^{n}(x_i - \overline{x}) * (y_i - \overline{y})$$

$$S_{xx} = \sum_{i=1}^{n}(x_i - \overline{x})^2$$

This can be expressed as for each pixel the value is compared to the mean value for the complete time series on dekadal (10-days) bases. To calculate the gain coefficient in ArcGIS first an average image (summarize all images and divide by 15) is produced. This forms values of $\overline{y}$, $\overline{x}$ is a constant and the time series will instead of specific years (e.g. 1982) instead be subsidized by 1,2,3,4, etc. Raster is used calculator to produce $\overline{y}$ and calculate $\overline{x}$ with table calculator. Then Sxy in ArcMap produced. Sxx calculated in excel as it only uses the 1 to 15 constants, and finally β calculated in the raster calculator. β is then be visualized to explore where in high positive / negative changes of NDVI has occurred. In order to see the trends of rainfall amount similar technique is used based on RFE 2 images for the period 2001 to 2009.

The temporal scale was categorised in two parts, for comparison in past and recent trends. These are the first 15 years between 1982 and 1996 and most recent 15 years which is from 1994 to 2008. The trend values are calculated based 10-days NDVI data and the monthly, seasonal and annual aggregation are prepared by taking the mean values of trends. The trend is further used to forecast the future vegetation pattern and compare it with the current.

There is continuous vegetation cover dynamics caused by climatic and other social factors. During the first half of the study period the overall vegetation cover was in constant decline in most parts of east African nations with the exception of Sudan were relative stability observed. In the central parts of Sudan vegetation cover in summer showed a positive trend and the reverse were true for most parts of southern Ethiopia and Somalia. Vegetation condition was improving during spring of this first half and in autumn it declined. There was fast decline in most part of Tanzania during winter time.

During the second half the overall vegetation trend is better than the first half since it is relative stable but there are areas with fast decline particularly in western escarpment of Ethiopian rift valley, southern Kenya and western Uganda (See Fig 3). A similar type of study was done Anyamba and Tucker using remotely sensed measurements from NOAA-AVHRR expressed as normalized difference vegetation index (NDVI) have generated a 23-year time series appropriate for long-term studies of Sahel region. These trend patterns can therefore only be considered to be a gradual recovery from extreme drought conditions that peaked during the 1983-1985 period (Anyamba 2005).
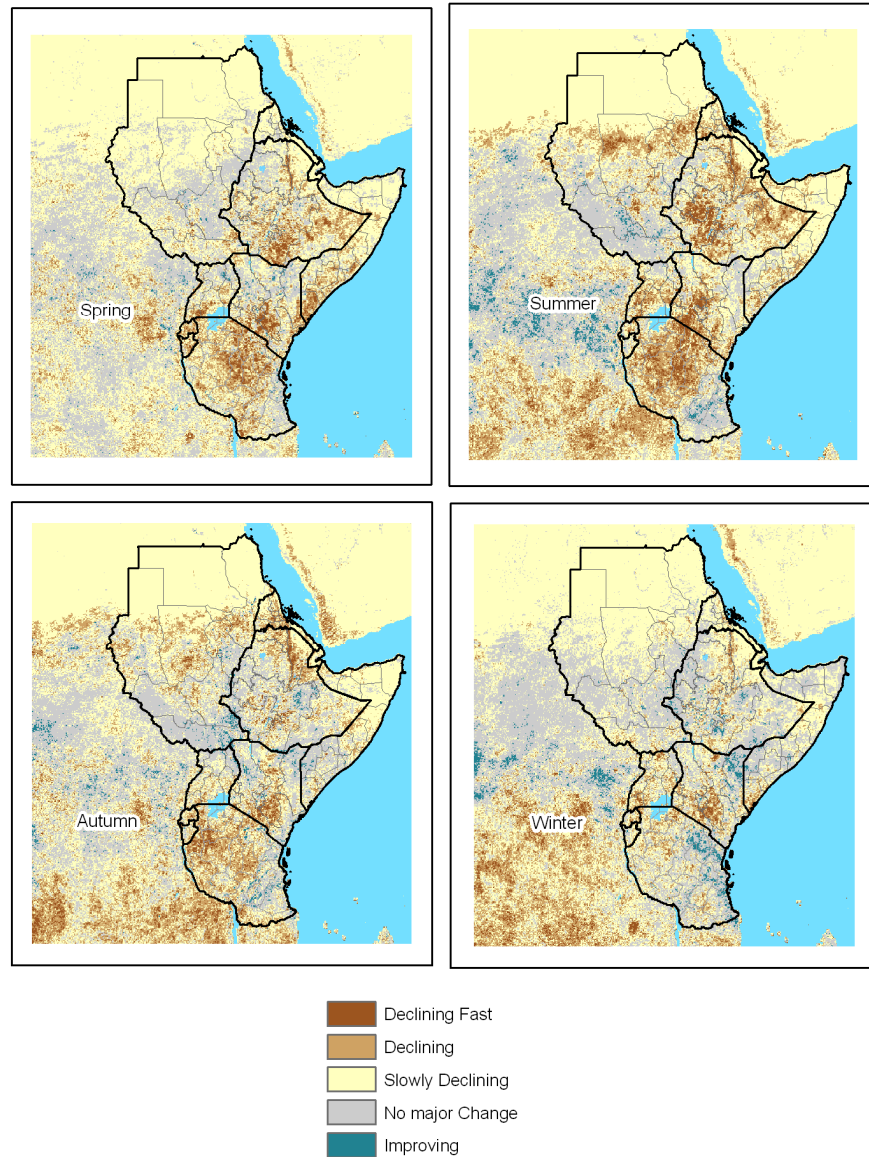
Figure 3. Trend of vegetation cover based on NDVI (1994 – 2008)

The trend showed higher decline during summer and spring seasons. The trend depicted the deterioration of vegetation cover near and around Victoria region, most part of central and northern Tanzania significant portion of southern Ethiopia and northern part of the rift-valley escarpment.

Analyses of satellite observations of vegetation cover have identified a problematic trend. The overall biomass production during main growing-season have decreased in food-insecure countries located in the Great horn of Africa Ethiopia, Sudan, Somali, Kenya, Tanzania (Funk 2009).
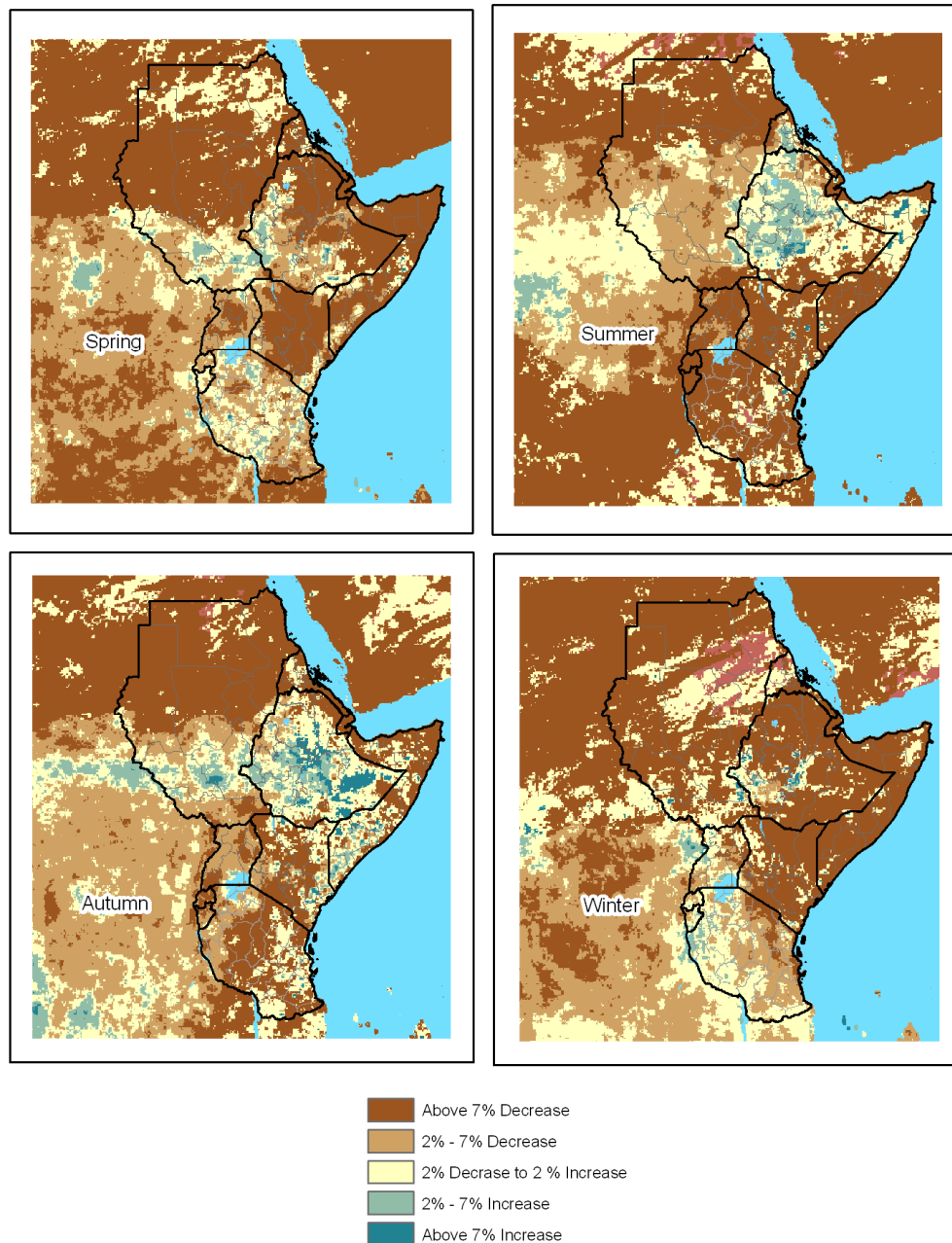
Figure 4. Forecast of Rainfall in 10 years compared with the current rainfall

In order to associate this trend with the rainfall trend based on the recent 10 years satellite RFE data the trend of rainfall is calculated which helped to forecast the total rainfall amount of the four seasons. By comparing the forecasted rainfall with the current rainfall the changes are calculated. In general there will a decrease in the rainfall amount in most parts of east Africa particularly during winter and spring. For example in more than 90% of the total area of the rainfall amount in spring is expected to decrease by 7 %. On the other hand in southern Sudan Autumn and Spring rainfall amount is in increasing trend so there will increase that reach up to 10% around central part of southern Sudan.
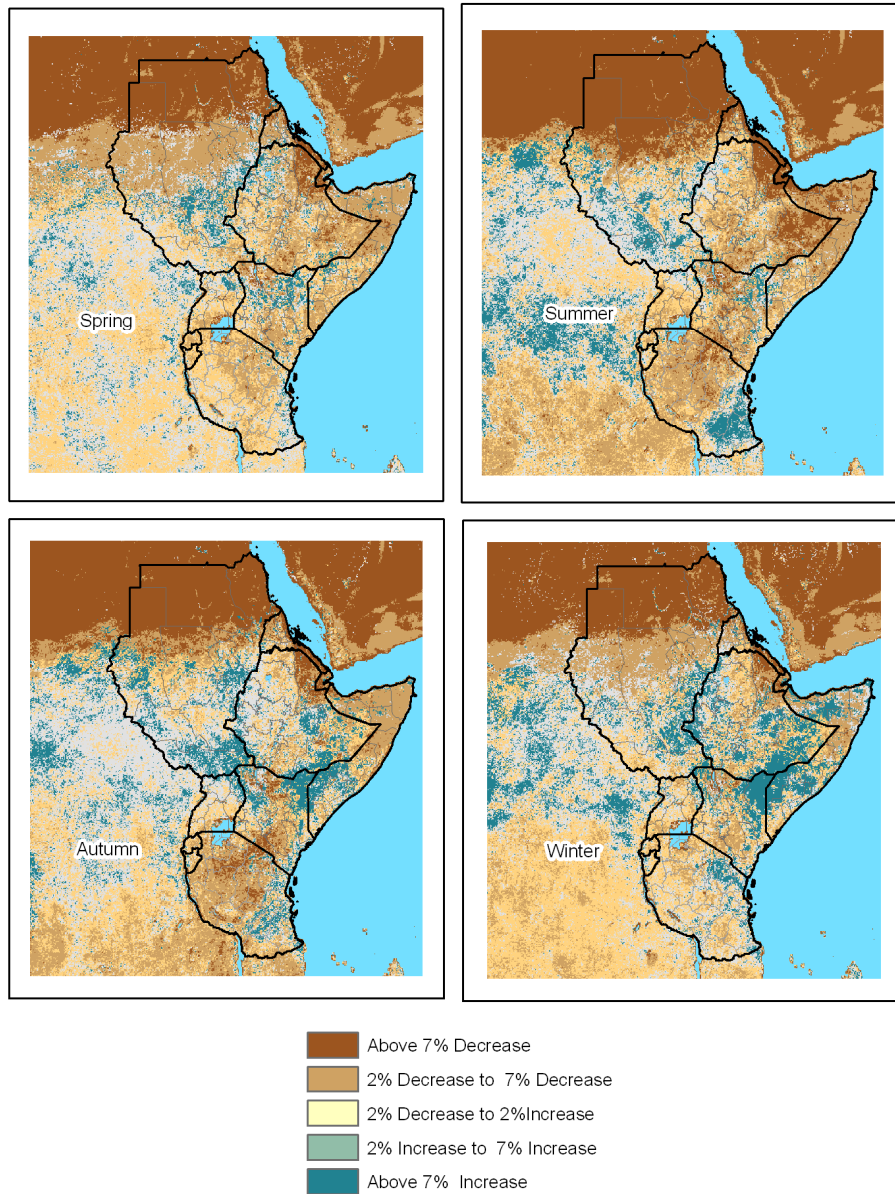
Figure 5. Comparison of Forecasted Vegetation cover after 10 years with the current Vegetation Cover

The increasing trend of autumn rain is expected to affect positively the vegetation situation of most part of south eastern Ethiopia, southern Somalia and eastern Kenya during autumn and winter seasons. More than 7% increase is forecasted by comparing the vegetation cover with the current average status winter season (See Fig 5). However the increase of autumn rains in the highland of Ethiopia will have distractive effect since during this period most of the crops are the final stage of their growth. Due to the declining trend of spring rainfall during spring in there will be vegetation decrease south eastern Ethiopia, northern Tanzania and southern Kenya. This will affect the livestock population and people depend on it in pastoral community of south eastern Ethiopia. The vegetation performance during the forecasted average autumn seasons there will be a decrease above 7% for most parts of southern Kenya and Tanzania which will have impact on pastoral community as well as the wildlife in some national parks.

3 Conclusion:

The vegetation cove trend in east Africa showed higher decline during summer and spring seasons. There is growing deterioration of vegetation cover near and around Victoria region, most part of central and northern Tanzania, significant portion of southern Ethiopia and northern part of the rift-valley escarpment.

The changes of the current rainfall with a rainfall amount forecasted using trend analyses were compared and it showed a decrease in the rainfall amount in most parts of east Africa particularly during winter and spring. This was reflected on the poor relative poor performance of summer vegetation. For example in more than 90% of the total area Kenya the rainfall amount in spring after 10 years of time it is expected to decrease by 7 % or more. On the other hand in southern Sudan Autumn and Spring rainfall amount is in increasing trend so there will increase that reach up to 10% particularly around central part of southern Sudan.

The declining trend of spring rainfall during spring will cause vegetation decrease in south eastern Ethiopia, northern Tanzania and southern Kenya. This will affect the livestock population and people depend on it in pastoral community of south eastern Ethiopia, southern Somalia and North eastern Kenya.

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Advances in GIScience and Current Developments

We believe that the central challenge we face today is to ensure that globalization becomes a positive force for all the world's people.

United Nations Millennium Declaration, 2000

Towards a "Navigational Sense" for Humans: Biomimetic Polarized Light-based Navigation System

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ABSTRACT:

Biomimetics is an interdisciplinary approach that brings together biologists, physicists and engineers to produce optimized solutions for engineering problems. Principles of materials, structures and processes from living nature are identified, understood and transferred to the field of engineering, in order to, e.g., develop technological devices that can assist, enhance and expand human sensory abilities. This work discusses the concept development for a bioinspired polarized light-based navigation sensor built in miniaturized MEMS technology for medical applications. This sensor shall be the first step towards a "navigational sense", and help people who are lost to find their way. With such a navigational sense-device, people could navigate and/or find their home independent of GPS technology. Current navigation systems are mostly dependent on the global navigation satellite system, the most fully operation system for global positioning. However the global navigation satellite system may be limited by the low precision of the signal in certain conditions such as in urban areas, intermittent coverage, and furthermore have high maintenance cost and is risk of being not globally accessible during conflict. Due to these risks, we initiated concept development of a new system that is GPS independent but possesses the global navigation satellite system performance. Our GPS independent polarization navigation sensor is a miniaturization of an existing polarized light based navigation system and shall be directly attached to the human body, delivering signals readily understandable even for patients with dementia and other disorders.

1 Introduction

1.1 Biomimetics

Biomimetics involves transferring the deep principles of materials, structures and processes as found in living nature to the field of engineering in order to, e.g., develop technological devices that can assist, enhance and expand human sensory ability (Gebeshuber et al. 2009). Micro-electromechanical systems (MEMS) involve the integration of electrical, mechanical, physical, optical, chemical and/or biological phenomena of interest on a single chip. The bioinspiration of living nature's principles could be realized through MEMS technology. Using MEMS devices, the range of human sensory ability could be enlarged: With the help of MEMS humans can perceive signals that would be otherwise too weak or too strong (X_1in Figure 1) or that are not covered by the human sensory system because of their type(X_2 in Figure 1) (Karman et al. 2011). The MEMS can then be linked to the human body (in our approach mainly *ex corpore* to avoid ethics conflicts) in order to assist, enhance and expand human sensory perceptions.

This paper discusses the potential development of a bioinspired MEMS polarized light navigation sensor for expanding the human sensory system towards a navigational sense. The mechanism and the key component of the sensor are inspired by the polarized light detection abilities of insects: Insects "see" the changing polarization of the skylight during the day and use it for navigation (Lambrinos et al. 2000). Polarization

detection in insects is mediated by ommatidia of the dorsal rim area of their compound eyes (Labhart et al. 2009). Each ommatidium contains photoreceptors called rhabdoms that are strongly polarization-sensitive(Wehner 1983). With a device inspired by this ability of the insects, people could navigate without being dependent on GPS signals.

X₁ ... Signals too weak for Human Sensory System (Strength)

X₂ ... Signal types not covered by Human Sensory System (Type)
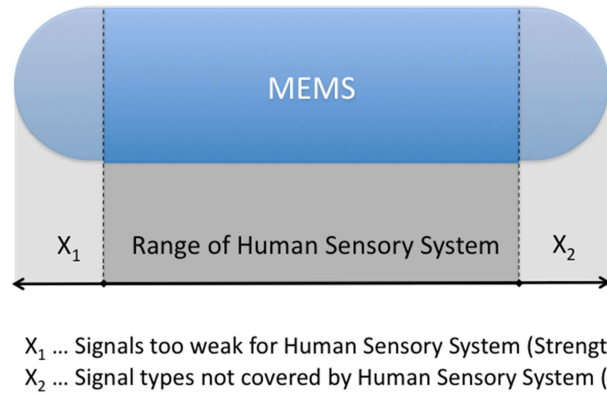
Figure 1. Functional Regions of Smart MEMS Sensors Compared to the Human Sensory System. Current MEMS cover nearly the whole range of the signals covered by people, plus signals that are too weak - or too strong - for us (X_1) and signals types that are not covered in humans by nature (X_2) (Karman et al. 2011, Makarczuk et al. 2011).

1.2   Trend of Navigation System Development

Navigation and finding the way home is very important for people, man-made devices and animals. Humans and animals navigate for finding food, in social activities, for communication and others. Over the years, starting from simple ways of navigation, people have developed a variety of navigation devices and systems, which are in many cases prerequisites for international communication, trading and others. As a consequence, systems such as VHF omnidirectional range (VOR) and tactical air navigation system (TACAN) were developed. Current navigation systems are mostly depended on the global navigation satellite system (GNSS), the most elaborate operation system for global positioning. The trend in GNSS augmentation started with the development of the Navy Navigation Satellite System (TRANSIT), US's Global Positioning System (GPS) and Russia's global positioning system (GLONASS) in 1960s and 1970s, continued by the launch of GNSS/Europe Global Navigation System (GALILEO) in 2012 and will be followed by the China's navigation system (COMPASS), Indian Regional Navigational Satellite System (IRNSS) and Japan's Quasi-Zenith Satellite System (QZSS) in the future (Mendizabal et al. 2009). The variability of function and integration of the new generation of GNSS has increased the market demand on related products (Mendizabal et al. 2009). However the application may be limited by low precision of the signal in certain condition such as in urban areas, intermittent coverage, and also by high cost maintenance and the risk to be shut down during times of conflict. Due to these risks there is need for systems that are GPS independent but possess the performance of GNSS.

1.3   Skylight Polarization Detection

The dynamic properties of skylight polarization provide useful information for various navigating animals and serve as the basis for a related man-made device. The static relationship between E-vector orientation and the sun's azimuth (Michael L 1980) serve as basis for the development of a bioinspired polarized light based navigation system as an alternative to GNSS.

The qualitatively robust pattern of polarized skylight direction can be obtained in any condition and even if the sun is not directly visible (Hegedus et al. 2007a), such as under canopy and foliage (Hegedus et al. 2007b), and on overcast and hazy days. This is because only a small section of clear sky needs to be visible for the animals to obtain a compass bearing for accurate navigation (Dacke et al. 1999). The polarization angle pattern of the cloudy sky is determined predominantly by scattering on cloud particles themselves (Hegedus et al. 2007a). Furthermore, the detection of polarization of downwelling light under clouds or canopies is most advantageous in the ultraviolet (UV) range; due to wavelength-dependent scattering properties in this spectral range the risk is the smallest that the degree of polarization is lower than the threshold of polarization sensitivity in animals (Barta and Horvath 2004).

2 Polarized Light Based Navigation Devices

Bioinspiration for polarized light navigation sensors has been realized both in the development of GPS independent navigation systems and in improvement of current GPS systems. Such devices comprise a novel polarized light based navigation sensor, a polarized light compass for mobile robot navigation and a polarized light based GPS/Inertial Navigation System (INS) integrated navigation system (Chu et al. 2008, Shashar et al. 2004). To improve the current GNSS system, the error measurement system needed to be improved (Lu et al. 2006). A pure INS integrates several differential equations containing inertial measurements to provide a navigation solution. The small errors in the measurements can lead to large velocity and position errors if allowed to integrate without correction for long times periods. Thus, to correct for this problem, the navigation system errors must be periodically corrected by external aiding instrumentation. Fan et al., 2009 (Fan et al. 2009) have implemented a new integrated navigation solution with polarized light assisting with geomagnetism and GPS.

Lambrinos et al. invented a GPS independent polarization compass model that is mimicking navigation of desert ants (Lambrinos et al. 2000). Enhancement of this polarization compass principle has lead to the development of the novel polarized light navigation sensor that has been developed by Chu and co-workers (Chu et al. 2009, Chu et al. 2008, Chu et al. 2007a, Chu et al. 2007b, Zhao et al. 2009) as well as the improvement in the error measurement. The key components of the polarization compass consist of a polarization sensor and a log-ratio amplifier inspired by the insects' polarized light sensitive photoreceptors and polarization neurons, respectively(Chu et al. 2007a, Chu et al. 2007b, Lambrinos et al. 2000). This device has large size electronic components such as photodiodes, polarizers, blue transmitting filters and log ratio amplifiers, and additionally needs a computer as controller. The orthogonal arrangement of the microvilli in the insects' rhabdomere of the dorsal rim area has inspired the development of the CMOS based wire grid polarizer which is used in a polarization sensor (Fantao et al. 2007, Sarkar et al. 2010b). Using newly designed polarization sensors, the changes in linear polarization underwater as a function of distance from a standard target also could be measured (Shashar et al. 2004).

3 Concept Development

The bioinspired polarized light based navigation device has been developed by a number of groups for more than a decade now (Chu et al. 2008, Fan et al. 2009, Lambrinos et al. 2000, Lu et al. 2006). Most applications are intended for mobile robots' navigation compasses and vehicles' navigation systems. Due to certain limitations, none of the devices are used for application directly on the human body, which would offer benefits regarding their potential medical applications.

As in insect, the polarization compass is located on the top area of the head, where this area is directly facing the sky. By mimicking the natural system, the novel polarized light based compass (PL-compass) needs to be placed on the top area of the human head (Figure 2). To avoid difficulties to the human caused by the device's size and weight, device miniaturization is important. The miniaturization could be done via MEMS technology. In this paper, the concept for a novel miniaturized MEMS PL-compass is introduced. The device consists of two major parts the polarized light detection unit and the signal processing unit (Table 1 and Figure 3). The polarized light detection unit consists of coupled metallic wire grid nanopolarizers-photoelectric material arrays (Sarkar et al. 2010a), while the nanoprocessing system will be used for signal processing unit (Yan et al. 2011). The existing PL-compass that is employed for mobile robots is of too bulky size, consisting of large size electronic components, making it not suitable for the human-contact application. The polarized light detection unit of the existing PL-compass consists of polarizers, transmitting filters and photodetectors, while the signal processing unit consists of the components such as the LOG104, analog to digital converter, ARM7TDMI based center processor and further components (Chu et al. 2008).

The workflow of the novel miniaturized MEMS PL-compass will remain exactly same as in the current existing device (Figure 3). A polarized light detection unit will detect the polarized light pattern as input. The input signal will be analyzed and processed in data acquisition and processing units, respectively, before being forwarded to the output channel for action. The metallic wire grid nanopolarizer has already been successfully employed for the development of a CMOS based polarized light image sensor (Sarkar et al. 2010a). By employing the nanoprocessing system, the size of the center processor and electrical circuit could be reduced (Yan et al. 2011). This would lead to the realization of a miniaturized PL-compass that can be applied for human's *navigational sense*.

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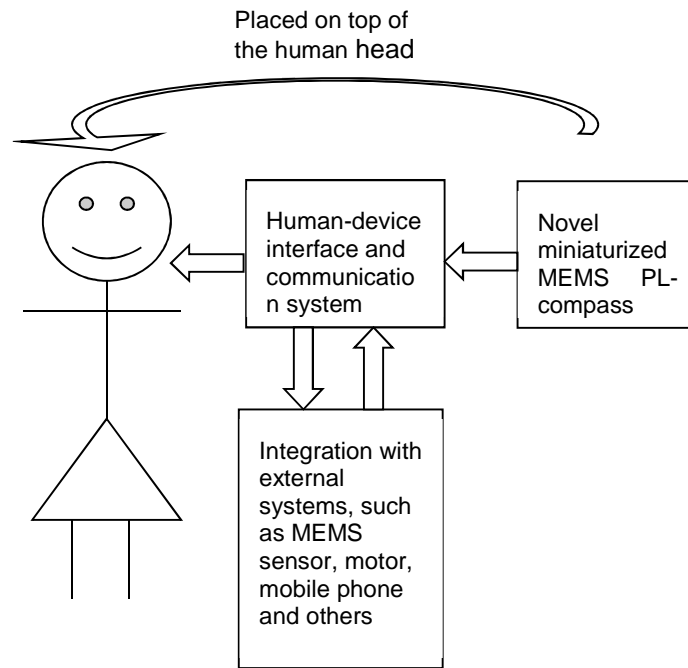
Figure 2. Schematic diagram of concept and application of novel miniature MEMS PL-compass for human navigation and medical application.

	Existing device	New device
Size	Macrosize	Nanosize
Application	Mobile robot	Human
Components	3 units of polarization direction analyzers (2 pairs of polarizers with photodetectors and transmitting filter in each units) with signal processing unit	Novel MEMS PL-compass with a metallic wire grid nanopolarizer amended in a photoelectric material and nanoprocessing system

Table 1. Components of polarized light compass (PL-compass)
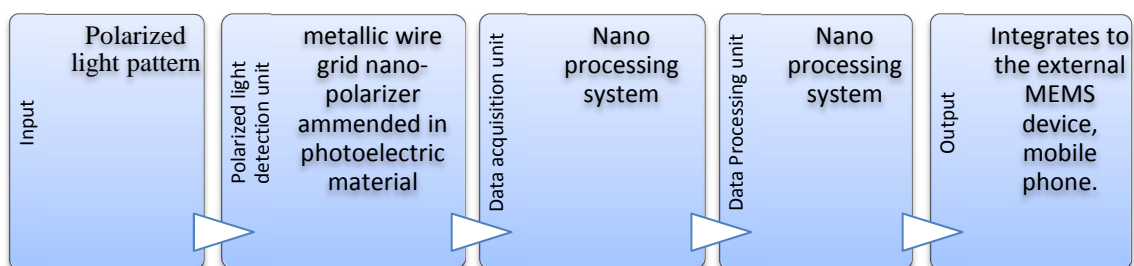
Figure 3. Flowchart of mechanism of novel MEMS PL-compass

4   Outlook and Discussion: MEMS, GIS and Health

The implementation of the bioinspired polarized light navigation sensor for enhancing the human sensory ability towards the "navigational sense" requires the connection between the devices and the human body. Thus, miniaturization of the existing devices needs to be performed -this can be successfully done with MEMS technology (Gilleo 2005). Using MEMS technology, the existing devices could be integrated with various techniques and devices and can enable the ability to obtain the desired characteristics in terms of shape, structure, bandwidth, working range, quality, and others. MEMS also can provide systems or devices with high

functionality and intelligence (Makarczuk et al. 2011). Integration techniques can lead to simple manufacturing methods. The MEMS can then be linked to the human body (mainly *ex corpore* to avoid ethics conflicts) in order to enhance the human sensory perception towards a polarized light based "navigation sense". This sense would be very beneficial to people at risk such as blind people, people bound to a wheelchair, people with Parkinson's disease and lost people including children.

The integration of the human's navigational sense with geographical information systems (GIS) such as from a smart phone will offer paramount potential in upgrading human health monitoring systems. Some existing devices, devices in development phase and devices that will be developed in the future are depicted in Figure 4.

Existing Devices	Devices Under Development	Potential Future Devices
• Mobile phone protosystems (quasisystems)	• Navigational sense • Google glass	• Implanted neurochips, direct connection to the brain, integration of the computer into our neural system
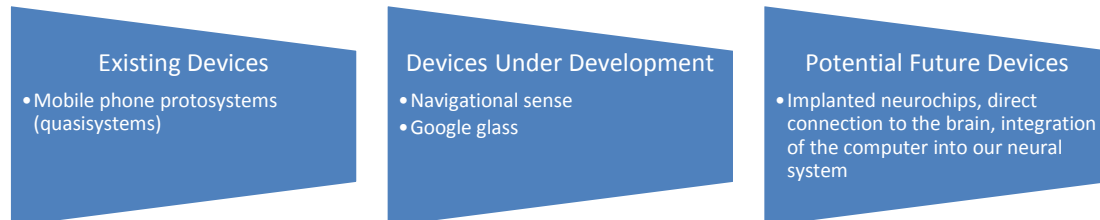
Figure 4. Phases of GIS implementation in human health monitoring systems

As "protosystems" we depict systems that "became" GIS systems, e.g., smart mobile phones that can calculate the position by extrapolating from the position of the mobile phone masts in the surroundings. Concerning the improvement of existing systems: push technology will be the future here. We will know where we are, and where all our friends are. And we will not just know the distance as the crow flies, which is in many cases useless (e.g. when the person and her friend are 200 meters apart, but there is a highway between the two, and they do not have a car) - the "user-centered distance" is the one that really counts: If for example the person is just one station by the train away from her friend, and the train comes soon, he is closer than when his friend is 200 meters away, but three streets which cannot be crossed are between the two. An example for a future system is the Google glass, a high technology system that provides the eye of the user with huge amounts of additional information.

Potential medical uses of combining GIS with MEMS: the position of the user and his biovital data could be transmitted to a central server, in a time triggered way (e.g. every 20 minutes). As soon as the health of the user goes down, the system would switch from time triggered to event triggered, and if the health state of the user reaches a certain tragical threshold, the central servers would send an ambulance to his position, and point him towards a shop (potentially with a navigational device that is directly coupled to the body) where there is somebody who can help him (and the system also would verify that this person is there and available) - somebody with a defibrillator for example if the user has heart problems, or somebody with experience in first aid. Another potential medical application of a combinational MEMS and GIS would be the following: when the user is on a bicycle tour, the route he is cycling could be adapted to his current health state, and also to the weather. This would of course also work when hiking or kayaking. If the user is in a group, the system could recommend splitting of the group, where the weaker ones stay together and take the easier way for example - or it could recommend that all stay together for health and safety reasons.

The combination of MEMS, GIS and health have a bright future.

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Precise GNSS-Georeferencing without Local Ground Control Points – Precise Point Positioning - A GNSS Method for Isolated Regions

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ABSTRACT

The use of GNSS, especially GPS, is a standard technique for geroreferencing spatial data. Its precision depends on receiver types and on the methods to eliminate systematic errors.

1.   Single Point Positioning based on runtime of signals has lowest acuracy (10 - 15 meter). It is available world wide easily.

2.   Differential GNSS based on differentially corrected runtime of signals has an accuracy of 0.3 to 3 meter depending on receiver and correction types. Run time corrections for real time positioning are available world wide; costs for corrections depending on service provider and accuracy. Reference stations of users itself only can only bridge limited distances . The positions are in the geodetic datum of the reference stations.

3.   Precise differential methods based on carrier phase observations are limited to certain distances and determine only coordinate differences (baselines) between receivers. So a reference frame is necessary to get positions related to a geodetic datum.

4.   Precise Point Positioning (PPP) is a single point solution that uses post processed precise satellite ephemeries and clock parameters from reference stations around the world. It currently enables cm-accuracy for long time observations with a delay of some days.

Compared with the well known solutions 1 to 3, the Precise Point Positioning (PPP) method has two main advantages:

1.   One dual frequency GNSS receiver can determine positions with cm accuracy.

2.   The positions are related to a well defined geodetic datum which is valid globally.

3.   Regions without any geodetic control points can be connected easily to global reference frames.

Disadvantages by achieving cm accuracy are long observation times, restriction to post processing, and costs for dual frequency receivers.

The presentation will compare PPP with the well known methods to use GNSS and discuss fields for using PPP. One year experiences in using the method at HFT Stuttgart will be shown and explained.

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The "Navigational Sense" in Living Nature: A Survey for Engineers

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ABSTRACT:

In biomimetics, materials, processes and systems in nature are analysed, the underlying principles are extracted and subsequently applied to science and technology. Once the basic principles of biological systems are understood, the engineer can start to work on the related bioinspired device. Many animals use combination strategies to orient themselves, and to navigate. They use long-distance and/or short-distance clues to forage and orient themselves to return back to their nest or hive, sometimes for kilometres. Famous navigators from the animal world are the honeybees (Apis mellifera) and the desert ants (Cataglyphis bicolor). Both use polarization-based navigation. The ants became model organisms for engineers on how they find their way back. Neurobiological and behavioural research yielded a model that was adapted for robot navigation. The skylight pattern of polarised light (the e-vector pattern) provides one of the cues for navigation. A specialized part of the insect compound eye has a small group of ommatidia and is located in the dorsal rim area. These detect the polarised light. Each ommatidium contains two photoreceptors and is strongly polarization sensitive, with orthogonally arranged analyser directions. Understanding the theory of the mechanism behind polarised light detection and subsequent navigation in insects is important in the development of a microelectromechanical (MEMS) based navigational device that uses the polarisation of the skylight as input signal. Such a navigation device is an alternative method for navigation, independent of GPS. The presentation will give a survey of biological principles regarding navigation systems based on polarised skylight. The presenter and first author is a biologist who has over the last year acquired experience in talking to engineers, discussing biomimetic approaches.

1   Introduction

1.1   Motivation

'Sense of direction is something you enter this world with and if it wasn't conferred upon you as a birthright you'll never acquire it, no matter how hard you study. I was born with this gift and it is impossible for any of us who are so gifted to explain how we do it.' (*The Australian bushman Lindsay sat firmly on one side*)

In the past decade, a large number of robots were built that explicitly implemented biological navigation behaviours. Reviewed biomimetic approaches using a framework that allows for a common description of biological and technical navigation behaviour. The review shows that biomimetic systems make significant contributions to two fields of research: First, they provide a real world test of models of biological navigation behaviour; second, they make new navigation mechanisms available for technical applications, most notably in the field of indoor robot navigation. While simpler insect navigation behaviours have been implemented quite successfully, the more complicated way-finding capabilities of vertebrates still pose a challenge to current systems (Mallot and Franz 1999).

1.2 Bioinspired

The nature and organization of biology and engineering are very different. Organisms develop through a process of evolution and natural selection; biology is largely descriptive and creates classifications, whereas engineering is a result of decision-making; it is prescriptive and generates rules and regularities (Vincent et al. 2006). Biomimetics involves transferring the principles of materials, structures and processes as found in living nature, to the field of engineering in order to, e.g., develop technological devices that can assist, enhance and expand human sensory ability. Biomimetics has not only united the fields of biology and medicine in order to benefit mankind, but has also integrated the principals of other applied sciences, including physics, tribology, chemistry and engineering (Gebeshuber, Majlis, and Stachelberger 2009). The structure of living organisms is highly elaborate. Natural materials and processes are refined and in some cases extremely complex, and MicroElectroMechanical Systems (MEMS) devices seek to reproduce nature's perfection. This paper provides an overview of senses of organisms as already represented in existing MEMS devices and uses push-pull analysis to review the potential these devices have for assisting, enhancing and expanding the human sensory system.

2 Biological Navigation Sense

2.1 Biological navigation systems

Researchers working on the exact capabilities and limitation of mapping and navigation systems used in nature provide valuable information including knowledge on what animals and insects can achieve using their own sensory and higher processing systems, and the theories and models of mechanism they use in the process (Milford 2008). Animals can use the great source of information to orientate themselves and for successful navigation they need to know the direction and the distance (Rodrigo 2002).

2.2 Navigation strategies in insects

Capable navigators in the animal world occur in vertebrates and invertebrates such as molluscs, cephalopods, and in all major arthropod groups, including insects and crustaceans (Wolf 2011). Navigating animals have the ability to identify and maintain a course or path from one place to another (Gallistel 1990). Insects are amazing animals with special anatomy and characteristics in adaptation of their life especially the ability of to return back to their hive after navigated for a kilometre or even more. Many animals navigate either long-distance or short-distance to forage, and they can return back to their nest or hive from places many kilometres away. Long-distance navigators include desert ants (Wehner 2003; Merkle and Wehner 2010; Cruse and Wehner 2011) and the honeybee (Collet 2008). Monarch butterflies who travel seasonally over thousands of kilometres (Brower 1996; Reppert, Gegear, and Merlin 2010) are different to the ants, bees, wasps and other social Hymenoptera. Worker honeybees fly from their nest for many kilometres foraging for pollen and nectar, and return back to their nest to inform nest mates on food sources using highly specific ways of communication (Frisch 1967). Insects use skylight polarization for different orientation tasks, for example for course control, navigation, foraging and others (Stalleicken, Labhart, and Mouritsen 2005). Polarization-based navigation specialists are for example the honeybee (*Apis mellifera*) or the desert ant (*Cataglyphis bicolor)*. Navigation strategies in social insects are performed dominantly through path integration or 'dead reckoning' where the animals keep track of the distance and direction of their current position from the past trajectory and return back to their nest without retracing the steps of the outward journey, but rather take a direct path or straight routes (Möller and Wehner 1988; Rodrigo 2002). In the last decades a social insect desert ant became an ideal study model for (biological) autonomous agents in navigation. Passing on the knowledge of a feeding site to a nest mate would not contribute to the colony's success. On the other hand, each ant that can be found outside the nest follows the same of searching for food and then safely and quickly navigating home.

2.3 Basic mechanisms and orientation in biological navigation systems

Vector navigation includes direction and distance of journey from nest/ hive to food source. Some researchers monitor the energy or time spent to cover a certain distance. Many day-active arthropods, such as ants, honeybees and spiders, use the polarization pattern from the sun as a compass cue when returning to their nests (Waterman 1981; Wehner and Labhart 2006). Insect vision occurs through a pair of compound eyes on both

sides of the head and three single-lens eyes, known as ocelli, that exist between the compounded eyes on the head. In many insects the perception of polarized light is mediated by anatomically and physiologically specialized ommatidia situated in the dorsal rim area of the compound eyes (Labhart 1986) and specifically detect the overhead e-vector pattern (Homberg 2004; Labhart and Meyer 2002; Wehner and Labhart 2006). A single ommatidium of a desert ant is shown in Figure 1a. The microvilli photoreceptors are well aligned along the rhadomere and oriented orthogonally to each other (R1, 5 *vs.* R2, 4, 6, 8 see Figure 1b).
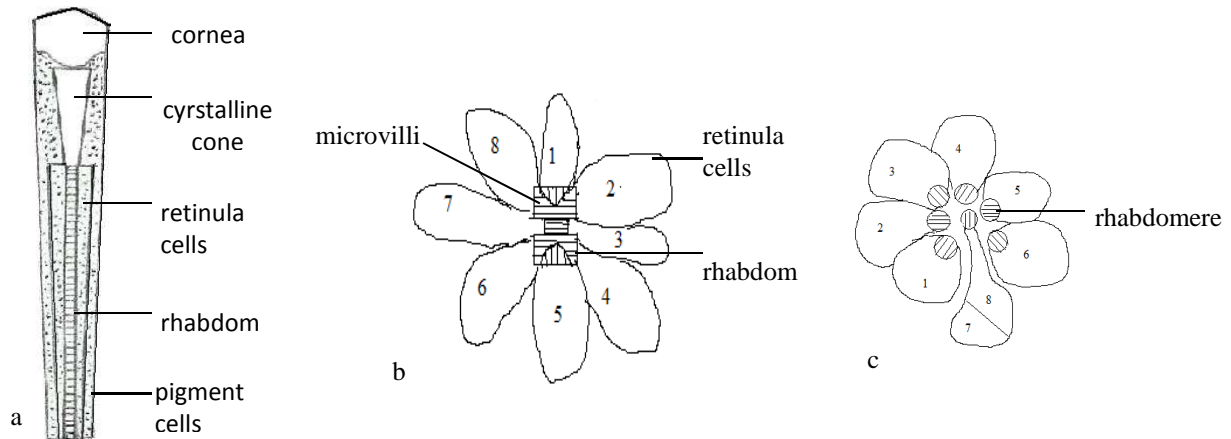
Figure 1: a) Single ommatidium of a desert ant. b) Cross section of an ommatidium of a desert ant, showing the orientation of the microvilli (R1, 5 are orthogonal with R2, 3, 4, 6, 7 8) and the rhabdom (dumb-bell shape and fused rhabdom) (image adapted from (Nilsson, Labhart, and Meyer 1987; Labhart and Meyer 1999). c) Cross section of flies having an open rhabdom in which six are in the outer and two in the central rhabdomeres. The central rhabdomere of retinula cells 7 and 8, which lie on top of one another (Manzel and Snyder 1983).

2.4   Architecture or behaviour of navigation

The organization of animal navigational performance can be described and explained. The correct information about directions and distances either in path integrator or the landmark-guidance routines are described in ants as shown in Figure 2. Path integration or vector navigation is a process where the animal keeps track of its direction and distance from a starting point (nest/hive) (Wehner 2009). Central place foragers such as honeybees, desert ants and many other hymenoptera make repeated foraging excursions and return back home safely each time (Wehner 2009; Srinivasan 2011; Wehner 2009). When *Cataglyphis* can access both polarization compass and sun compass, they tend to choose the polarization compass (Wehner and Müller 2006). Many animals use the sun as a compass or the skylight polarization pattern produced by scattering of the sunlight in the atmosphere (Wehner 1997). The skylight compass is based on the azimuthal position of the sun and the pattern of polarized light (e-vector pattern) (Wehner, Michel, and Antonsen 1996) and the polarization is at its most intense at a 90° angle from the sun. The odometer measured of travelling distances. Measured travelling distances in path integration are difference between desert ants and honeybees. In honeybees, they use optic flow (pattern of apparent motion) during the flight experience. While the desert ants measured of travelling distance using proprioreceptive (ability to sense stimuli arising within the body regarding position, motion and equilibrium) cues (Labhart and Meyer 2002). In honeybees, the primary cue of distance estimation is self-induced optic flow. Flight distance is not perceived in absolute units but as the total amount of image motion experienced during flight time (Esch and Burns 1995); (Srinivasan et al. 2000). In community odometer, the worker honeybee communicate the location of a nectar source to their hive mates by the waggle dance which the duration period of one waggle is longer indicate the goal are further (Dyer 2002). Insect optomotor system is critically dependent on image speed (Srinivasan, Poteser, and Kral 1999).
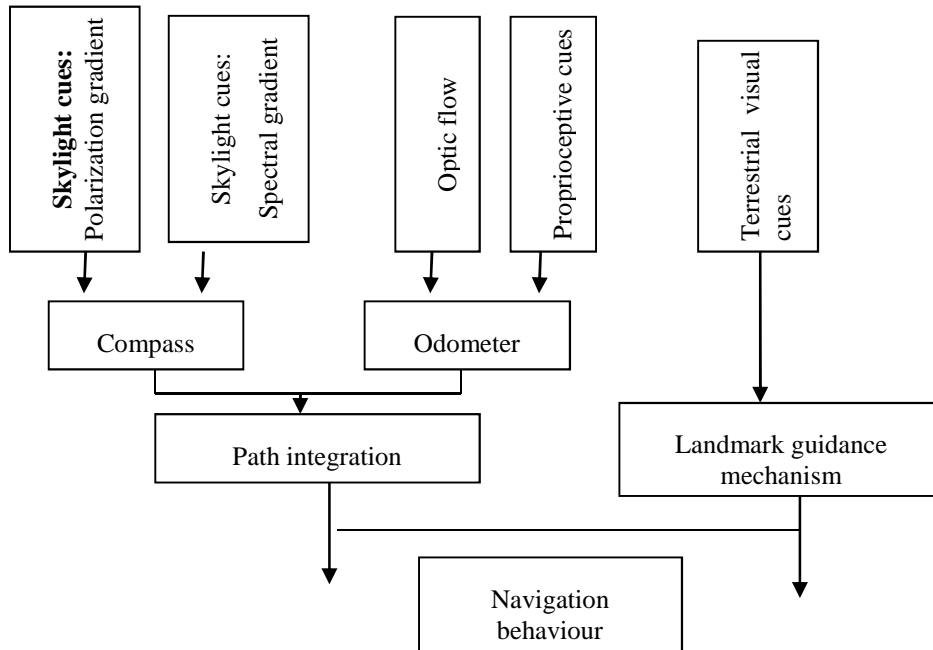
Figure 2: Schematic architecture of insect's navigation system. In path integration includes compass (external stimulus: skylight cues polarization gradient/ pattern and spectral gradient) and odometer (internal- optic flow mostly in honeybees and propriceptive in ants). The landmark-guidance modules include terrestrial cues (e.g view-based image matching, flow-field detection, and beacon aiming. The network and association to generate efficiency and successful navigation (adaptation from Wehner 2009)

3   Bio-inspired development

Biology is prepared for technology and engineering to develop device for human instrument. Conversion theoretical from biology to technology can be realized in many ways such as algorithms, simulation and modeling and mathematically. The animal kingdom are always become a great source of inspiration for the development of new and innovative navigation systems. Neuron in insect such as dragonflies are found in optic lobe (part of brain) that response nicely sensitive to small, dark and moving target regardless the motion of surrounding background. Recently, researcher applied the navigation system in desert ants to robot (Lambrinos et al. 2000); (Lambrinos 2003); (Srinivasan 2011). In the ongoing attempt to meet the engineering challenges of the present and future, systems science has often looked to biology for examples of what is possible and clues as to how it might be achieved (Hristu-Varsakelist and Shaof 2004). The implementation some of great gained from research of vision and navigation in insect to the guidance a device. Lambrinos et al. (2000) have done insect-inspired polarization compass to autonomous robots are called "Sahabot" (Sahabot - a terrestrial robot steered by polarization compass). Nowadays, the human navigation technology for navigation system is Global Positioning System (GPS). This system working where a receivers use a code to determine distances to each satellite and calculate their position and altitude (Cox and Vreysen 2005). However, GPS cannot currently perform in indoor and highly urban locations.

4 Outlook and Discussion:

Researchers are proposed models of honeybee map and navigation process vary from one extreme to other. Although navigation capabilities of insect are well known but little neural mechanism they use to perform that navigation. A growing number approaches in robotics get inspiration from the navigation capabilities that insects show despite diminutive brains (Möller and Wehner 1988). In future technologies inspired Microelectromechanical System (MEMS) can be developed to enhance, to assist and expand human sensory system.

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Internet-based Applications and Open Source Solutions

Object-Based Remote Sensing Image Analysis with OSGeo Tools

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KEY WORDS: Remote Sensing, Image analysis, Object-based, High-resolution, Open-source

ABSTRACT:

The increasing spatial resolution of satellite remote sensing image introduces the possibility to delineate individual objects and hence, object-based image analysis approaches received more attention and proved to be a suitable solution. Over 800 relevant articles have been published (Blaschke 2010) comprising both algorithms development and applications. Whilst many applications rely on eCognition, a powerful commercial package, lesser has been found with open-source tools. This paper is to introduce a few existing open-source geospatial tools for object-based image analysis. The capability and easy of use of one selected tool, Orfeo toolbox, is further explored. An open-source comprehensive package comprising high-performance segmentation and knowledge-based classification like eCognition has not yet come. However, the existing open-source tools provide numerous advanced tools that are capable to handle similar tasks as well as provide the freedom in tool selection.

1   Introduction

Earth observation data has been playing a significant role in providing timely synoptic and details views of the Earth surface, the critical information required for environmental monitoring and management, food security, biodiversity conservation, disaster management, and urban planning, to name a few. The medium spatial resolutions like Landsat and SPOT, as they were called high resolution satellite images in the 80s, together with coarser resolutions data like MODIS, NOAA were extensively used in those applications. To derive information from satellite images, the pixel-based approaches have been the norm, which were also applicable for higher resolution aerial photographs. The operation of new satellite sensor capturing sub-meter spatial resolution image such as IKONOS, Quickbird, Geoeyes and Worldview since late 90s extended the capability of deriving details from the sky on one hand. On another hand, it raised a critical question: existing pixel-based approaches seem to be inapplicable in handling such high-resolution images (Blaschke & Strobl, 2001; Blaschke et al. 2004).

The new trend, object-based image analysis, has emerged as a solution and proved to be the suitable one. As reviewed by Blaschke (2010), more than 800 relevant articles have been published. The steps involved in an object-based image analysis or named GEOBIA (Hay & Castilla, 2008) include segmentation and object-based classification. Segmentation could inherit numerous developed techniques from computer vision, image processing and some particularly developed for remote sensing images (Pal & Pal, 1993; Schiewe, 2002, Tzotsos & Argialas, 2006). Segmentation produces homogeneous clusters or objects each of which may be associate with additional attributes such as mean, variance, shape index, textural measures, etc. depending on the segmentation method used. As a result, the subsequent object-based classification can exploit that valuable information. In addition, segmentation also helps to open the original image into a multi-scale space to allow the incorporation of scale into classification (Hay et al. 2003; Vu et al. 2009). With rich contextual information as resulted from segmentation, object-based classification involves the integration of expert knowledge into a hierarchical scheme of sub- and super- objects.

Most of the initial deployment of GEOBIA was around the eCognition software (Benz et al. 2004), Blaschke (2010) identified that about 50%-55% of published works were related to eCognition or Definiens (its new name). This package has driven the way that a GEOBIA should be, in deed. Following eCognition and

responding to the increasing demand from the users, other key commercial players like ENVI and Erdas IMAGINE have integrated the feature extraction and analyst components in their remote sensing package. The high cost of those commercial packages is the big obstacle for many researchers and practitioners. Originated from researches, there have been quite a number of open-source segmentation and classification tools few of which consist of full components dedicated to object-based image analysis. However, such open-source deployment showed some promising outcomes. A few of commonly used tools, i.e. GRASS, InterIMAGE, GeoDMA, and Orfeo Toolbox will be introduced in this paper aiming at strengthen the awareness. More detailed processing for urban mapping using Orfeo Toolbox will be described to illustrate the friendly and easy to use interface of open-source package.

2   Overview of existing OSGEO tools for object-based image analysis

2.1   GRASS GIS

GRASS (Geographic Resources Analysis Support System) originated from a development by U.S. Army Construction Engineering Research Laboratories in 1982-1995 became the leading open-source software and an official project of the Open Source Geospatial Foundation later (http://grass.fbk.eu/). With numerous raster and vector analysis modules developed over 20 years, GRASS GIS is the most popular open-source GIS desktop package and as a result, a huge network of developers and users worldwide. Though there has no dedicated set of commands for object-based image analysis, GRASS GIS has its potential capability to handle this job. Recently, there have been a few promising published works.

Rutzinger et al. (2006) developed an object-based analysis of airborne laser scanning data in GRASS environment. Similarly, Höfle & Hollaus (2010) implemented their object-based image and point cloud analysis in GRASS GIS. Sofina et al. (2011) also developed their object-based detection of earthquake-destroyed buildings using GRASS. There was an expression of interest to develop an equivalent of eCognition's object-based classification in GRASS (http://grass.osgeo.org/wiki/GRASS_SoC_Ideas_2008) but has not been fully realized so far.

2.2   InterIMAGE and GeoDMA

InterIMAGE (Interpreting Image freely) and GeoDMA (Geographic Data Mining Analyst) are the recent efforts by Brazilian National Institute for Space Research (INPE) and its collaborators in development of open-source tools for image analysis. They has been introduced and proved the capability in handling high-resolution satellite images in an object-based way (Korting et al., 2010; Novack & Kux, 2010; and Kux & Souza, 2012).

InterIMAGE is developed as a knowledge-based framework for Automatic Image Interpretation, which is an extension of an earlier project called GeoAIDA, developed by the Leibniz Universität Hannover (http://www.lvc.ele.puc-rio.br/projects/interimage/). InterIMAGE interprets the images based on user-defined rules structured as a semantic network. Similarly to eCognition, the process starts with extracting objects in images and calculation of spectral, geometric, topological and texture properties prior to modeling of explicit knowledge. The current version includes the following operators TA arithmetic (based on threshold image), TA Baatz Segmenter (similar to eCognition segmentation), TA C4.5 Classifier and a few others. Other image operators provided within TerraAIDA using TerraLib. InterIMAGE is an open framework, easily extended.

GeoDMA (http://www.dpi.inpe.br/geodma) is devoted to data mining of geographical data. It is developed in C++ as a plugin for TerraView GIS (http://www.dpi.inpe.br/terraview/). Currently, GeoDMA provides Region Growing and Baatz segmentation algorithms. The main classification algorithm is Decision Tree but Self-Organizing Map (SOM) and Neural Network are also available.

2.3   Orfeo Toolbox

Orfeo Toolbox is developed by CNES (French Space Agency) and released as an open-source package. Its objective is to provide cutting-edge processing algorithms quickly to the users, shorten the delay from research outcomes to practical uses (Christophe & Inglada, 2009). Numerous advanced image-processing algorithms have been released and deployed. Christophe & Inglada (2007) illustrated the road extraction from high-resolution images using Orfeo whereas May & Inglada (2009) introduced the uses of Orfeo in urban area detection and segmentation, for instance. There was even a session "Open Source Initiatives for Remote

Sensing" consisting of 9 papers on Orfeo Toolbox during IGARSS 2009. In addition, Orfeo Toolbox proved to be potentially developed for high-performance computing (Christophe et al. 2011). It, therefore, provides necessary segmentation and classification algorithms serving object-based image analysis. Since this paper is to illustrate the easy to use of open-source object-based image analysis, the next section will present a test using Monteverdi, Orfeo Toolbox-Applications package with graphic user interface.

3   Object-based image analysis with Orfeo Toolbox

3.1   Data and study area

HoChiMinh city is an important hub of industry, finance and trade of Vietnam. Its population now reaches over 7 million and is increasing over 200,000 people per year (http://www.gso.gov.vn). The on-going development plan is expanding the city to the southeast, bringing the huge population closer to the coastline of the East Sea. A small area (750pixel x 650pixel) in this newly developed area was chosen as our test area. The WorldView-2 (WV-2) 8-band image was acquired on Feb 9, 2010. Figure 1 presents the study area in both true color and false color composites. In the selected portion, the bottom (south) part is on going developed new areas with better plan whereas the top (north) part is highly dense old town. With higher spectral resolution and slightly better spatial resolution, WV-2 image is expected to produce better discrimination among various material in urban areas in comparison with Quickbird image.

Red (band 5), Green (band 3) Blue (band 2)   Red (band 7), Green (band 5) Blue (band 3)

Figure 1. Worldview-2 image of the study area

3.2   Segmentation

Numerous textural, morphological filters, etc. are available for applications to image segmentation. The test here employed the popular mean-shift segmentation (Commaniciu, 2002) implemented in Monteverdi. The operation is straightforward with 3 adjustable parameters via the sliding bars. The spatial radius defines the searching neighborhood, the spectral range defines the interval in the spectral space and the minimum region size is for the smallest objects to be kept after clustering (Figure 2). The user can choose to display the clusters or the boundaries of the segmented regions.

Figure 2 presents the user interface of this segmentation task. 3 window views help to navigate and examine the original images as well as the segmented results. Figure 3 illustrates one of the segmented results in true color and false color composite, which produces a quite well forming of most of the objects in the scenes. A few building roofs, however, are still fragmented. By adjusting the parameters, a hierarchical object scheme would be formed and that's the key idea of object-based image analysis.

Spectral range value = 15.0   Spectral range value = 50.0

Figure 2. Mean-shift segmentation interface.

Red (band 5), Green (band 3) Blue (band 2)   Red (band 7), Green (band 5) Blue (band 3)

Figure 3. Mean-shift segmented result.

3.3 Classification

The hierarchical object-based classification scheme has not been implemented in Monteverdi package. However, it provides a SVM (Support Vector Machine) tool, which has been widely used in remote sensing image classification recently (Mountrakis et al. 2010). SVM (Vapnik 1998), a machine-learning algorithm, seeks the optimal separating hyperplane between classes, which was originally designed for binary classification (two classes). It was then extended to multi-class separation (Hsu & Lin, 2002) and proved to be a better classification approach in comparison with other conventional methods (Melgani & Bruzzone, 2004). Another advantage of SVM is its efficient performance with lest training data that is particularly useful for remote sensing data. Over one hundred publications relevant to SVM's uses in remote sensing could be found (Mountrakis et al. 2010). Current development is exploring the integration of SVM in object-based image analysis (Li et al. 2010; Tzotso 2006). Figure 4 illustrates the result of supervised SVM classification of the objects that was segmented earlier (Section 3.2). Training data can be easily selected on screen or imported as region-of-interest (ROI) in vector format. After the training data is ready, the classification process starts by 'Learn', followed by 'Display' (after classification done) and 'Validate' whereby the ground-truth data needs to be defined for generation of confusion-matrix and other accuracy measurements.

Red (band 5), Green (band 3) Blue (band 2)   Classified image
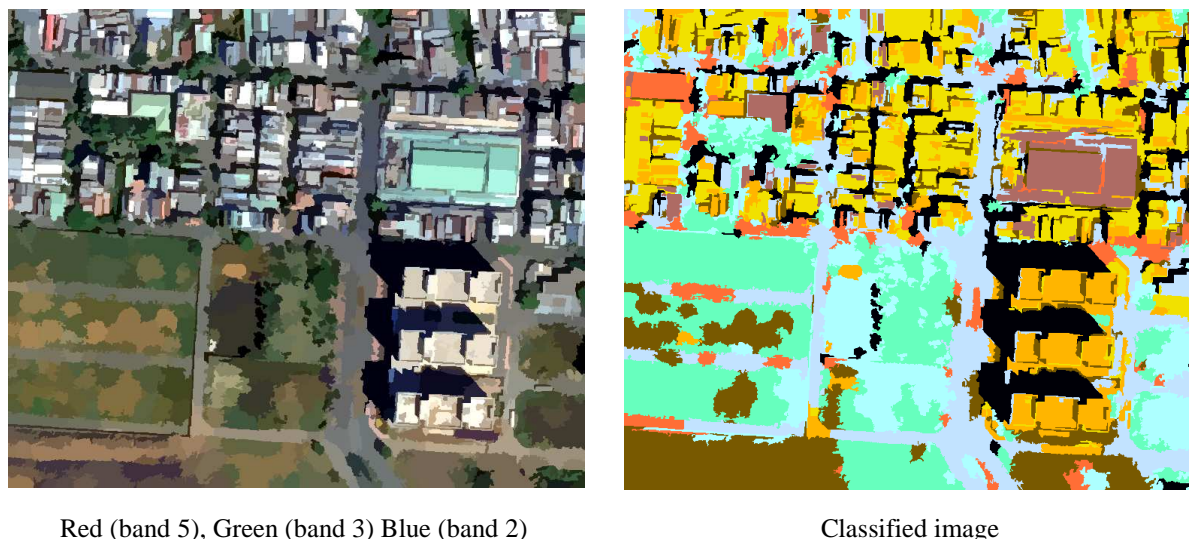
Figure 4. SVM result.

4   Conclusions

A few OS GEO tools workable for object-based image analysis has been introduced to enhance the awareness of such useful tools and to prove that there is no need for a steep learning curve when engaging with OSGEO. The discussion here is not thoroughly comprehensive; the selection of tools was based on the hit of Scopus search, the introduction of OSGEO live and the author's experience. There are more existing tools and the development is expanding. For instance, Opticks is one of the newly introduced open-source remote sensing analysis package with various built interface to IDL, Python, C++ programming that allows the easy attachment of new object-based image analysis tool. Likewise, it is the case of InterIMAGE and GeoDMA. There remaining issue, however, of unstable performance of OS tools across different platforms, which will be always fixed by the developer communities.

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Evaluation of Open Source Spatial Database Systems

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ABSTRACT:

Spatial Database Management Systems (SDBMS) form a core component of any Geographic Information System (GIS) and are very essential to the successful implementation of any GIS project. SDBMS with their underlying Database Management Systems (DBMS) ensure the logical consistency and security of both spatial and non-spatial data in any GIS implementation. Therefore, it is imperative that the functionalities of SDBMS are evaluated to analyse their support for spatial and non-spatial data storage, management and retrieval. This research evaluates three Open Source SDBMS namely PostgreSQL with PostGIS, SQLite with SpatiaLite, and MySQL. The choice of open source software is necessitated by their growing popularity, free use and distribution, and they possibly provide better alternatives to most proprietary software. The evaluation is based on database benchmarking using Python, and interaction between the three SDBMS and six GIS clients namely ArcGIS, GeoMedia, QGIS, OpenJUMP, gvSIG and uDig. The research answers the question of which of the three SDBMS performs fastest in terms of their responses to data upload, Open Geospatial Consortium (OGC) specified queries and typical GIS application queries. The research also identifies which of the three SDBMS interacts most with the GIS clients and how interoperable the GIS clients are with respect to the three SDBMS. An assessment of the user-friendliness of the interaction between the SDBMS and the GIS clients is also done by this research. The results of this research indicate that SpatiaLite and MySQL perform faster than PostGIS with SpatiaLite being the fastest. PostGIS was identified as the only SDBMS that interacts with all the GIS clients. The interaction between SpatiaLite and the GIS clients was adjudged to be the most user-friendly even though SpatiaLite was the least supported in terms of reading data using the GIS clients. MySQL was not supported at all in terms of writing spatial data using the GIS clients.

Building local government capacity in resource planning and disaster risk management through free and open source geospatial technologies

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ABSTRACT

Free and Open Source Geospatial (FOSS-Geo) technologies have evolved to become a complete replacement to many proprietary geospatial solutions. The adoption of FOSS-Geo has penetrated many geospatial domains and organizations in the world. One of the greatest enabling factors towards adopting FOSS-Geo technologies is the cost barrier of acquiring proprietary products. FOSS-Geo technologies clearly reduced this capital cost. Although the adoption of FOSS-GEO technologies in the Philippines is increasing, it is moving at a slow pace.

In early 2010, Environmental Science for Social Change (ESSC) started to developed basic geomatics training courses and workshops using free open source software (FOSS-Geo). It generated positive feedback and institutional learnings that reinforced the relevance and urgent need for creating and developing capacities. This training program was designed specifically for resource planning and disaster risk management and seeks to bridge the gap between many institutions looking for opportunities to build their capacity to utilize FOSS-Geo technologies within their programs and projects.

This paper presents two case studies demonstrating the adoption of FOSS-Geo technologies among ESSC's partner institutions, particularly with local government units (LGUs) and universities in the Philippines. A set of modules and course material is developed for subsequent training activities. The modules cover the usual mapping workflow, from data collection, input, analysis and map design using Quantum GIS.

First, the case of Municipality of Pilar, Bohol (LGU-Pilar). The LGU of Pilar is updating its Comprehensive Land Use Plan (CLUP). Primarily, the LGU is concerned with attracting investments that contribute to socio-economic development while ensuring environmental stability. ESSC provides technical assistance to the local government through a comprehensive and participatory planning process using FOSS-Geo technologies.

Second, the initial outcome of the partnership with the Ateneo de Davao University (AdDU) in developing the GIS courses using FOSS-Geo technologies for post-graduate degree program is presented. The course is designed primarily for local government personnel. This partnership essentially involves linking with LGUs and contributes to efforts in better resource planning and management.

We can draw out several learnings, challenges and opportunities from using FOSS-Geo technologies within the context of local development planning in a developing nation.

1   Introduction

Free and Open Source Geospatial (FOSS-Geo) technologies have evolved to become a complete replacement to many proprietary geospatial solutions. The adoption of FOSS-Geo has penetrated many geospatial domains and

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organizations in the world. One of the greatest enabling factors towards adopting FOSS-Geo technologies is the cost barrier of acquiring proprietary products. FOSS-Geo technologies clearly reduced this capital cost. Although the adoption of FOSS-GEO technologies in the Philippines is increasing, it is moving at a slow pace.

In the last five years, there is an increasing number in tertiary education institutions that are adopting FOSS-Geo technologies within their undergraduate and graduate degree courses. However, the utilization in education is often faculty-driven with no clear institutional guidelines in terms of open source adoption.

Proprietary vendors are largely influencing this through the educational license approach. Many proprietary vendors are donating computers and software in the university provided that they teach the proprietary software. This ensures that graduates are trained to use their software, thus increase market share. The educational license although cheaper, needs annual renewal.

Very little educational materials are available to faculty while many of the GIS subjects are simply designed on how to use the software and not on the geo-analytical skills.

Environmental Science for Social Change (ESSC) sees the value of developing a program that strengthens geo-analytical skills of faculty and local officials for improved land use and local planning and resource management. In relation to this, ESSC developed in 2010 basic geomatics training courses and workshops using free open source software (FOSS-Geo). It generated positive feedback and institutional learnings that reinforced the relevance and urgent need for creating and developing capacities. The training program was designed for resource planning and disaster risk management and seeks to bridge the gap between many institutions looking for opportunities to build their capacity to utilize FOSS-Geo technologies within their programs and projects.

ESSC adopts FOSS-Geo technologies among its partner institutions in the Philippines, particularly with local government unit in Bohol, Visayas and Ateneo de Davao University (AdDU), Mindanao. Key learnings, challenges and opportunities from using FOSS-Geo technologies within the context of local development planning in a developing nation are shared.

2   Case 1: GIS Capacity Building towards the development of the Municipal Comprehensive Land Use Plan of Pilar, Bohol Philippines

The Local Government Unit of Pilar (LGU-Pilar) is the local governing body of the Municipality of Pilar in the island province of Bohol, Central Philippines.

LGU-Pilar is set to review and update its 1996-2007 comprehensive land use plan (CLUP) and to gain capacity on Geographic Information System (GIS).

A CLUP is the basis for the regulation of land uses within the territorial jurisdiction of a locality. It specifically defines the policies of the LGU pertaining to settlements, protected and production areas, and infrastructures consistent with a locality's overall development vision (HLURB, 2006). The formulation of a CLUP by all local government units in the Philippines, through a participatory approach, is prescribed through several legal mandates such as the 1987 Constitution, Local Government Code of 1991 (Republic Act 7160), Executive Order 72, Urban and Development Housing Act (Republic Act 7279) and Executive Order 648. The CLUP has a prescribed period of 10 years.

On the other hand, the Department of Interior and Local Government (DILG) encourages LGUs in the country to include GIS capacity building in their capability development agenda. It is now one of DILG's criteria in rating the LGU's annual performance. But the high cost of acquiring proprietary GIS software and the associated training for its use hinder several LGUs in the country from obtaining GIS capacity. Not to mention the subsequent cost that has to be expended for future software updates.

Republic Act 10121 otherwise known as the Disaster Risk Reduction and Management (DRRM) Act of 2010 mandates, among others, the mainstreaming of disaster risk reduction and climate change in development processes which include land use planning. The DRMM Act also mandates the integration of disaster risk reduction measures into the Comprehensive Development Plan (CDP) and CLUP of LGUs.

In 2011, LGU-Pilar and the Environmental Science for Social Change (ESSC) forged a partnership initiative to review and update its CLUP and to build its capacity on GIS using free and open source technologies. This initiative is still ongoing.

The effort has increased the capacity of LGU-Pilar GIS unit resulting to a build-up of its GIS-based data-holdings. GIS proved to be a useful tool in assessing physical characteristics and existing land uses in the municipality. It also helped in determining the development constraints and potential areas for development.

The data generated through these processes are required inputs for the update of the comprehensive land use plan of the Municipality of Pilar.

2.1   Objectives

In general, this component of the partnership initiative aims to build the capacity of LGU-Pilar on GIS. Specifically, it aims to:

1.   To provide GIS training to selected municipal staff;

2.   To build the GIS-based data-holdings of the municipality;

3.   To use GIS to generate information required for the updating of LGU-Pilar's CLUP.

2.2   Process

2.2.1   Creation of a Municipal GIS Unit

The Municipal Mayor of Pilar issued an executive order creating the municipal GIS team of which the management and supervision is handled by the Municipal Planning and Development Office (MPDO). Eight municipal staff composed the team.

2.2.2   GIS Training

Preliminary to the training, trainees were asked to have their individual laptops. Everyone was then provided with QGIS (Quantum GIS) 1.6 installer and related training and handout materials. The training was set for five days that involved the provision of orientations/overviews and hands-on exercises. The orientation sessions covered the following topics: a) concept of GIS, b) coordinate systems, c) map projection, d) global positioning system (GPS), e) features and interface of the free and open source application QGIS, f) file naming conventions, and g) map elements.

The hands-on training involved the use of GPS and QGIS. In the case of the GPS training, the team was divided into two groups where each group was composed of four members. Each group surveyed road network, locations of institutional facilities, and other points of interest in the municipality. The GPS data collected were downloaded using the freeware application, GPSBabel.

The training on the use of QGIS on the other hand, involved the a) registration/georeferencing of a sample scanned topographic map, b) data capturing/digitizing, and editing including attribute table population, c) the use of some QGIS plugins for geoprocessing, data conversion, and d) map layouting.

2.2.3   Primary and Secondary Data Gathering

The gathering of primary data using GPS focused on the road network, locations of Pilar's institutional facilities and other points of interest (POIs) such as the water line and extent of the two lakes (Malinao and Bayongan) within municipality territorial jurisdiction. Also gathered were point locations of the issues and concerns raised by the stakeholders during consultations and focused-group discussions.

The collection of secondary data involved mostly thematic analog maps (in various scales) required for the update of Pilar's CLUP. Most of these maps were sourced from national agencies like the National Irrigation Administration (NIA) and the Department of Environment and Natural Resources (DENR). A satellite image of the municipality sourced from Google Earth was also downloaded for reference purposes. Secondary data, in tabular format, such as population from the National Statistics Office (NSO) were also gathered.

2.2.4   Build-up of GIS-based Data-holdings

Discussions with the members of the GIS team and the Municipal Planning and Development Coordinator (MPDC) were held to come up with a structure of municipal GIS-based data-holdings. Discussions include protocols on data security, data access and incremental data-banking. It was also agreed that the build-up of the municipal GIS-based data-holdings is first focused on the spatial data requirements in updating their CLUP.

2.3   Results and Discussion

2.3.1   Capacity Building on GIS

As part of the training exercise, all trainees were asked to survey using a GPS receiver and to add the downloaded data into their individual QGIS project. They experienced data capturing/digitization, editing, attribute table population, and map layouting. By the end of the training period, all trainees were able to present their respective map layout.

2.3.2   Municipal GIS-based Data-holdings

The build-up of the GIS-based data-holdings of Pilar started with the digitization of their 1:20,000 administrative analog map where layers of the municipal and barangay boundaries were generated. NAMRIA's (National Mapping and Resource Information Authority) 1:50,000 topographic maps was the source in generating other baseline data (i.e. stream network). Data from GPS surveys carried out also composed the baseline information of the municipality.

To date, the structure of Pilar's GIS-based data-holdings is composed primarily of thematic data requirements for the update of its CLUP. The GIS layers generated as well as softcopies of other relevant data collected (e.g. scanned analog maps, SRTM digital elevation model (DEM), geotagged photos.) were classified and stored in a dedicated computer unit

All vector layers generated by the GIS team are in shapefile format; the standard data format of QGIS with Luzon 1911, UTM Zone 51N and Clarke 19866 as the datum, projection, and reference ellipsoid, respectively. The team has produced the administrative map of their municipality with 19 other thematic layers.
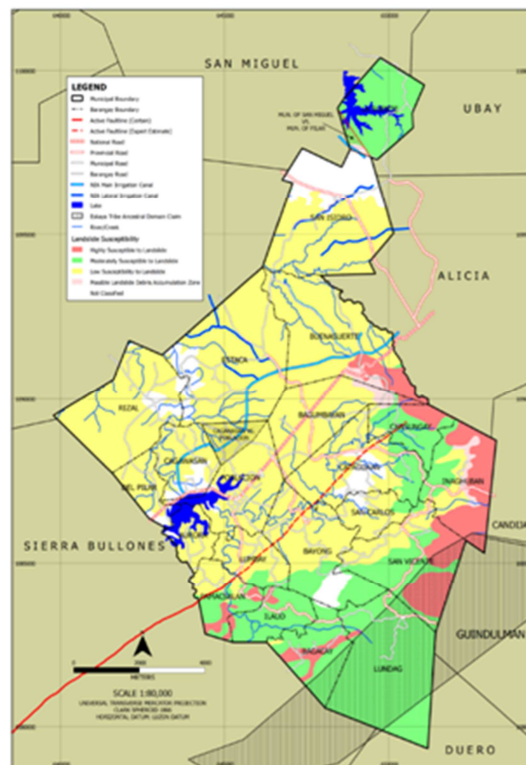
Figure 1: Geological Hazards, Municipality of Pilar (source of map? Date?)

Aside from surveying and transect mapping, the generation of existing general land use data for Pilar involved participation of barangay officials and other stakeholders living within its 22 barangays . For LGU-Pilar, which has been used to the manual ways of map production, map overlaying for analytical purposes and statistical data generation for land use planning, the application of GIS particularly improved their capacity to undertake such tasks faster and accurately. They also appreciate the other potential uses of GIS as a tool for monitoring, risk reduction and management, and visualization that facilitates substantive dialogues among its constituents.

Data gathered from Philippine Institute of Volcanology and Seismology (Phivolcs) indicates a fault line running across the municipality while the geohazard map of the Mines and Geo-Sciences Bureau (MGB) shows areas of highly susceptible to landslide (see Figure 1). Considerably, LGU-Pilar view these geohazards important factors

in planning the land uses of the municipality.At the national level, government encourages all LGUs throughout the country to capacitate themselves on GIS. It has made it one of the criteria in assessing the LGU's performance however, the high cost of acquiring proprietary GIS software and undergoing training often hinders many LGUs particularly of 4th and 5th income class municipalities to implement capacity building agenda. The use of free-and-open source application like QGIS with comparable functionalities with the propriety ones is indeed timely.

3 Case 2: Integrating a Free and Open Source Geospatial Curriculum to a Graduate Degree Program

ESSC in partnership with the Ateneo de Davao University (AdDU) and other Jesuit universities in Mindanao is implementing a four-year program entitled "Establishing strategic Partnerships in research to strengthen local governance in land and water management towards greater human security in Mindanao" (EPaM). Part of the initiative is to develop a Land/Soil Information System and build capacity among local stakeholders (academe, LGU and local communities) in strengthening individual capacity on research collaboration and land use management.

3.1 Objectives

The specific partnership with AdDU's Tropical Institute for Climate Studies (TropICS) is strengthening its use of geospatial technologies to support the Masters of Tropical Risk Management (MTRM) program and TropICS research agenda (Ignacio, 2011). Currently, the activities conducted within the project's scope are:

1.   Procurement of computer equipment and GPS receivers for the geomatics laboratory, which will be maintained by AdDU.

2.   Providing training of faculty and staff in using geospatial technologies specifically Free and Open Source Geospatial (FOSS-Geo) technologies.

3.   Create comprehensive resource materials that will be used in the geomatics course (GIS 1 and GIS 2) within the MTRM program. Materials are developed through course/module content, testing and course implementation in SY 2011-2012.

3.2 Process

MTRM is a multi-disciplinary degree designed for local government employees. The focus is to build capacity of local government agencies to support local development efforts in the fields of resource management and disaster risk.

The first batch of students is 20 pre-selected scholars of the Provincial Government of South Cotabato in Mindanao (PIO South Cotabato, 2011). At the end of each course, the students are required to develop and risk management plan of their own municipality integrating specific geospatial analysis discussed throughout the course. The program is currently in its second course for this year. The focus this year's course is to integrate the basic concepts discussed previously and to develop a comprehensive geospatial-based assessment of risk within the province.

3.3 Result

As a result of this partnership, AdDU-Tropics and ESSC was able to develop several research activities and educational modules:

1.   Web-base monitoring tool for internally displaced persons (IDPs) in Mindanao.

2.   Land-use/cover mapping.

3.   Historical analysis of flooding.

4.   Suitability analysis for prioritizing rain gauges and AWS installation.

5.   Course modules on various topics and exercises on geospatial technologies using Quantum GIS and other free and open source tools.

All exercises and data are at a local scale, providing context to the local situation of the participants. Subset of the training modules are published online under an open source license, which allow the general public to access and use the materials. The general topics include: a) applications installation, b) managing data attributes, c) digitizing vector layers, d) map design with Print Composer, e) using GPS data, f) using External Map Services, g) vector geoprocessing, h) rectifying raster data, and i) raster based terrain analysis.

Relevance of the engagement?

4   Lessons learned

4.1   On choosing FOSS Geospatial technologies

The zero capital cost of using FOSS is a very attractive incentive for local government units with limited budget to purchase expensive proprietary technologies. The resources saved from software purchase are then allocated to increase number of participants during training courses, extend data gathering activities, or purchase more computing hardware for the LGUs.

4.2   Availability of FOSS-Geo to most operating systems

FOSS-Geo technologies (specifically QGIS) are available to almost all operating systems like MS Windows, Linux, Mac OSX and Android. This allows us to install the application to existing hardware utilised by our partners and to as many units there are without the burden of encouraging software piracy.

4.3   The training activities contributes towards building a better software

Every training session is a bug hunting session. During the course of the training sessions, course facilitators took notes on possible bugs and participants' impressions on the user interface of the specific application they are using. After each session, identified bugs are reported (mostly minor and non-critical) to the specific FOSS-Geo developers (QGIS, 2012).

This is our way of giving back to the FOSS-Geo developer community. We had several cases where the reported bug was fixed because of the feedback we gave immediately after the training session. As a result, a new version of the application that includes the fix was made available by the time the next training was conducted. By using open source and providing feedback to the developers, we contribute in making the software even better.

4.4   On using local data

Participants appreciate the concepts more if they use datasets closer to home or related to their own fields.

4.5   On providing public access to course materials

By publishing the materials online, we are able to provide wider access to the resources developed by the training program. This allows others to access the materials over the web learn how to use the technology on their own without necessarily enrolling to the course. This is also our own contribution towards popularizing the use of open source in the country. The open source license of the documents allows other training providers to re-use the materials within their own training programs.

5   Continuing challenges of towards popularizing FOSS-Geo technologies in the country

As the use of FOSS-Geo in the Philippines is gaining popularity, yet many challenges are limiting the wider expansion of supporting the number of users. These challenges need to be addressed in order to widen the reach of the users community within the country. What are these challenges?

5.1 Limited access to consistent, relevant and timely local geographic data

Many of the geospatial information available in many government agencies are not readily available to local users. Most of them are in analog formats (paper maps) and if digital, not in an open standard forms. Within government institutions very little openness and sharing mechanisms are in place. Some geographic data are completely outdated. Moreover, acquiring information among these organizations require going through bureaucratic processes making it difficult data users to easily access the information. Several government agencies are starting to provide web portals for data access but these are also very limited.

Volunteer geographic information (VGI) such as OpenStreetMap and non-government institutions are filling this gap in many areas in the country. An institutional policy shift is therefore necessary across government agencies to encourage open access to this data.

5.2 Offline community of users

In many parts of the country, communication/internet infrastructure is very poor. The open source community is providing a wealth geographic information in the form of developed software, education materials and geographic data. Many local government institutions are still "offline". It is very difficult for ESSC to provide regular support to these institutions. We need to develop innovative ways to support local users that may not necessarily rely heavily on the Internet.

5.3 Limited adoption of tertiary educational institutions to using FOSS

An institutional policy should be adopted encouraging the use of FOSS as an option. By adopting FOSS among educational institutions, they can help build local capacity to:

1.   Develop tools and extensions of the most popular FOSS-Geo technologies that is adapted to the local condition and context.

2.   Contribute language translations to the tools and resource materials.

3.   Build new training materials for the local government.

4.   Contribute to collaborative efforts of local government on data collection and aggregation.

ESSC is committed to support local organization in building capacity in the use FOSS-Geo in the Philippines. Over the next years, ESSC aims to work with the international community of FOSS-Geo users, developers and advocates and serves as the important link towards expanding the user base in the Philippines.

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Geoinformatics Solutions in Gliding Competitions

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KEY WORDS: Python, IGC, glider, optimization, open source, Quantum GIS, ArcGIS,

ABSTRACT

This study focuses on how to integrate geoinformatics solutions with glider sport. It creates a connection between glider flight recorder data and commonly used GIS applications and automates the necessary IGC (International Gliding Commission) post-processing in the case of Hungarian National Glider competition. IGC is the glider's flight recorder output file format, which is similar to the format used by a common GPS track recorder, and records metadata and sequential waypoints. The first section introduces the official flight recorder device for gliding and the associated IGC file format. Instead of working with IGC files, a small program to convert IGC into shape file format is written. The second section implemented the optimization process for the Hungarian National Glider competition. The main issue is how to calculate scores after a flight, for which few waypoints (a maximum of five) must be selected and tagged as turn points. This is done manually in the case of the Hungarian competition; other competitions use proprietary optimizer programs. To achieve the stated target, dynamic programming was applied in Python language. Dynamic programming refers to an algorithm that solves each sub-problem just once, in this case the distance between two particular waypoints. The last section focuses on the visualisation possibilities. Results indicate that a new converter was successfully developed for IGC and shape files, and an automated program identifying the best turn points was successfully implemented. These programs can be run in either ArcGIS or Quantum GIS as open source plug-ins.

1   Geoinformatics in Gliding

Logging the flight data in case of gliders requires special certificated equipment that is a flight recorder (FR). The requirements are established by the Fédération Aéronautique Internationale (FAI) and the International Gliding Commission (IGC). To summarize these requirements, it includes the provision of a pressure altitude sensor in addition to a GNSS (Global Navigation Satellite System) receiver. It logs the GNSS positions during the flight in every 2-10 seconds and the pressure altitude. The output must be an IGC formatted file.

1.1   IGC file format

The IGC file format is also established and published by the FAI/IGC. An IGC-format file consists of lines of characters, each line giving a set of data such as for a GNSS fix. Each line starts with an upper-case letter denoting one of the Record types, and ends with CRLF (Carriage Return Line Feed). Some Record types take up only one line, while others such as task and header take up several lines. For instance, the task/declaration (C) Record includes a line for each Waypoint, and the Header (H) Record includes separate lines for GNSS FR type, pilot name, glider identification, etc. The order of Record types within an IGC file is strictly given. Record types occur only in only one place in the file (single instance Records), while others such as fixes re-occur as time progresses (multiple instance Records). The record H contains the meta data such as the name of the pilot, type of the plane, the type of the FR used, type of the GNSS receiver and pressure altitude sensor, amongst other things. The record B includes the logged waypoints, this section is a vital part of this study. The G Record verifies that the data has not been altered during or following the flight. The C record gives information about the currents tasks, for example what are the turn points or the destination? The other records provide more information about the flight or the structure and additional stored datasets, those are less important in this case *(FAI & IGC 2001).*

1.2 B record

The B record consists of the UTC, WGS84 latitude, WGS84 longitude, pressure and GNSS-altitude. All of the information within each B-record must have a data issue time within 0.1 seconds of the time given in the B-record. In the following parts, the time and the altitude will appear as attributes and additional information, thus their accuracy is less important. The following table shows an example of the B record *(FAI & IGC 2001)*.

B	HHMMSS	DDMMMMM	N/S	DDDMMMMM	E/W	V/A	PPPPP	GGGGG	CR	LF
B	114412	4617200	N	02001758	E	A	00827	00864		

Table 1. example of B record

The given example means that at 11:44:12 UTC, at 46°12.200' N, and at 20°01.758' E. In case of V/A using A for a 3D fix and V for a 2D fix (no GPS altitude) or for no GPS data. Altitude above 1013.25 hPa sea level datum is 827, the altitude above the WGS84 ellipsoid is 864 *(FAI & IGC 2001)*.

This study mainly uses the information from the B record.

1.3 IGC to Shape

Working with IGC files is not the best solution because it requires a lot of preprocessing to make it ready for se . To avoid this problem, a Python program was developed. This program uses all the B records of an IGC file and converts it into a shape file. Every single waypoint are edge of a polyline (see figure 1.) This Python code uses numpy.py and shapefile.py libraries. Numpy.py is necessary because storing thousands of points which have four kinds of information (latitude, longitude, time, elevation) require huge arrays. Shapefile.py helps to create the structure of a shape file and can easily fill it with data. Python language is selected because it is easy to use, furthermore common GIS programs allow to run python scripts, e.g. ArcGIS or Quantum GIS.

2 IGC optimization

2.1 Glider competition

Before the digital era, analog techniques were used in the sport of gliding. It is worth mentioning that a glider does not fly straight to its destination, but it tries to catch the thermal waves in the air to gain elevation. These stations make the flight route very irregular. In a competition some easily identifiable targets are given (e.g. bridges, churches, train stations etc.) which should be reached within a desired distance (area?), i.e. 500 – 3000 m.These targets are the turn points. In the ancient times pilots took pictures of the object to prove that they were there, nevertheless it was hard to prove that they were within the 500 m circle rather than the 600 m circle. With this FR it is easy to prove being inside or outside.

After FR was developed a new type of competition was invented: free flight. In this case the pilot can fly wherever he wants, and wherever he could without declarations. Every competition has different rules for free flight. This study focuses on the Hungarian National Gliding Competition. In this case, the pilot could determine turn points after the flight using his IGC file. This means he could select fixes from the B record as a turn point. Connecting the takeoff, landing and turn points gives the total distance flown. Maximizing this distance and finding the most appreciate turn points is the core issue. For that an algorithm was developed.

2.2 Optimizer algorithm

2.2.1 Principal of Dynamic programming

The core of the algorithm is the dynamic programming. Dynamic programming, like the divide-and-conquer method, solves problems by combining the solutions to subproblems. Dynamic programming applies when the subproblems overlap, i.e. when subproblems share subsubproblems. In this context, a divide-and-conquer algorithm does more work than necessary, repeatedly solving the common subsubproblems. A dynamic-programming algorithm solves each subsubproblem just once and then saves its answer in a table, thereby avoiding the work of recomputing the answer every time it solves each subsubproblem. We typically apply dynamic programming to optimization problems. Such problems can have many possible solutions. Each solution has a value, and we wish to find a solution with the optimal (minimum or maximum) value. We call

such a solution an optimal solution to the problem, as opposed to the optimal solution, since there may be several solutions that achieve the optimal value (*Thomas et al. 2001*).

2.2.2 Method

The general procedure for this method is as follows: the distance between the 1st and all the other waypoints was calculated. Then, three for loops were embedded in each other, with the outer loop showing the number of turn points, the middle loop verifying that the waypoint can be a new, optimal turn point and the inner loop presenting the actual end point. This means that the turn points never explicitly searched for the entire distance flown, but only up to a certain point. In the first case, just one turn point (instead of five) is searched for, while the remaining way points are interpreted as end points. In order to find the casual end point all the waypoints were examined and the maximum distance for new turn points is recorded. In subsequent cycles the previous measurements and optimums are used until five turn points are processed; the last point is identified as the casual end point. The core of this algorithm can be found in Appendix A.

2.2.3 Distance measuring

For measuring distance between two WGS84 fixes the coordinates are transformed to UTM projection, Zone 35. The transformation equations are based on the notes of *Takács, B*. The accuracy of the transformation is checked by comparing the five Hungarian EUREF Permanent Network (EPN) coordinates in the Hungarian projection (EOV) and the converted coordinates from WGS84 to UTM. The distance difference between all the possible combinations of the EPN stations in EOV and UTM are calculated and the difference m / 1000 m is shown in table 2.

UTM-EOV m/1000 m	*Csanádalberti*	*Csarnóta*	*Penc*	*Sopron*	*Tarpa*
Csanádalberti	0.0000	0.2843	0.2790	-0.1239	0.3356
Csarnóta	0.2843	0.0000	0.0215	-0.5372	0.2604
Penc	0.2790	0.0215	0.0000	-0.3024	0.3844
Sopron	-0.1239	-0.5372	-0.3024	0.0000	0.0866
Tarpa	0.3356	0.2604	0.3844	0.0866	0.0000

Table 2. Distance difference.

The highest difference is 0.537 m which is enough in case of gliders because the FR GPS accuracy is worse than this.

The limitation of this transformation is that it always works only in Hungary in UTM zone 34. Nevertheless Hungary consists of zone 33 and 34, the main part of the country is covered by the zone 34, therefore the coordinates from zone 33 can be transformed to zone 34.

3   Visualization

In order to visualize the results, an ArcGIS toolbox is invented which runs the IGC to shape python script and the optimizer python script. The background map is an aeronautical chart with airspaces and other important objects such as main roads, lakes, rivers etc. The source of the airspace data are the open air maps. The additional data comes from the DTA50 provided by the HM Térképészeti Közhasznú Nonprofit LTd. The symbology tries to give back the symbology of the official International Civil Aviation Organization (ICAO) aeronautical chart (see figure 1.).

4   Results

A converter was developed for converting IGC files to shape files. Its limitation is that all of the metadata and additional data from the IGC are lost. The advantage is that it keeps all the fixes.

Although the optimizer algorithm is slow, i.e. 5-10 minutes, it finds the best solution for the Hungarian National Glider Competition and gives the longest distance as a result.

Both of the python scripts can be run in itself or in Quantum GIS or ArcGIS as a plug in.

Symbology

Route

Altitude

— 90,0 - 500,0

— 500,1 - 1000,0

— 1000,1 - 1500,0

— 1500,1 - 2000,0

— 2000,1 - 2500,0

● Turnpoints

Environmental protected area

Flight Information Region

Terminal Control Area (TMA, MTMA)

Control Zone (CTR, MCTR)

Control Area (CTA)

Temporary reserved airspaces

Traffic Information Zone

Prohibited areas

Danger areas

Restricted areas

Glider Area

Railway

Road under construction

Primary road

Rivers

Artificial lakes

Lakes

Settlements

0 5 10 15 20

Kilometers

1:500.000

Figure 1: ArcGIS layout chart

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Appendix A

```
f = zeros((nr_p+1,nr_t+1)) #nr_p: number of fixes, nr_t: number of turnpoints
turnpoints = zeros((nr_p+1,nr_t+1,nr_t+1))
for i in range(1, nr_p+1):
      f[i][2]= distance(1,i)
      #print(str(f[i][2]))
      turnpoints[i][2][1]= 1 #  turnpoints[i][2][2] = i
j = 1
k = 1
l = 1
for j in range(3,nr_t+1):
for i in range(j,nr_p+1):
      mx=0 #maximum
      for k in range(j-1, i):
            x = f[k][j-1]+distance(k,i)
            if x>mx:
                  mx=x
                  for l in range(1,nr_t+1):
                        turnpoints[i][j][l]=turnpoints[k][j-1][l]
                  turnpoints[i][j][j] = i
      f[i][j]=mx
```

Web Processing Services for Data Quality Control

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KEYWORDS:
WPS, GDI, Web Data Service, GeoServer

ABSTRACT:

The Geodata Centre of the State Office for Spatial Information and Land Development of Baden-Württemberg, Germany, is responsible for providing geodata for the different administration offices. In the moment, the Geodata Centre is setting up a Geodata Infrastructure (GDI) including Web Portrayal Services (WMS) as well as Web Data Services (WFS and WCS). In cooperation with HFT Stuttgart the integration of a Web Processing Service (WPS) into the infrastructure was tested. In the paper the implementation using open source components will be discussed. Here GeoServer with the Java Topology Suite (JTS) was used to set up several WPS for data quality check, like detection of spikes and sliver polygons. It was shown that such an application is manageable; thus there are some drawbacks concerning the availability of generic clients supporting WPS and concerning the performance.

Replication and Presentation of Openstreetmap Database for Application on Regional or National Level

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ABSTRACT:

A Map is the visual representation of the earth in meaningful way to serve specific purposes. With time it has developed from cave drawings to paper maps and then digital and finally web based maps. Web based online map services such as Google Maps, Yahoo maps, bing maps, OpenStreetMap (OSM), etc. are very important tools because of its various interactive qualities such as zoom and pan, highlighting specific objects and route planning etc. Most of online map services are normally commercial and authorized with restrictions on its data usage and accessibility whereas OSM is volunteer based with an open licensing model. The rate of collaborative collection of geo-data is increasing in terms of both quantity and quality in OSM. Hence, this data can be considered as an alternative source of data which can provide similar functionalities as other commercial online map services. Especially, it is the best data source for the area where the availability of the data is low, expensive and not updated regularly. According to the OSM license, OpenStreetMap project provides geo-data for all and can be used for any purpose. Osmosis is a Java command line tool for downloading and updating the data and the downloaded data is imported inside the PostGIS database using osm2pgsql utility tool. With the use of rendering software Mapnik, data is rendered depending upon the specific rendering rules set after the study of printed maps, web based maps, online survey and interviews of the local people to produce a cartographic map. The Tilelite serves on demand rendering web tiles. For web application, there is OpenLayer JavaScript as user interface library which is powerful, community driven, open source library mainly for displaying map data in most modern web browsers. It implements an API for building rich web-based applications similar to the Google Maps. Finally, a web based cartographic rendered map is generated for serving specifically for local people. Since, the developed system uses data from OSM and all software packages are open-source and free, it is very economical and efficient way of producing up-to-date interactive cartographic web based map.

1   Introduction

In the 21st century, life has become very fast and information plays an influential role in making it more systematic. The significance of information, however, relies in its availability. If the information is timely available, it can be considered useful otherwise they lose their importance and become outdated. With the extensive development in the field of information technology, the mapping sector has also entered in the new dimension, of digital format. The increase in accessibility to internet and availability of online map services such as Google maps, Bing maps and Yahoo maps have made mapping sector reached new perception with broad horizon and wider user.

Though these online map services are providing many significant facilities, there are certain limitations due to which users are restricted for the use of the data. In other words, they are not allowed to edit the data provided in these platforms. On the other hand, OpenStreetMap (OSM) database being easily accessible to everyone, open, updated regularly, and has no legal issues when the user accesses, downloads or edits the data. "It is dedicated to encouraging the growth, development and distribution of free geospatial data and to providing geospatial data for anyone to use and share." (Wiki, 2011).

1.1 Objectives

The objectives are as follows.

1. Production of a map according to the requirements of Nepal and neighboring countries

2. Specification of the cartographic rules and symbology

3. Translating these cartographic rules into IT, i.e. to XML format and icons

4. Promotion of OpenStreetMap in South Asia region

1.2 Motivation

For creation of any map, first and foremost the important factor is data, without which it is impossible to create a map. Aforementioned factors such as the availability, accuracy as well as cost of the data do not meet the expectation of people of South Asia region. This is where OSM database takes the centre stage as it is properly and accurately built. Therefore, it can be termed as the most possible solution.

In this digital age, advanced and sophisticated software packages are required for map generation which is readily available in the market but the main factor for any user is its cost. The license are quite expensive and do not meet the cost-benefit ratio of any user in developing countries. Keeping this in mind, all software packages used in this research such as Ubuntu, PostGIS, Osmosis, osm2pgsql, Mapnik and Python are free and open source. Hence, producing maps in this case will be undoubtly economic than the application of the commercial software packages and more or less created with same effectiveness.

According to the OSM licence, the data can be copied which gives the freedom to mould data in new way and the public can do the same with the data produced (OpenGeoData, 2008). Due to these reasons, this platform provides map maker the ability of creating the map in their own condition. Furthermore, the online mapping services have developed the maps with their own definition and styles which may or may not fulfill the requirements of that region. So another motivation of is to incorporate the regional needs and styles within the map.

1.3 Area of Study

The proposed study area is South Asia. It is geographically located in the southern region of Asian Continent and comprises eight countries; Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal and Pakistan. The total land is covered by this region is 5,142,760 square kilometres and spans from 3°N to 34°N latitude and 65°E to 90°E longitude. Being from the same area and having the prior knowledge of mapping requirements, it would be of great assistance for the ease in collection of necessary data or cartography and know the sentiment of the population of the sample area. Due to the time constraint in the research as well as accessibility to relevant cartographic norms of whole area, the research place was limited to Nepal.

1.4 Data and software Packages

OpenStreetMap database is used as the input data. It is downloaded to the personal database and then the data is rendered in a meaningful way in order to get the map which is suitable for application in the regional level. The names of the software Packages used and their purposes have been listed in the table below.

No.	Softwares packages	Purposes (for this Study)
1	Ubuntu 10.11	operating system
2	Postgres/postgis	to store the OSM data
3	Osmosis	to extract the required area and update the database
4	osm2pgsql	to convert the OSM data in PostGIS database
5	Mapnik	to render the database
6	MapnikViewer	to view the map
7	Tilelite	to generate the tiles of the map on the fly
8	Openlayer	to view the map on internet browser

Table 1 Software Packages and Purposes

2 Methodology
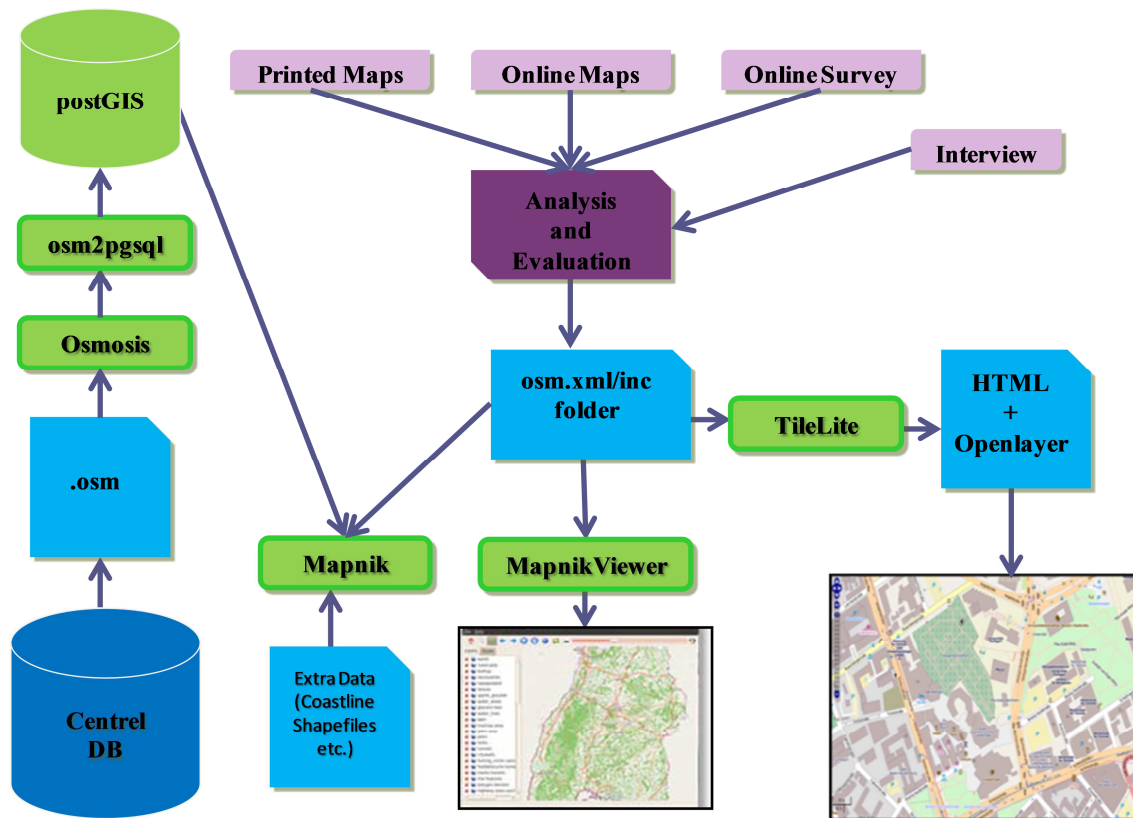
Figure 1 Workflow for rendering raw OSM data

2.1 Analysis and Evaluation of Styling Rule

2.1.1 Study of printed map

Printed Maps represent geographical or other features and are created to fulfill specific purpose or convey special information to the targeted audience. There are various types of printed maps such as topographic map, road map, tourist map etc. The research area consists of developing countries with minimal economic capacity. With the scarcity of fund and required human resource in this department, there is much more to be done for the progress of this field in this region as most of the required data are yet to be collected and presented. For this research only topographic map (1:25000) and tourist map are studied due to lack of recourses available.

2.1.2 Study of online maps

In the second stage, the study of online maps was carried out. With the advancement in the field of information technology and development of new methodologies, there are various resources available in the online maps (Google Maps, Yahoo Maps, Bing Maps, OpenStreetMap, NAVTEQ Map24, MapQuest, and Mappy etc). As the feature representation on these online maps of South Asia region is comparatively few in terms of details than Europe, for the study of online map, the area of Stuttgart was chosen in order to get better view. During the investigation it was found that different map services have different style, colour, font, zoom and symbols.

2.1.3 Online survey

This is the third step that was carried out so as to approach a large number of users as well as get their opinion in short interval and cost effective way. In this step, a survey form was created using the web service polldaddy.com and the form was sent to larger audience via mail and making use of social networking site such as facebook. To build the web based online map, different details such as linear features (roads, rives), polygonal features (Pond, lake, forest), point features (hospital, school, temples, restaurants, bus stops), fonts, zoom levels, etc. are considered.

2.1.4   Direct Interview

This was the last step in which the interview was carried out with the local people of the research area so as to get their view about the usage of the OpenStreetMap and viability of the styles that were applied for rendering the data. Their valuable suggestions and recommendations were also collected and implemented as far as possible.

2.2   Mapnik Map Definition Files

In Mapnik, there is a Map Definition File which is an XML-format file. It defines all the symbolizers, filters, rules, styles and layers used to generate a rendered map. To build rendering style from the Mapnik, it is not necessary to start writing XML codes from scratch. Map definition file modified according to styling rule to get rendered map. In order to understand the mechanism behind the Mapnik rendering procedure one should study the structure of "osm.xml" and files inside the "inc" folder.
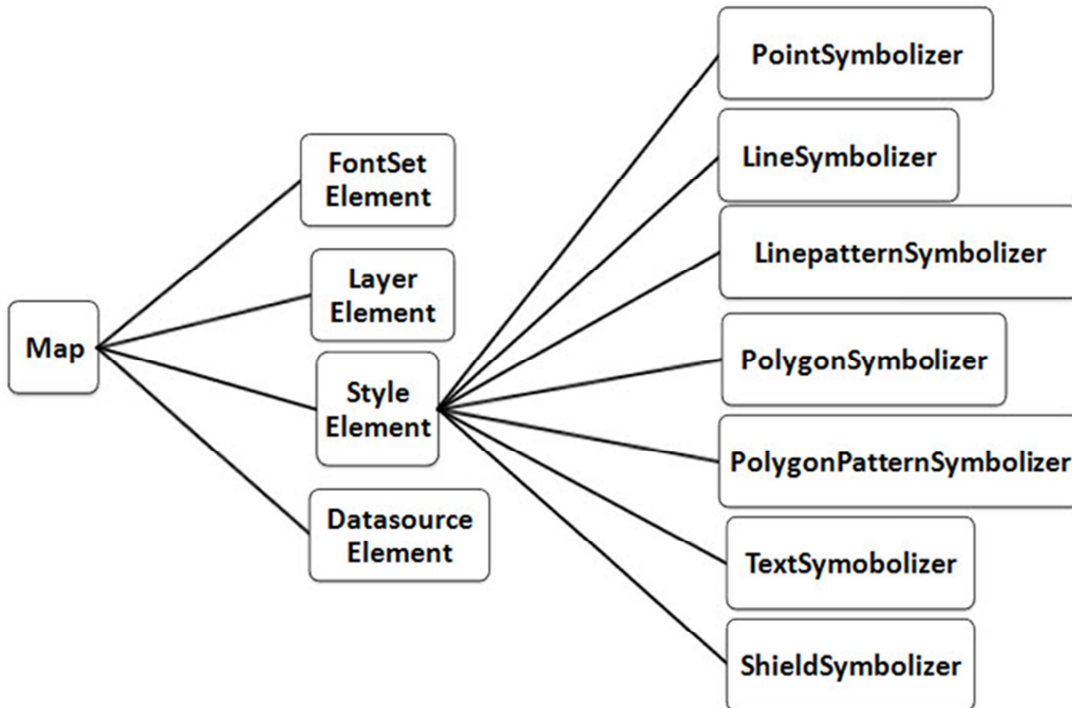
Figure 2 Family diagram of Mapnik Map Definition file

3   Result

3.1.1   Colour

After investigations of printed map, web based map, online surveying and direct interview with some of the people from South Asian region, the result of the research was derived (Table). These results were then applied and visibility, clarity and beauty of the map were checked. Since the results had the colour scheme only in terms of names and not in terms of hexadecimal colour codes, different combinations of the colour scheme was carried out and viewed until the map was eye catching.

Features	osm.xml (OLD)	osm.xml (New)
background	**#B5D0D0**	**#A5BFDD**
land	**#F1EEE8**	**#FFF7DC**
International boundary	**Purple**	**Grey**
Regional boundary	**Purple**	**Green**
International boundary	**Purple**	**Yellow**
motorway (fill)	**#809BC0**	**#EF8484**
motorway (casing)	**#506072**	**#DC241F**
trunk (fill)	**#CDEACD**	**#DC643C**
trunk (casing)	**#477147**	**#DC3C1F**
Primary (fill)	**#EC989A**	**#FEBA64**
Primary (casing)	**#8D4346**	**#DC641F**
Secondary (fill)	**#FED7A5**	**#F9C387**
Secondary (casing)	**#A37B48**	**#DC821F**
Airport runway	**#BBBBCC**	**#D3CABD**
Water bodies	**#B5D0D0**	**#59AFDD**

Table 2 Comparison of color between old osm.xml and new osm.xml
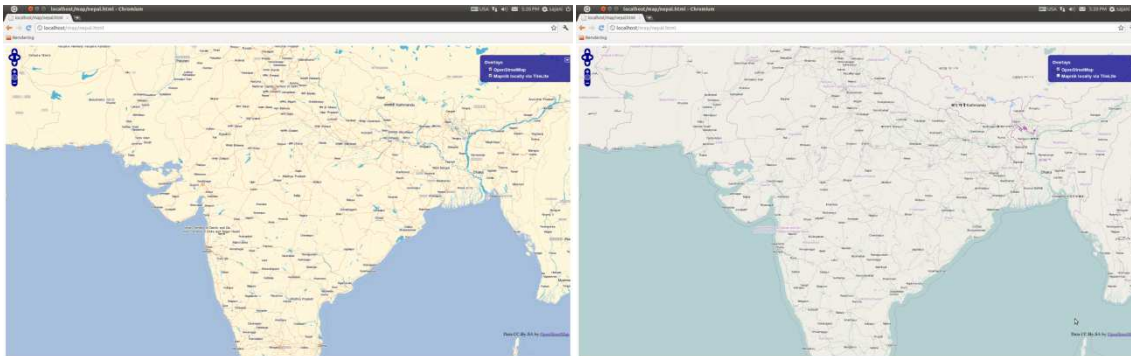
Figure 3 Comparison of data presentation at zoom level 6
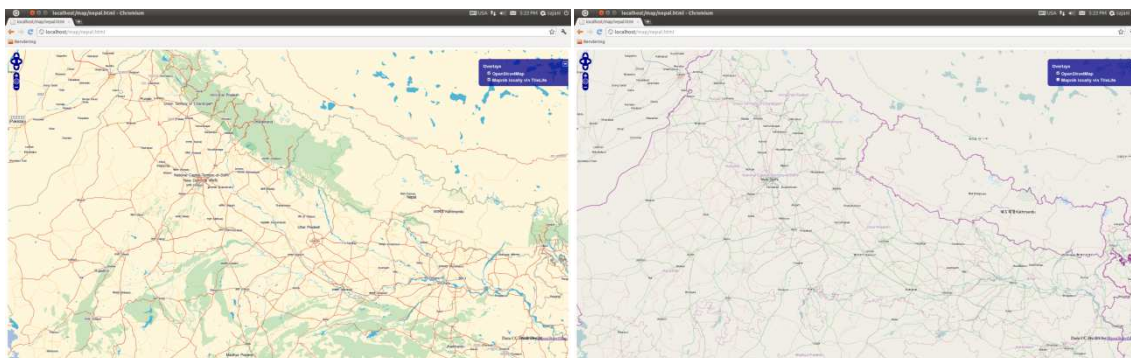
Figure 4 Comparison of data presentation at zoom level 7
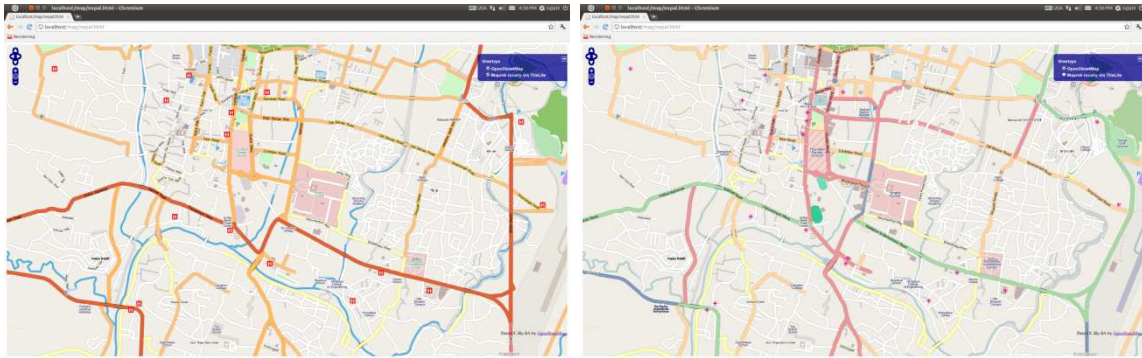
Figure 5 Comparison of data presentation at Zoom level 15

3.1.2 Symbols

The xml file, called layer-amenity-points.xml.inc of Mapnik, is responsible for displaying the point features in the map. Most of the symbols used were relevant and were not changed. However, in this code, point features related to the religion did not include Hindu and Buddhist religions which are one of the predominant religions in South Asian Region. Also the points for educational buildings are not mentioned in the source code. However, these are mentioned in PostGIS database and hence were called and displayed in the map prepared during the research. The symbols related to the religion were created and others were modified. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows the different presentations with old and new symbology.
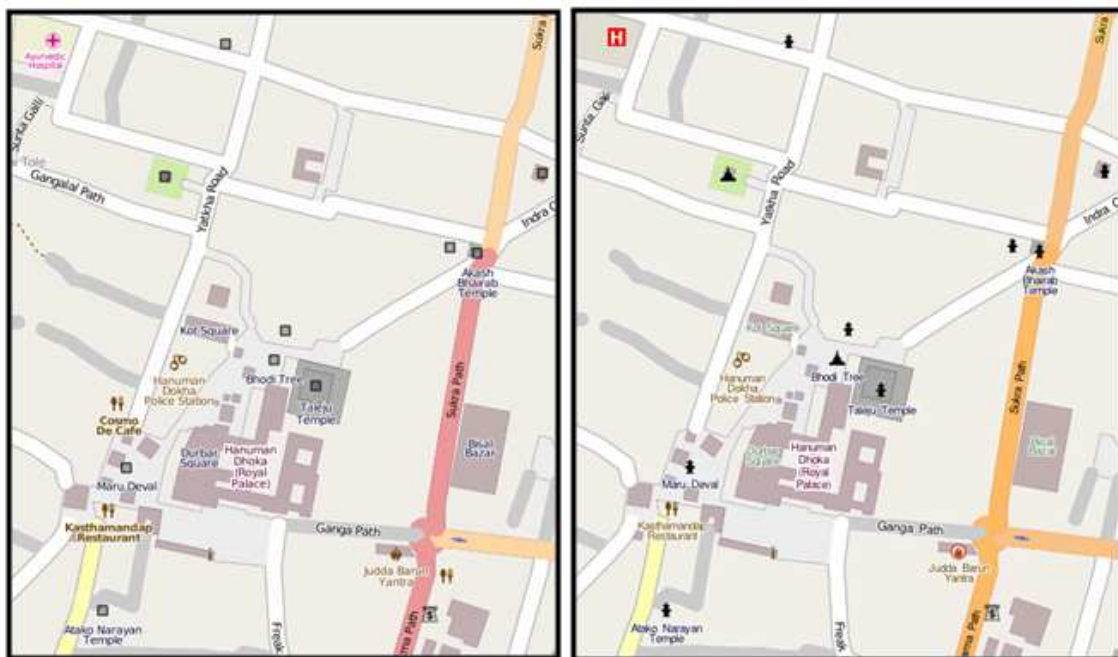
Figure 6 Comparison of Symbols between old and new presentation.

4   Conclusion

The changes were made in the map but the model and the functionality of the rendered map was kept same as that of the original OpenStreetMap. For the comparison, both the old layers of OpenStreetMap as well as the new ones are also overlaid.

Reach out to the large number of people in online survey as well as with the direct interview so that a more precise conclusion regarding the changes would be possible. Furthermore, detail questions could be added in the online survey so as to be more specific regarding the style that the users would like, which would in turn help them to make the decision.

With the regular update in the OSM server, it is better to synchronise database with the server. The data types in the database of OpenStreetMap are based on the UK mapping system which may not be compatible with the systems of other countries. Thus when using the data of such countries, some area will be misclassified due to the unavailability of specific attributes describing such features. Hence, it would be advisable to incorporate the attributes used in different regions in the OpenStreetMap database rather than being specific.

The open source software used in this research were easily compatible and user friendly as well. Also the open and free source software and open geo-data would be very useful especially in terms of third world countries who cannot afford the licensed software for the mapping purpose.

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OpenStreetMap: Data Model, Licensing, and Technologies

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ABSTRACT

Volunteered Geographic Information (VGI), is one of the characteristics of the Web 2.0. Every person having local spatial expertise can act as a "living sensor". If this local knowledge is collected on a regional or global level in a structured way a valuable and comprehensive information repository is established for a multitude of use cases.

The OpenStreetMap (OSM) project started currently is one of the most successful VGI projects. Up to now approximately 2.9 billion GPS points have been uploaded by more than 640.000 registered users, converted to 1.5 Billion nodes (points) and 141 Million ways (linear features) (OpenStreetMap Stats 2012). In contrary to the approach used in Geographic Information Systems (GIS) where geo-objects (features) are categorized into feature classes or layers, OSM is based on a surprisingly simple data model consisting of just four data types: Nodes, representing points of interest (POIs) and acting as vertices, ways, and relations which aggregate nodes, ways and other relations to larger units. Relations are used for geo-features comprising several sub-features, similar to a feature collection in the Geographic Markup Language (GML), and are among others used to model turn restrictions for further routing. These structural elements are used to build polygons as well as topological relationships.

In order to create map features users can tag nodes, ways, and relations in a very flexible way by key value pairs, e.g. key=amenity, value=Parking or key=Highway, Value=Residentia. In addition they are uniquely identified by an identification number.

The tags are based on a consensus principle, i. e. there is no fixed catalogue of features classes which is defined by a custodian instance. In contrary, it is based on user agreement and is subject to some userdebates, modifications, and developments encompassing the evolvement of the whole project. For orientation a list of commonly used features is listed in the wiki (http://wiki.openstreetmap.org/wiki/Tag). This flexibility of course has some disadvantages but enables easily to capture new kind of features.

Typically data collection is based on using GPS devices. In addition it is possible to use licence free maps or records for data collections. In addition Yahoo!'s geo-imagery or freely available web map services can be used for digitization. According to different level of user experience and requirements different editors for data capture and update are available. For many purposes, the Flash-enabled browser-based editor Potlach can be used. The Merkaartor editor offers some more functionality which is still exceeded by the Potlach editor, at the expense of complexity.

All data are stored in a common geo-database. Through an application program interface it is possible to obtain the whole dataset (the so-called planet file), incremental updates, features for certain regions on the earth, and features with specific tags or other characteristics. Also a web-based graphical user interface for data export in different formats. OpenStreetMap has its own data format, mirroring the structure of nodes, ways, relations, and tags in its own XML based markup language. Conversion programs support the transformation in other formats and the bulk loading into geo-databases. Some Geographical Information Systems already support import of OSM data. Different application programming interfaces allow interopable data exchange with the database.

Closely related to OpenStreetMap are some software packages supporting the rendering of the data. Thi visualization is based on style rules which can be adapted for many cases of cartographic needs. The generation and provision of tiles allows the integration in maping application, e. g. the browser based OpenLayers mapping solution. Its data usage is principally not dominated by a restrictive licence. This flexibility and

freedom (see Creative-Commons-Attribution-ShareAlike-Licence encourage the usage of OpenStreetMap data and tools in many fields of application. The upcoming license change to the Open Database License however might impose some new aspects.

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Extending Spatial Analysis Toolboxes for Desktop GIS

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ABSTRACT

Beside data management and visualization spatial analysis is the third major constituent of a GIS. Desktop GIS – proprietary as well as open source – usually include their own native toolsets for spatial analysis. Based on his or her background knowledge the GIS analyst has to choose the appropriate tools – which may not always be available in his or her day-to-day working GIS. On the other hand learning different GIS is a time consuming task and will not always increase productivity. Possibilities to overcome this problem are either to integrate libraries locally with additional toolsets into the desktop GIS or to access additional tools remotely. In both cases no switch between user interfaces of the GIS is needed.

In this technical overview paper different approaches of integrating local libraries as SEXTANTE, SAGA, GRASS and R into a proprietary GIS as ArcGIS as well as open source GIS as gvSIG are discussed. From the experience of several projects the advantages but also some limitations as well as obstacles are shown. In addition, accessing geoprocessing tools using Web Processing Service (WPS) of the OGC has been implemented and tested in two projects at the Hochschule für Technik Stuttgart. One has used ArcGIS Server 10.1 Beta to implement a complex geoprocessing chain of the Universal Soil Loss Equation, whereas the other has focused on an open source solution. Here services for quality checking of vector data based on the JTS library have been implemented. The two implementations are discussed and compared.

A new type of a visualization tool allowing for an integrated text and geodata study

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KEYWORDS:
OpenSource GIS; geodata quality; forest use history

ABSTRACT

A new type of a visualization tool has been developed based on OpenSource GIS technology. It consists of three components: a scientific text, numerous geodata building the basis of the scientific conclusions, as well as detailed information on the respective geodata quality. While a printed monograph is only able to include a selection of maps and images, the implementation of the tool was driven by the idea to communicate the conclusions to the reader in a directly traceable manner.

Hyperlinks included in the text lead to the opening of the map view, where a selection of relevant geodatasets is displayed in an appropriate zoom level. As the geodata stems from distinct sources and times, the reader can view the quality of each geodataset via six criteria combined in a nevertheless easy to remember diagram. This facilitates the understanding of the scientific statements and conclusions made by the author. The user of the tool decides for himself when to return to the text view in order to proceed with reading the text. The technical implementation has been realized as a WebGIS implementation applying the UMN Mapserver, a PostgresSQL DB including PostGIS Extension, PHP, and JavaScript. SVG is the means to display vector data.

Thus a comprehensive visualisation and information tool has been developed which can be accessed via the Internet by anyone who is interested in the forest use history of three rain forest areas in Kenya and Uganda covering the last more than 100 years. It encompasses in total 300 geodatasets. The core, however, is historical as well as recent map and image information for twelve selected, detailed studies with whom the reader can interact, thus stimulating critical assessment of the author's statements.

Spatial Data Infrastructures and Land Management

A spatial data infrastructure provides for a basis for
spatial data discovery, evaluation, download and application for users and providers within
all levels of government, the commercial sector, the non-profit sector,
academia and the general public.

Hartmut Müller, Promoting Land Administration and Good Governance,
5th FIG Regional Conference
Accra, Ghana, March 8-11, 2006

Developing and Implementing an INSPIRE Based SDI at the European Academy of Bozen-Bolzano

Tania Puspita Firdausy

European Academy of Bozen Bolzano

ABSTRACT:

Nowadays, the need to implement a Spatial Data Infrastructure (SDI) is becoming more important for organizations which host spatial data. The presence of a standardized SDI will enable rapid spatial data discovery, access and exchange. The European Academy of Bozen – Bolzano (EURAC) is in the process of developing and implementing an INSPIRE (Infrastructure for Spatial Information in the European Community) compliant SDI that started in 2010. This paper describes the current situation of how spatial data is archived by EURAC, the proposed SDI architecture, as well as the development and implementation steps undertaken in developing the SDI.

1   Introduction

Currently spatial data is under the spot light due to its importance as base information used for making political, economic and governmental decisions which concerns many lives. Unlike usual data, for instance documents or spread sheets, spatial data contains geographic information, therefore spatial data is treated differently. Before the computer era, the conventional two dimensional images were stored in data cabinets. With the development of computers, spatial data is stored in digital formats as coordinates and topology in geodatabases. A geodatabase represents geographic features and attributes as objects which are hosted inside a relational database management system. An infrastructure exceeding one geodatabase can be named as a spatial data infrastructure. An SDI is a framework of spatial data, metadata, users and tools that are interactively connected in order to use spatial data in an efficient and flexible way.

The development and implementation of SDI has become a major topic in many countries around the globe. There are many expected advantages of having an SDI such as, it will eliminate spatial data redundancy, enable more effective spatial data search, provide a better data organization system, and also ensure spatial data availability. The aim of implementing such an infrastructure is to enable more efficient spatial data sharing and discovery between stakeholders. In order to achieve that aim, spatial-data exchange standards are needed. In 2007, the European Union (EU) created a directive that can be considered as a spatial data exchange standard between the 27 EU countries named INSPIRE.

The Institute for Applied Remote Sensing of the European Academy of Bozen-Bolzano (EURAC) is in the process of developing and implementing an INSPIRE compliant SDI. The SDI will become the core repository of spatial data that the institute owns and produces. At the moment, the institute holds a vast amount of spatial data varying from raw data obtained from their own receiving station, located on Mount Renon (2260 m.a.s.l), until near real time scientific products used by the local province for monitoring purposes. Most of the data must eventually be publicly available that currently is not the case. With the development and implementation of the SDI this situation will be changed.

1.1   Advantages of SDI Implementation

As stated briefly in the introduction, there are several benefits that an SDI is expected to accomplish, for instance eliminate spatial data redundancy this means by having an SDI data duplication can be minimized because data constraints and triggers can be set up. It can also provide a 'virtual' centralized infrastructure that will reduce the occurrences of spatial data islands and can make data search faster and more efficient. Figure 1 pictures the condition of the community's access to geographic information before an SDI implementation where the community must search through many sources until they can find the correct data.
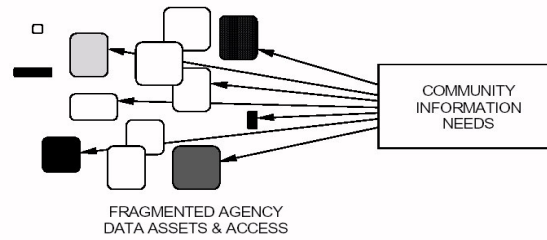
Figure 1 Community access to geographic information: without SDI (CANRI, 1999)

Another advantage if an SDI is present in an organization is spatial data dissemination and exchange will be done more easily over the network and data availability will not be an issue for users who need spatial data then and there. Every user who needs geographic information or data can easily search data through the SDI, in contrast to the condition before SDI implementation (Figure 1) where the users must search through different storage systems and places.
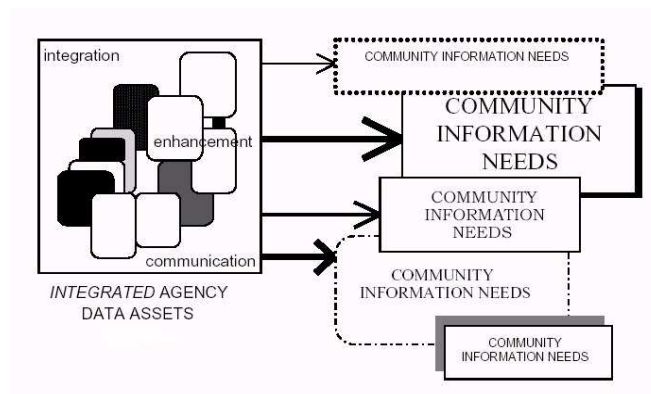
Figure 2 Expected optimal condition after SDI implementation (CANRI, 1999)

Figure 2 illustrates the expected optimal condition after an SDI implementation. Spatial data from different agencies or sources will be 'virtually' centralized or integrated, thus the community only needs to search data through one main data source or geoportal. This will lead to effectiveness in spatial data search as the users need to access only one main data source instead of multiple scattered data sources. The main goal of an SDI implementation is to make spatial data sharing and discovery more efficient.

2   Current Status of Data Repository at EURAC

The Institute of Applied Remote Sensing at EURAC hosts and produces a huge number of spatial data. The main data is received from their own satellite receiving station that has been active since March 2009 which provides near real time processes and services. At the moment, the receiving station receives data from the Moderate Resolution Imaging Spectrometer (MODIS) sensor onboard of NASA's Terra and Aqua satellites. It also has been receiving data from sensors on the newly launched NPOESS Preparatory Program (Suomi NPP) satellite since late February 2012. Other spatial data and ancillary data used for further processing the satellite data received from the receiving station into user specific products are similarly archived by the institute which later will be equally ingested into the SDI.

There are two main systems in the current repository, the first system is dedicated for archiving the raw data received from the receiving station that acts as a backup system in case the data connection link between the receiving station and EURAC fails. The second system is the main archive that is used for archiving pre-processed data, ancillary data and other spatial data which resides in EURAC and has already archived up to 47 TB of MODIS data. Figure 3 illustrates the data transfer process from the receiving station to a Compact Station (CS) located at EURAC using a radio link and repeater. The repeater is needed because the receiving station and CS are not in a direct view range as they are separated by mountains in between.
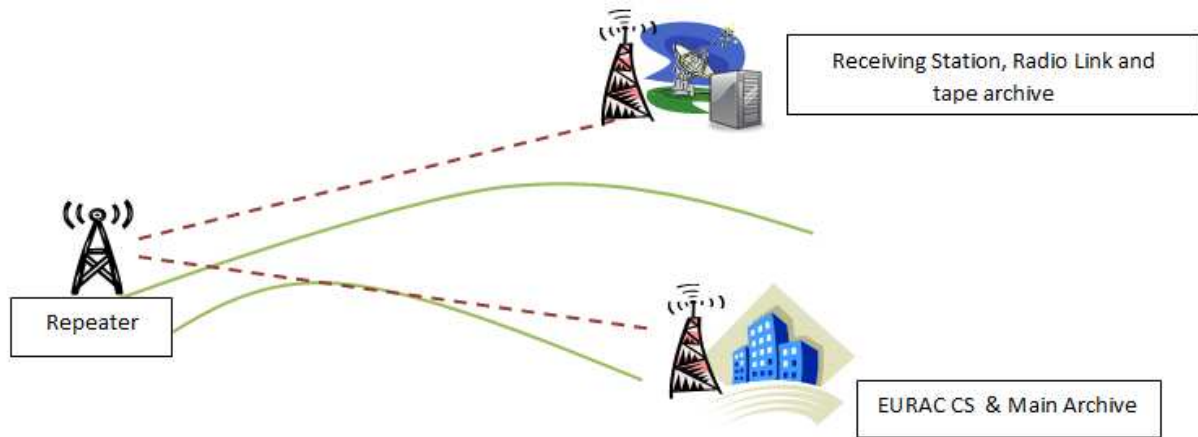
Figure 3 Data transfer process from receiving station to main archive (Author. et. al, 2012)

The CS is managed by a payload data segment (PDS) facility that contains all of the ground segment elements related to payload data acquisition, processing and archiving. Its main functionality is not only to process MODIS raw binary data into level 0, MODIS Level 1B and Level 2G products, but also to processes the NPP Suomi products from raw data into NPP Raw Data Records (RDR). The MODIS data are later processed into further products for example a near real time snow cover monitoring product, a meteo nighttime product that highlights clouds and physical cloud properties used for local weather services, also an air quality particulate matter map. EURAC's present receiving station and archiving system (figure 4) which is based on the notion of data redundancy is meant to prevent data loss and also enables a continued near real time data processing environment.
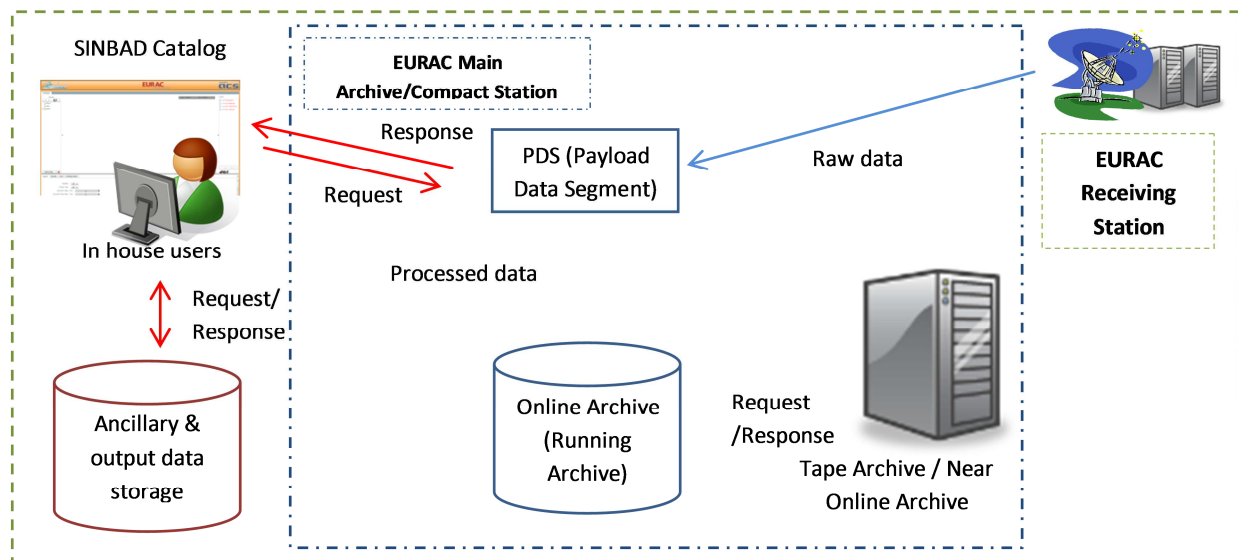
Figure 4 EURAC's Present Receiving Station Archiving System and Data Flow (Author. et. al, 2012)

The current data archive can be accessed through a cataloging system named SINBAD – Satellite Images Navigation Browsing Acquisition Delivery that was developed by Advanced Computer Systems A.C.S. S.p.A. SINBAD is a proprietary cataloging application developed by an independent company thus modifications and changes are not permitted. The system is only accessible to specific users as user access policies and data access policies cannot be explicitly defined. Due to these limitations an open source geo-cataloging application will be used for the coming SDI.

3   Proposed SDI Architecture at EURAC

The proposed SDI will be based on the principles of free and open source software and comply to INSPIRE, international standards and open standards. This decision was taken to eliminate the problems and issues present in the current infrastructure. The improved architecture is depicted in figure 5.
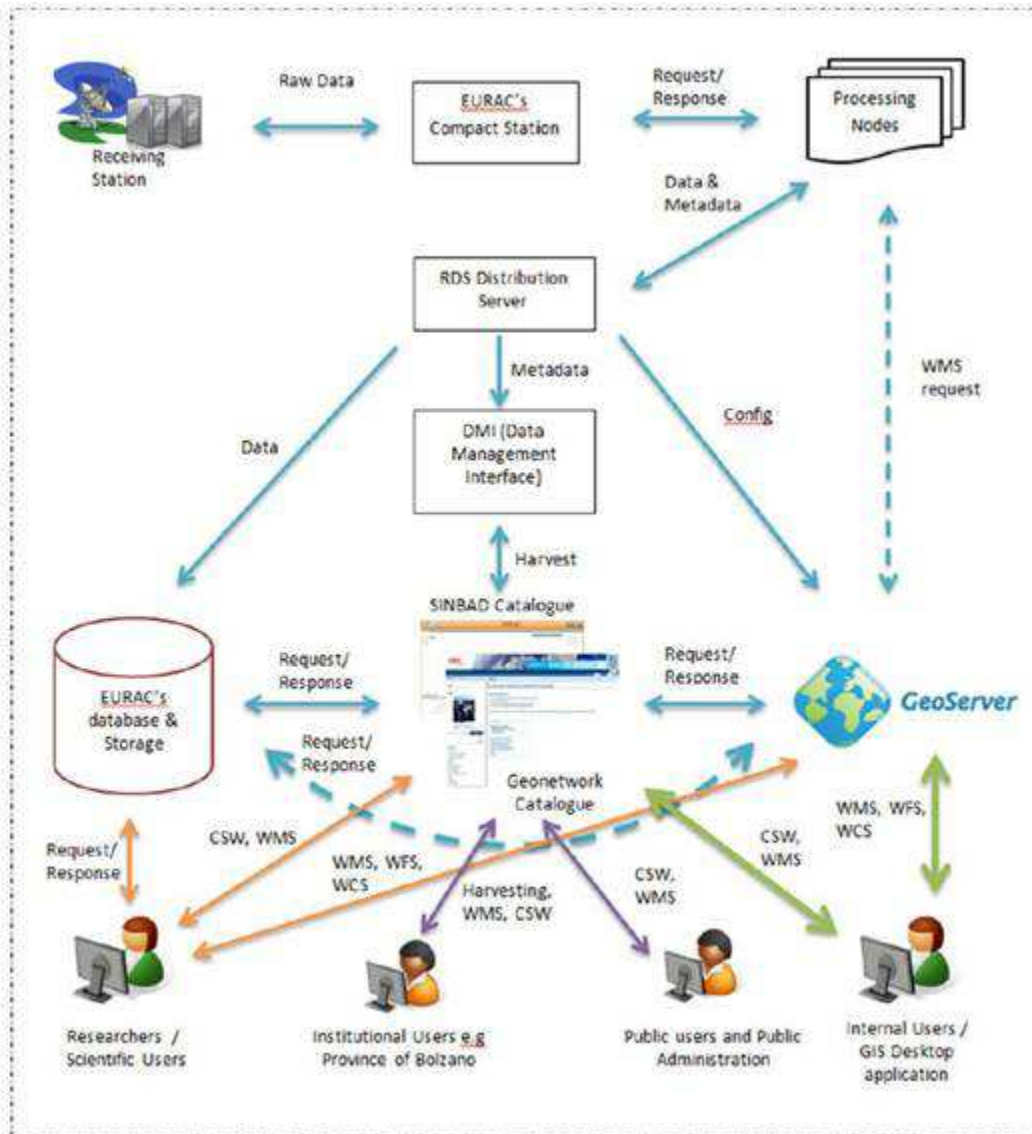
Figure 5 EURAC's Proposed SDI Architecture (Author. et. al, 2012)

The upcoming infrastructure is an improvement of the current system. Raw data from the receiving station will be transferred to EURAC's Compact Station and according to the request from the processing nodes the raw data will be processed into further products for instance snow, air and temperature products that is used mainly for research purposes. These products will be transferred to the Remote Sensing Distribution Server (RDS) where the data is distributed to the correct nodes. The Data Management Interface (DMI) is used to manage and track the data harvested by Geonetwork (www.geonetwork-opensource.org). The new SDI will use Geonetwork instead of SINBAD as its cataloging application. It will be the main data access point for users to search and retrieve spatial data that EURAC hosts. Geonetwork is an open source geo-cataloging system that offers Catalogue Service for the Web (CSW), and an interactive web map viewer. It will communicate with the database management system (DBMS) and GeoServer to request data. The DBMS will use PostgreSQL/PostGIS as its DBMS software and Geoserver will provide the Web Map Service (WMS), Web Feature Service (WFS), also the Web Coverage Service (WCS).

The goal of EURAC's SDI is not only to enable more efficient and effective spatial data exchange among public sector organizations and users, but it is also meant to make spatial data discovery and access easier for the in-house users. The in-house users are the researchers and users which are working for EURAC. A personalized INPIRE compliant metadata schema with additional metadata elements is developed to make data search easier for the in-house users. User access and data usage policies will be explicitly defined in Geonetwork.

4   The SDI Development Process

According to the "SDI-Africa: An Implementation Guide" there are three general steps in developing an SDI, which are (Economic Commission for Africa, 2004) :

1. The consultative phase: in which an understanding of and support for SDI is widened, and a deeper understanding is developed of one's requirements;

2. The defining or consolidating phase: in which the goals of the SDI program, as well as structures to guide its development are formulated and refined;

3. The phased implementation: resulting in components of infrastructure becoming operational and finally, fully functional.

The three steps above are not in strict sequential order, may overlap and repeat when it is considered necessary. It can be said that this approach is based on the iterative development methodology that is usually mostly used in software development projects. The iterative development methodology consists of four main phases, which are analysis, design, implementation and testing. Generally, based on the findings conducted in the first phase during a software development project it can be determined whether the project is feasible or not.

The development of EURAC's SDI is based on similar steps. The phases are the planning phase that includes the requirements analysis and architecture and design definition, the implementation phase, the testing phase, and also the deployment and maintenance phase. At present EURAC's SDI is at the second phase that is the implementation phase.

The implementation and adaptation of Geonetwork according to EURAC's specification is currently undertaken. Since EURAC hosts mostly raster data, INSPIRE's metadata definition had to be added with metadata elements which are not defined by INSPIRE's metadata implementing rules but are needed for EURAC's personal requirements. XML and XSD files are used by Geonetwork to define the metadata schema. Also an automated process for metadata creation is being developed.

5   Conclusion

Currently there is a need for institutions that hold spatial data to develop and implement an SDI. This is due to the reason that spatial data is playing an important role in our daily lives. Having a more efficient infrastructure will result in a more effective way for spatial data exchange and discovery. The necessity to have an efficient infrastructure is crucial when disaster occurs as spatial data must be available to authorities in a very timely manner. As stated in the paper earlier the other advantages of implementing an SDI are, reducing spatial data redundancy, permitting more effective spatial data search, providing a better data organization system, and also ensuring spatial data availability. But in order to create such an infrastructure standards are needed. INSPIRE is a European Union standard for spatial data exchange and SDI's which came into force in 2007.

EURAC is in the process of developing and implementing an INSPIRE compliant SDI. Currently the development is still in its implementation phase and needs many steps to complete in order to guarantee a working and efficient SDI that complies to the INSPIRE directive and international and open standards.

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A Sustainable Land Use Model for Nepal (A Case Study of Nawalparasi District:Terai Area of Nepal)

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KEY WORDS: Land-use, Environment, Sustainable, Agriculture, GIS, Socio-economic, Remote Sensing

ABSTRACT:

Land use planning in today's competitive world requires exploitation of spatial information for effective management of land resources, if sustainable development is to be realized. The development strategy of Nepal, since six decades, has depended mainly upon the exploitation of its land based natural resources. Unfortunately Nepal is still facing serious development challenges including rampant poverty, hunger and environmental degradation. Sustainable land and land based resources planning requires a systematic approach towards a comprehensive study of land use patterns, land forms, soil, vegetation, climate and other socio-economic aspects. Realizing this need, Government of Nepal, Ministry of Land Reform and Management, National Land Use Project has undertaken an initiative to study and map the present land use pattern and soil characteristics as well as land capability and land use zoning based on soil and physiographic characteristics at grass-root level using remote sensing and GIS technology. World View 2 high resolution satellite image, topographic database and Land Resource Maps/reports were used in this study. This study will provide a comprehensive and extensive database that includes the land use pattern, soil resources and land capability for suitability analysis, zoning of land for various functional purposes and superimposition of cadastral layer on land use and zoning maps. Implementation of this program will create an environment for sustainable development from local to national level and ultimately support for good governance in Nepal.

1   Introduction

1.1   Introduction

Nepal is a small landlocked country in Asia bordered by China and India. It covers 147181 km2, and has a population of approximately 28.5 million (CBS, 2011). Some 20 percent area of Nepal consists of sub-tropical lowlands, known as the Terai, which forms a belt along the Nepalese-Indian border. From this southern belt, Nepal's land forms rise in successive hills and mountain ranges, culminating in the Xizang (Tibet) plateau in the inner Himalaya. These are shown in Figure 1. The Terai contains areas of agriculture land, tall grassland, fragments of habitats which are believed to have covered extensive areas of the northern plains of the Indian sub continent. The development strategy of Nepal, since independence, has depended mainly upon the exploitation of their natural resources. These include agriculture, minerals, energy, water and other biological resources. Unfortunately, the strategy did not bring about the expected results but created environmental degradation and increased poverty (World Bank, 2003). After almost five decades of development efforts, most of the Asian countries including Nepal are still facing with serious development challenges including rampant poverty, hunger, environmental degradation, and HIV/AIDS pandemic. The situation was exacerbated by the lack of land and land based resources use planning couple with overall inappropriate socio-economic policies.

1 Rara National Park
2 Shey Phoksundo National Park
3 Annapurna Conservation Area
4 Langlang National Park
5 Shivapuri Wildlife Park
6 Sagarmatha (Mount Everest) National Park
7 Makalu-Barun National Park/Conservation Area
8 Kosi Tappu Wildlife Reserve
9 Parsa Wildlife Reserve
10 Royal Chitwan National Park
11 Dhor Patan Hunting Reserve
12 Royal Bardia National Park
13 Royal Suklaphanta Wildlife Reserve
14 Khaptad National Park

High Himalaya
High Mountains
Middle Hills
Siwaliks
Terai

0   80km

Figure 1 Ecological Zones and Protected Areas in Nepal

Sustainable land resource management requires a systematic approach towards a comprehensive study of land use patterns, land forms, soil, vegetation, climate and other socio-economic aspects of the study area. The land use practice has a direct impact on environment, ecology and other socio-economic factors. Realizing this need, Government of Nepal, Ministry of Land Reform and Management, National Land Use Project has undertaken an initiative to study and map the present land use pattern and soil characteristics as well as land capability and land use zoning based on soil and physiographic characteristics at VDC level.

The National Land Use Project was established so as to harmonize and co-ordinate all land use related policies, legislation and as well as promote effective protection and enhancement of land quality with the aim of ensuring sustainable utilization of land and land based resources so that it can provide optimal production to foster socio-economic development and maintenance of land quality for long-term productivity. This initiative will produce integrated land based resource inventory at VDC level within the country-Nepal using modern technology such as Remote Sensing and Geographic Information System.

Realizing the needs, NLUP has undertaken initiative to prepare land use zoning maps and superimpose it on cadastral layer at VDC/Municipal level in Nepal. The rational for the superimpose of cadastre layer on the land use zoning maps (prepared using RS and GIS) at VDC and Municipal level by NLUP is to identify zones of agriculture land, forest area, pasture land, built up area, water body, industrial, commercial and public service area, cultural and heritage area within a VDC.

1.2   Rationale and Objective of the Study

This study aims to provide a comprehensive VDC level land resource inventory and maps in order to formulate and implement sustainable land use planning of VDCs of Nawalparasi District. The land resource inventory includes the study of existing land use pattern, soil resources and land capability for suitability analysis, zoning of land for various functional purposes and superimpose of land use zoning maps with cadastral maps. The main objectives of the study are:

a. Preparation of Soil Resource Map and GIS inventory of Pithauli VDC based on a soil field survey and lab analysis.

b. Classification of land based on landform and soil properties to identify nonagricultural land.

c. Classification of land for agricultural land usages for identifying lucrative crops based on soil characteristics.

d. Management of land use on the basis of land characteristic within the conceived policy.

1.3   Study Area (Nawalparasi District- Part of Terai Area of Nepal)

The Terai region is agriculturally productive, and was relatively sparsely populated until forty years ago. However, since the designation of protected areas in the 1970s, and with large immigration into the region from the mountains and hill regions, conflicts over land use have intensified. In this paper one of the VDC (smallest unit of administration) of Nawalparasi district named Pithauli is taken as study area. Pithauli VDC is one of the 73 VDCs of Nawalparasi District. Geographically the VDC is situated in between 84° 35'30" to 84° 36'41" east longitude and 27°11'39" to 27° 28'45" north latitude. The elevation ranges from 100 meter to 400 meter above mean sea level. (See Location Map)

2   Data Sources

The primary data source used for land use classification is high resolution 2.0m WorldView□2 satellite imagery with 8 multispectral bands. Various other vector and raster data sets were used as ancillary data, which enhanced interpretation and classification of land cover/land use classes. This chapter describes, in brief, the sources and characteristics of various datasets used for the study.

2.1   WorldView-2 Satellite Imagery

Land use classification was done primarily using BGRN (Blue, Green, Red, and Near Infrared) band of WorldView-2MSS imagery having 8bands. WorldView 2 MSS imagery has spectral range of 0.400μm to 1.040μm covering spectral bands from Coastal Blue to Near Infrared2. (See satellite image page-6)

2.2   Digital Elevation Model (DEM)

Digital Elevation Model (DEM) was created using Topographical data "Contour and Spot Height" from Department of Survey. DEM was created at 5m resolution using ANUDEM algorithm (Hutchinson, 1993). This DEM was used for ortho-rectification of WorldView2 satellite imagery. These DEM derived datasets were used for terrain analysis, to differentiate sloping terrace with level terraces cultivation and to delineate erosion hazard prone areas. (see digital elevation model page-6)

2.3   Land Resource Mapping Project- Maps/Reports

Land Utilization, Land System and Land Capability maps and reports prepared by Land Resource Mapping Project (LRMP), 1986 were used as references. These maps and reports were studied in detail in order to get an in-depth insight of existing land use classification and zonation system of Nepal. Physiography, land use, land form type, climatic conditions as well as capability zonation of the area were reviewed. LRMP data that covered the study area of Nawalparasi district are used.

2.4   Topographical Map/Digital Data

Topographical maps prepared by Survey Department, 1996 were used as base maps for conducting field work and preliminary soil survey works. Digital GIS datasets including land cover, river features and topographic features were used as ancillary data for GIS based analysis and the study of existing land use pattern.

3   Conceptual Basis of Land Use Classification

Land use mapping at VDC/municipal level requires thorough understanding of the land use pattern, which are often influenced by local culture and tradition, agricultural practices, modern development trends in infrastructure, population growth as well as by unplanned sprawl and haphazard development trends. In order to

study the association of land cover patterns with rural morphology at VDC level for areas like Dumkibas, Rajahar, Pithauli, a review of existing land use studies as well as land use development plans were done. Based on this review and extensive field survey works a flexible conceptual basis for land use categories is formulated. The concept is based on modular hierarchy classification system (Gregorio & Jansen, 2000)(American Planning Association, 1999).This paper presents the proposed land use concept and describes in detail each land use classes in the system.

3.1 Hierarchical Land Use Classification System and Criteria

A hierarchical classification system is a multi☐tiered abstract representation of the situation using well☐defined diagnostic criteria, the "classifiers." Hierarchical classification system aggregates objects into groups or sets on the basis of their relationship with each other and with the objects in the higher order. This system is scale independent and is independent of the means used to collect information (whether satellite imagery, aerial photography or field survey or a combination of them are used)(Gregorio & Jansen, FAO Land Cover Classification: A Dichotomous, Modular☐ Hierarchical Approach, 1996).This system offers more flexibility because of its ability to accommodate different levels of information, starting with structured broad☐level classes which allow further subdivision into more detailed sub-classes.

3.2 Classification Levels

The classification levels designed for land cover/use classification at VDC/municipal levels uses classifiers related to the terrain physiography, lithology/soil, settlement pattern, cultural practices and other specific parameters. These classifier parameters are adaptable to the whole of the country with some modifications as needed in different physiography and environment.

Level 1	Level 2	Level 3	Level 4
Agricultural	Terai Cultivation	Wet Land Cultivation	Crops/Cropping Pattern
		Dry Land Cultivation	Cereal Crop
		Mixed Land Cultivation	Commercial
	Hill Slope Cultivation	Level Terraces	Vegetable
		Sloping terraces	Fruit
	Valley Cultivation	Valley Floors/Tars/Foot Slopes	Orchards/Nurseries Cash Crop
		Tars/Alluvial Fans/Lower Foot Slopes	Livestock Farm and Grass Lands Poultry/Fish Farms Agro Forestry
Residential			
Commercial	Governmental Institution and Service Areas		
	Business Areas		
Industrial			
Forest	Coniferous Forest	Subtropical (dominant species)	Government
	Hard Wood Forest		Community
	Mixed Wood Forest	Temperate and Alpine Types (Dominant species)	Leasehold
	Shrub		Private
	Grazing Land/Grass Land		Religious
Public Services	Educational (School, College and Universities)		
	Security Services (Police, Fire Station)		
	Transportation Infrastructure (road trial, airport, bus park, etc)		
	Public cultural and religious places		
	Recreational Facility (park, picnic spot, open spaces,		

Level 1	Level 2	Level 3	Level 4
	stadium, playground, etc)		
	Water body (river, lake, pond, canals)	River	
		Pond	
		lake	

Table 1 Hierarchies of present land use categories

Under the class hierarchy, the classes are described based on their specific properties. National Land Use Policy 2068 provides the nomenclature of the Land Use classes.

4   Methodology

Land cover and lands use classification was done base on hierarchical framework described in the previous chapter using high resolution WorldView-2 MSS imagery. The land use classification was done by adopting object based classification technique using ENVI EX software. Object based classification method was augmented by visual interpretation of high resolution imagery, field observations and secondary datasets of the area. This chapter describes, in detail the approach methodology adopted for land use classification.

4.1   Methodology Framework

In general, the approach methodology included following integrated steps:

- Orthorectfication of WorldView-2 imagery by GCPs collected from Vector- Topographical Data and DGPS data directly from field observation.

- Field observations and training sample collections

- Image segmentation and manual editing and smoothing of segmented image objects

- Object based hierarchical classification

- Aggregation and smoothing

- Accuracy Assessment

- Final land use geo◻database creation

The main steps are described in brief in the following sub-sections.

4.2   Methodology

Geometric corrections include correcting for geometric distortions due to sensor-Earth geometry variations, and conversion of the data to real world (Tempfli, Bakker, & Kar, 2001). Geometric correction was done to compensate for errors caused by variation in altitude, velocity of sensor platform, rotation of the earth, earth curvature and relief displacement Differential GPS survey was carried out using L1capable ASHTECH Promark-2 DGPS for collecting Ground Control Points (GCPs) and independent check points. Affine transformation was used to generate new grid for the rectified image. To assign the pixel value for these grids nearest neighbourhood algorithm was used. The pixel value is assigned to the DN value of closest pixel in the original image. This method was used because it preserves the original image's spectral information. Proper measurements were taken to ensure that RMS error is less than 0.2 mm of map scale. In this research no radiometric correction was applied because the data quality is good enough for classification and interpretation. Moreover there is not significant haze and cloud in the image.

4.3   Classification

The geometrically corrected image was then used for segmentation and classification of objects (Figure 3.3) using SPRING 5.1.3 (Camara et al., 1996). Image segmentation was carried out using region's growing algorithm with object parameters defined by similarity and pixel area. Segmented image was used to create

context with samples from different land cover classes. The classified image is then mapped into classes. Segmentation was carried out to ease digitization process during visual image interpretation.

| Location Map | WorldView-2 Imagery | DEM of study area | Image segmentation of study area |
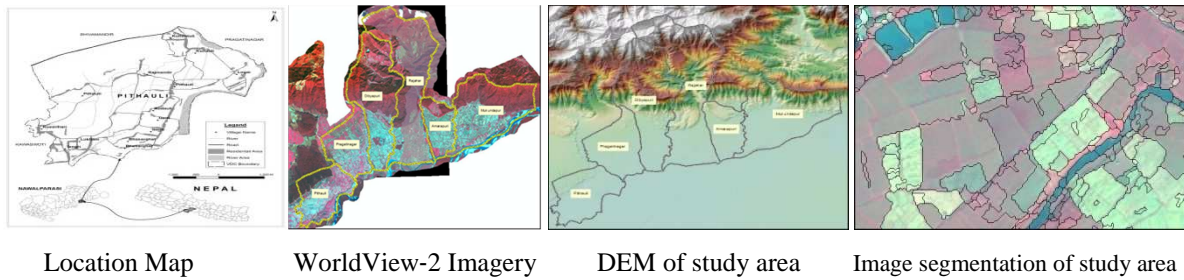
4.3.1 Visual Interpretation

Most intuitive way to extract information from the satellite imagery is visual image interpretation (Tempfli, Bakker, & Kar, 2001).Visual image interpretation assisted by extensive field visit was used to derive the land use classes from the imagery. Different ancillary layers such as NDVI, simple ratio, DEM along with field data were used while performing this task.

Two extremely important issues must be addressed before undertaking task of image interpretation for delineating land use classes. The first is the definition of the criteria to be used to separate the various categories of features occurring in the photographs. For example, in mapping land use the interpreter must fix firmly in mind what specific characteristics determine if an area is residential, commercial, public service or industrial. This was guided by the definition of land use classes defined by Land Use Policy (2068). Interpretation elements such as tone, texture, shape, size, pattern, site and association were used for digitizing, editing and assigning land use classes. Many natural and man-made features on the ground have very unique shapes that can be referenced in photo and image interpretation. Knowledge of the bands other than the visible range of spectrum increased the quality of the interpretation. Some parameters of site are elevation, slope, aspect, type of surface cover, value of the land, adjacency to water etc. We can classify agricultural land into sub classes using these parameters. Association refers to the fact that combination of object makes it possible to infer its function or meaning. The interpretation was based on the Hierarchy of classes used in classification. Before interpretation, extensive field visit was done for the ease of interpretation. The land use classes yield better accuracy because the classes are designated manually based on ground knowledge rather than automatic classification.

4.3.2 Land Use GIS Database

The derived land use classes are saved as vector data in shape file format. The data contain fields that describe land use category at different hierarchy and legend needed for mapping at scale 1:10000. The fields that are present in the data are described in the table below.

Field	Data Type	Description	Remarks
FID	Feature Id	Feature	FID
SHAPE	Geometry	Geometric Object type	SHAPE
ID	Long	Unique Object ID	ID
LEVEL 1	String	Land Use Class	LEVEL 1
LEVEL 2	String	Land Use Class	LEVEL 2
LEVEL 3	String	Land Use Class	LEVEL 3
LEVEL 4	String	Land Use Class	LEVEL 4
AREA	Double	Area in m2	AREA
AREA_HA	Double	Area in Hectare	AREA_HA

Table 2 Database for present land use

4.3.3 Accuracy Assessment

Accuracy of the Land Use of the VDC was assessed using contingency matrix. Test data was collected in file for this. 10 samples were collected for each land use class from each VDC using hand GPS and overall accuracy and Kappa coefficient were calculated. The overall accuracy was found to be 93.8% with Kappa Statistics of 0.93.

RMSE assessment of satellite image orthorectification was performed and found as follows:

No.of GCPs 10, RMSE X=0.49 , RMSE Y= 0.70, Total RMSE is 0.85

5   Present Land Use Pattern of Pithauli VDC

The chapter describes the present land use pattern of the Pithauli village development committee. General land cover pattern shows that agriculture dominates land use of this area. This chapter presents land use assessed in different levels of hierarchy.

5.1   General Land Use type of Pithauli VDC

The total land area of the VDC is found to be 1560.96 hectares. Major portion of the land is used for agricultural purpose with 67.51% of the area followed by forest with 22.29%. Public Services which include rivers, sand, road, open space etc covers about 5.66% of the area and residential area is 4.50%. Very small commercial area is present in this VDC which comprises of 0.04% of the VDC area.

General Land use	AREA_HA	Percentage
Agricultural	1053.85	67.51
Commercial	0.57	0.04
Forest	347.95	22.29
Public Services	88.37	5.66
Residential	70.24	4.50
Total	1560.96	100

5.2   Agricultural Pattern

All of the agricultural land of the Pithauli VDC is classified as Terai Cultivation based on the physiographic region. This VDC contain 12 % of its agricultural land used as Wet land cultivation while mixed land comprises 88%. The cropping pattern of the VDC varies with the cultivation land type available with the availability of the irrigation water or rainfall. In wet land primarily rice is cultivated twice a year. Rice is dominant crop in the mixed land. Major portion of the land remains uncultivated in winter because of the fear of Rhinoceros.

Cropping Pattern	AREA_HA	Percentage
Fishing Pond	0.46	0.04
Maize-Wheat	33.57	3.19
Rice-Fallow	325.54	30.89
Rice-Lentil	182.77	17.34
Rice-Lentil-Maize	53.58	5.08
Rice-Linseed	112.66	10.69
Rice-Maize	28.74	2.73
Rice-Mustard	27.88	2.65
Rice-Mustard-Maize	60.55	5.75
Rice-Potato	3.00	0.28

Rice-Rice	144.64	13.72
Rice-Wheat-Maize	80.45	7.63
Total	1053.85	100

5.3 Public Services

Public services which include road, public religious place/ building, open spaces, educational place/building, water body such as river and sand area etc cover 88.37 hectare which is 5.66% of the total VDC area. 43.7% area of Public services is covered by river bed and sand and 26.86 % of the area is the water body.

Public Services	AREA_HA	Percentage
Educational	1.24	1.40
Riverbed/Sand	38.67	43.76
Transportation Infrastructure	24.72	27.98
Water body	23.73	26.86
Total	88.37	100

5.4 Forest

Pithauli VDC has forest cover of 22.29%. Out of this 87.29% is subtropical hardwood forest. 8.70% of the total forest is grassland and 4.01% of the forest is the shrub.

Forest	AREA_HA	Percentage
Subtropical Hardwood Forest	303.73	87.29
Grazing Land/Grass Land	30.26	8.70
Shrub	13.96	4.01
Total	347.95	100
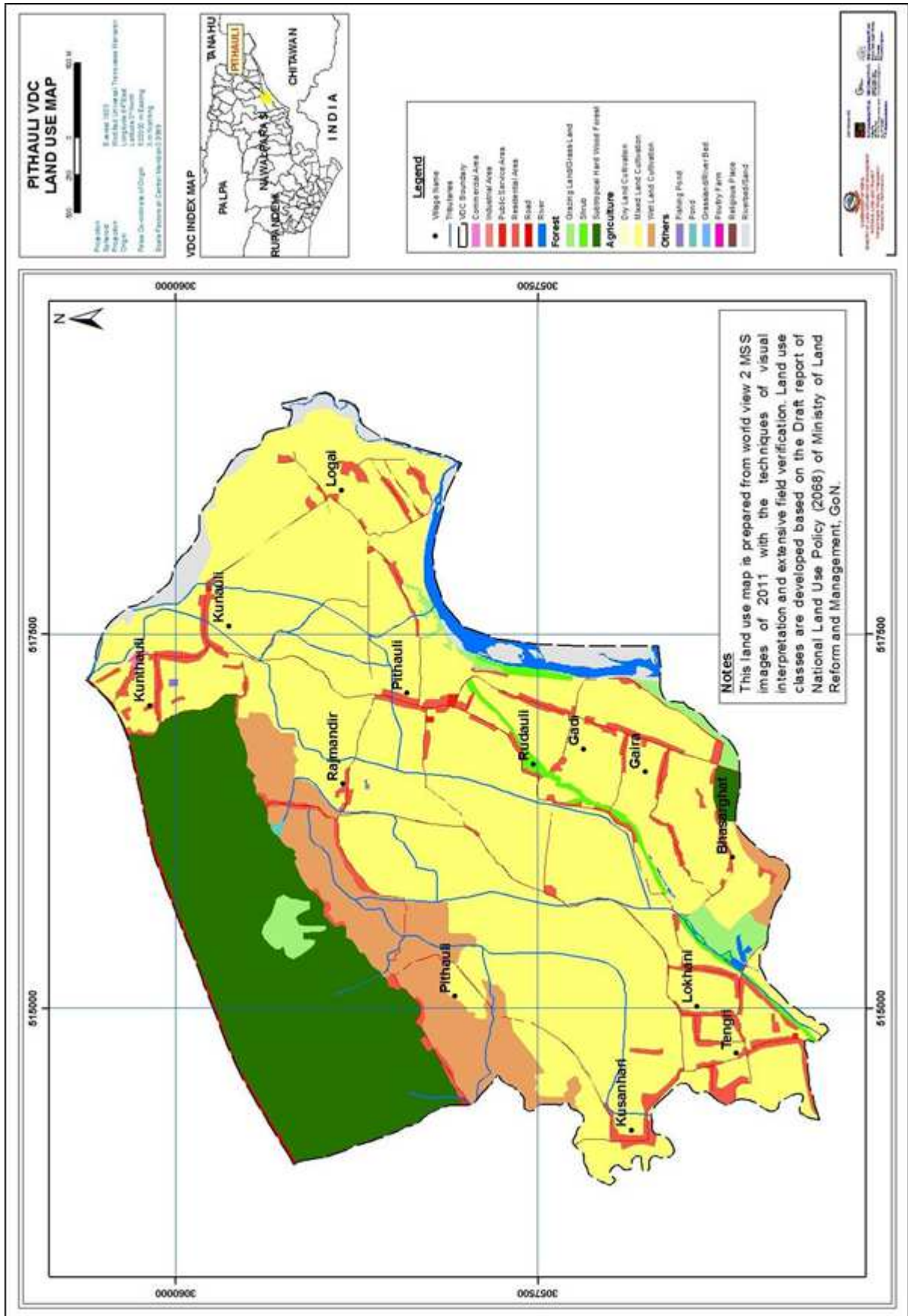
Fig.2: Land Use Model of Nawalparasi District:Terai Area of Nepal

6   Conclusions

6.1   Conclusion

Rural land use in Nepal is a complex heterogeneous functional spatial unit of land influenced by various factors including socio□economic, cultural and traditional practices, development trends, population growth as well as conceived policy and political factors in certain extent. Study of land use pattern of such area requires proper understanding of all the aforementioned factors. This heterogeneity and complexity also influences, in certain extent, to the methodology chosen for the land use study. The availability of higher spatial resolution imagery in much lesser costs has superseded much of the traditional methods of land use classification studies. However, the implication of such higher resolution is that the spectral signature of a pixel(s) representing certain object on the ground is also very heterogeneous. In other words, a single homogeneous pixel does not represent an object on the ground. Thus, in this scenario, the traditional method of pixel based automated image classification does not produce optimal image classification. The image classification requires new methods of image segmentation and object based classification, which perfectly suits for high resolution image data for complex characterization of land. Considering the complexity and heterogeneity of land use in rural environment, a modular hierarchical land use classification framework is developed. This framework is suitable for land cover/land use classification for various user needs and for various applications. The modular nature of the framework enables to extend and add custom classes as required. The first level of the framework defines/represents the general land cover class, the second level further classifies general land cover classes to detailed land use class base on certain classifier parameter. Similarly, the third order sub□classifies the second level classes and fourth level either sub-classifies or gives a specific designated name to the third level classes or further classify in fifth level. In this sense, the fifth order is the highest classification tier. The overall accuracy of these target land use classes was obtained above 90%. This considerable higher accuracy was obtained due to object based hierarchical classification and manual editing and designation of land use classes based on extensive ground knowledge. This study will be a model to evaluate and portray land-use patterns and gradual change over time in the Central Terai of Nepal.

6.2   Recommendations

There were certain constrains encountered during the study, which should be addressed for future undertaking of similar projects. Based on these constraints, following recommendations are made.

Lands use classes (categories) should be such that they represent the land/natural resources of the VDC as well as the rural development pattern of the region. This will enable land use data/map to be used for multiple purposes i.e.; land resource planning, rural planning as well as other applications. An attempt is made to multi represent the land uses of Pithauli VDC in this study and is applicable to all the other large as well as small VDCs. This modular hierarchical classification system is widely used in many countries as well as recommended by FAO for land resources study.

Land use change study (from past two decades) is necessary to identify the pattern of changes as well as the catalyst and factors of changes. This land use changes study will enable to analyze land use change trends and factors that are likely to influence future land use growth such that effective land use zoning can be done based on the existing trends and land use change factors.

We are already late to implement this type of study in Nepalese perspective and recommend it to implement soon. However Government of Nepal is seeking financial assistance from developed countries to implement such type of project directly in the grass root level.

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Forest Fragmentation Monitoring in Nagarjunasagar-Srisailam Tiger Reserve, Andhra Pradesh, India

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ABSTRACT:

Forest Fragmentation is considered a primary issue of concern in conservation biology. Remote sensing plays a vital role in assessing the forest resources information. A study was carried out to map the forest fragmentation of Nagarjunasagar-Srisailam Tiger Reserve (NSTR), Andhra Pradesh, India using multi-season IRS P6 AWiF data of 2010. Maximum likelihood supervised classification indicates that 61 % of land within the NSTR (2653.9 km2) was under forest cover in 2010. The fragmentation analysis statistics of forest type was analyzed and categorized into high (H), medium (M) and Low (L) areas.

1   Introduction

Forest fragmentation is one of the most important factors threatening biodiversity of natural ecosystems. Forest fragmentation is a process of conversion of continuous forests into fragments separated by non-forested lands. The process of forest fragmentation has been increasing alarmingly throughout the world, especially in tropical forests that are rich in biodiversity and, hence a major concern for the conservationists. Forest fragmentation is a dynamic process in which the habitat is progressively reduced into smaller fragments that become more isolated and increasingly affected by edge effects [1] [2] [3]. Fragmentation is considered a primary issue of concern in conservation biology. This concern centers around the disruption of one large continuous blocks of habitat into less, primarily by human disturbances such as land clearing and conversion of vegetation of which agricultural development is playing a major role.

Forest fragmentation may reduce biodiversity by making it more difficult for some species to raise population and forage. The processes of habitat loss and fragmentation are inextricably linked. As a large habitat becomes fragmented, all that is left are disjointed fragments of varying size. A fragmented forest habitat is reduced in size but tends to retain ecological characteristics and organisms of the forest. Up to a point, in fragmentation, no species are lost. However, as the process continues, the remaining area is reduced to a critical size below which it will not support many of the original species and a number of them would disappear. As the unrelenting fragmentation results in deforestation, global warming may be accelerated, because of releasing of carbon stored in plant biomass. [4] [5].

Employing patch size, shape, abundance and forest matrix characteristics, fragmentation of ecological units have been documented well at landscape level [1]. The ecosystem degradation and patch characteristics are found to be associated with the degree of spatial fragmentation [6][7]. Information on fragmentation of forest is very important for planning, management, and conservation of forest [8]. As the conventional methods for collection of information on vegetation and land use have been found to be expensive and arduous, there is a need of knack technology for a holistic management of forest. Remote sensing and GIS have successfully been employed to monitor the fragmented ecosystems and thus can prove to be imperative state-of-art tools to address the impacts of forest fragmentation. Various satellite sensors with different spatial resolution have been utilized in the study of forest fragmentation. For a scientific and precise mapping tropical forest fragmentation at regional and global scales, remote sensing is perhaps the only feasible way [9].

2   Materials and Methods

2.1   Study area

Nagarjunasagar-Srisailam Tiger Reserve (NSTR) is a massive stretch of forest situated 130 kms south of Hyderabad city on the banks of River Krishna and is bounded between latitude 15° 53' North to 16° 43' North and longitudes 78° 30' East to 79° 28' East in Eastern Ghats in the state of Andhra Pradesh. The Reserve, spanning an area of 4347 km2 (with a core area of 1200 km2) was declared as a Protected Area (Wildlife Sanctuary) in 1978 and became a Project Tiger site in 1983. Today, it remains one of the largest Project Tiger sites in India and the only one in Andhra Pradesh. Presently it is known as Rajiv Gandhi Tiger Reserve. Topographically, the Reserve is located in the biodiversity rich Nallamalais and it spreads over five districts, Nalgonda, Mahaboobnagar, Kurnool, Prakasam and Guntur. The Krishna River flows through the Reserve over a distance of 130 k. Monsoon rains occur from June to September. It receives rains from South-West monsoon as well as North-East monsoon. The South-West monsoon is active from second half of June to end September and the mean annual rainfall is 590-760 mm.

Nallamalais composed of various floral elements of Eastern Ghats. Nallamalais represent 1541 species of flowering plants [10]. The vegetation of the Reserve is primarily southern tropical dry deciduous forest type [11]. The floral composition of this forest shows prominence of Tectona grandis Anogeissus latifolia, Terminalia alata, Diospyros melanoxylon, Lannea coromandelica, Xylia xylocarpa and Gardenia spp. Moist Deciduous forest is restricted to areas where rainfall is more and soil moisture is comparatively high. The faunal assemblage represents the Deccan Peninsular zone of biogeographic classification of India [12]. The forests are mainly southern tropical dry mixed deciduous forests [13].

Figure 1: Location of study area

2.2 Vegetation mapping

Nagarjunasagar-Srisailam Tiger Reserve (NSTR) falls in path/row 100/59, 103/63 of IRS P6. IRS P6 AWiFS data of 14th October 2010 (path raw-101/59C) was used for Forest Density/type classification and 25th December 2010 data as a reference map based on ground truth data of NRSC. to delineate forest types, IRS P6 AWiFS data of March/April 2010 was employed. Each image was enhanced using linear contrast stretching and histogram equalization to improve the image quality and to identify ground control points (GCP). The datasets were brought into Universal Transverse Mercator (UTM) projection and WGS 84 datum.

2.3 Fragmentation analysis

Fragmentation is the number of patches of forest and non-forest type in per unit area. The forest type map was reclassified into two classes' viz., forest and non-forest, resulting in a new spatial data layer. A user grid cell of n x n (e.g. n=500 m) is convolved with the spatial data layer with a criteria of deriving number of forest patches within the grid cell. The iteration is repeated by moving the grid cell through the entire spatial layer. An output layer with patch numbers is derived and associated to this a look up table (LUT) is generated which keeps the normalized data of the patches per cell in the range of 0 to 10 [14]. Fragmentation study takes into account connectivity (corridors), presence of ecotones, the metapopulation structure etc. Fragmentation increases the vulnerability of these patches to external disturbance with threat on the survival of these patches and on the supporting biodiversity [15]. It reduces the size and quality of the habitat over a period, with loss of corridors and continuous impact of edges. Severity of tropical forest fragmentation has been studied with respect to distance effects, fragment size, edge effects and biotic changes [16].

The SPLAM (Spatial Landscape Modeling) software Developed by Indian Institute of Remote Sensing (IIRS), was used for fragmentation analysis. This software is portable to all window based environments. SPLAM uses generic binary image as the input and the output is also written in the same format. It has the flexibility to use a variable grid size. The grid size for landscape analysis has been determined by employing a variable grid call convolution on the spatial data [17].

3   Results and Discussion

The results obtained from this study proved that IRS P6 AWIFS as a reliable data source for forest area mapping. False colour satellite images used in the study were shown in Figure 2. In the present study different vegetation / land cover classes which are delineated using remote sensed data of 2010. The different vegetation and land cover found in the NSTR are Moist Deciduous forest, Dry Deciduous forest, Bamboo forest, Riverine forest, Savannah, Grassland, Plantation, Agriculture land, Barren land, Water bodies. In NSTR the forest cover is estimated as 2653.9 Km2 and the area under forest cover is proportionately 61% of the total geographic area of NSTR. The most abundant forest type is deciduous forest which comprises about 2257.2 Km2 (51.9%) of the total area.
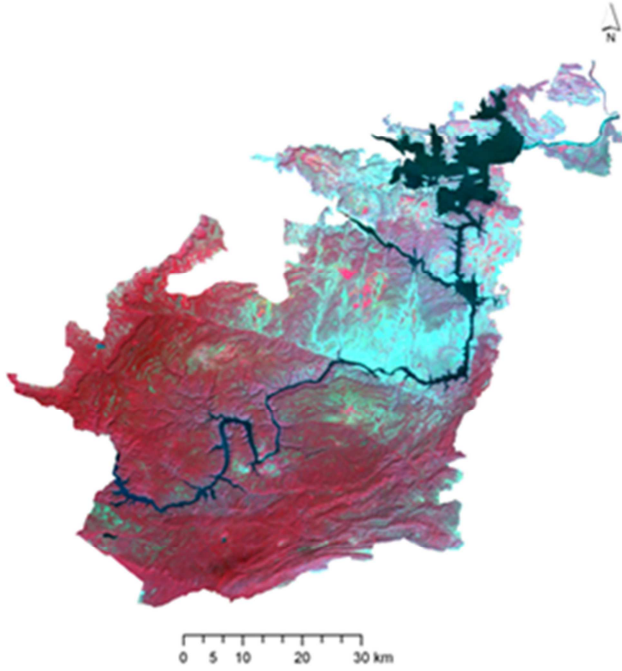
Figure 2: IRS P6 AWiFS FCC image of NSTR (October, 2010)
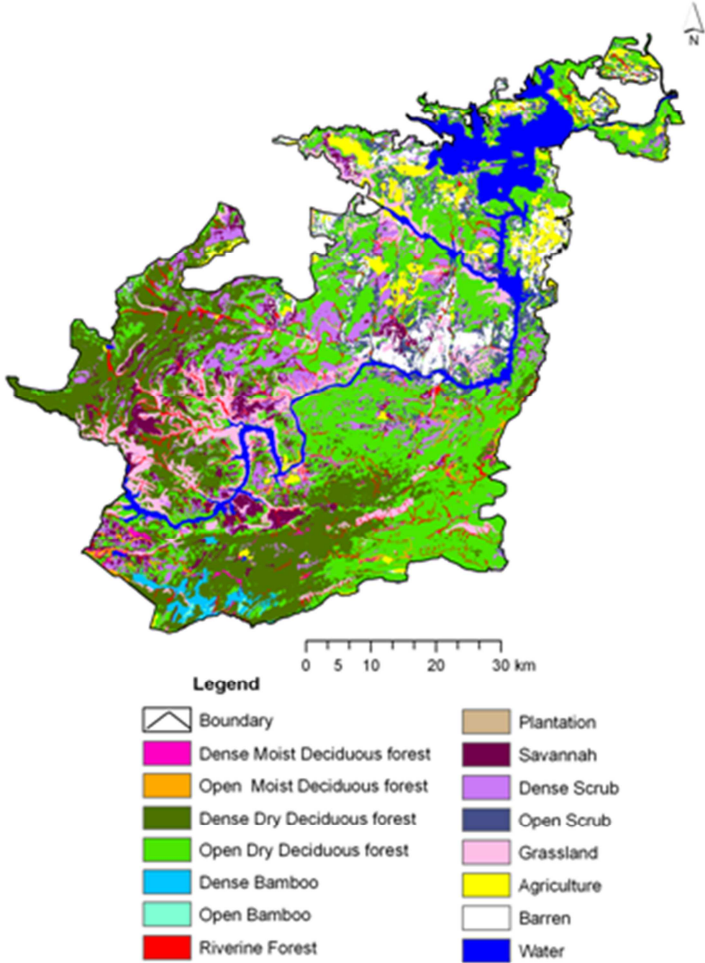
Figure 3: Vegetation and land cover map of NSTR

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Fragmentation analysis was carried out by recoding all the forested classes and non-forest classes into two categories. This map was based on 500 m x 500 m size of areas on the ground in terms of low to high fragmentation areas on a qualitative basis. The fragmentation analysis statistics of forest type was analyzed and categorized into high (H), medium (M) and Low (L) areas. The forests are the least fragmented with 82% in the low fragmentation category followed by medium 16.9 % and low 1.1% of the total vegetation area of NSTR. The result of patch statistics shows that, the total numbers of forest type patches in NSTR are 3514. Among these, 15 patches of Dry Deciduous forest and one patch of Grass land having more than 2000 ha. The study observed in NSTR, the 3178 forest patches are less than 100 ha (3981.7 ha).

Table:1 Patch size distribution of vegetation types of NSTR (number)

Sl.no	Type/patch number	<100ha	100-500ha	500-1000ha	1000-2000ha	>2000ha	Total
1	Moist Deciduous	55	10	0	0	0	65
2	Dry Deciduous	570	64	9	7	15	665
3	Bamboo	9	2	1	0	1	13
4	Plantation	3	0	0	0	0	3
5	Riverine	510	20	0	0	0	530
6	Savannah	480	34	0	0	0	514
7	Scrub	1392	88	13	5	0	1498
8	Grassland	159	51	10	5	1	226
	Total	3178	269	33	17	17	3514
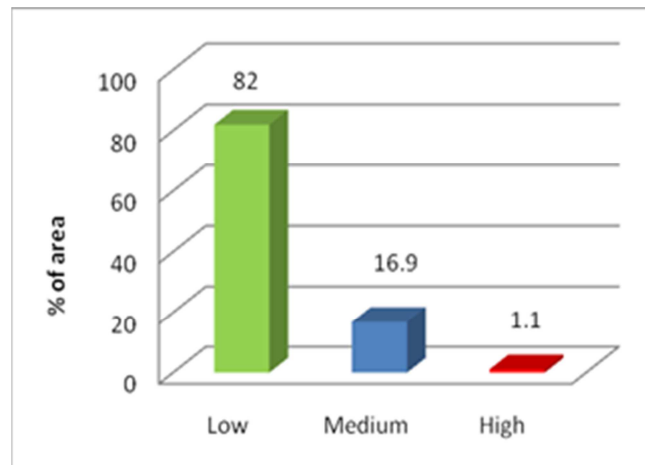
Figure 4: Fragmentation index map of NSTR

4   Accuracy Assessment

An unbiased set of testing samples has been selected from the reference field data for assessing the classification accuracy. Using random statistics techniques, overall classification accuracy and kappa statistics were computed. The results show an overall accuracy of classified map is 91.3%, and kappa statistics is 0.90.
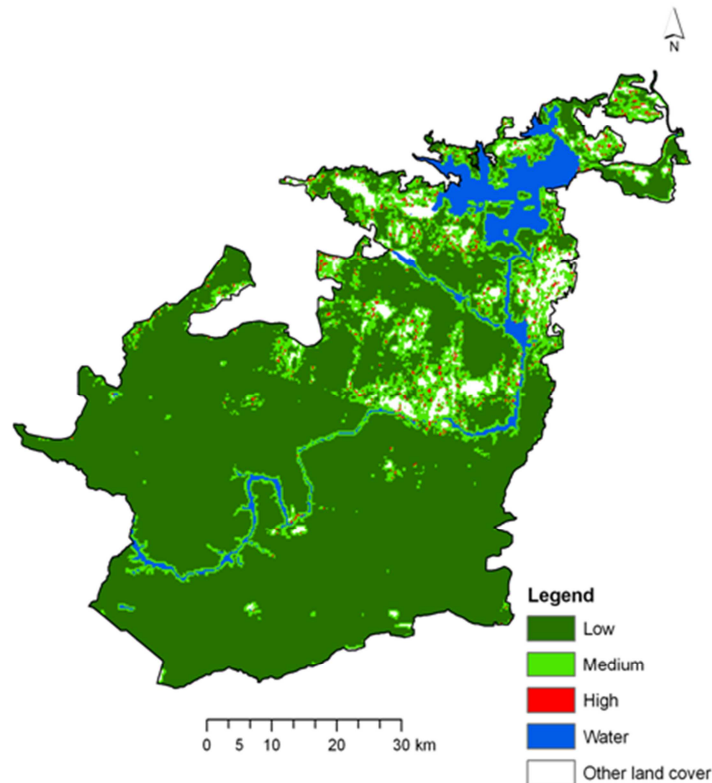
Figure 5: Forest Fragmentation map of NSTR

5   Conclusions

Forest fragmentation is a widespread phenomenon and is recognized as one of the major threats to ecosystems and biodiversity. Habitat fragmentation results in habitat loss and alteration increased edge effects, increased isolation of forest populations, and invasion by exotic species. Fragmentation can also restrict pollinator movement, which may reduce gene flow and result in increased inbreeding. The present study is demonstrated the importance of remote sensing for understanding the structure and composition of forest types. The scientific community has looked increasingly towards the remotely sensed data as a means of obtaining more accurate land cover information for wide range of applications.

Acknowledgement

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Environmental Issues and Sustainable Development

We resolve … to stop the unsustainable exploitation of water resources
by developing water management strategies
at the regional, national and local levels,
which promote both equitable access and adequate supplies.

United Nations Millennium Declaration, 2000

Cartographic Modeling of Potential Sand Dunes Movement Risk Using Remote Sensing and Geographic Information System in Sinai, Egypt

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KEY WORDS: DEM, GIS, sand dunes, sand encroachment, weighted linear combination, SRTM

ABSTRACT:

Sand dunes encroachment is a challenge that faces land development in arid zone countries. Movement of such dunes threatens cultivated lands, roads, and urban settlements. This study modeled the potential risk of sand dunes encroachment related to their terrain characteristics in Sinai Peninsula, Egypt. The Food and Agricultural Organization's land cover map of Egypt together with SPOT4 imageries was used to identify the sand dunes bodies from the desert of Sinai. Four parameters were derived from Shuttle Radar Topography Mission data, namely the elevation, slope, aspect, and relative moisture index. Ten-year average data for prevalent wind direction and speed were used. A weighted linear combination model was applied using the six parameters as criteria maps. The output is a sand dunes risk index map which was overlaid with some urban features such as cities, highways and airports. The result identified those urban features vulnerable to sand dunes encroachment risk. Such a risk map is essential for land use planning and environmental management.

1   Introduction

The purpose of this study was to classify the sand dune relative risk of encroachment for an area in Sinai Peninsula. It also explores the potentials of the integrated techniques of remote sensing and GIS cartographic modeling in understanding such phenomenon. Sinai is partially covered by sand dunes and sand sheets and characterized by sand dune movement that frequently affects roads, agriculture areas, and towns. Six parameters having important roles in the sand movement were modeled. A land cover map produced by the Food and Agricultural Organization (FAO) of the United Nations (2002) from Landsat Enhanced Thematic Mapper (ETM+) satellite images was first used to identify and extract the area and outlines of sand dunes in the study area. This land cover has been produced from visual interpretation of digitally enhanced satellite images (bands 4, 3, 2). The land cover classes have been developed using the FAO/UNEP international standard land cover classification system (LCCS). Food and Agriculture Organization of the United Nations (FAO) (2002). Spot 4 images of year 2009 were then used to update the FAO land cover map especially for sand dunes body outlines.

For this study, the six parameters were used in the analysis to classify sand dunes based on their ability for movement. Terrain characteristics parameters are elevation, slope angle, slope angle direction (aspect), and relative moisture index derived from SRTM DEM using a model (figure 2). All the previously mentioned parameters were derived from an existing Digital Elevation Model (DEM). Prevailing wind direction and wind speed were extracted from the meteorological information generated by the available weather stations in Sinai Peninsula. Sand grain size is an effective parameter in sand dunes movement, yet this parameter was not considered in this study due to lack of data at the present stage.

1.1 Study Area

Sinai Peninsula is situated between Gulf of Aqaba and Gulf of Suez from East and West respectively, and is bounded from north by the Mediterranean Sea (figure 1). In the northern part, the horst block of the mountainous basement terrain is flanked by an extensive stretch of flat-topped plateau, covering most of the central Sinai. The general elevation of the plateau terrain increases southward. The region is located within the arid belt which dominates the northern part of Africa and extends to the southwest of Asia. It is characterized by arid climatic conditions dominated by long hot, rainless summer and mild winter. The peninsula is divided into two administrative governorates, North and South Sinai. The region is rich in geological resources reflected in extensive mines and quarry sites, where Kaolin, Manganese, Zircon, coal, Feldspar and Albite in addition to quarrying activates where Gypsum, glass sand, Marble, Granite, Dolomite and Limestone are being extracted.
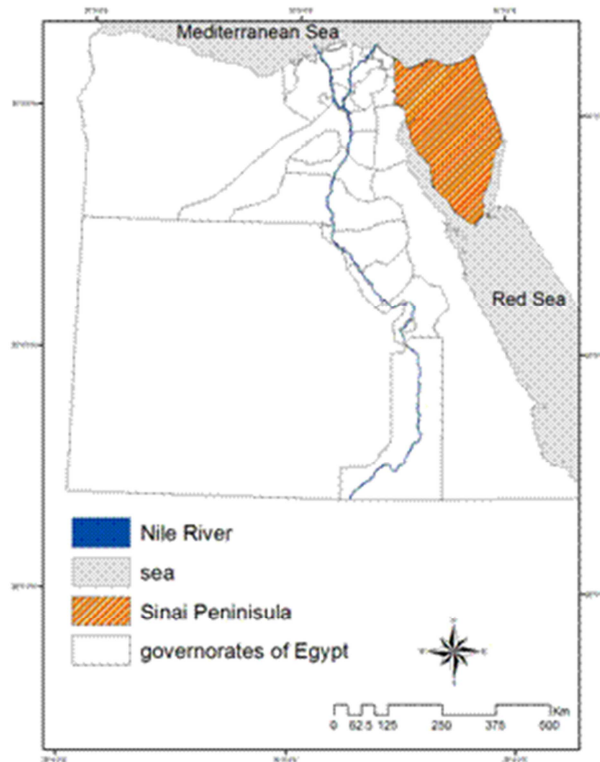
Figure 1 Location map of Sinai Peninsula

2 Data sources and model parameters

Two primary data sets were used to model the migration of dunes in this region of the Egyptian terrain. The first is a DEM obtained by the U.S. Shuttle Radar Topography Mission (SRTM) data (United States Geological Survey, 2000). SRTM collected single-pass radar inter-ferometry data covering about 120 million km2 of the earth's surface on a single space shuttle mission in February 2000. SRTM DEM was the available data believed to match reasonably with the FAO land cover produced in 1997, as a three-year period is not supposed to have a big change in the sand dunes movement. This coverage included about 99% of the land surface between 60 north latitude and 56 south latitude. C-band and X-band data were collected and, to obtain an interferometric baseline suitable for data acquisition from space, a 60 m mast was extended from the shuttle while in orbit. These data have a spatial resolution of 3 arc second (90 m) and an absolute and vertical accuracy of better than 10 and 16 m, respectively (Lillisand, Kiefer, and Chipman 2004). The second data source for this study is meteorological station data over a 10-year period. For this study area, there were records available from five stations. All data sets were converted to raster using ESRI ArcGIS Spatial Analyst function and compiled at the cell size of the DEM data of 90 m using the nearest neighbor assignment re-sampling technique.

Six parameters were obtained from the two primary data sets to model potential dune migration. They are elevation, dune slope angle, dune slope direction (aspect), relative moisture index, prevailing wind speed, and prevailing wind direction. These parameters were given relative weights using the rank sum method according to their relative importance for dune migration. The parameters are described in the following sections.

2.1   Prevailing wind speed and direction

The surface wind is defined as the horizontal motion of air. Hence it is a two dimensional vector quantity specified by direction and speed. Wind speed is reported in knots (nautical miles per hour) or in meters per second, where one knot= 0.5m/s, while wind direction, which is defined as the direction from which the wind blows, is measured east of true north to the nearest 5 degrees. The sand dune encroachment risk is an aeolian factor that is very much a wind-related process. The wind speed and wind direction monthly averages from 1986 to 1996 were obtained from the Egyptian Meteorological Atlas (Egyptian Meteorological Authority 1996). A database was created for the meteorological parameters for each month. The prevailing wind speed attribute was then interpolated using the inverse distance weighted (IDW) function to create a prevailing wind speed surface from the set of measured wind speed data for the meteorological stations. The IDW estimates cell values by averaging the values of sample data points in the neighborhood of each processing cell. The closer a point is to the center of the cell being estimated, the more influence, or weight; it has in the averaging process. A surface was created for the 10-year average of each month. Finally annual average prevailing wind speed map was obtained. The resultant map was standardized to a common risk scale giving a high score for the higher wind speed values and vice versa (Table 1 and Figure 4).

The wind direction, which is defined as the direction from which the wind blows, is measured east of true north to the nearest 5 degrees. Sinai Meteorological Atlas was used to derive wind direction data from the wind roses (Figure 4). A grid surface for the prevalent wind direction was created for each month. These monthly grid maps were averaged into an annual wind direction map. Prevalent wind direction ranking (Table 1) was made according to their frequency of occurrence and thus their impact on sand dunes movement. The map was standardized to a common risk scale.

2.2   Terrain Characteristics

Terrain characteristics play an effective role in the sand dune potential motion. The height or elevation of the sand body, its slope angle, and the slope direction (aspect) are all variables that have to be considered in the assessment of sand dune risk. Moisture of the sand is also a factor as it causes some coherence in the grains, making it looser or more attached to each other thus contributing to the sand resistance to wind impacts. Finally, the wind direction and magnitude (speed) are contributing parameters in sand migrations.

2.3   Dune slope angle

The slope angles of the sand bodies affect their movement. Sand on steep slopes is more subjected to wind impacts resulting in more active sand bodies. The slope was derived from the SRTM data and classified into equal defined intervals (Table 1 and figure 5). The steeper the slope, the higher is the weighting. The slope map was standardized into a common risk scale for the reason of comparison and addition in a map overlay function.

2.4   Dune aspect

The dune aspect were derived from the SRTM DEM. Slope angle direction is crucial for the dune risk classification model. Dunes facing the prevalent wind direction are most likely to have grain movement and thus have more risk. The aspect map was standardized into a common risk scale (Table 1 and Figure 5).

2.5   Relative moisture index

The SRTM DEM was used to extract and map the drainage patterns using the ESRI ArcGIS hydrology module. The drainage patterns reflect the influence of the lithologic and structural character of the underlying rocks, as well as the climatic conditions and erosion history of the area at the time of formation (Summerfield 1991). The flow direction, the drainage basins, and the streams network were extracted for the study area. The relative moisture index is derived using a simple equation based on surface water flow models after Anderson and Burt (1985). The index combines two factors, namely the catchments area and slope, using formula:

$$\text{Moisture index} = \ln\left(\frac{\text{catchments area} + 1}{\text{slope} + 1}\right)$$

The formula assumes that relative moisture in a particular area (the grid cell) primarily depends on two factors: how much water is flowing into the area and how fast the water can flow out of the area. The catchments area is determined for each cell using the flow accumulation command in ArcGIS software. This is the amount of upslope area. This is the amount of upslope area that contributes water to the cell. The slope at the cell then determines how fast the water can run off the cell. The resulting moisture index is relative (figure 2). This means the resulting number do not have units yet they provide relative index numbers; the higher the numbers are wetter and the lower, more negative numbers are more dry (Andersen and Burt 1985). In this study, the rainfall calculations were not taken into account as the investigated area lies in the arid zone with scarce precipitation rate. The model used to derive the moisture index grid is shown in figure 2. Resultant moisture index map (figure 5, lower left) was later standardized to a common risk scale giving a higher risk score to the relatively low moisture sand body (dry sand) and vice versa.
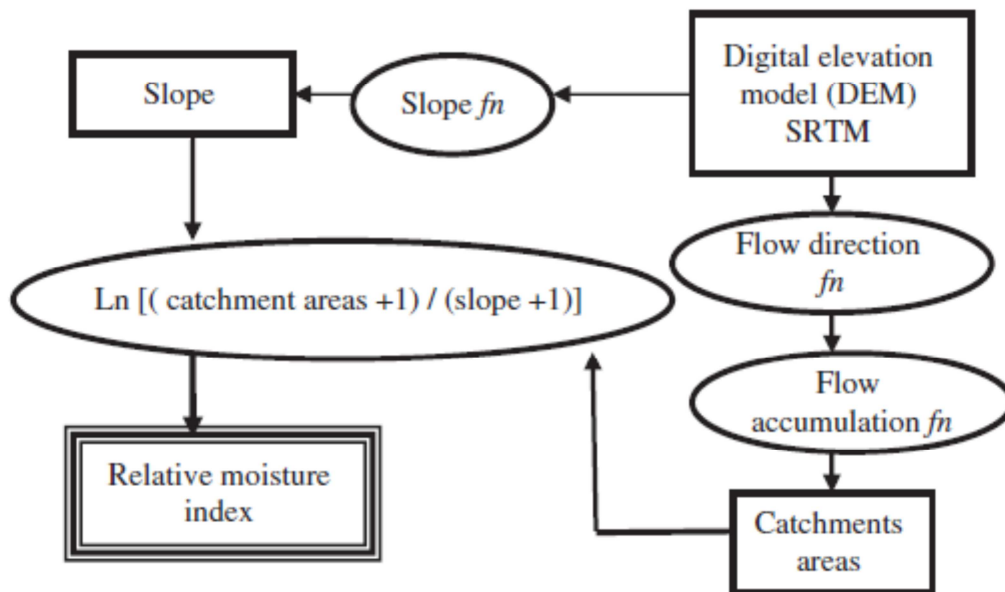
Figure 2: Flow chart for producing the relative moisture index from SRTM data

Risk scale	Wind speed (knots)	Wind direction (Azimuth)	Elevation (m)	Slope (degrees)	Aspect (Azimuth)	Moisture index
1	≤ 4.5		0-135	0-8		8.53 - 9.98
2	5.6 – 6.4	180-225	135-269	8-16	45-180	7.08 – 8.53
3	6.4 -7.0	90-180	269-4-3	16-22		5.63 – 7.08
4		225-270	403-537	22-30		4.18 – 5.63
5	4.5 - 5.5	45-90	537-672	30-38	180-270	2.73 – 4.18
6		0- 45	672-806	38-45		1.28 – 2.73
7			806-940	45-53		-0.16 – 1.28
8	7.0 - 7.5	270-315	940-1074	53-60	0-45	-1.6 – -0.16
9	7.5 -8.0		1074-1208	60-68	315-360	-3.05– -1.61
10		315-360	1208-1342	68-74	270-315	- 4.5– -3.05

Table 1 Rating the six criteria for sand dunes movement study

3   Model Implementation

Each of the six criteria is represented as a layer in GIS data sets. Except for the moisture index map, equal ranks were assigned the rest five maps. The moisture index parameter which was given least importance as the region is quite dry with seldom precipitation rate and thus was considered having least significant impact on sand dunes. Thus each of the five factors was given twice importance of the moisture index. The weights were calculated using the Analytical Hierarchy process (Nijkamp, Rietveld, and Voogd 1990; Janssen 1992; Beinat 1997; Belka 2005). Wind data were used representing 10-year average monthly maps. The 12 monthly average wind speed and wind direction maps were combined into two annual average maps and used in the model. A weighted overlay function was applied using the six standardized criteria maps (figure 3). The values for each of the six model parameters were summed to provide an average annual index map of risk for sand dune encroachment. From the cumulative score for each cell, high-value scores indicate a high risk and vice versa.
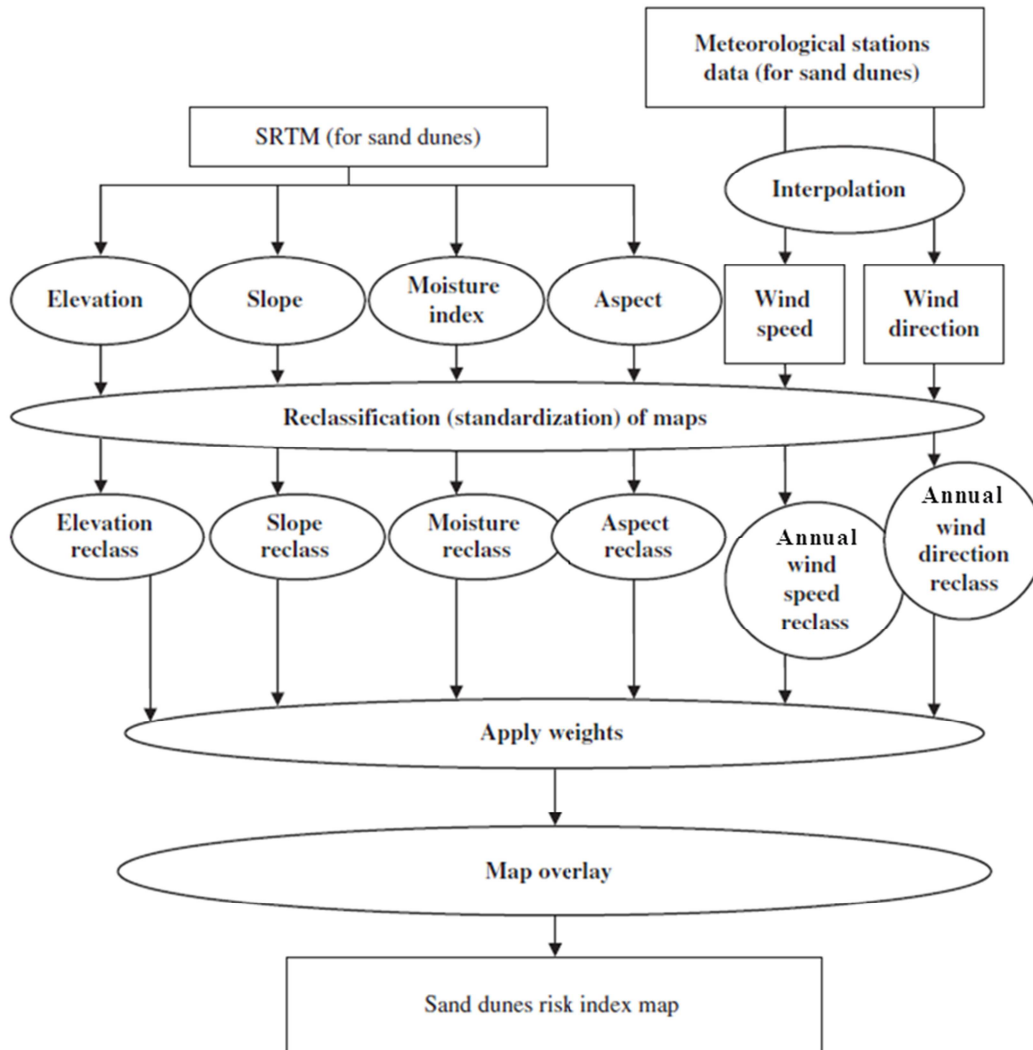
Figure 3: Road map for the methodology

4   Results and discussion

The total area of the sand dunes in Sinai is 14,245 square kilometers. The area of such huge mass is a post classification measurement derived from Landsat and SPOT images. By examining the six sand dunes movement triggering criteria maps the following observations were obvious: Examining the wind pattern criteria maps it was noticed that the maximum wind speed over the sand dunes exist along the Gulf of Suez. The prevalent wind direction which is the North-West and North-East is a triggering factor for the dunes movement. The prevalent wind direction map distribution is depicted on figure 4. The elevation of the sand dunes increase

toward south with lowest elevations along the Mediterranean coastal line and Bardawieil lake. Such elevations increase to reach 1,345 meters high in the central and southern zones of the Peninsula. (Figure 5 *top left*). Most of the dune slopes ranged between 1-20 degrees with least dune slopes extending along the Mediterranean shoreline and Bardaweil Lake (Figure 5 *top right*). It is noticed from the aspect image that the aspect of the sand dunes varies as nearly all azimuth directions are resembled in the map. The dunes moisture index is quite low and is limited to the streams network (Figure 5   *lower left*).
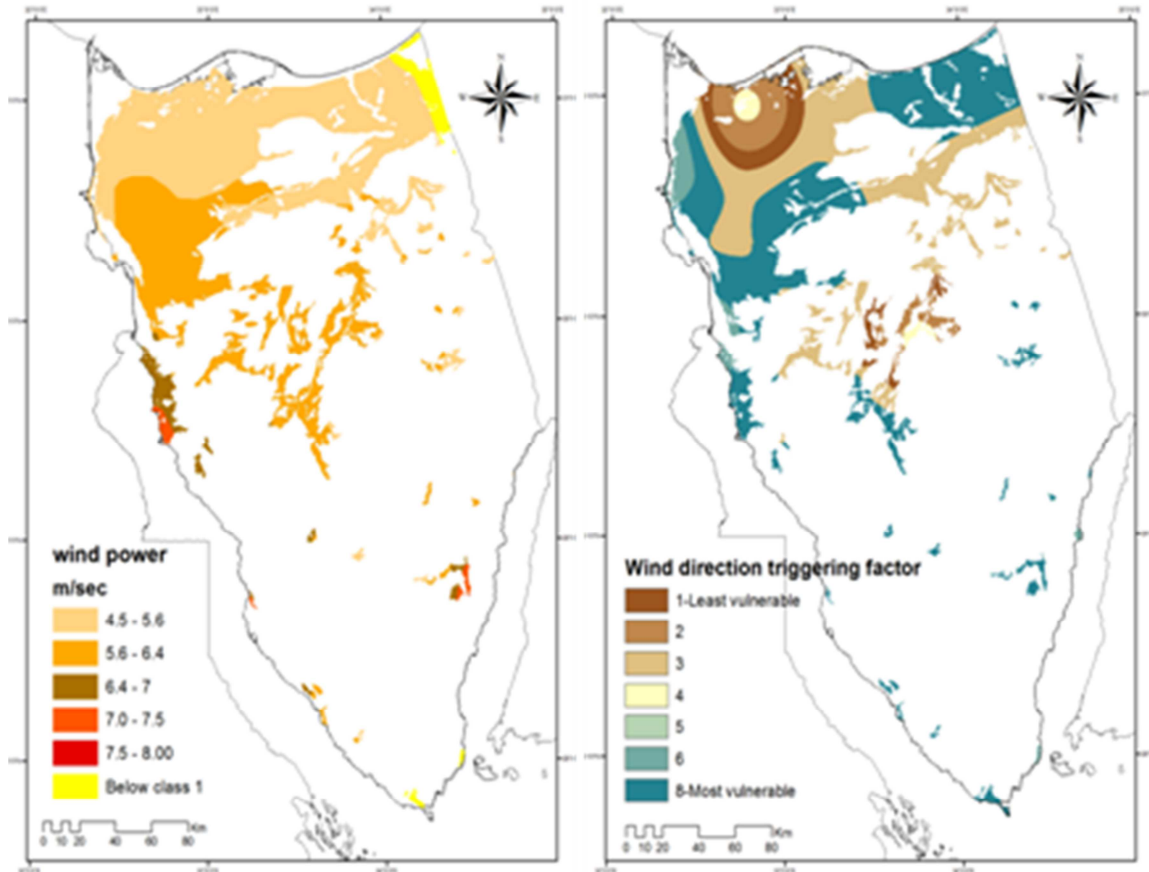
Fig. 4: Annual average wind power in sand dunes. Right: Aspect of sand dunes

Running the weighted linear combination model provides some interesting observations and information that can be useful in planning and development decisions for Sinai Peninsula. The resultant thematic map is an aggregation of a weighted overlay model that combined the six criteria thematic maps into a single risk index map. The classification of resultant risk index into four risk classes revealed the risk intensity and surface areas of such dunes. Class1 identifies the least dune movement risk extending in an area of 1879 square kilometers; class 2 identifies more risky dunes extending for approximately 4,858 square kilometers; class 3 represents high risk dune covering an area of 4,790 square kilometers. Finally class 4 which is the highest risk dunes covering an area of approximately 2,225square kilometers. (Figure 6)
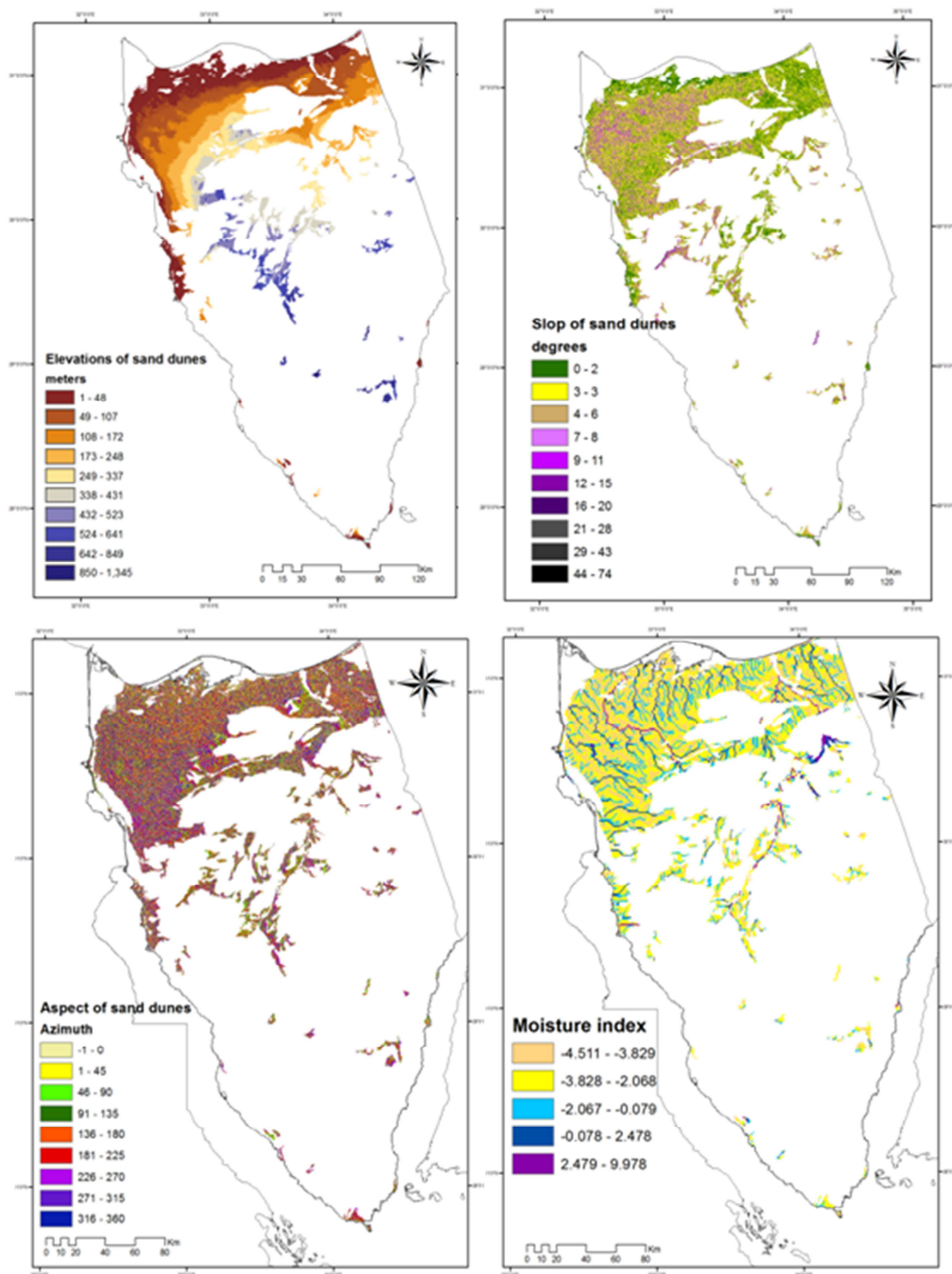
Figure 5 Terrain characteristics parameters derived from SRTM data: *Top left:* Dune elevations, *Top right:* sand dunes slope angles in degrees. *Lower left:* aspect in degrees azimuth. *Lower right:* moisture index

Examining the resultant risk index map, it is noticed that the relative least risky zone is represented by the north western part. This is due to the low elevations of such dunes in addition to a relatively higher moisture index and

a weaker annual wind speed and least dominance of prevalent wind direction (North-West). Class four (the most active dangerous dunes) extend along the northwest and west of the peninsula, in addition to some scattered patches and spots in middle. This distribution can be interpreted as follows: the high elevations of the terrain in addition to a more strong wind speed and the dominance of the prevailing wind direction (North-West).
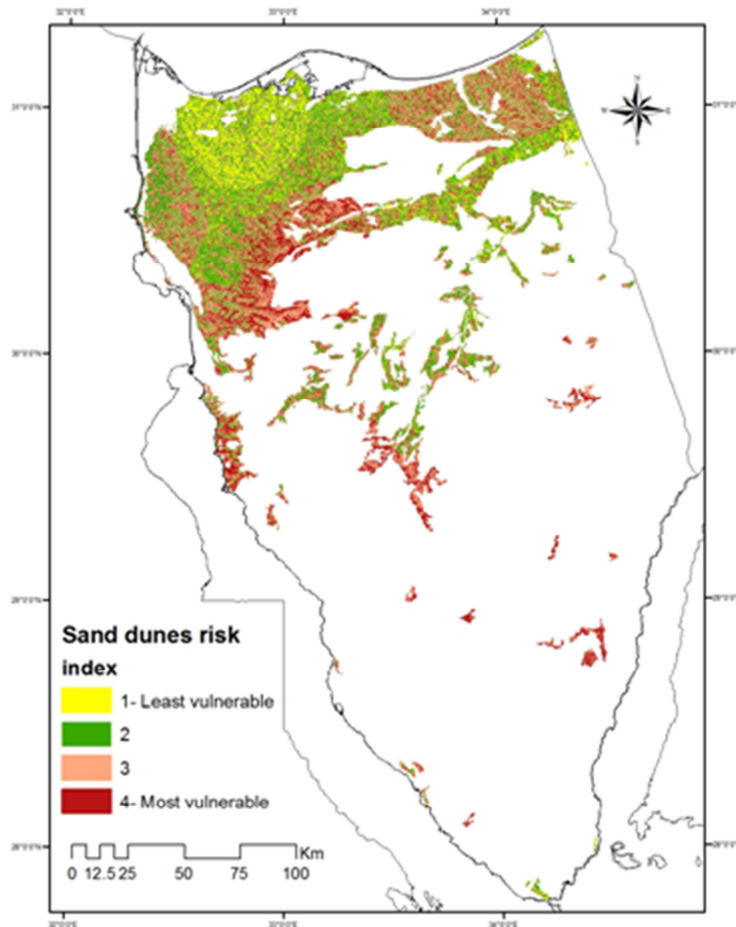
Figure 6 Sand dunes risk index map

By overlying the model output on the Sinai cities, we find that most of North Sinai cities and towns are lying on sand dunes. All these urban settlements are vulnerable to potential dune encroachment on roads, airports and cultivated lands. Such cities are expected to suffer from the sand storms during the Khamasein winds which are common in spring. The overlay of such cities on the sand dunes vulnerability index points out that the most vulnerable city is Nakhel being located inside a high risk sand body. Such city lies in the central part of Sinai Peninsula and are surrounded by sand dune bodies with risk index values three and four. It means that such dunes represent encroachment threat to the city. Bir El Abd city lies in a zone with a dune risk index of two. Rumana city lies in a zone with dune risk index equal to one while El Mazar city lies in a sand dunes body with risk index equal to one (low risk) yet, it is surrounded by sand dunes with risk index equal to three from the west and North West directions. As the North West direction is the prevalent direction, it makes such city in need for sand dunes protection measures.
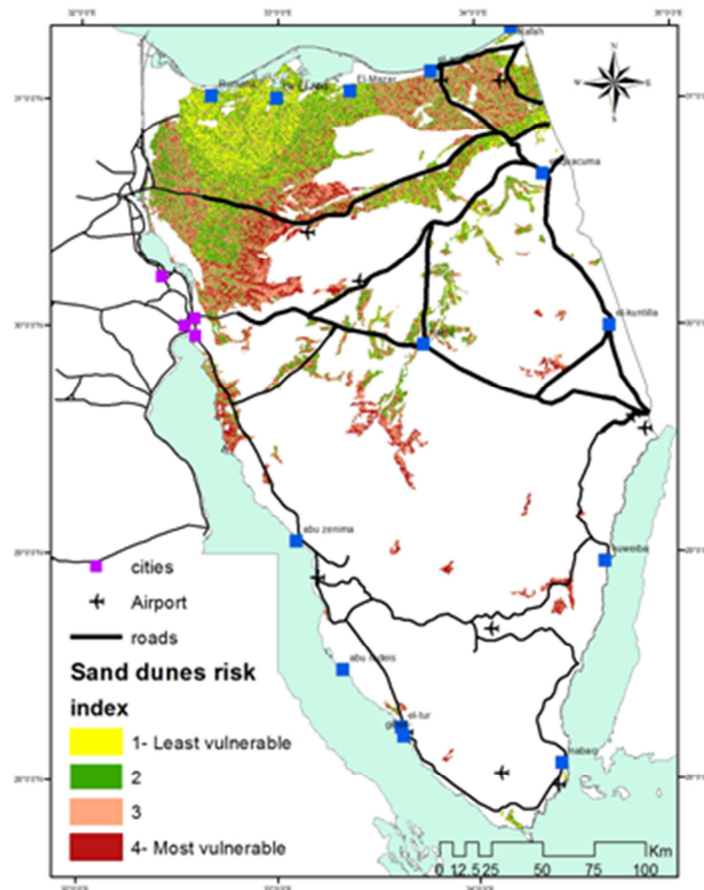
Figure 7 Assessment of locations of urban features relative to the sand dunes risk index

Examining the highways sectors, it was noticed that such highways extend through sand dune bodies with high risk of movements. These highways are: El Arish Beer Sabei, El Esmailia-Beer Sabei and Suez-El Qusayyema. Most of Sinai airports are safe regarding sand dune risk except for few vulnerable airports. Such vulnerable airports are: El Gora airport that lay in a sand dune body with risk index equal three and El Tor airport as it is located close to a sand dunes body with risk index equal one but it can suffer from sand storms blowing during Khanasein.

5   Conclusion

Integration of remotely sensed data and geographic information system was used to classify the sand dunes of Sinai Peninsula based on their terrain characteristics and the wind parameters. Results of the study show the capability of such technology in analysis of sand dunes in remote desert zones with minimum costs. Such technology can provide an early warning system for dune encroachment and is crucial to road planning and prior to locating new urban settlements or airports.

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Remote Sensing in Bandung Basin Erosion Assessment

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ABSTRACT:

Environmental mismanagement and the improper use of land tend to degrade elements of the ecosystem, thus threatening the sustainability of life on earth in general. An example can be seen in West Java in the Bandung Basin, where disastrous erosion results from improper land use. Erosion is controlled by several factors like climate, soil, human intervention, topography and vegetation. The last three factors cause considerable change in the Bandung basin, leading to undesired land use changes. Erosion assessment for small areas are commonly performed by field survey measurement, which however is too time consuming to be implemented in a large area. Remote sensing combined with GIS has the ability to analyse landuse change, spatiotemporally on a large area. The RUSLE model developed to predict average erosion on a long term comprises six factors viz., rainfall intensity, erodibility, slope length and steepness, vegetation and conservation treatment. Vegetation factor is obtained from NDVI analyses using band 3 and 4 Landsat imagery. The possibility to improve erosion prediction models using NDVI from satellite imagery is examined.

1   Introduction

Soil is the basis of life and the human environment in an ecosystem. Challenging problems in soil management arise from the rapid growth of population and consequent increasing need for food production on the other side. This leads to destruction, toxification and contamination of the soil and seriously threatens the sustainability of live on earth. Erosion at disastrous levels in West Java specially in the Bandung Basin of Indonesia is studied here to illustrate this model.

The Bandung Basin is used as the study area since land use change occurs rapidly as the consequences of human intervention in this area. Erosion itself has naturally affected the area but human intervention like illegal felling, ecosystem mismanagement has triggered landslides, enhanced sedimentation and erosion rates (www.bbwscitarum.pdsda.ne, 2012) and degraded the ecosystem quality. The other consequences are the degradation in soil fertility, reduction in area of cultivated land.

Saving the soil from erosion obviously can enhance soil fertility and ultimately provide a healthier ecosystem. Well managed watersheds will ensure baseflow, secure water resources and control soil erosion (Djunaedi 2011)

The study aims at developing a model for recommendation of proper land use treatment and management to avoid disastrous erosion.

2   Methodology

In this study LANDSAT imagery and some topographical data are used to analyse variables that are required for RUSLE calculation method. The software used are ArcGIS, ERMapper, ENVI and Global Mapper. The RUSLE model was implemented since this method is applicable for estimating erosion in tropical watersheds (Millward and Mersey, 1999). RUSLE in an updated version of the USLE (Lu et al., 2003; Lufafa et al., 2003; Millward and Mersey, 1999). The RUSLE is given as:

A = R x K x LS x C x P   (1)

A is the average annual soil loss predicted (t/ha y). R is rainfall run-off erosivity factor (MJ mm/ ha h y). K (ton ha h/ MJ ha mm) is soil erodibility factor, this factor is related to the integrated effect of rainfall, run-off, and infiltration and accounts for the influence of soil properties on soil loss during storm events on sloping areas. The LS accounts for the effect of slope length (L) and slope gradient (S) on erosion. The C is the cover factor, which measures the effects of all interrelated cover and management variables (Renard et al., 1997). Values of C can vary from 0 for forest areas with 100% ground cover to 1 for bare area.

Research methodology consist three main steps 1) Data collection, 2) image processing, modeling and 3) model integration. Generally can be drawn as follow:
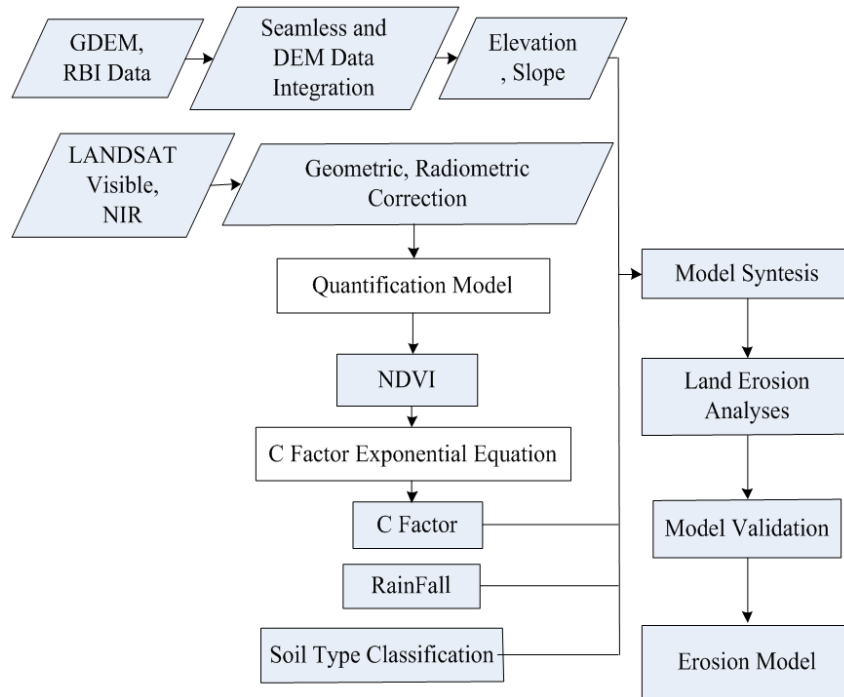
Figure 1 Methodology

NDVI obtained from Visible and NIR channel of landsat imagery to describe the land use characteristic. C factor of RUSLE calculated directly from NDVI value using exponential equation. For this Landsat ETM, NDVI computed utilizing band 3 (red) and band 4 (nir / near infrared).

DEM data acquired from ASTER GDEM data with 30 meter resolution and topographical map scale 1 : 25.000. Both data manipulated and processed using global mapper software. In advance the process performed to yield slope feature class using Arc GIS software.

2.1   Study Area

The study area is Bandung basin of Indonesia. It consists of the river Citarum (Citarum watershed). Bandung basin is a geological depression structure within the West Java mountains formed about 2 millions years ago (Brahmantyo.B., 2004).

Bandung basin is surrounded by high elevation active volcanoes with a low land in the center of basin. Rapid land use change in recent decades is threatening the land quality leading to change in land suitability and complexity in land evaluation.

Figure 2 Bandung basin study area

2.2 Image Processing

Landsat imagery with large area coverage of about 180 x 180 km2 and 30 meter spatial resolution, consisting of three visible bands (RGB), two Near Infrared band and one far infrared band with 16 days revisit time was used. The image was recorded in 2009. The reason for using Landsat imagery for this research was the large coverage area offered with suitable resolution for data analyses.

In order to perform proper interpretation of the imagery, image processing through several correction steps like geometric and radiometric correction was done. Radiometrically corrected images will be free of distortion. Geometric correction was carried out to eliminate geometric distortion. Geometric correction was performed concurrently with image orthorectification step using Ground Control Point identification and registration.

2.2.1 Image Correction

Geometric correction eliminates non-systematic error. Some errors arise due to instrument limitation and nature of the Earth. The errors that occur at the recording process are due to earth curvature, earth rotation, sensor speed, inconstant altitude etc. Ground Control Point (GCP's) are very important to eliminate the effect of distortion that comes from the nature of the Earth. GCPs were investigated from Indonesia Topographic Basemap (RBI) scale 1:25000. For 30 meter image resolution RBI map can be utilized for GCP identification of all six bands of Landsat imagery.

2.2.2 Digital Number Image (DN)

Satellite imagery comprises of a 2D pixel arrangement in rows and columns, each pixel representing a type of land use in the study area using typical values known as intensity value. Intensity value of each pixel shows the physical quantitative sun light radiance. Pixel resolution defines an area as large as 30 m x 30 m, the radiance value is taken as average of each single radiance event within pixel resolution area.

Pixel intensity value is digitized and recorded as digital number. Because of memory space limitation the digital number is stored in limited bit number (binary), bit value size defining image radiometric resolution. Certain intensity value of the object of interest can be exposed dominantly using scaling and quantification process in order to gain precise information on characteristic land use in the study area.

Figure 3: Landsat imagery bands covering study area

Pixel position is defined in the form of coordinates with row and column, a one-to-one relationship is built between pixel coordinates and its datum coordinate system, in this case UTM coordinate system zone 48 was used with WGS 84 datum. Correction process refers to topographic base map. Digital number of ETM Landsat comprises 6 bands of 7 (1, 2, 3, 4, 5 and 7) recorded in the form 8 bit with pixel value ranging from 0 to 255.

2.2.3   NDVI Derivation

The aim of image processing besides obtaining finer and accurate information, is to calculate difference indices like NDVI (Normalized Distribution Vegetation Index), which helps in the preliminary assessment of vegetation in the study area. NDVI value will used to define C factor as one significant variable in the RUSLE erosion model. NDVI was calculated using the band 3 and 4 of Landsat imagery acquired in 2009. NDVI calculation is based on the concept that vegetation grows very effective by absorbing visible spectrum radiation (PAR or Photosynthetic Active Radiation) (Ryan , 1997), while green vegetation mostly reflects near infrared. NDVI is determined using equation:

$$\textbf{NDVI} = \frac{(\text{NIR}-\text{Vis})}{(\text{NIR}+\text{Vis})} \qquad\qquad (2)$$

NIR   = Near Infrared (band 4)

Vis   = Visible(band 3)

NDVI values range from -1 (water) to +1 (very vegetated). Vegetation coverage is represented by the range 0.1 to 0.7, values above this represent the health level of vegetation. The denser the vegetation the larger the NDVI value and vice-versa. The NDVI values were obtained from Landsat ETM band 3 (red; 0.63-0.69 µm) and band 4 (near infrared; 0.76-0.90 µm) and processed using ENVI software package.

The image resolution of the study area was high and processing it was time consuming and demanded very high performance hardware and software for processing. To overcome this issue the resolution level was degraded to the level of 100 meter transect size for one pixel. This resolution is relatively acceptable considering the regional data.

2.2.4   DEM Processing

DEM data for erosion modeling was acquired from several sources, but mainly ASTER Data was used. DEM with 30 meter resolution was combined with topographical data from 1 : 25000 base map. DEM verification process utilizes digital topographic map by the overlay process within the study area. The identified objects were sampled and registered to enhance DEM data confidence.

After overlaying with topographic map, DEM represents real world geomorphological situation. For analyses, DEM was converted into GIS format and reclassified it into five slope classes, with specific weight for each slope class. This weight of each class was specified considering the slope angle.

2.3   Erosion Modeling

Physical erosion can be defined as a land fertility degradation indicator. Erosion is the loss of soil, fully or partly, when it is transported from one place to another lower elevation location usually by water. Erosion can cause top soil layer fertility degradation which is bad for plantations, decrease soil absorbency capability and increase soil detachment.

Hudson classified erosion effect factors into two main components, erosivity and erodibility. Erosivity primarily stresses on the rain water's capability to detach soil. Practically the term high erodibility soil means sensitivity of soil for erosion and vice-versa.

2.3.1   RainfallErosifity Index (R)

Rainfall Erosivity Index (R) factor looks at the impact level of rain drop per unit of time and run off, R as the product of Rainfall Kinetic Energy (E) with Maximum Rain Intensity in 30 minutes (I30). Rain Erosivity Index (R) is formulated as

$$R = (0.41 \times (\text{Rainfall})^{1.09} \tag{3}$$

Rainfall data for this research were taken from two climate stations:

1) Bandung, Climate Station Bandung (station number 96783)

2) Lembang, Climate Station (station number 96001)

The result of calculation using Rainfall erosivity formula (3) is tabulated as follow:

Rain Erosivity Index (R)	
Rainfall	R
1000 - 1500	1,187.75
1500 - 2000	1,625.20
2000 - 2500	2,072.71
2500 - 3000	2,528.40
3000 - 3500	2,991.01
3500 - 4000	3,459.63
4000 - 4500	3,933.56
4500 - 5000	4,412.26
5000 - 5500	4,895.30
5500 - 6000	5,382.31

Table 1 Rainfall erosovity(Calculation Product, 2009)

2.3.2   Soil Erodibility Factor (K)

Soil erodibility factor is erosion volume by time periods by rain erosion index (R), measured on bare reference plot with size 72.6 feet (22.2 meters) and 9% slope is (Wiscmeier and Smith ; (1960)) formulated as follows:

100K = 1292(2.1 M1,14(10-4)(12–a)+3,25(b–2) +2,5(c–3)   (4)

Where M = Very fine sand + dew x (100 – clay %), a = organic matter %, c = Permeability class. According to formula (4), erodibility factor for various soil type arranged in following table:

Soil Erodibility			
Soil Type	K	Latosol	0.26
Alluvial	0.29	Litosol	0.13
Andosol	0.28	Mediteran	0.16
Brown Forest	0.28	Organosol	0.29
Glei	0.29	RedPodsol	0.20
Glumusol	0.16	Regosol	0.31

Table 2 Soil erodibility (Otto Soemarwoto, 1998)

2.3.3   Slope Factor (LS)

Slope factor (LS) in soil erosion equation comprise of two variables, L is slope length defining the ratio between soil erosion / loss occurrence in certain slope length to soil erosion with slope length 72.6 feet under identical circumstances, S is steepness factor describing the ratio between soil erosion occurrence with certain steep angle to the erosion occurrence on 9% slope under identical circumstances. For practical purposes, L and S are calculated simultaneously as LS factor. LS value can be calculated from the equation:

LS = $\sqrt{X}$ (0.0138 + 0.00965 s + 0,00138s^2)   (5)

where X is slope length in meter and s is slope steepness in %. According to the above equation LS factor value is tabulated as follows:

No.	SLOPE	LS
1	0 - 8 %	0.4
2	8 - 15 %	1.4
3	15-25 %	3.1
4	25-40 %	6.8
5	>40 %	9.5

Table 3 Slope factor classification (SitanalaArsyad, 1989)

2.3.4   Vegetation Factor (C)

Vegetation is an important factor to check erosion. Vegetation decreases erosion caused by rainfall and run off, increasing infiltration, soil physical and chemical improvement, (Baver, 1956). In RUSLE (Universal Soil Loss Equation) erosion model, vegetation coverage is noted as C factor. C factor denote vegetation covered soil and crop treatment is the ratio of erosion of area interest covered by vegetation and applied crop treatment to the identical soil erosion without crop. Vegetation characteristic in are of interest can be distinguished from the different C factor values.

In this study C factor is calculated based on landuse map consideration and NDVI value from Landsat image processing, especially band 4 and 3 and combined with landuse data, topographical map and secondary onsite data.

Based on landuse map analyses, coverage is grouped into classes. Class can be defined according to NDVI study. There is interesting relationship between C and NDVI; NDVI from 0 to 1 represent the denser vegetation while C from 0 to 1 represent barer soil. De Jong et al (1999); Lin et al (2002; 2006), Knijff et al (2002) and Suriyaprasit (2008) in their research try to correlate C factor with NDVI. De Jong at al (1999) and Lin et al (2002, 2006) found a linear correlation between NDVI and C, while Knijff et al (2002) and Suriyaprasti (2008) found that correlation between C factor and NDVI is in a nonlinear form with exponential function (Sulistyo et al 2011). Sitanala Arsyad (1989) compared nonlinear exponential function to linear function with correlation value 0.08 for linear and 0.84 for nonlinear function. According to earlier research the background C factor calculated from NDVI is as in the following chart.
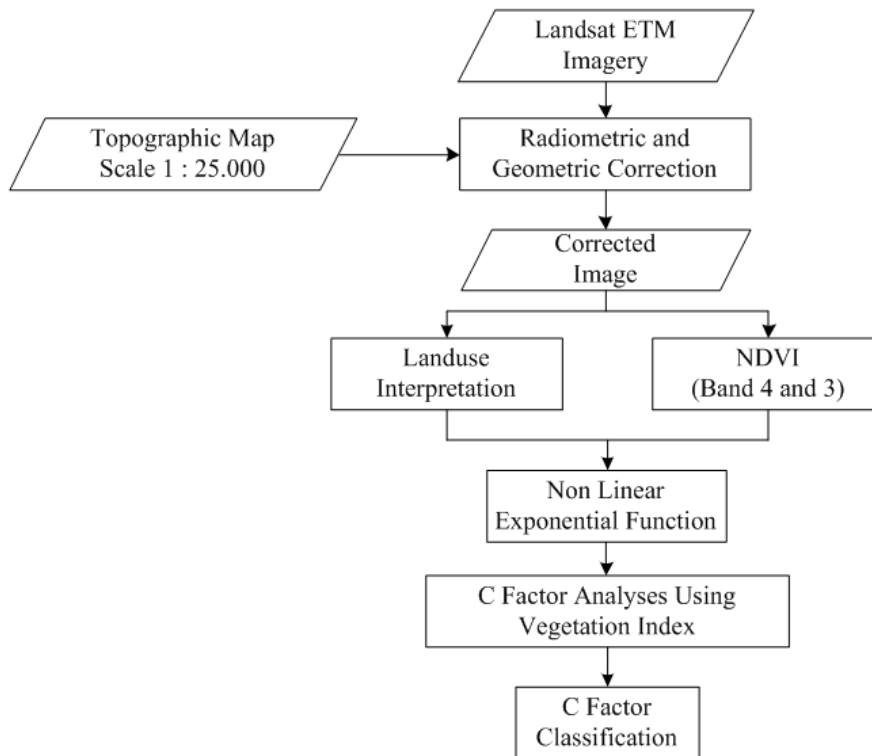
Figure 4: C factor flow chart from NDVI

Considering correlation value of non linear exponential C factor calculated using equation (Sulistyo B. ; 2011) ;

$$Y = ae^{(bX)} \qquad\qquad (6)$$

Where :

Y = C Factor

For this research we replace X withNDVI Value.

2.3.5 Treatment Factor (P)

Treatment factor P is a specific conservation factor applicable to the study area. It is a ratio of soil erosion of soil with conservation treatment like terracing, crop pattern to total soil erosion managed in line of slope in identical circumstances. For this research P factor is considered as 1. P factor is related strongly with land conservation.

3 Analyses and Result

An erosion level distribution analysis was performed using ArcGIS, which integrates all factors related to erosion in the geospatial database. All factors like slope, soil type were converted from polygon data into point data as we have for C factor, which is C factor derived from NDVI. Landsat was in pixel format, so we converted all data to point format and geospatially calculated using RUSLE model to obtain erosion values.

Spatial analyses result show that the study area is dominated by two regencies, Bandung regency and West Bandung and another 6 regencies and we classified it into five erosion levels ; very low erosion (< 15 ton/ha/year), low (15 – 60 ton/ha/year), moderate (60 -180 ton/ha/year), heavy erosion (180-480 ton/ha/year), very heavy (> 480 ton/ha/year). This classification refers to erosion velocity prediction (ton/ha/year) and soil destruction control policy for biomass production with stress on soil solum criteria and critical erosion threshold and to Erosion Hazard Level reference.

Spatially erosion value distribution as the result of RUSLE modeling for whole of study area figure out as follows.
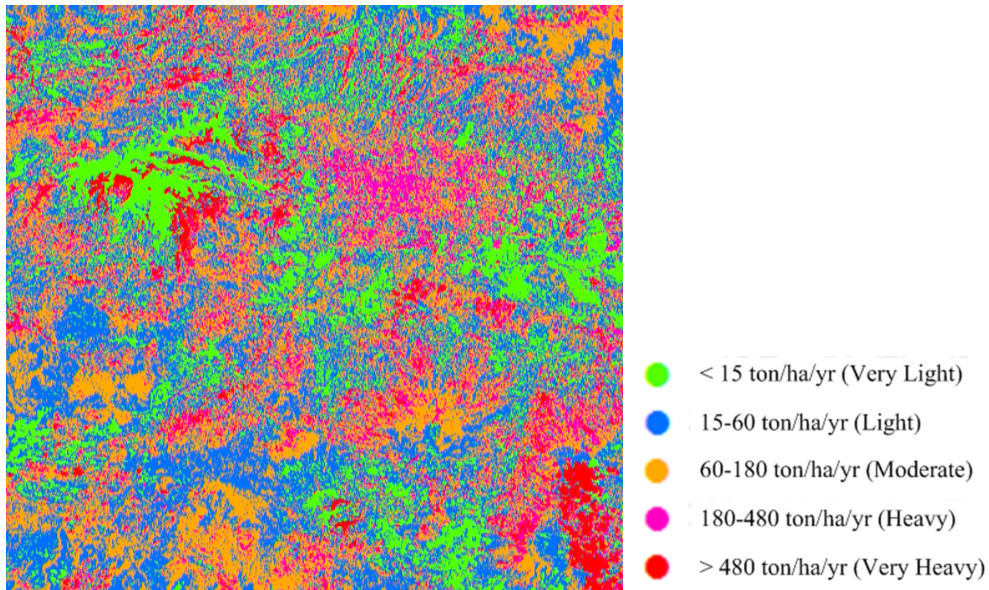
Figure 5: Erosion spatial distribution in Bandung Basin

It is seen that erosion level generally is in the class of moderate and low with average 37% and 34% of total study area. Heavy erosion class is shown by Garut regency with 27% it is in relation with topographical aspect (LS). In the north of Garut regency high mountains dominate, while the southern part has deep steep slope and is not stable.

Erosion result for Subang regency shows mostly a moderate level in 57% of the area studied. Subang is surrounded by deep steep slopes in the border with West Bandung and Sumedang, the existence of tea plantatios here holds erosion in checl to a moderate level. Overall analyses results are arranged in following table including all study area.

Regency / Town		Erosion Class (HektardanPersen)					Grand Total
		Very Low	Low	Mod	Heavy	Very Heavy	
Bandung Reg.	Ha	23.54	54.6	49.0	14	4.754	146.3
	%	16	37	33	10	3	100
West Bandung Reg.	Ha	14.93	31.5	27.1	7.6	4.994	86.24
	%	17	37	31	9	6	100
Cianjur Reg.	Ha	615	4.77	3.86	740	331	10.32
	%	6	46	37	7	3	100
Garut Reg.	Ha	484	2.63	2.97	1.1	2.669	9.868
	%	5	27	30	11	27	100
Bandung	Ha	1.704	4.30	6.16	4.9	193	17.24
	%	10	25	36	28	1	100
Cimahi	Ha	734	1.39	1.48	673	174	4.445

	%	17	31	33	15	4	100
Subang Reg.	Ha	95	640	1.62	411	73	2.842
	%	3	23	57	14	3	100
Sumedang Reg.	Ha	497	2.08	1.49	209	22	4.293
	%	12	48	35	5	1	100
Total	**Ha**	**42.603**	**102.060**	**93.696**	**30.068**	**13.209**	**281.636**
	%	**15**	**36**	**33**	**11**	**5**	**100**
Average	**%**	**11**	**34**	**37**	**12**	**6**	**-**

Table 4 Spatial analyses result

To validate the analyses results a comparative study of the result with existing erosion map of West Java development and planning bureau for random sampling was done. Statistically C used is in the 5% and 1%. The suitability erosion class and position are compared. For every single erosion stratum we took 50 samples, in total there are 250 samples for the study area. The number of samples is based on normal distribution 3.3logn+1. The sample recapitulation for each class (50 samples) of erosion is as follows:

No.	Stratum	Comp Result	Validation (%)
1	Very Heavy	42	84
2	Heavy	29	58
3	Moderate	48	96
4	Low	47	94
5	Very Low	45	90

Table 5 Sampling result

According to the statistic calculation, sampling result shows data validity variation is on 2.38% or 1.19% for deviation. Based on confidence level the sampling show that for error possibility 5% or confidence level 95% is on 0.191876, meanwhile for 1% or confidence level 99% is on 0.318183.

Statistic Analyses Result			
Mean	0,845	Mean	0,845
Standard Error	0.089209	Standard Error	0,089209
Median	0,92	Median	0,92
Standard Deviation	0.178419	Standard Deviation	0,178419
Sample Variance	0.031833	Sample Variance	0,031833
Kurtosis	3.595099	Kurtosis	3,595099
Skewness	1,88567	Skewness	-1,88567
Range	0,38	Range	0,38
Minimum	0,58	Minimum	0,58
Maximum	0,96	Maximum	0,96
Sum	3,38	Sum	3,38
Count	4	Count	4
Confidence Level (95,0%)	0.191876	Confidence Level (99,0%)	0,318183

Table 6 Statistical analyses

4   Conclusion

Visible and Near Infrared wave range satellite imagery are applicable for erosion analyses by applying nonlinear exponential function to derive C factor value. From all of the six factors in RUSLE model, five factors are

considered relatively static to C factor. C factor correlates to land cover, whereas for the study area population density increases rapidly and changes land cover into significant levels within a short period. At the end this research this can be used for erosion hazard level spatiotemporal analyses. This will take the benefit of satellite imagery, massive, cheap and relatively faster compared to direct survey. On the other side C factor derivate from NDVI is one or other of the factors in erosion modeling using RUSLE till required advanced research to involve another 5 factors derive from satellite imagery.

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Adaptation to the Climate Change and Geographic Information System

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ABSTRACT:

Observational evidence from all continents shows that many natural systems are being affected by regional climate change, particularly by temperature increases (IPCC, 2007) which have been generating impacts on economic, environmental and social sectors around the planet. In order to reduce those impacts, it is required to identify, planning, implementing and monitoring adaptation measurements in the near future. Bolivia is considered as high vulnerable country to climate change where its development has been impaired by climate disasters. It is important to use the scarce financial resource in communities that needed most. GrADS and the use of climate scenarios will give valuable information for the identification of the locations of zones that have a high climate hazards and where the available resources could be used efficiently.

1   Introduction

1.1   The Global Context

According to the Intergovernmental Panel on Climate Change (IPCC, 2007), warming of the planet climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures (0.74 ± 0.18 ºC in the period of 1906-2005), widespread melting of snow and ice (since 1978 the annual average Arctic sea ice extents has shrunk 2.7 ± 0.6 %) and rising global average sea level (1.8 ± 0.5 mm per year over 1961 to 2003). Additionally, during the last 50 years, it was observed that the extreme weather events have changed in frequency and/or intensity.

The increase of the global average temperature of the planet compromises the hydrological cycle around the world, generating different impacts on the social, economic and environmental sectors along the countries, affecting more to the poor people that live on the margins, have limited resources, knowledge and technologies to face them. During the past decades, it was reported that climate change and variability have been affecting the progress of the developing countries, which they felt the burden of the impacts of more droughts, floods, strong storms, and heat waves, taxing individuals, firms, and governments, drawing resources away from development (World Bank, 2012).

The current emission rate of green gas gases, responsible of climate change, shows that in the short and medium terms, it must be expected a series of impacts that affects freshwater resources and their management; ecosystems stability; food, fiber and forest production; costal systems and low-lying areas; industry, settlement and society; and health (IPCC, 2007). Those impacts will be more severe as the years pass, requiring specially from governments to have clear actions to reduce the economic, environmental and social effects. Those actions are knows as adaptation measurements to climate change impacts.

1.2   Climate Change Adaptation Process

Adaptation is a process by which individuals, communities and countries seek to cope with the consequences of climate change, including variability. This process should be considered as a continuous one, since the impacts are not static but dynamic. The basic components of most adaptation process include:

Figure 1: The process of adaptation

Component 1 - Scoping and designing an adaptation project: Involves ensuring – whatever its scale or scope – is well-integrated into the national policy planning and development process. The purpose of this component is to put in place an effective project plan so that adaptation strategies, policies and measures can be implemented.

Component 2 - Assessing current vulnerability: Involves responding to several questions, such as: Where does a society stand today with respect to vulnerability to climate risks? What factors determine a society's current vulnerability? How successful are the efforts to adapt to current climate risks?

Component 3 - **Characterizing future climate risks:** Focuses on the development of scenarios of future climate, vulnerability, and socio-economic and environmental trends as a basis for considering future climate risks.

Component 4 - **Formulating an adaptation strategy:** In response to current vulnerability and future climate risks involves the identification and selection of a set of adaptation policy options and measures, and the formulation of these options into a cohesive, integrated strategy.

Component 5 - **Continuing the adaptation process:** Involves implementing, monitoring, evaluating, improving and sustaining the initiatives launched by the adaptation project.

2   Contribution of the GIS in the Adaptation Process

The objective of adaptation to climate change is to reduce the susceptible degree of a natural or human system to cope with adverse effects of climate change, including climate variability and extremes, not only for the present, but most important for the future. In that sense component 3 – Characterization future climate risk of the adaptation process is so important and where geographic information systems (GIS) can greatly contribute.

During the last decades, there were many researches initiatives to identify tools that allow knowing the future climate, one of them is the climate change scenarios, which is a plausible and often simplified representation of the future climate, and one of the most used tools for characterizing future climate (Nakicenovic, 2000). Each scenario produced is based on the determination of the greenhouse gases emission and evolution in the future. They are organized in four narrative scenario "storylines" to describe alternative future, built on how human societies develop in terms of demographic and economic development, technological change, energy supply and demand and land use change.

For each of the four storyline, several different scenarios were developed using a variety of modeling approaches to examine the range of outcomes arising from the mathematical model. The A1 storyline describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system, distinguished by their technological emphasis: fossil-intensive (A1FI), non-fossil energy sources (A1T) or a balance across all sources (A1B) (where

balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

3   Study Case

3.1   Objective of the Study Case

The objective of the study was to identify the areas in the department[*] of Tarija, which has the highest potential of being affected in the future by climate change, based on current available information.

The department of Tarija is situated on the southern part of Bolivia; it is neighbor of Argentina and has an extension of 37,623 Km^2 and a population of 291,407 inhabitants. Geographically is located on the longitude between 294º and 298º, latitude between -23 and -20.5' and an altitude of 1866 masl.

Due to the topography, Tarija is divided in valleys and tropics with an average temperature of 17 to 23 ºC and 25 to 35 ºC respectively. The rainy season is between December to February. It is classified as an arid and/or semiarid area with a high vulnerability to climate change.

The climate model developed available for the study area was developed by the Meteorological Research Institute (MRI) of the Japan Meteorological Agency and it is identified as MRI/JMA TL959L60, which use the A1B storyline scenario, and categorized as a general circulation model, with a mesh of 20 Km by 20 Km which contains climate data (i.e. precipitation, temperature, wind velocity and direction) for the present conditions (1982-1993) and projected future (2080-2099).

3.2   Climate data Processing

To process the climate data of Tarija, it was used the software Grid Analysis and Display System (GrADS) on UBUNTU, a Linux operation system platform. It was selected to work with the two most important climate variables: precipitation and temperature, for the present and future modeled climate conditions.

Base on the previous studies, there is a higher confidence on the temperature modeling rather on the precipitation one. Additionally, it was found by a research work (Garcia, 2006) that the temperature increase in the zone has the effect of increasing of the water deficit for all purpose. Therefore, for the study case, it was decided that the decisions will be rely more on the temperature data than in the precipitation one.

The GrADS script for the climate processing for this study case is presented in the Appendix. Following will be explained the main parts of the process:

a)   Files used

It was used six files of monthly data, four to depict the precipitation and two for the temperature. The total precipitation, for the present and future conditions is calculated adding the large scale and the cumulus precipitation, which is multiplied by a constant to have millimeter of rain by each month. In the case of the temperature, a conversion from Kelvin degrees to Centigrade degrees was applied.

b)   Setting environmental variables

GrADS requires to set the environmental variables, which include the time frame of calculation (from January to December) and geographic frame in the range of longitude and latitude which includes completely the area of the department of Tarija.

c)   Calculation of the change between future and present precipitation.

Since the precipitation is monthly generated and presented by the model for present and future time, in a period of ten years each, it is required to calculate the total annual average precipitation for the present and future time. For that, it was calculated the average precipitation for each twelfth months of the year and after that added. At the end, it will have a set of ten data for the annual average precipitation for present conditions and other for the future surface rainfall.

---

[*] Bolivia was divided in nine departments, which are the equivalents of a state or a province.

The change in the precipitation over the study area is calculated resting the calculated future to the present precipitation, which is depicted in figure 2.
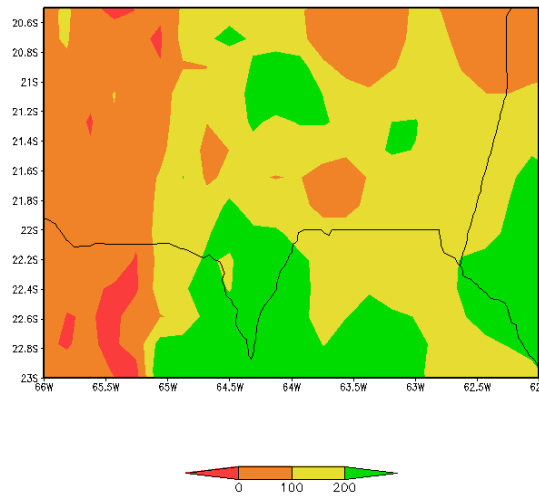
Figure 2: Precipitation Change (Future - Present)

d) Calculation of the change between future and present temperature.
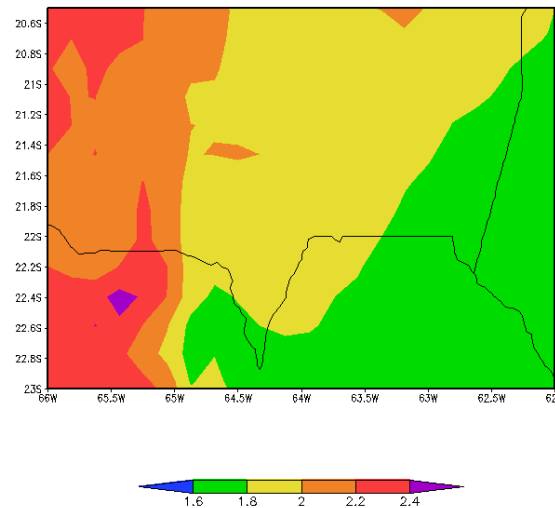
Figure 3: Temperature Change (Future-Present)

The processes of the calculating the change of the temperature between future and present time, follows, the same procedure as precipitation, with the difference that at the end instead of sum the month temperature, it was averaged. The result is presented in figure 3.

e) Calculating the climate hazard index (haz)

Once it was calculated the change in future and present precipitation and temperature, it is required to combine both in one map, using an index, which in its calculation was used the expression:

$$haz = 0.75 * tC + 0.25 \frac{1}{pC} \quad (1)$$

where   haz = climate hazard index
tC = temperature change (future – present)
pC = precipitation change (future – present)

The formula is a weigh sum of the influence of the temperature (75 % of the total) and precipitation (25 % of the total). In the case of precipitation it is computed the inverse value considering the fact that the more the precipitation the less is the climate hazard. The result of the index is presented in figure 4.

Formula (1) is not for the general use, it was establish for arid and semiarid regions, considering that the model depict for the present time better temperature than precipitation conditions.

Though the data was ranked in the scale of 1.4 and 1.6, the color meaning is more important, in which red means high, yellow means medium and green low hazard.
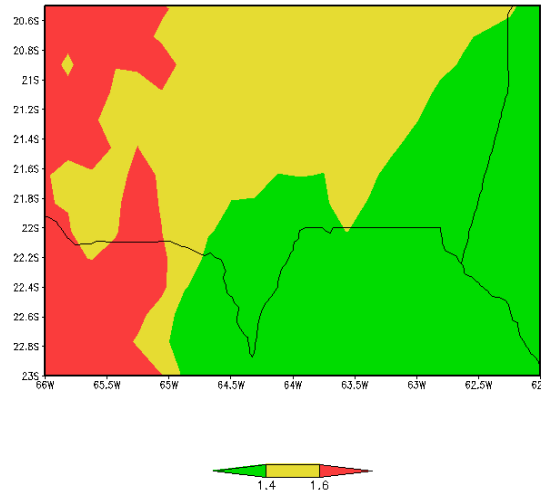
Figure 4: Hazard Ranking for Tarija Province

4   Conclusions

GrADS is considered one of the most used tools for analysis and display climate information. The reliability of the maps generated by it depends heavily on the input data of the models, which at the present contains uncertainties that make it not completely trustworthy for which is used as the only parameter for the decision making process.

Even though, there is the possibility to present all the maps in a more detail rank, due to the mentioned uncertainties, it is advisable to have few aggregated class.

The generated output presented in figure 4, should be used as a theme in a vector geographic information systems, where it must be combined with other layers of information as population growth, distribution of the poorness, human development index, food security maps, which will allow to have a most robust information for defining the communities and/or zones where the adaptation measurements could be carried out, leading to a more efficient use of the scarce resources that developing countries have for reducing the impacts of the climate change and vulnerability.

5   References

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Appendix – Script Code

```
# REINITIALIZATING GrADS
'reinit'
'!clear'

# FILES OPENING
'open /home/jose/TjaGrADS/m2/m2_PPLI_AJ.ctl' ;* Present Large Scale Precipitation
(kg/m*m/s)
'open /home/jose/TjaGrADS/m2/m2_PPCI_AJ.ctl' ;* Present Cumulus Precipitation
(kg/m*m/s)
'open /home/jose/TjaGrADS/m2/m2_PPLI_AK.ctl' ;* Future Large Scale Precipitation
(kg/m*m/s)
'open /home/jose/TjaGrADS/m2/m2_PPCI_AK.ctl' ;* Future Cumulus Precipitation
(kg/m*m/s)
'open /home/jose/TjaGrADS/m2/m2_TA_AJ.ctl' ;* Present Surface Temperature at 2
meters (K)
'open /home/jose/TjaGrADS/m2/m2_TA_AK.ctl' ;* Future Surface Temperature al 2
meters (K)

# ENVIRONMENTAL VARIABLES
'set t 1 12'
'set lon 294 298'
'set lat -23 -20.5'

# -----------------------------------------------------------------------------
#   CALCULATIONS AND MAPPING CHANGE IN PRECIPITATION (FUTURE - PRESENT) IN
PERCENTAJE
# -----------------------------------------------------------------------------
'clear'

# CALCULATING THE AVERAGE MONTHLY PRECIPITATION
' define lip = ave(ppli, t+0, t=120, 1 yr)'
' define cip = ave(ppci.2, t+0, t=120, 1 yr)'
' define lif = ave(ppli.3, t+0, t=120, 1 yr)'
' define cif = ave(ppci.4, t+0, t=120, 1 yr)'

# CALCULATING THE PRESENT AND FUTURE MONTHLY PRECIPITATION
' define pmP = (cip+lip)*3600*24*30' ;* Monthly Present Precipitation
' define pmF = (cif+lif)*3600*24*30' ;* Monthly Future Precipitation

# CALCULATING THE PRESENT AND FUTURE ANNUAL PRECIPITATION
' define pAP = sum(pmP, t=1, t=12)'
' define pAF = sum(pmF, t=1, t=12)'

# CALCULATING THE ANNUAL PRECIPITATION CHANGE (FUTURE - PRESENT)
' define pC = pAF - pAP'

# FORMATING THE PLOT
'set mpdset hires'
'set grid off'
'set display color white'
'set grads off'
'set gxout shaded'
'set clevs 0 100 200'
'set ccols 2 8 7 3'

# DISPLAYING THE MAP
'set t 1'
'display pC'
'/home/jose/TjaGrADS/Script/cbarn.gs'
```

```
# PLOTTING THE MAP - EXTERNAL FILE
'printim precChange.gif'

# ------------------------------------------------------------------------------
#   CALCULATIONS AND MAPPING CHANGE IN TEMPERATURE (FUTURE - PRESENT) IN PERCENTAJE
# ------------------------------------------------------------------------------
'clear'

# CALCULATING THE AVERAGE MONTHLY TEMPERATURE
' define tp = ave(ta.5, t+0, t=120, 1 yr)'
' define tf = ave(ta.6, t+0, t=120, 1 yr)'

# CALCULATING THE PRESENT AND FUTURE MONTHLY TEMPERATURE
' define tmP = tp - 273' ;* Monthly Present Temperature in Degrees
' define tmF = tf -273' ;* Monthly Future Temperature in Degrees

# CALCULATING THE PRESENT AND FUTURE ANNUAL TEMPERATURE
' define tAP = ave(tmP, t=1, t=12)'
' define tAF = ave(tmF, t=1, t=12)'

# CALCULATING THE ANNUAL TEMPERATURE CHANGE (FUTURE - PRESENT)
' define tC = tAF - tAP'

# FORMATING THE PLOT
'set grid off'
'set display color white'
'set grads off'
'set gxout shaded'
'set clevs 1.6 1.8 2 2.2 2.4'
'set ccols 4 3 7 8 2 9'

# DISPLAYING THE MAP
'display tC'
'/home/jose/TjaGrADS/Script/cbarn.gs'

# PLOTTING THE MAP - EXTERNAL FILE
'printim tempChange.gif'

# ------------------------------------------------------------------------------
# CALCULATIONS AND MAPPING THE CLIMATE HAZARD CREATED BY THE PRECIPITATION AND
TEMPERATURE
# ------------------------------------------------------------------------------
'clear'

# CALCULATING THE CLIMATE HAZARD USING DATA OF PRECIPITATION AND TEMPERATURE
' define haz = 0.75*tC+ 0.25*(1/pC)'

# FORMATING THE PLOT
'set grid off'
'set display color white'
'set grads off'
'set gxout shaded'
'set clevs 1.4 1.6'
'set ccols 3 7 2'

# DISPLAYING THE MAP
'display haz'
'/home/jose/TjaGrADS/Script/cbarn.gs'

# PLOTTING THE MAP - EXTERNAL FILE
'printim HazardIndex.gif'
```

Desktop and Web GIS Based Spatial Decision Support System for the Site Selection of Wind Farms - Applied in the State of Baden-Württemberg (Germany) -

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KEY WORDS: Wind energy, automation, Python, ModelBuilder, ArcGIS Desktop, ArcGIS Server, Arcpy.

ABSTRACT:

Wind energy production is one of the fastest growing sectors of modern economy, leading to the installation of a great number of new turbines all over the world. Planning the exploitation of wind resources entails a complex decision making process including diverse criteria which importance depends not only on the decision makers' interests but also on the geographical area where the wind farm is planned to be installed. This article focuses on the development of two Spatial Decision Support Systems based on Geographical Information Systems in order to assist the decision makers in the preliminary site selection of wind farms.

Both have been designed to automatically perform the spatial analysis required to find the most suitable locations for wind farms, according to the users' criteria and as a Transparent To The User technology, not demanding any knowledge in the involved technologies. The first one was developed as a desktop application adaptable to any kind of wind energy project, extending the functionalities of the software ModelBuilder for ArcGIS Desktop with Python programming language. The second one has been designed as a prototype to be implemented as a Web application with ArcGIS Server in the "Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg" (Germany).

1 Introduction

The interest in renewable energy has increased since the energy crisis of 1973 (Michalak & Zimny, 2011). Reasons like shortage of fossil fuels, external energy dependence and the environmental consequences derived from non-renewable energies have boosted governmental policies to promote the use of renewable resources (Ramirez-Rosado *et al.,* 2008). Wind energy stands out among them, being one of the fastest growing sectors of modern economy (Michalak & Zimny, 2011) and providing a free and inexhaustible resource distributed all over the world.

Planning the installation of wind turbines carries a complex decision making process in which a multi-criteria spatial analysis is essential to ensure the profitability of a wind farm. For example, an installation of turbines far away from roads prevents from visual impact but increases the construction and maintenance costs. Besides, the importance of these criteria depends on the geographical area where turbines are planned to be installed. For instance, the noise generated by turbines usually causes less nuisances in industrial than in urban areas. Furthermore, the installation always involves decisions makers with diverse interests which tend to generate different alternatives for the same project, prolonging the decision making process. Some examples are investors more focused on economical aspects, government on short-term results and ecologist on the environmental consequences.

On the one hand, numerous multi-criteria spatial problems require decision making (Keller & Strapp, 1996) where Decision Support Systems aid in rapidly finding effective solutions (Ramirez-Rosado *et al.,* 2008) due to their analytical capacity and search procedures (Keller & Strapp, 1996). On the other hand, manipulation and visualization of data is also required to generate alternatives and analyze "what if" scenarios. Geographical Information Systems (GIS) offer the perfect technology.

The aim of this project is the development of two GIS based Spatial Decision Support System (SDSS) capable of automatically find the most suitable locations for wind turbines according to the decision makers' priorities. It will be designed as a TTTU (Transparent To The User) technology, not requiring knowledge in the involved

technologies. This way, the specialists in environmental sciences and wind energy shall need only to analyze and choose between the generated alternatives of location.

The desktop application

The desktop application will be designed to assists any decision maker of a wind energy project in the first site selection of wind turbines as well as in the comparison between project's alternatives. Users shall be capable of automatically distribute suitability weights between the most common patterns analyzed by Environmental Impact Assessments (EIAs), without knowledge of the involved technologies thanks to a self-explanatory user friendly interface designed with the GUI programming toolkit Tkinter.

The Web application

The Web based SDSS will be designed for the "Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg" (LUBW), a public institution in charge of environmental, nature and radiation protection, health, occupational and product safety in the State of Baden-Württemberg (http://www.lubw.baden-wuerttemberg.de). It is under the supervision of the "Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg" (UM), the Ministry in charge of environment, climate and energy economics issues, which will be the final user of the developed SDSS. It will be designed as a political tool of assessment in the installation of wind turbines in the State of Baden Württemberg, with the aim of identifying suitable wind resources within the State and reject those located on restricted and protected areas as well as their surroundings, where environmental constrains are the predominant criteria. The application will be accessed through an intranet developed with ArcGIS Server 10.

Therefore, the Web application focuses on Germany, where wind energy is the major renewable resource, being implemented in the State of Baden-Württemberg, one of the States with less installed wind capacity (Weigt, 2009) and whose Government plans to supply a 10% of the total electricity demand with wind power by 2020. This ambitious plan requires the installation of a great number of new turbines owing to the fact that wind supply reached only a 0.8% share in 2009 (Betken, 2011). Furthermore, Germany plans to switch off all its nuclear plants by 2022 (BBC, 2011; Breidthardt, 2011), leading to a shortage of energy that could be replaced with wind energy.

2   Methodology

The Development of the SDSSs starts with the documentation and selection of the main criteria involved in a decision making process for the site selection of wind farms. Once the conceptual design has been developed, these criteria must be processed to identify the suitable locations. Although the required spatial analysis can be performed manually in ArcGIS Desktop, the analysis must be documented as a model in ModelBuilder in order to achieve automation. With the inclusion of model parameters, the users are able to automatically generate different alternatives of location without directly manipulating the ArcGIS software.

Furthermore, the functionality of ModelBuilder must be extended because this application obliges to process all the source data (ArcGIS Help 10), while the number of inputs in a site selection project will depend on the users' requirements and the characteristics of the project. Therefore making the inputs optional is essential. To this purpose, the models have been exported to Python scripts and further programmed in order to complete the expected functionality for the desktop and Web applications.

For the desktop application, a user friendly interface needs to be implemented in order to allow the users to easily modify the model parameters without directly editing the source code. For the Web application, a modification of the models must be performed in order to be able to publish them in the Server, since not all the data types supported by ArcGIS Desktop are also supported by ArcGIS Server (ArcGIS Help 10). Then, a Web application must be created to allow the clients to easily communicate with the server and request the GIS services.

3   Outcomes

3.1   Models: automation of the spatial analysis

Three different spatial analyses for the identification of suitable locations have been automated with ModelBuilder from ArcGIS Desktop 10, connecting the inputs with the appropriate tools and in the sequence required to obtain the desired outputs.

First model: The first model has been developed according to the demands of LUBW as a political tool of assessment in the installation of wind turbines in the State of Baden Württemberg. The tool has been designed in order to allow the users to identify the suitable wind resources within the State and reject those located on restricted and protected areas, being the environmental constrains the predominant criteria. Thus, the final output will indicate the areas where the wind speeds are profitable and no restrictions have been found.

As a request of LUBW, this model has been designed to be tested in the desktop trough a simple Graphical User Interface (GUI) and later modified for its publication in the Server.

Second and third models: They include the most common criteria analysed by the Environmental Impact Assessments (EIAs) of wind farms in order to be applicable to any kind of project for the site selection of wind turbines. These models select the areas where the technical requirements assure the profitability of the wind farm and reject those located on restricted and protected areas. Besides, each analysed criterion adds a percentage of suitability to the final suitable areas, reflecting their importance in the final site selection.

When these models are executed, the users are asked to introduce a percentage or weight for each criterion. This weight is then assigned to the suitable areas but with two different approaches. For the second model, all the suitable areas received the full weight. For the third model, the weight is assigned with the fuzzy membership tool of ArcGIS, being distributed proportionally to how much they fulfill the suitability criteria indicated by the users.

For example, a minimum distance from settlements is applied in order to avoid negatives impacts such as noise or visual impact. The three models will extract the settlements and their surroundings from the final suitable areas. Additionally, the users decide to increase in 10% the weight of those areas outside settlements. While the model 2 would assign the weight 10 to all these areas, the model 3 would assign a value 0 to the boundaries, increasing the weight until 10 in the furthest areas. Hence, the minimization of the impacts with the distance is considered only by the third model.

Therefore, the final outputs of the models 2 and 3 will not only indicate the areas where the exploitation of the wind farm is profitable and no restriction has been found but they will also classify the suitable areas by percentage of suitability. Both have been designed to be accessed as a desktop application through a GUI.

The source data that are used as input to a model as well as some parameters required by the tools have been defined as model parameters. In this manner, every time a user executes a model, a dialog opens asking the users to indicate the inputs and other values such as the suitable wind speeds or a minimum distance from settlements. Thus, each model is automatically executed generating different alternatives according to the input criteria. A list of the created model parameters is given in table 1.

Due to the dimensions of the models, they have been subdivided into submodels in order to facilitate their analysis, management, correction and reuse as scripts during the applications' programming. Therefore each criterion is processed by an independent submodel. A representation of the combination of the different submodels is given in the figures 1 and 2.

	Submodel	Model	Included	Inputs demanded to users
Technical requirements	**1. Wind resources**	1	Yes	2 vectors, 2 SQL expressions
		2 & 3	Yes	4 rasters, 4 where clauses, 4 weights
	2. Slopes	1	No	No considered
		2 & 3	Yes	1 DTM, 1 value of slope (expression), 1 weight
	3. Roads	1	No	2 vectors, 2 distances
		2 & 3	Yes	2 vectors, 2 SQL expressions, 4 distances, 2 weights
	4. Power lines	1	No	No considered
		2 & 3	Yes	1 vector, 1 SQL expression,1 distance, 1 weight
Abiotic impacts	**5. Railways**	1	No	No considered
		2 & 3	Yes	1 vector, 1 distance, 1 weight
	6. Land use	1	Yes	1 vector, 1 distance
		2 & 3	Yes	6 vectors, 6 SQL expressions, 6 distances, 6 weights
	7. Water bodies	1	Yes	1 vector, 1 distance
		2 & 3	Yes	2 vectors, 2 SQL expressions,2 distances, 2 weights
	8. Restricted or protected areas	1	No	No considered
		2 & 3	Yes	5 vectors, 5 SQL expressions, 5 distances, 5 weights
Biotic impacts	**9. Natural protected areas**	1	Yes	13 vectors, 13 distances
		2 & 3	Yes	6 vectors, 6 SQL expressions, 6 distances, 6 weights

Table 1 Summary of the criteria and inputs demanded to the users per submodel and model.

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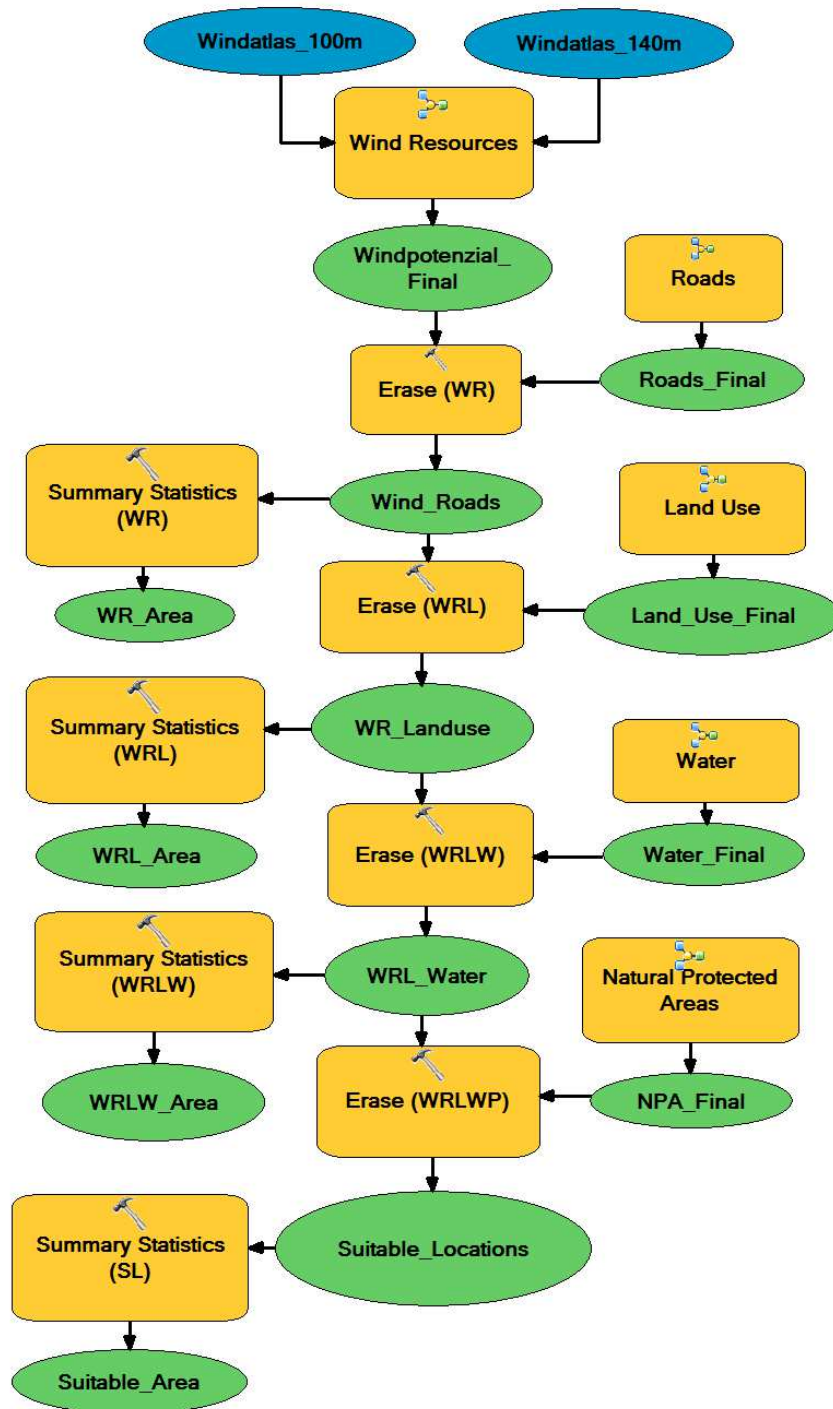Figure 1 Complete model 1. Combination of all the submodels to generate the entire model 1. First of all the submodel of Wind resources is processed in order to identify suitable areas. Then the outputs of the following submodels are erased from these areas one by one with the aim of calculating the reduction in suitable areas after each restrictive criterion is applied (calculated with the tool "Summary statistics").
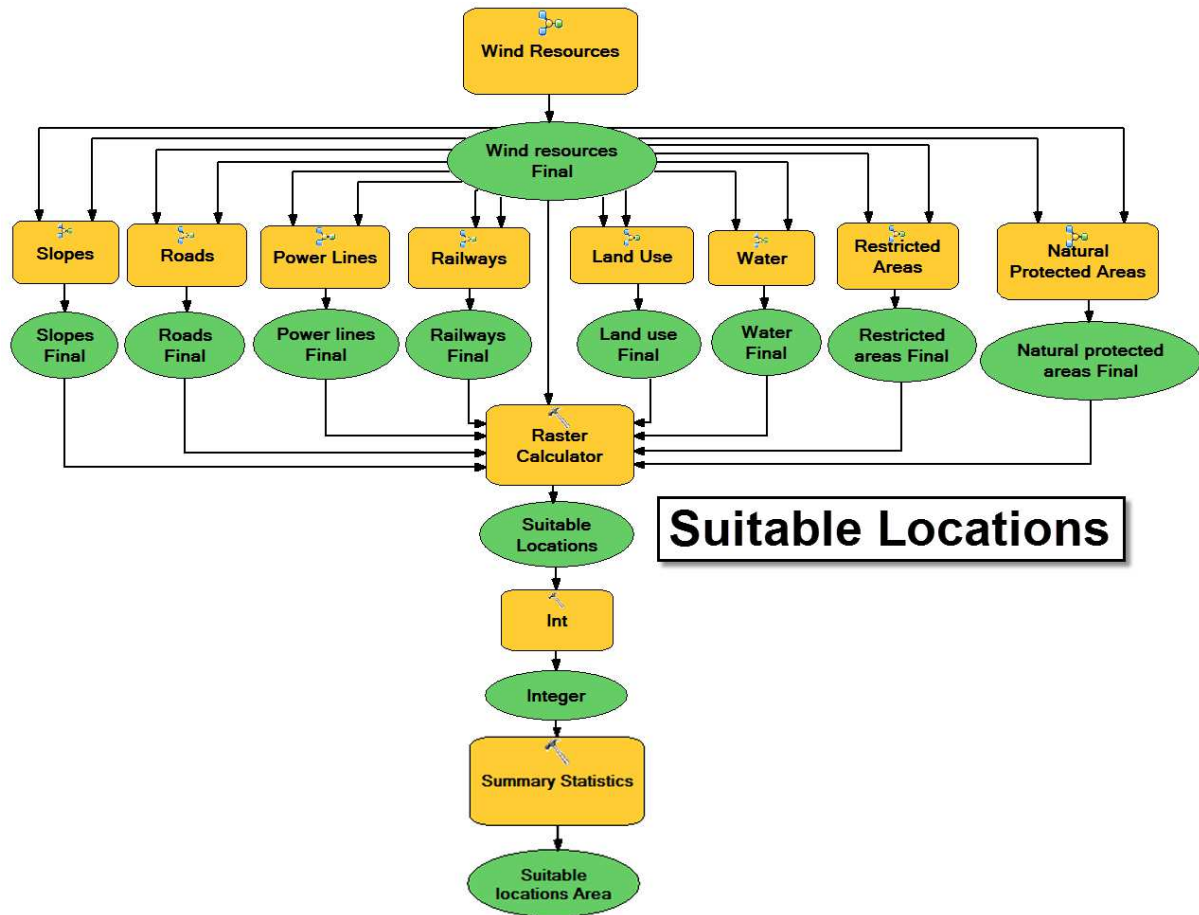
Figure 2 Entire model 2 and 3. Combination of all the submodels to generate the entire models 2 and 3. The desktop application has been designed for any kind of project related to wind farms; therefore the nature and characteristics that the input data will have at the moment of geoprocessing are unknown. For this reason, first of all the submodel of wind resources is processed and the cell size and processing extend of its output will be use by the rest of submodels. Since the model 3 can be considered as a variant of the model 2, the combination of all the submodels follows the same structure. All their outputs are added by the "Raster calculator" tool in order to eliminate the restricted areas and add the suitability weights of each criterion. Afterwards other tools are applied to indicate the users the area of the final suitable locations.

3.2   Desktop application

The desktop application has been developed with the third model in order to give a more accurate distribution of weights, offering two main advantages over ModelBuilder. On the one hand, all the inputs have become optional thanks to a serial of check buttons on the interface and their connection to a system of geodatabases. If a button is selected, the criterion will be processed with the input parameters assigned by the users within the interface. Then, the output generated will be stored in a system of geodatabases which is managed in order to detect and process only the selected criteria.

The other purpose of the desktop application is the creation of a more user friendly interface to the model. After a model has been created and the model parameters are set up, the model can be run in ArcGIS Desktop like other GIS tool, opening a dialog window which requests the users to introduce the input values. ModelBuilder offers the possibility to organize and rename the model parameters in order to make them more intuitive for the users. For example, the figure 3 shows a dialog that opens when running the Land use submodel, which includes 24 model parameters distributed inside a scrolled window. Then if the entire model were run, the number of model parameters would reach 108 input variables listed inside this dialog box.
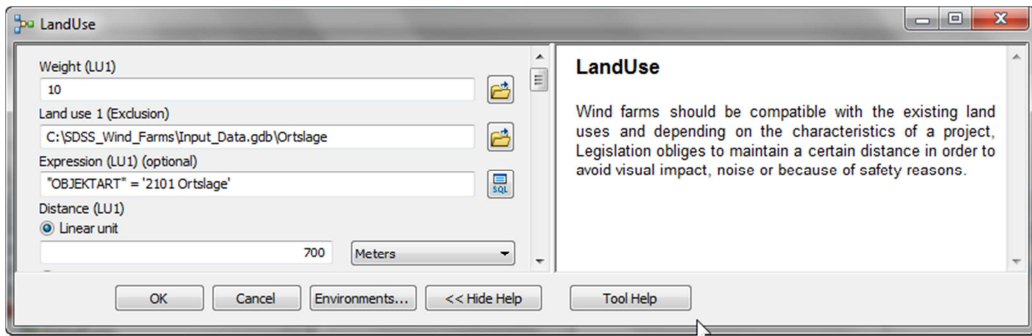
Figure 3 Dialog box for a Land Use in ModelBuilder. This image represents the dialog box which appears when running the submodel of Land Use for models 2 or 3 from ModelBuilder.

In order to create a friendlier interface, a conceptual design of the SDSS has been carried out in order to organize these criteria in a more intuitive structure, as well as to include additional functionality to cover the potential users' needs, such as vector and raster transformations, restriction of the area of study or resampling of rasters... As a result, the submodels have been classified by categories (Technical requirements, Abiotic impacts and Biotic impacts) separated in different views within the interface (see figure 4). Besides, the application automatically generates a map containing the final suitable areas, exported to pdf and opened directly in ArcMap (in case a further editing is desirable).

The application can be installed anywhere in the computer being completely operative after 10 minutes.
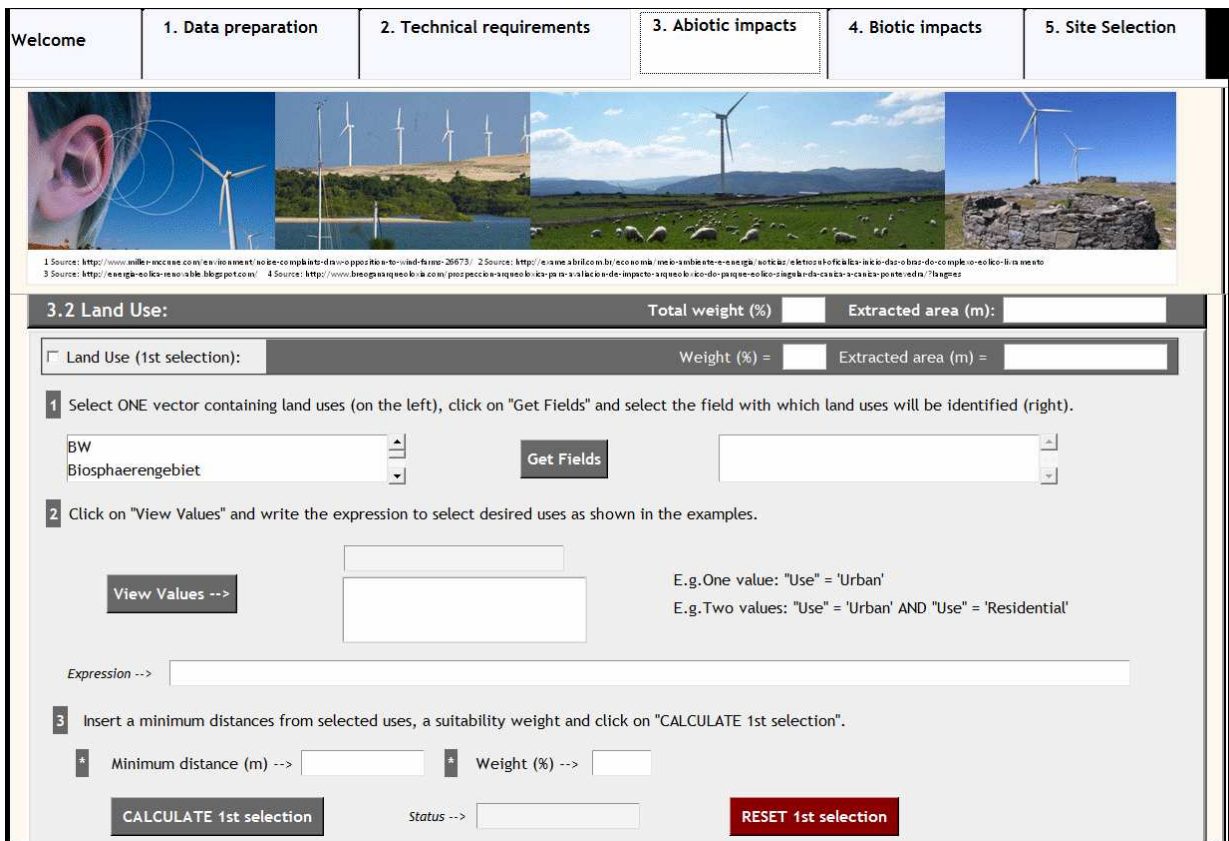
Figure 4 Land Use in the desktop application. This image represents a screenshot of the land use criterion in the tab of abiotic impacts of the desktop application.

3.3   Web application

The purpose of the Web application is to allow the specialists of the UM to perform a site selection of wind farms through their intranet. The GIS services offered by the application are the geoprocessing service in charge of executing the spatial analysis required for the site selection as well as a map service capable of displaying the inputs and the final output.

In order to publish the geoprocessing service, the model of LUBW must be modified since all the inputs are feature classes, which are not supported as model parameters. In this case, the tool "Select Data" from ModelBuilder, which allows users to access all the shapefiles stored in the input database, has been placed at the top of the model. Then, the possible selections have been transformed to model parameters, allowing the clients to indirectly select a feature class by selecting a string which is sent to the server in order to indicate which input to process.

Afterwards, the model has been inserted into a map document in charge of displaying its inputs and output, making them accessible to the clients. In this manner, the map service and the toolbox containing the model can be easily published either through ArcCatalog or the Server Manager.

Finally, the Web application has been developed with the Server Manager, which offers a simple and fast method of Web application design (see figure 5). The purpose of this Web application is the confirmation that the geoprocessing service can be accessible by the clients. Afterwards a more complex Web application is planned to be developed by LUBW in order to make all the inputs optional, following a similar methodology than the desktop application but in a different developer platform.
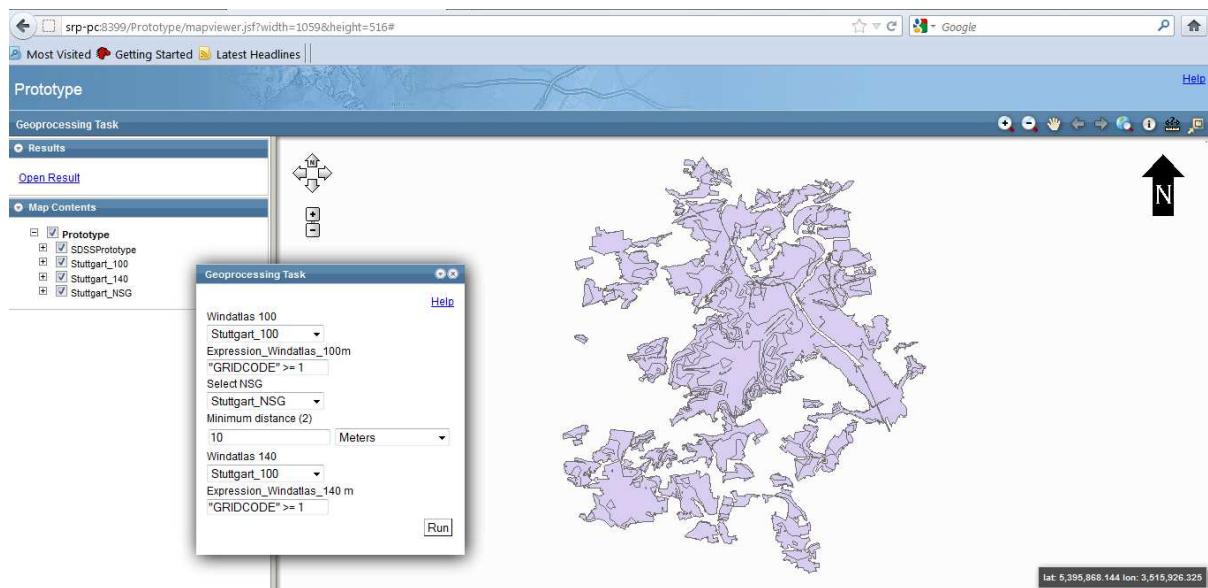
Figure 5 Web application developed with Server Manager. This figure represents a prototype of a Web application including the geoprocessing of the wind resources and the natural protected areas.

4   Conclusions & Discussion

Design and development of the SDSSs

ModelBuilder provides an interface where easily build and edit geoprocessing models, being capable of documenting the workflow required to find the most suitable locations for wind farms. Besides, it includes the definition of model parameters which allow the users to automatically generate diverse alternatives according to the input criteria.

The three developed models identify suitable wind resources where none restricted or protected elements are located. In addition, the models 2 and 3 assign percentages of suitability to those areas, reflecting the importance that each criterion has for the users.

The comparison between the three models showed that the more information included in the decision making process, the more chances to find the most suitable location for the wind farms. Thus, the model 3 provides the most accurate analysis. But also the more complex and flexible the model, the more time is required in the geoprocessing and the more model parameters are required. Therefore, the choice between the three models should take into account the needs of the clients. For example:

- For environmentalists, the first model is able to rapidly confirm that a wind project respects all the minimum distances included in the legislation in order to protect natural areas.

- In the case of a Government, the second model could be precise enough to assure that not only the technical requirements are being taken into consideration, but also that the wind farm will have a good acceptance between the citizens because the negatives impacts have been minimized, such as noise or visual impact.

- On the other hand, the model 3 probably will be the best choice for the investors because the more information is analyzed, the more chances to find the most profitable location.

Development of the desktop application

Python is able to connect Graphical User Interfaces developed with Tkinter to Python scripts generated with ModelBuilder. Therefore, all the models designed in the previous phase could have been programmed to be executed from the GUI of the desktop application.

Although Tkinter provides a platform sufficient to develop GUIs, it showed limitations during the development of the application and in consequence, its functionality needed to be extended with the tix module. Other libraries for the development of the interface could have been used, but Tkinter and tix were chosen because both are included into the installation package of ArcGIS. Thus, the users do not require additional installations.

After connecting the GUI with the corresponding model, the desktop application adopts the same GIS functionality than the models, being able to access the values demanded by the model parameters with the values inserted in the interface. Moreover, the desktop application was further programmed to extend the functionality of ModelBuilder by making all the inputs optional, offering a more user friendly interface and not demanding knowledge in the involved technologies.

In this manner, the application has been designed to be adaptable to any project related to the site selection of wind turbines. Actually, this application allows the experts on wind energy and environmental sciences to find the most suitable location for wind farms without manipulating the source code or needing to learn ArcGIS. Their expertise is still essential since a deep and long study is needed in order to give a meaningful value to the model parameters. But on the other hand, if these values are documented in a report, any user will be also able to fulfill the application and get the same results.

Furthermore, the desktop application gives to the users the freedom to place the software anywhere in the computer, since the operating system module was successfully applied to locate the paths demanded by all the elements of the application. Actually the application takes 10 minutes to be copied from one computer to another; being completely operative afterwards.

As disadvantage, the software cannot be run as a standalone application since the arcpy module is imported into the code, consequently ArcGIS's license is still required and the software must be installed in order to execute the application. Besides, the application can only run on windows platform because of ArcGIS Desktop's requirements.

Between the numerous functionality provided by ArcGIS, the arcpy module was implemented to manipulate an existing map document to contain the final output of the site selection in order to make it inherit a predefined layout and symbology. Thus, arcpy allows users to export the final output to a map document and a pdf (other formats are also supported such as GIF, JPEG or TIFF), being easily printed.

Development of the Web application

The Web application allows clients to access the same GIS functionality included in the model 1. Thus, the users are able to find the suitable wind resources where no restrictive criteria are located and just through a Web browser. The great advantage is that no ArcGIS license is required to perform the site selection since the application will deposit the costs of the software license on the server side, dismissing the temporal and local barriers for the potential clients of the SDSS.

But in the case of LUBW and UM, the Web application is intended to be accessed through the intranet of the UM and they are responsible of the costs of the ArcGIS Server license. Therefore, another possibility would have been the direct use of the desktop application since the costs of ArcGIS Desktop license are much smaller and the software takes only 10 minutes to be installed. Besides, the site selection is going to be performed always with their input data which do not required a constant update, consequently the advantage of ArcGIS Server in offering the most up to date data is dismissed.

On the other hand, although the installation and configuration of ArcGIS Server 10.0 generated many difficulties, ArcGIS Server allowed a fast publication of the GIS resources and a fast development of the Web application.

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Javan Gibbon (Hylobates Moloch) Distribution and Population Estimation Using Maximum Entropy

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ABSTRACT:

Information on distribution and population of Javan Gibbon (Hylobates moloch) is needed to assess its conservation status. Javan Gibbon was listed as Critically Endangered Species in 1996 due to its population below 400 individuals in the wild. The population number was based on the number of individuals encountered during field surveys. Its status was changed to Endangered in 2006 due to the increase in population estimation to 4,000 - 4,500 individuals. It was based on the number of Javan Gibbon found in the assessment of the Javan Gibbon population in its known areas of occurrence during 1994 - 2002. The result was then extrapolated to estimate total population by using existing forest cover (Nijman 2004). The use of existing forest cover as the extent for population estimation was ambiguous which could result in over-estimate population estimation. This is due to the reason that not every part of the forest has equal probability to be used as Javan Gibbon habitat. This research was carried out to estimate Javan Gibbon distribution and population by defining its habitat variables from previous researches. These variables were used to estimate the distribution and population of Javan Gibbon in West Java using Maximum Entropy (Maxent) Model. The Maxent model shows (AUC=0.938, SD=0.014) that elevation, the distance from road and temperature are important variables that define Javan Gibbon distribution. The result shows lower population estimation (567) than current number (4,000 - 4,500). Although the distribution and population estimation from this research could not be used as an input for defining conservation strategy of Javan Gibbon, species distribution modeling (i.e, Maximum Entropy) can be utilized as a precautionary measure for Javan Gibbon distribution and population estimation.

Disaster and Risk Management

Developing Vulnerability Indicators and Assessing Spatial Vulnerability to Floods

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ABSTRACT:

Vulnerability assessment is a significant component of effective disaster management. Following the Hyogo Framework for Action 2005-2015, countries need to identify appropriate vulnerability indicators and to assess the impact of disasters. Vulnerability assessment is a prerequisite for disaster risk reduction and capacity building of communities. It can play an important role especially for developing countries to achieve the Millennium Development Goals (MDGs). At present, no standard method of vulnerability assessment exists. Different scientific communities follow different approaches. In this paper, the author presents a grid-based approach for spatial vulnerability assessment to floods with special reference to Bangladesh. Some advantages of a raster (or 'grid')-based approach are demonstrated particularly to overcome the problems of data availability and to increase the transferability and applicability of a spatial vulnerability assessment. At first, a GIS-based approach is developed to transform census-based population data to 100x100 m population grids. Different vulnerability domains and indicators are selected in consultation with disaster experts, stakeholders, and the community people. As vulnerability is multidimensional, a comprehensive approach is followed, which reflects various physical, social, economic and environmental factors. Relative weights are assigned to the selected vulnerability domains and indicators on the basis of expert opinions using the Analytic Hierarchy Process (AHP) and pairwise comparisons. Then spatial vulnerabilities are assessed using the GIS weighted overlay techniques. Finally, the author presents some key findings and discusses the transferability of the approach to other areas.

1 Introduction

1.1 Motivation

Vulnerability assessment is increasingly being considered as a key step towards effective disaster risk reduction (Birkmann, 2006). In many vulnerable countries, disaster management is usually concentrated on disaster relief, response, and rehabilitation activities. Several studies suggest that a paradigm shift is needed from disaster relief and response to disaster risk and vulnerability reduction (Birkmann, 2006; Yodmani, 2001). Realizing the importance of disaster risk and vulnerability reduction, the United Nations in 1989 declared the 1990s as the 'International Decade for Natural Disaster Reduction (IDNDR)'. Over the past years, the international community has placed more emphasis on a collective requirement worldwide to increase the understanding of vulnerability and develop methodologies and tools for its assessment.

The final declaration of the World Conference on Disaster Reduction (WCDR) in 2005 in Kobe, Japan came up with the Hyogo Framework for Action (HFA) for the period 2005-2015. It underlined the necessity to develop vulnerability indicators in order to enable decision-makers to assess the impact of disasters (UN, 2005). The Hyogo framework emphasises that there is a close relationship between vulnerability assessment and sustainable development. Sustainable development is characterized by the three main pillars: social, economic, and environmental (UN, 1993). The Hyogo framework underlines that impact of disasters on (1) social, (2) economic, and (3) environmental conditions should be examined through necessary indicators. As per the strategies adopted by the Hyogo framework, respective countries need to develop vulnerability indicators as a key activity.

In addition to the Hyogo framework, respective countries need to achieve the Millennium Development Goals (MDGs) within the target deadline of 2015. Disaster risk reduction (DRR) is a key strategy especially for vulnerable countries to achieve the MDGs. The countries need to ensure the reduction of risk and vulnerabilities in order to achieve the millennium development goals within the deadline. The achievement of the MDGs within the target deadline will be unsustainable and difficult if DRR is not properly ensured. For example, frequent natural disasters such as floods, cyclones, earthquakes, etc may deteriorate the poverty situation and affect the overall development of vulnerable countries. As a result, the achievement of the MDGs of these countries may be obstructed or delayed (Vashist and Das, 2009).

Vulnerability assessment is a prerequisite for disaster risk and vulnerability reduction. It plays an important role to identify the extent and level of vulnerabilities and coping capacities to disasters within the communities. This paper presents a methodology for developing vulnerability indicators and spatial vulnerability assessment to floods with special reference to Bangladesh. The methodology incorporates different physical, social, economic, and environmental indicators for spatial vulnerability assessment to floods.

1.2   Statement of the problem

Almost all the countries in the world are prone to one or more forms of disaster. Frequent occurrence of natural disasters causes huge loss of lives, properties, and physical infrastructure. It also causes socio-economic disruptions and environmental degradation in the affected communities. Disaster statistics indicate that the frequency and intensity of extreme natural events have increased in recent years (UNDP, 2004). The Least Developed Countries (LDCs) and coastal areas are particularly vulnerable to the impacts of natural and climate-induced disasters. The Asian Tsunami as well as the tremendous impacts of hurricane Katrina in New Orleans point out the special vulnerability of coastal zones, their inhabitants, economics, and ecological systems (Kaiser, 2007). Coastal areas are at great risk due to climate change, an accelerating sea level rise, salinity intrusion, erosion, an increase of extreme natural events, etc.

Different studies indicate that the occurrence of disasters is almost unavoidable. However, timely and appropriate measures can help reduce the adverse effects and negative consequences caused by disasters. The consequences of a disaster event such as flood or cyclone depend on vulnerability of affected socio-economic and ecological systems (Cutter, 1996). Therefore, vulnerabilities of different socio-economic and environmental systems need to be properly assessed. In addition, vulnerability and risk maps based on proper vulnerability assessment may help decision makers to adopt appropriate policies and actions (De Bruijn and Klijn, 2009).

Though the assessment of vulnerabilities is essential, it is complicated due to the social, economic, political, and institutional patterns of societies (Villagrán, 2008). At present, no standard model/methodology exists to carry out spatial vulnerability assessment (Thywissen, 2006; Alwang et al., 2001; Brooks, 2003). Different scientific communities follow different approaches for spatial vulnerability assessment. Additionally, vulnerability and risk assessments are not properly done and available in many disaster prone countries. For example, Bangladesh being one of the most flood prone countries in the world lacks proper vulnerability and risk assessment. In maximum cases, the analysis of disaster damages mainly focuses on the economic evaluation of tangible effects, and important social and ecological aspects of vulnerabilities are neglected.

Therefore, it is a challenge to develop a wider perspective for vulnerability assessment including physical, social, economic, ecological, and other important factors. Several studies suggest that there is necessity to develop a comprehensive methodology for spatial vulnerability assessment. The potential methodology should incorporate relevant vulnerability indicators and appropriate approaches for spatial vulnerability assessment. In addition, vulnerability assessment should be conducted at the appropriate level/scale.

1.3   Grid-based spatial vulnerability assessment

The selection of appropriate approach and methodologies is important for spatial vulnerability assessment to disasters. Most existing methodologies used for vulnerability assessment are based on administrative units/boundaries. The administrative units are used as the operational unit for vulnerability and risk assessment. But in this approach, detailed spatial variation of hazards and damages are overlooked. This approach also suffers from a classical problem of geography - the modifiable area unit problem (MAUP) (Su et al., 2005). On the other hand, grid (raster)-based approaches have many advantages over the administrative boundaries for spatial vulnerability assessment. Additionally, a grid-based method is useful for monitoring of vulnerability over the periods and incorporating new indicators or components.

Over the past years, a number of initiatives have been undertaken by the scientific communities to develop the techniques to transform population vector data based on census counts to raster data especially at the global

level. The first global population density estimation in raster format was developed under the requests from the international agriculture research institutes (Deichmann, 1996). The Centre for International Earth Science Information Network (CIESIN) at Columbia University has developed the "Gridded Population of the World" (GPW), a large-scale data product that demonstrates the spatial distribution of population across the globe at a resolution of 2.5 arc-minute (5 km). In addition, the centre also developed the Global Rural-Urban Mapping Project (GRUMP) population dataset at a resolution of 30 arc-seconds.

In another initiative, the LandScan dataset developed by the Oak Ridge National Laboratory (ORNL), USA provide population density grids at the global level at approximately 1 km resolution through an interpolation method. In this approach, the allocation of population is based on weighting computed from slope categories, distance from major roads, and land cover. From the currently available population data in grid formats, it can be noted that the resolution of the data is relatively coarser. Therefore, these population datasets are not really useful for different applications especially at the local/community level, and more precise population density datasets at finer scales are essential. In addition, grid dataset for some socio-economic indicators such as income, health, water, sanitation, poverty, etc are not available from the existing initiatives.

2   Study area and data

2.1   Study area

Dacope, an upazila (sub-district) of Khulna district of Bangladesh, is selected to test the developed methodology for spatial vulnerability assessment to floods. The major aspects, which motivated the selection of the study area, are the availability of data, socio-economic characteristics of the area, the level of vulnerability, effects of past disasters, the necessity for flood risk and vulnerability assessment, etc. Figure 1 shows the location of the study area in context of Bangladesh and the coastal area. The study area is located in the south-western and coastal areas of the country. It lies between 22°24' and 22°40' N and between 89°24' and 89°35' E. The study area is divided into a total of 10 unions (administrative units of the local government system in Bangladesh) and 26 mauzas (lowest administrative sub-units).
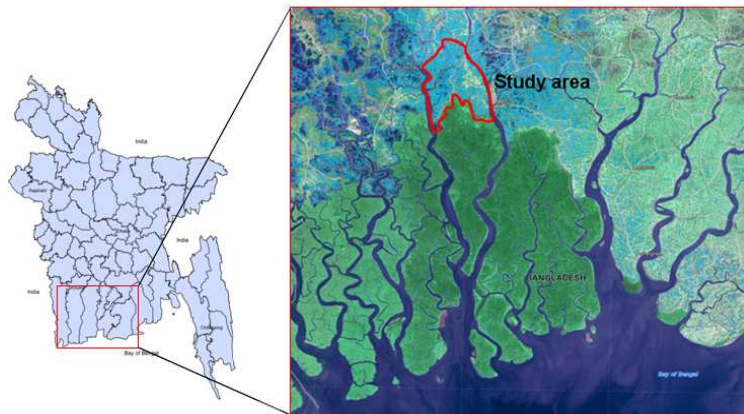
Figure 1   Location of the study area

Figure 2   Physical features of the study area

The upazila occupies a total area of 991.57 sq km including 495 sq km of the Sundarbans reserve forest (BBS, 2001). According to the national population census 2001, the total population of the upazila is 157,489. During the field survey in 2010, the 2001 population census was the latest source of population data for this area. Under the study, the population is projected with the annual growth rate of 1.4 percent to estimate the number of population in 2010. The projected population of the upazila in 2010 is 180,980. The population density is 183 per sq km considering the total area of the upazila including the forest area. But excluding the forest area, the population density of the study area is 616 per sq km. According to the Bangladesh population census 2001, the overall literacy rate of Dacope upazila is 49.34%. Figure 2 shows various physical features of the study area. The road infrastructure of the area is not in good condition. Recent natural disasters like Cyclone 'Aila' in 2009

show that the embankments are highly vulnerable to the impacts of floods, cyclones and other natural disasters. According to the Bangladesh population census 2001, predominant housing structure of the upazila is kutcha (89.81%), which is characterized by housing materials such as mud, thatch, bamboo, etc.

2.2 Data collection

Different datasets such as ancillary data, population census data, GIS data, and a number of satellite images are collected for spatial vulnerability assessment to floods. Population census and other socio-economic data are collected from the Bangladesh Bureau of Statistics (BBS). Population census is usually conducted every ten years in Bangladesh. The national population census 2001 was the latest source of population and other socio-economic data for the study area during the field survey in 2010. The GIS datasets are collected from the GIS unit of the Bangladesh Local Government Engineering Department (LGED). These datasets include different administrative boundaries, rivers, roads, embankments, settlements, educational institutions, health centres, shelters, markets, etc.

2.3 Preparation of grid-based data at finer resolution

Grid-based population and other socio-economic data are essential for the implementation of the grid-based approach for spatial vulnerability assessment. Still, the required grid-based dataset at finer resolution are not available for the study area. Therefore, a GIS-based methodology is developed to transform census population data of different mauzas to population grids (100x100 m). For this purpose, two assumptions are made, namely that people only live within outlines of the settlements, and they are evenly distributed within these areas. The whole methodology is divided into a number of subsequent steps. For this purpose, population census data, settlement data and other geospatial datasets are used. For transformation of census population data into grid population data, geographic information system (GIS) techniques are used.

Under the approach, mauza-wise settlements are identified overlaying the mauza boundaries and the settlement data using the identity method in an ArcGIS software environment. The numbers of population living in individual settlements of different mauzas are calculated. Hence, a vector grid polygon layer with 100 m grid sizes is created using the Hawths Tool in ArcGIS environment. Then the vector grids and settlements having population counts are overlaid using the intersection method. Subsequently, population numbers for the intersected settlements are calculated and these population numbers are then converted into raster grids with 100 m resolution using the 'polygon to raster conversion' method in ArcGIS. Figure 3 shows the prepared population grids (100x100 m) of the study area.

3   SPATIAL VULNERABILITY ASSESSMENT

3.1   Development of vulnerability domains and indicators

Various studies indicate that appropriate vulnerability domains and indicators can play an important role for spatial vulnerability assessment (Kienberger et al., 2009). It is difficult to directly measure vulnerability due to its multidimensional characteristics. For its spatial measurement, different physical, social, economic, and environmental dimensions should be taken into account. For the present study, vulnerability domains and indicators are selected which shall reflect major study area characteristics. This is based on consultations with the disaster experts and the community people and on literature review. The selected indicators particularly address the type of hazard, different dimensions of vulnerability, relative importance of the indicators, and other factors.

Table 1 shows the vulnerability domains and respective indicators selected in the present study for the spatial vulnerability assessment to floods. In total, 12 vulnerability domains are selected and divided into two major categories: nine domains fall into the group 'sensitivity domains' and three belong to 'coping capacity domains'. For each of the 12 domains, a number of indicators are selected to assess and analyse different aspects of the respective vulnerability domain. In total, 44 indicators are selected under the different domains for the spatial vulnerability assessment to floods.

Sensitivity domains	Indicators
Population and age	Population density, Population aged <10 years, Population aged 10-60 years, Population aged >60 years, Population having any sort of disability, Dependency ratio

Livelihood and poverty	Number of unemployed people, People living below the poverty line, People engaged in agriculture, People engaged in small business, People engaged in household works
Health	Distance to nearest hospital, Distance to nearest primary health care facilities, Number of village doctors available
Water and sanitation	Households using pond water, Households using tube well water, Households using tap or filter water, Households having sanitary latrine, Households having no toilet facilities
Housing and shelter	Households having thatched houses using bamboo and mud, Households having houses using corrugated iron sheets, Households having houses using brick or concrete materials, Distance to nearest shelters
Roads and other infrastructure	Distance to major roads, Distance to minor roads, Distance to nearest growth centre or market, Proportion of people having electricity connection
Land use/cover	Agricultural lands, Settlements, River or water bodies,
Environment	Area under shrimp cultivation, Area having salinity intrusion
Gender	Female literacy rate, Sex ratio, Female workers engaged in non-agricultural works
Coping capacity domains	
Assets	Households having radios, Households having televisions, Households having fixed or mobile phones, Households having bicycles, Households having agricultural lands
Education and human resource capacity	Adult literacy rate, School attendance rate
Economic alternatives	Proportion of non-agricultural workers, Distance to nearest city or town

Table 1   Selected vulnerability domains and indicators

3.2 Assigning relative weights

The Analytic Hierarchy Process (AHP) is used under the present approach for making priorities and assigning weights to the selected vulnerability domains and indicators. The AHP is a multi-criteria decision making method that uses hierarchical structures to represent a problem and then develop priorities for alternatives based on the judgements of the experts or users (Saaty, 1980). It provides a comprehensive and rational framework for structuring a decision problem. Under the AHP, pairwise comparisons are used to determine the relative importance of each alternative in terms of each criterion. A pairwise comparison matrix is used to compare and rank the selected vulnerability domains and indicators through the judgements by the experts. A pairwise comparison matrix consists of elements expressed on a numerical scale. The experts are asked to prioritize the vulnerability domains and indicators on the basis of a pairwise comparison weighting scale. The weighting scale consists of nine qualitative terms that are associated with nine quantitative values. The scale enables the decision-maker to incorporate experience and knowledge intuitively and indicate how many times an element dominates another with respect to the criterion.

4   Results and Discussion

Finally, an overall vulnerability assessment is performed using the selected sensitivity and coping capacity domains. For this purpose, the selected sensitivity and coping capacity domains are overlaid using the assigned relative weights within the ArcGIS software environment. Figure 4 shows the overall vulnerability assessment results. The level of vulnerability shown in the figure ranges from least to high. The overall vulnerability assessment results in a significant share of vulnerable areas. In particular, the classes 'most vulnerable', 'medium vulnerable' and 'least vulnerable' account for approximately 1.5%, 25% and 10% of the area, respectively.
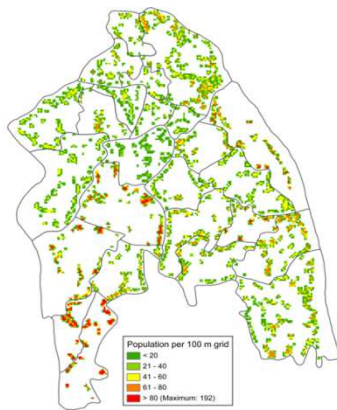
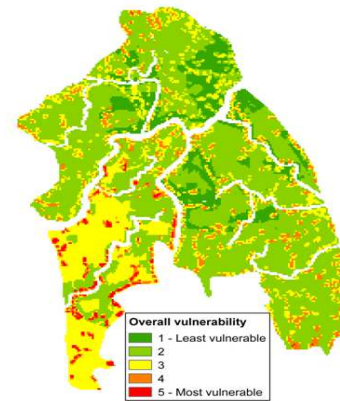Figure 3   Prepared population grids (100 m)

Figure 4   Overall vulnerability assessment result

In general, the south-western part of the study area is more vulnerable than other parts. The major reasons for the high level of vulnerability in this area are poor road infrastructure and embankments, extensive shrimp cultivations, high salinity, proximity to the coast, frequent occurrence of cyclones and tidal floods, high poverty levels, lack of health and safe drinking water facilities, etc. Conversely, the north-eastern parts are assessed less vulnerable due to their proximity to the upazila headquarters and hospital, availability of better road infrastructure, etc.

The vulnerability assessment results based on this approach are promising. It turned out that the AHP method is well suited to effectively differentiate vulnerability to disasters spatially. As this grid-based approach is relatively new, especially for developing countries, there are a number of challenges for its implementation. One of the challenges is the lack of grid-based population and socio-economic data. Recently a number of initiatives are undertaken to develop global grid population dataset such as the LandScan population grid. But the resolution of these population grid dataset is considerably coarser. High resolution grid data are crucial for spatial vulnerability assessment at the local or community level.

5   Conclusion

The paper presents a methodology for developing indicators and spatial vulnerability assessment to floods with special reference to Bangladesh. For the implementation of the methodology, a simple GIS-based approach is developed for preparation of the grid population data at finer resolution (100 m). The developed vulnerability assessment methodology is comprehensive, and it incorporates necessary physical, social, economic, and environmental indicators. The developed methodology can play an important role for spatial vulnerability assessment for Bangladesh as well as other vulnerable nations. This methodology can be adapted to other areas and contexts considering different relevant factors such as local area characteristics, selection of necessary vulnerability domains and indicators, availability of data, study objectives, etc. It is also recommended that appropriate vulnerability domains and indicators should be selected for future vulnerability assessments.

A number of potential areas are identified here for future research in the area of grid-based vulnerability assessment. Firstly, more researches need to develop grid-based population and socio-economic data at finer resolution especially in the context of developing countries. Secondly, grid-based methodologies for vulnerability assessment are still new. More research needs to be conducted in order to establish this integrated methodology for spatial vulnerability assessment. More emphasis should be given to spatial vulnerability assessment to disasters at the local or community level. Thirdly, the development of a grid-based multi-hazard approach for spatial vulnerability assessment seems to be a logical next step. Future research will incorporate hazards such as cyclones, earthquakes, droughts, etc. Fourthly, proper validations of the vulnerability assessment results and the methodology developed are needed. Rigid validation through field checks beyond the fieldwork in this study is indispensable if this approach shall substitute existing vulnerability assessment methodologies.

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Risk Mapping of Bangladesh in Terms of Natural Hazards

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ABSTRACT:

Bangladesh is prone to natural calamities due to its unique geographic location. Every year multiple events strike this tiny country causing significant damages in terms of resources and lives. An effective hazard risk assessment tool can reduce the losses to a great extent. In this study we have made a direct approach to depict each of the hazards by analyzing past datasets such as cyclone, tornado, flood etc. Each of the hazards is classified with respect to potential vulnerability in the form of raster datasets. These raster datasets of each hazard is further reclassified considering the probability of occurrence with a view to bring the vulnerabilities into a common scale. An interpolation is performed based on this common scale to produce an integrated vulnerability map. The vulnerability map is then coupled with the population density in order to obtain the risk map. The output of this study can prove a quick visual impression about the spatial extent of the foretold events. Disaster management professionals, decision makers, policy makers, NGOs and researchers can be benefitted from this study in the realm of risk mitigation and early preparedness.

1   Introduction

Disaster is a very common phenomenon in Bangladesh. High density of population and poverty make the situation even more critical. Our study considered the events like Tsunami, Cyclone Storm Surge, Tornado, Earthquake, Flood & Drought. Having prepared the individual risk maps they are combined to generate an integrated disaster map for the whole country using Weighted Sum Methods. This approach can help the disaster management professionals a lot in regional scale or even smaller context.

2   Study Approach

All of the available raster data sets are projected and re-sampled with a same grid cell size of 500m. The re-sampled data are then reclassified with scale range of 1 to 10 where the maximum cell values indicate the most potential risk. The disaster maps of Cyclone, Tsunami and Storm Surge are prepared by multiplying the Population Density and Euclidian Density to the Shelters while the same are prepare from Flood, Earthquake & Drought by simple multiplication of Population density. These two sets of disaster maps are then combined with a method of Weighted Sum. The integrated disaster map of the whole country is further reclassified for making a district wise index of spatial occurrence. The diagram on the following page illustrates the total process at a glance (Figure 1).

3   Data and Software

Both vector and raster data sets are used for this study the majority being the later. The data sets were in different projections and grid cell sizes; they are rationalized in order to bring them into conformity of the intended purpose. Some of the events prevailed all over the country like flood while others occurs only in the specific zones like Storm Surge prevailing only in the coastal regions. The most of the data we collected from the official website of the Disaster Management Bureau of Bangladesh.

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┌─────────────────────────┐
│      Available Data     │
└─────────────────────────┘
             │
             ▼
┌─────────────────────────┐
│                         │
│         Tsunami         │
│                         │
│         Cyclone         │
│                         │
│       Storm Surge       │
│                         │
│         Tornado         │
│                         │
│        Earthquake       │
│                         │
│          Flood          │
│                         │
│         Drought         │
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└─────────────────────────┘
             │
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┌─────────────────────────────────────────────┐
│  Re-sampling Each Raster Data with 500m cell size │
└─────────────────────────────────────────────┘
             │
             ▼
┌─────────────────────────────────────────────┐
│  Reclassifying each set of Data in a scale of 1 to 10 │
└─────────────────────────────────────────────┘
             │                              │
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┌───────────────────────────────────┐      │
│ Risk map: Cyclone/Tsunami/ Storm Surge │   │
└───────────────────────────────────┘      ▼
       │        ┌─────────────────────────────────────┐
       │        │  Risk map: Flood, Earthquake & Drought │
       │        └─────────────────────────────────────┘
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┌─────────────────────────────────────────────┐
│  Combining Risk Maps into Integrated Disaster │
│         Maps using Weighted Sum             │
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│          Conclusion & Remarks               │
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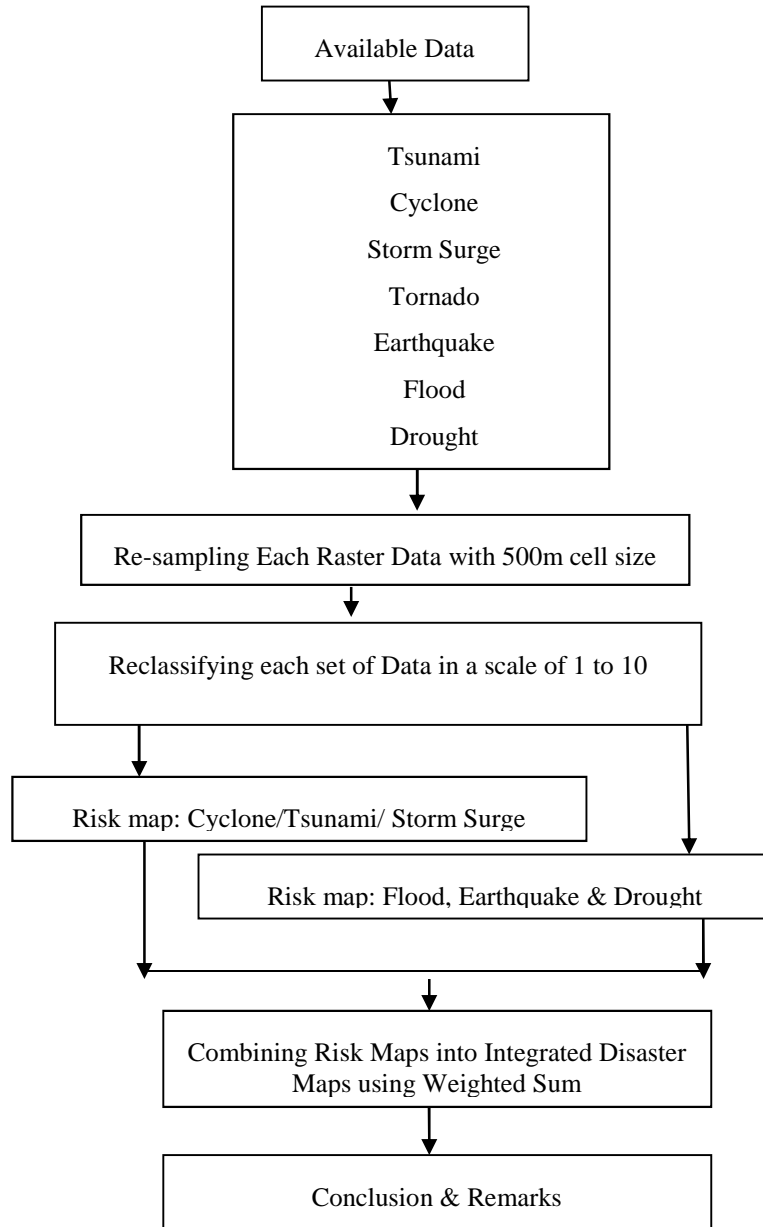
Figure 1 Methods & Approaches of the Study

Data processing and analysis were performed using ESRI's ArcGIS 9.3. In addition the 3D analyst and Spatial Analyst tools were widely used for the accomplishment of the study while MS Excel was used to prepare district level index table.

4   Analysis

This section includes data preparation, analytical procedures, map preparation and result analysis

4.1   Data Preparation

The raster data sets were almost ready for analysis. We have only assigned the intended projection system along with a re-sampling of grid cells of size 500 m. We used Euclidian Distance Tool from the spatial analyst toolbox

in order to determine most vulnerable areas with regards to Cyclone, Tornadoes & Tsunami. The risk maps were brought into a common scale of 1 to 10 with a view to derive the integrated disaster map. The Zonal Statistics as Table is utilized from the spatial analyst tool for performing statistical analysis.
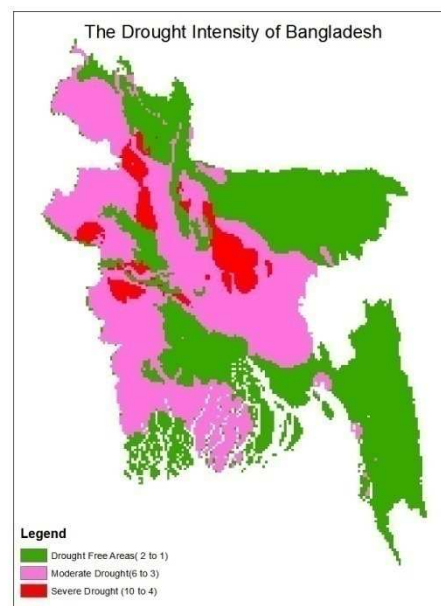
4.2   Analytical Procedures

We have got flood maps with grid cell size of 500 m which is for the year 1998. Each of the Cells has the inundation depth in millimeter. We reclassified the flood depth with Natural Breaks where deepest cell values get the highest score (10) indicating the most vulnerable areas in terms of flooding incidents (Map 1). This risk map is then multiplied by the population density of the particular cell which gives an idea disaster of that location. The above stated method is also used for preparing individual maps for the case of the Drought (Map: 2) and Earthquake scenario. In case of the Cyclone, Tornado & storm Surge another factor of Euclidian Distance from the location of Cyclone Shelters are also used for determining the disaster prone areas. All of the individual classified maps are then combined into a single one with a method of Weighted Sum in order to obtain the integrated disaster scenario map of the whole country (Map 3 & 4).

4.3   Map Preparation

A number of maps have been prepared under this study. After reclassifying the flood depth maps, they are further grouped into three categories like severely flooded having score 10 to 7, moderately flooded having score 6 to 3 and Flood free areas with score 2 to 1. This map provides clear picture of flooding phenomenon for the study area with specific period of time (Map 1). . As percentage of area coverage the severe & moderate category includes the 29 % of the total country.
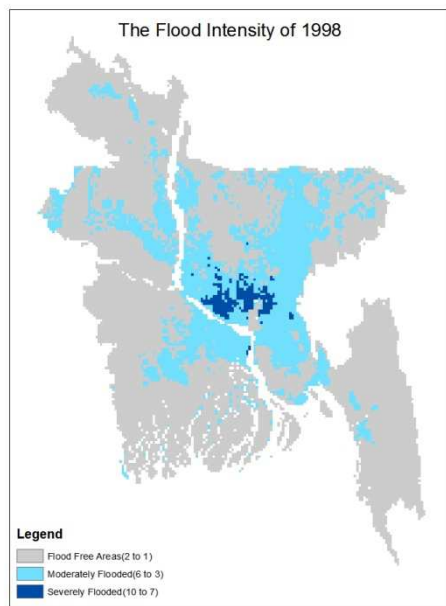
Map 1 Showing the Flood Intensity (1998)   Map 2 Showing Drought Intensity of Bangladesh

The drought map is prepared with grouping of scores from 10 to 7 as severely drought affected, the score 6 to 3 as moderately drought affected and the score value from 2 to 1 goes into the category of drought free areas(Map 2). As percentage of area coverage the severe category includes the 7 %, the moderate category cover 42 % and the risk free zone in terms of drought is 51 % of the total country.

4.4   Result Analysis
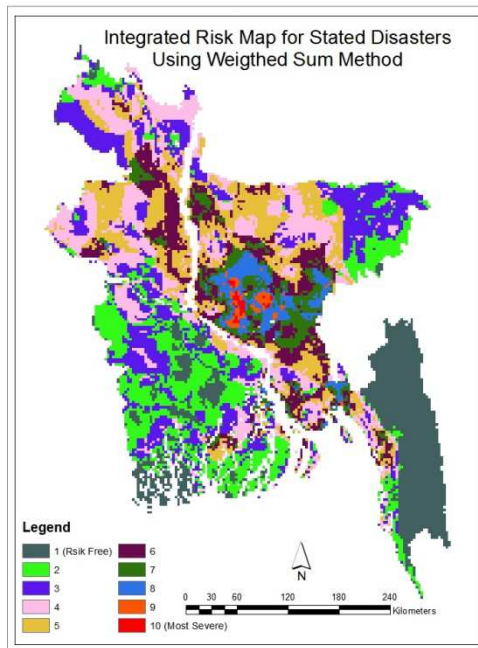
Map 3 Integrated Risk Map (Weighted Sum)   Map 4 Integrated Risk Map, Zonal Statistics(Mean)
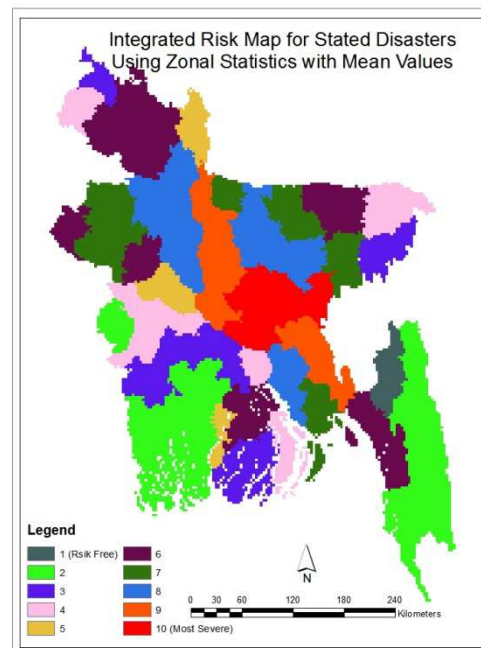
The risk map shows that high risk areas are most densely populated areas of the country. Since hazards are multiplied by population density to assess risk, high hazard intensity and low population density areas could produce high risk zone. But this is not evident for most of the areas, which conforms very uneven population distribution throughout the country. Thus in case of Bangladesh, population density governs over other factors as well as hazards itself in contributing risk. This is why Dhaka, the capital and most densely populated city of Bangladesh has the highest Risk Index (10) according to our study. Disaster prone regions like Shatkhira, Bagerhat, Chittagong hill tracts have low Risk Index for the same reason. There is no risk free district (risk index 1) indicating zones of multiple or single hazards considered throughout the country (Table 1).

4.4.1   Division wise Summary of the Risk Index

The table 2 shows that two of districts in Dhaka division are having highest level of potentials threats in terms of stated events. Dhaka & Sylhet divisions don't have any least potential threat areas.

5   Limitations

Equal weights of individual disasters are considered in this study. Probabilistic and frequency based disaster weighting would produce more accurate result. For risk assessment, more factors of vulnerability should be considered for each hazard e.g., distance of safe drinking water source for flood, structural characteristics of buildings for earthquake etc. Early preparedness facility for hazard could also be included in the risk map. Integrating more natural hazards like erosion, land slide etc. into the combined risk map would be more pragmatic representation of district wise hazard index.

6   Conclusions

This study produces the individual risk map of major natural hazards as well as a multiple hazard risk map. It reveals from the study that population density is the governing factor for delineating risk regions in the context of Bangladesh. Policy makers, urban planners and government can utilize the maps for planning of rational urbanization and lucid population density distribution. Spatial strategy for early preparedness in terms of individual hazards can be adopted also based on prepared maps.

Sl. No.	District Name	Division Name	Risk Index		Sl. No.	District Name	Division Name	Risk Index
1	Barguna	Barisal	3		33	Sherpur	Dhaka	4
2	Barisal	Barisal	2		34	Tangail	Dhaka	4
3	Bhola	Barisal	2		35	Bagerhat	Khulna	2
4	Jhalokati	Barisal	6		36	Chuadanga	Khulna	2
5	Patuakhali	Barisal	3		37	Jessore	Khulna	6
6	Pirojpur	Barisal	4		38	Jhenaidah	Khulna	4
7	Bandarban	Chittagong	2		39	Khulna	Khulna	6
8	B. Baria	Chittagong	2		40	Kushtia	Khulna	6
9	Chandpur	Chittagong	8		41	Magura	Khulna	6
10	Chittagong	Chittagong	2		42	Meherpur	Khulna	6
11	Comilla	Chittagong	2		43	Narail	Khulna	6
12	Cox's bazar	Chittagong	2		44	Satkhira	Khulna	2
13	Feni	Chittagong	2		45	Bogra	Rajshahi	2
14	Khagrachhari	Chittagong	6		46	Dinajpur	Rajshahi	6
15	Lakshmipur	Chittagong	6		47	Gaibandha	Rajshahi	2
16	Noakhali	Chittagong	6		48	Joypurhat	Rajshahi	6
17	Rangamati	Chittagong	4		49	Kurigram	Rajshahi	6
18	Dhaka	Dhaka	10		50	Lalmonirhat	Rajshahi	6
19	Faridpur	Dhaka	3		51	Naogaon	Rajshahi	7
20	Gazipur	Dhaka	3		52	Natore	Rajshahi	6
21	Gopalganj	Dhaka	3		53	Nawabganj	Rajshahi	6
22	Jamalpur	Dhaka	6		54	Nilphamari	Rajshahi	6
23	Kishoreganj	Dhaka	8		55	Pabna	Rajshahi	6
24	Madaripur	Dhaka	6		56	Panchagarh	Rajshahi	6
25	Manikganj	Dhaka	6		57	Rajshahi	Rajshahi	4
26	Munshiganj	Dhaka	6		58	Rangpur	Rajshahi	6
27	Mymensingh	Dhaka	6		59	Sirajganj	Rajshahi	8
28	Narayanganj	Dhaka	10		60	Thakurgaon	Rajshahi	4
29	Narsingdi	Dhaka	6		61	Habiganj	Sylhet	3
30	Netrakona	Dhaka	6		62	Maulvibazar	Sylhet	6
31	Rajbari	Dhaka	4		63	Sunamganj	Sylhet	4
32	Shariatpur	Dhaka	4		64	Sylhet	Sylhet	4

Table 1: District wise risk index for stated hazards.

Divisions	Indexes							Grand Total
	2	**3**	**4**	**6**	**7**	**8**	**10**	
Barisal	2	2	1	1				6
Chittagong	6		1	3		1		11
Dhaka		3	4	7		1	2	17
Khulna	3		1	6				10
Rajshahi	2		2	10	1	1		16
Sylhet		1	2	1				4
Grand Total	**13**	**6**	**11**	**28**	**1**	**3**	**2**	**64**

Table 2: Distribution Risk Index in Six Divisions

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Flood Modeling and Simulations using Hydrodynamic Model and Aster DEM - a Case Study of Kalpani River

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ABSTRACT:

Flooding is the most uncertain phenomena for the mankind. Due to change in climate, the flood frequency and its magnitudes are drastically increased throughout the world. Heavy precipitation in Monsoon over river catchments generates high surface runoff resulting in overflow and thereby ravaging the downtown and its suburbs in addition to inundation of thousands of acres of fertile land. Due to this situation the demand for flood zones and risk mapping through flood modelling has increased. The scope of this study was to model 30 km section of the Kalpani River passing through Mardan district in Khyber Pakhtunkhwa province starting upstream from Mardan city to downstream of Muqam River, and to integrate three fields such as modelling, Remote Sensing and GIS. HEC-RAS One-dimensional model was used for flood modelling and its capabilities were checked for the flood inundation forecasting. HEC-GeoRAS, an extension for ArcGIS was used for pre and post processing of data for model. 3 D coordinates were extracted from ASTER 30 m DEM. Model was simulated for flood 2010 event of 1901 m3s-1 (upstream) and 3361 m3s-1 (downstream) with the known water surface boundary condition. Further model was calibrated by two parameters i.e. contraction and expansion coefficients and Manning's 'n' value, which was derived from the satellite based landuse map of the study area. The average difference between known and computed water surface for model's pre-calibration was 0.64 m which was reduced in calibration up to 0.11m while for model validation average difference between known and computed water surface was 0.10 m. Calibrated Model was simulated with critical depth boundary conditions which proved earlier results. Model was then validated by simulating it for flood 2006 event with known discharges i.e. 1951 m3s-1 (upstream) and 2285 m3s-1 (downstream). Calibration and validation results are within the acceptable limits of Federal Emergency Management Agency (FEMA) i.e. ± 0.2 m. Model results show that river passes through flat topography having average slope of 0.000786 m m-1. Model results show good correlation between the known and computed water surface having correlation coefficient R2 of 0.999 and 0.996 for calibration and validation respectively. Finally model was simulated for 5, 10, 20, 50 and 100 year return periods with critical depth boundary condition and water surface elevation and velocity at each cross-section was calculated. Due to the coarser resolution of DEM, area flatness and river width flood inundation and risk maps were not produced. HEC-RAS model can be used as decision support tool for flood risk reduction.

1 Introduction

Flood hazards are the issues of the 21st century. Recently flood frequency and magnitude are dramatically increased due to the change in climate throughout the world. The climate change influences the rainfall in watersheds, which is a reason for flooding in rivers. Other reason includes deforestation in river catchments which increase the surface runoff, urbanization causes the floodplain encroachments which ultimately influence runoff and flood behaviour. Forest not only offers some resistance to the flow due to which peak discharge are delayed and infiltration rate increases but also control sediment load in the entire river system and associated reservoirs, thereby reducing their overall water holding capacities. The word flood is basically derived from an old English word "flod" meaning overflow of water that inundates the land. Floods are of many types on the basis of their nature such as riverine, estuarine, coastal, catastrophic and muddy flood. Human population as well as economical activities are more often effected by severe flooding in rivers but some time floods with smaller magnitude can also bring useful benefits such as recharge of ground water, enhancement of soil fertility

and nutrients enrichment in deficient soil. Due to low precipitation in arid and semi-arid regions, flood water is the main source of utilization for domestic as well as agricultural purpose. Flood risk can obviously be reduced by moving away from rivers course and other water bodies, however, people have been living and working by the water for their subsistence and capitalizing it for easy and cheap means of travelling and commerce since centuries ago. The humans continued to populate the areas endangered by flood is the evidence that the perceived value of living near the water exceeds the cost of repeated periodic flooding.

Pakistan is a victim of many natural disasters including earthquake, land sliding, floods, and cyclones. However flood is the most common and frequent disaster in the nation history. Pakistan has faced five major floods 1973, 1976, 1988, 1992, and 2010 in history. Being densely populated in Indus basin, the impact of these natural phenomena is widely felt in the country. During the last sixty-three years the country has suffered a cumulative financial loss of more than Rs, 385 billion on account of 15 major flood events and more than 7,800 precious lives have so far been lost, besides dislocation of millions of people (Daily Pakistan Observer, 2010). These flood events usually occurred during the monsoon period (July - September) due to heavy rain in the plains and the catchments of the rivers, coupled with snow melting in the northern areas cause great devastation to lives and livelihoods in Khyber Pakhtunkhwa, Punjab and some parts of upper Sindh. Swat, Nowshera, part of Charssada and Mardan districts in KP province were flooded most frequently by river Kabul and its tributaries in the recent past i.e. 2010, 2008, 2005, and 2002.

2   Motivation

Mardan is the second most densely populated district of Khyber Pakhtunkhwa is always prone to floods due to heavy rainfall in the catchment of hill torrents i.e. Malakand and Buner districts in monsoon due to flat topography. Runoff water drains through various streams passing through Mardan and cause severe damages in the district. Kalpani River is one of the main rivers that causes severe damages and inundates much of urban area due to flash floods every year. Flood 2006 is said to be the worst flood in Kalpani River with the peak flow of 1951 m3sec-1 at Bughdada Bridge. The gushing floods swept away 3,000 houses on both sides of the River in addition to the loss of 100 precious lives. Maximum flood of 3361 m3sec-1 recorded in July 2010 at chowki Risalpur. However, an un-precedent flood of 4814 m3sec-1 has been recorded in 1976 at its outfall near Nowshera which exceeded the 30 years average by 165% due to heavy rainfall of 832mm in its catchment. Kalpani annual runoff is estimated at 954.9 x 106 m3 at Risalpur (Govt. of KP, 2005). These were the reason to choose this study area to model the Kalpani River using HEC-RAS 1D model and to identify the flood affected areas using Geographic Information System (GIS), and to prepare flood inundation maps of the affected areas.

3   Study Area

Mardan the second largest city of the KP province is vulnerable to the flooding from Kalpani River since decades. The total area of the district is 1632 km2 with an average altitude of 283 m. Kalpani River originates from the mountain region of Dargai and Malakand regions and falls into river Kabul at Nowshera after passing through the city centre of Mardan. Major tributaries are Baghiari, Halkai and Muqam Rivers. River Kalpani has catchment area of 2813 km2 and is 70 km long out of which 30 km was selected for study. In general, river flows from North to South in the study area. Flood in Kalpani River occurs more often which cause serious scratch to life and property. Heavy precipitation in catchment varying from 350 mm in the north west of Mardan district to 750 mm in Malakand Agency generates high surface runoff resulting in over flow and thereby ravaging the city and its suburbs in addition to inundation of thousands of acres of fertile land (Govt. of KP, 2005). The floods of 1973, 1975, 1976, 1978, 1997, 2005, 2006, 2008, 2009 and 2010 caused severe damages to human life, houses, livestock, infrastructure and communication.

4   Objective

➢ Modelling of Kalpani River using HEC-RAS 1D model;

➢ To calibrate the model for 2010 historical flood event;

➢ To validate the model for 2006 peak flood data;

➢ Simulation of the model for different return periods; and

➢ To prepare flood inundation maps.

5   Data and Software

5.1   Data

- ➤ ASTER DEM (30 m)   (Web)
- ➤ SPOT (2.5 m) pan sharpened satellite image (SUPARCO)
- ➤ Landuse/ Landcover Map   (SUPARCO)
- ➤ River cross-sections (Irrigation Department Peshawar, KP)
- ➤ Bridge cross-sections (Communication and Works Department Mardan, KP)
- ➤ Hydrological data (Discharge for HQ2, HQ5, HQ20, HQ30, HQ50 and HQ100 years)
- ➤ Historical flood data and water surface height (Irrigation Department Peshawar, KP)

5.2   Software

- ➤ ArcGIS 9.3 with 3D Analyst tool and Spatial Analyst tool (ESRI)
- ➤ HEC-RAS 4.1 1-D flood model (US Army Corps of Engineers)
- ➤ HEC-GeoRAS is an extension for ArcGIS (US Army Corps of Engineers)
- ➤ ERDAS IMAGINE 9.2 (Intergraph)

6   Methodology

Kalpani River was modelled using HEC-RAS 1D Model which does not have the capability to model flow perpendicular to the channel i.e. 2D, however, it works very well for those channels where water remains inside the channel or remains parallel to the channel. HEC-RAS analyzes the stream flow as a series of cross-sections along the channel. Kalpani River section of 30 km length was selected for modelling which passes through the downtown of Mardan city. HEC-RAS requires two types of data i.e. geometric data and hydrological data for river modelling. Geometric data is the important input to the HEC-RAS model as it provides spatial information of the river and its floodplain. Geometric data including river centre line and banks, cross sections, weirs, and bridges was pre processed using the HEC-GeoRAS extension for ArcGIS 9.3. Surveyed cross-sections from RD 3000 to RD 107500 available in hard copy format with 152m step apart were digitized. Digitization and updation of   these cross-sections at right location into the model was a hectic job. HEC-RAS by default inundates all low lying areas even though if there is no overbank flow and this problem was solved by considering cross sections left and right bank as a levee. Bridge structure causes contraction and expansion of river which directly affects the flood water behaviour i.e. from gradually varied flow to rapidly varied flow (which is supercritical condition). ASTER 30 m DEM was used for 3D coordinates extraction for all layers. Processed data was exported to HEC-RAS for the model setup and were edited with help of paper based cross-sections.

Model requires hydrological data i.e. discharge and water surface height recorded at stream gauges for the simulation of a particular profile. Kalpani River 30 km study area was divided into two sections as there is a change of flow at Muqam where Muqam River joins Kalpani. Two gauge stations are located in study area; one at Bughdada Bridge in Mardan city and other at Chowki Bridge near Risalpur downstream of Mardan city. The known water surface data for the year 2006 and 2010 were used in model calibration and validation process, respectively. Boundary conditions are required to keep the starting water surface (upstream and downstream) at the ends of the river network. Return periods including 100 years were estimated by using Weibul's formula (Reddy, 1997) on the basis of available long term historical data with only peaks only annual peak for Kalpani River. Discharge values for a particular water surface height were calculated through stage-discharge relationship curve for upstream and downstream sections. Calculated return periods are placed in Table 1.

$$T = \frac{n+1}{m} \qquad\qquad (1)$$

Where 'T' is Returns Periods, 'n' is the number of the observation, and 'm' is the rank.

Return period	Upstream (m3s-1)	Downstream (m3s-1)
Q5	1105	1420
Q10	1559	2130
Q20	1927	2635
Q50	2400	3400
Q100	2835	3940

Table 1: Kalpani River discharge for return periods

To simulate the HEC-RAS model, steady flow, subcritical regime was selected because most of the real world problems are assumed steady and subcritical. Hydrological data was entered through steady flow data window. Kalpani River consists of single reach. However, there is change in the flow at RD 86500 which was set using "add flow change location" option. Flood 2010 discharge and known water surface i.e. 1901 m3s-1 (9.45 m) for upstream and 3361 (9.45 m) m3s-1 downstream were used for model simulation. HEC-RAS calculate water surface for each cross section while water depths in between cross sections are calculated by interpolation using the water surface at Upstream and Downstream cross sections. HEC-RAS calculate water surface profiles from one cross-section to the next by solving the energy with an iterative process called standard step method. However when water surface passes through the critical depth, then momentum equation is used for the computation. The energy equation is valid only for gradually varied flow conditions. The flow regime is changed due to the changes in the channel slope, bridge, drop structures, weirs and stream junctions.

Model was calibrated by matching the computed water surface with known water surface at each cross-section for the entire study area. Known water surface of flood 2010 was used as reference during calibration. Calibration was done with help of Manning's 'n' value and channel contraction and expansion coefficient as primary and secondary components, respectively.   Kalpani is a natural clean stream with some weeds and most of its bed is composed of fine silt material. Keeping in view the nature of the stream Manning's 'n' values for channel, left and right banks were selected according to land use from the Manning's 'n' standard chart (Dyhouse 2003). Model was initially run for Manning's 'n' of 0.025 and model was calibrated in fifth run with Manning's 'n' value of 0.06. The difference between known and computed water surface was in acceptable range i.e. ± 20cm for most of the cross-sections, hence meeting Federal Emergency Management Authority (FEMA) standard (Farooq 2007). However, there were still some cross sections where results were outside the acceptable limits. Difference between known and computed water surface for such cross-sections were minimized to the acceptable limit by using channel contraction (0.1-0.6) and expansion coefficient (0.3-0.6). HEC-RAS model uses 0.1 and 0.3 for channel contraction and expansion coefficient as default values which represent very gradual change in the channel geometry which is almost negligible. Calibrated model was then simulated for the same flood event with critical depth boundary condition in order to check model behaviour and its impacts on results. Critical depth boundary condition does not require known water surface height as boundary condition as it calculates water surface height using total energy head equation. Calibrated model result shows a strong correlation R2 =0.999 (Figure 1) between known and computed water surface which reflects that model is successfully calibrated.
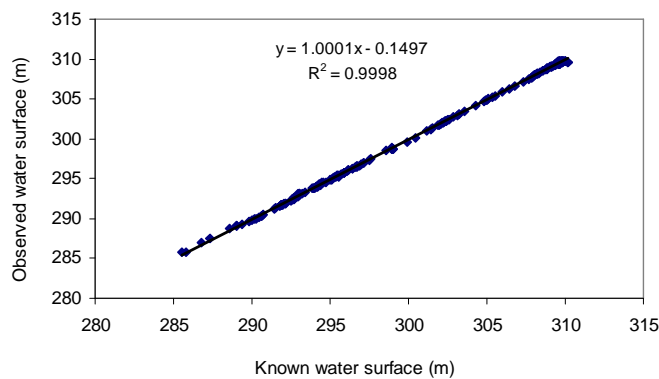

Figure 1 Correlation of Calibrated Output

Model validation is the process of checking the model performance whether it is calibrated correctly or not and provides the way for model's ability to reproduce accurately the known events (May et al., 2000). Model was validated by running the model for flood 2006 known events having discharge and know water surface 1950 (10.06 m) m3s-1 and 2284 (7.92 m) m3s-1for both sections of river with calibrated n-values. The computed water surface is compared to the known water surface. Model result was slightly on higher side for some cross-sections but overall model result was very much in the acceptable limits of FEMA standards. The average known water surface and computed water surface for the year 2006 flood was 302.22 and 301.12 m, respectively. To analyze the gap between the known and computed water surface correlation graph between the data were constructed. Figure 2 shows correlation of R2 = 0.996 between the known and computed water surfaces. Model was finally simulated for five return periods i.e. 5, 10, 20, 50 and 100 year return periods with critical depth boundary condition. HEC-RAS model has the capability to simulate more than one profile at a time
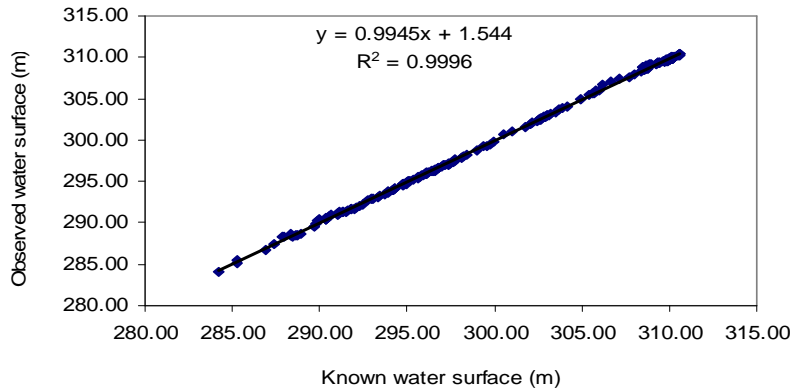

Figure 2 Correlation for validated output

Generally the output of any flood model is the depth, velocity, and extent regardless of their nature i.e. 1D or 2D. HEC-RAS model calculate water surface and velocity at each cross section for main channel and banks (in case of overflow). The output is generated usually in two formats graphical and tabular. Analysis of the model is the important process for understating the model results. The output of the model generally shows how accurately the problem was solved. The graphical output is the easiest way for analyzing the model output. HEC-RAS gives a variety of graphical output from 2D to 3D plots which can be used for analyzing the results. A 3D plot was valuable in the visual validation of data, particularly contraction and expansion of flow through bridges and weirs. Multiple profiles can be visualized in 3D plots and water surface for different profiles can be compared. Typical graphical outputs are cross sections plots, rating curve, and profile plot. In addition to the graphical output HEC-RAS gives tabular outputs. Tabular output gives values of different parameters at each river station for a particular profile. There are two main types of the tabular output in HEC-RAS, detailed output and summary output. Detailed output table provides details about different parameters including channel velocity, depth, surface area, discharge, and reach length etc and can be used to see the behaviours of parameters from one cross section to another. In addition to the detailed output table HEC-RAS gives summary output table for all river station profile wise reflecting Froude No. for each station and profile which was used for verifying flow regime. Due to the coarser resolution of the ASTER DEM which cannot map small river, it was not possible to prepare the inundation maps.

7   Conclusion

Kalpani is a natural, clean stream, and a source of flooding in Mardan city particularly in monsoon. The average slope of river is 0.000786 m m-1 which shows that river passes through very flat topography. Cross sections in the Mardan city (RD 19000- 50000) are mostly narrow with low left bank which is mostly flooded while downstream cross sections are comparatively wider and more stable because of reduction in longitudinal as well as banks slope which make it less prone to scouring. The cross sections data provided by the Irrigation Department of Khyber Pakhtunkhwa was not only in paper format but also un-georeferenced. The cross sections input was hectic job in this study. DEM is the main input for flood modelling as it represents river geometry in addition to the floodplain characteristic and was used for 3D coordinate extraction of the geometric data. Kalpani River was successfully modelled using HEC-RAS 1D Model. HEC-RAS model was simulated for subcritical flow regime because most of the real world problems are considered subcritical. HEC-RAS model was simulated and calibrated for flood 2010 with the known water surface boundary condition. Model was calibrated using Manning's n as primary component while channel contraction and expansion coefficient as

secondary component. Calibration results were within the acceptable limits of the FEMA standards i.e.± 0.20 m. Model output shows that river station from RD 3000-6500, 32500-45500, 54500-64500, 69500-73500, 83000-86000 and 98500-102000 were not in the acceptable limits of ±20 cm. Therefore channel contraction and expansion coefficient were used for calibration of these cross sections as channel contraction and expansion affects river flow. However there were still some cross sections (RD 3000-4000, 53500-56500, 60000 and 98500-102000) which are not in the acceptable limits due to unknown reasons. Calibrated model was validated for the flood 2006 using the calibrated n values. Model result was slightly on higher side for some cross-sections but overall model result was very much within the acceptable limits of FEMA standards. In order to analyze the calibrated and validated model output correlation between the known and computed water surface were computed which shows a strong correlation. Model was simulated for five 5, 10, 20, 50 and 100 year return periods with critical depth boundary condition. HEC-RAS computes water level at each cross section which can be viewed in graphical as well as tabular format for understanding the model behaviour. HEC-RAS model works very well for low slope gradient (May et al., 2000). HEC-RAS model output can be used as decision support tool for flood risk reduction for certain return period i.e. 100-year return period.

There were some limitations including cross sections were too short in length and did not cover the whole floodplain, no return periods were available with irrigation department and were computed statistically using he historical annual peaks, no historical flood extent maps, and non-availability of the high resolution DEM as coarser resolution ASTER DEM does not represent low slop topography very well. Further due to the coarser resolution DEM and flatness of the study area as well as small river width post processing in ArcGIS was not possible. It is recommended that a DEM of 5 m may be used for the post processing. It is also recommend that 2D flood model may be used for comparative study.

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Appropriate Interoperability - from Technical to Socio-Technical

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ABSTRACT:

Emergencies, conflicts and crises are complex and very dynamic situations where the context changes almost continuously, 'unexpected' things can emerge and where many more or less known and identified factors interact with each other. For governments, agencies and humanitarian organizations working in disaster management and intervention to bring about change and to effectively support preparedness, immediate response and early recovery there is the difficult question of what the 'right thing to do' is in these situations. This is because what is appropriate depends on the context and the agencies involved must be able to adapt accordingly. Appropriateness can refer to a wide variety of factors, one of which is interoperability and the degree to which it is enabled. The paper provides a characterization of different types of technical (and social) interoperability needed for various kinds of high-level user scenarios that involve spatial information and their applications. These range from self-contained systems to ad-hoc collaboration in disasters. The characterization indicates that effective support provided by spatial information to human decision-making and operational activities in the disaster context relies on socio-technical interoperability. This includes the ability of those actively engaged in disaster management to adapt themselves and their capabilities to be fitting for the situation and its dynamics. The paper will illustrate these points with practical examples from emergency response contexts.

1   Introduction

1.1   Background

Software interoperability has been described by the OpenGeospatial Consortium as the "ability of locally managed and heterogeneous systems to exchange data and instructions in real time to provide services", where services are the "activity […] performed by a server component on behalf of a client component" (McKee, 2005, p 4).

In line with this definition standards-based open specifications have been developed over the years and successfully tested and implemented for manifold spatial application contexts. Designing and developing spatial information systems that effectively support human day-to-day activities and decision-making with suitable information products relies on the exploration and understanding of the context in which the systems and the information are operating. Based on this understanding and the resulting formulation of user requirements, system requirements are identified and information systems built that are intended to be suitable to the context. In fact, there is more to it than this. These systems and applications actually provide part of the input to what Goodchild (2011, p 2442) calls "critical spatial thinking", where users compare their critical reflection on reality with what the computer seems to indicate.

Emergencies, conflicts and crises, such as the devastating earthquake that struck Haiti in January 2010, are complex and very dynamic situations where the context changes almost continuously, 'unexpected' things can emerge and where this critical spatial thinking is paramount. Many more or less known and identified factors interact with each other. Governments, agencies and humanitarian organizations have been and are continuously looking for the 'right things to do' to effectively support preparedness, immediate response and early recovery in natural hazard and conflict situations. In the Earthquake in Haiti 2010 there has been an overwhelming response from a wide range of actors in the international community, who helped in many different ways and at many operational levels (Patrick 2011). The Haiti disaster did raise issues regarding the actual role that information and communication technology (ICT) played given the ever-changing capabilities for data

collection and analysis. In the Haiti case, and in other emergencies and conflicts, open source software applications, commercial satellite imagery, social networking media, applets, mobile phone text messaging and other mobile technologies have established themselves as new players or have been used more than ever before by responders and in early recovery for information provision and communication (US Department of State Humanitarian Information Unit, 2010; Coyle & Meier, 2009). Many of these technologies enabled moderated and un-moderated self-organization and in some cases, beyond that, mobilized an excited crowd of largely untrained volunteers around the globe who participated in information and data provision, mapmaking and information verification. Crowdmaps, as in the case of the Russian Wildfires in 2010, the Queensland, Australia, Flood in January 2011 and the Libyan uprising in 2011 (Dunn Cavelty & Giroux, 2011) and SMS based initiatives for capturing basic needs of the population in Haiti after the earthquake through the Mission 4636 project (Munro, 2012) are just some examples of the use of new technologies.

1.2   Challenges for appropriate interoperability in real-world emergency contexts

Many insights have been gained from reviewing operations, organizational setups, capabilities and capacities in the immediate response and aftermath of the Haiti 2010 earthquake and in other emergencies. Some of these activities and conditions have been identified as not being as successful, suitable or efficient as anticipated or even 'planned for'. The reviews and evaluations carried out by the international community after the earthquake revealed the following challenges which have direct relevance for the ways that interoperability should be provided:

▪   The multiplicity of autonomous ICT initiatives and the lack of standards-based information capture and exchange among agencies leads to the duplication of efforts in terms of collaboration, data collection and processing and hampers the interoperability between information systems and platforms used by stakeholders (Hattotuwa & Stauffacher, 2011; US Department of State Humanitarian Information Unit 2010). Yet, this inevitable diversity has to be accommodated as an operational reality.

▪   Information availability is an issue that has several aspects to it: on the one hand there is a lack of information to support emergency response, including, as reported from other emergencies by Woof (2009), the availability of basic maps, and a delayed exploration of information needs by some actors (Wall & Chery, 2011); on the other hand, there can be a digital information overflow, the handling of which, in the case of Haiti, the international community was not prepared for (Harvard Humanitarian Initiative, 2011) and that sometimes results in people loosing sight of the reality 'on the ground' (Snoad, 2011). Hence, it is not enough just to provide interoperable capability without awareness of its utility, or otherwise, to users.

▪   The magnitude of the damage caused by earthquakes and other disasters can challenge the logistics supply chain and assets, as well as the coordination of the overall response. In Haiti, lines of communication were destroyed or interrupted, roads were impassable and covered with rubble, buildings had collapsed and the electricity and water supply had broken down or was intermittent (OCHA, 2010). Such circumstances are unavoidable reality for those operating at the scene. Over-reliance on the use of technical equipment and technology that needs an electricity supply and / or on the availability of telecommunication signals and Internet access can also affect the collection and sharing of information via interoperable platforms.

▪   There is a shortage of coordination, and lack of readiness for communication and collaboration between different stakeholders active in the field, as well as a lack of adequate institutional support, dedicated human and financial resources and technical capacity (Wall & Chery, 2011). More specifically, questions regarding the setup and management of operations, the role of leadership and the assignment and division of responsibilities among different stakeholders have been raised (Bhattacharjee & Lossio, 2011; Beiser, 2010; Patrick, 2011). In terms of interoperability, there need to be a number of complementary, socio-technical, capabilities made available. These will provide the behavioural dynamics and operational skills necessary to form relationships between the various actors involved in operations.

▪   Organizations fail to understand the local context and how to engage with it. This shortfall leads to mis-judgements about what is relevant, needed and appropriate, and to errors in strategy development. Such inadequacies were observed to be related to inexperience with disasters of the scale of the Haiti earthquake, but also to organizations and groups being ill-informed. Furthermore, the lack of 'internal' preparedness for such a disaster and inflexibility and unsuitability of the organizational strategies employed by some organizations, NGOs and agencies in Haiti did not allow for understanding and engaging with the complexity of the situation and caused duplication of efforts in operational activities and data collection (Holmes, J., 2010; Patrick, 2011; DARA, 2010). In these circumstances it should not be expected that technical interoperability alone can make up the deficiencies. Instead, when judging the appropriateness of

interoperability capabilities to support operational activities, the degree to which they need to be social or technical should be considered.

▪ Related to the previous point is the lack of engagement with local communities and stakeholders and the failure to use local knowledge, information and capacities in emergency response. The local population is often not considered as a resource, with their own important capabilities and capacities, by those intervening from 'outside'. Though, for example, in the case of Haiti, the manifold self-help and initiative of people who dug out other people from underneath the rubble, created shelters and so on in the hours immediately following the quake have been documented (e.g. by Patrick, 2011).The neglect of the value of this local self-organization in turn can lead to the lack of local 'ownership' of interventions initiated by outside actors who most likely have a different grasp and viewpoint of the situation (Potaet, 2011). Hence, potential interoperability in the context can be enhanced by enabling the inclusion of local knowledge in the shared understanding.

In short, these challenges point at the importance of collaboration, information needs and sharing, leadership and decision-making structures, organizational and technical adaptability and agility in the context and preparedness for disaster situation. When determining suitable ways of working such factors are inextricably interconnected with each other and so must be attended to when considering interoperability issues.

To illustrate how appropriateness in terms of interoperability can be judged, and how the corresponding necessary capabilities can be determined for working effectively in different contexts, four high-level user scenarios and corresponding (spatial) information system architectures are distinguished in the following section. These range from self-contained applications for repeatable, defined procedures to the ad-hoc collaboration that happens in disasters. They will be characterized in turn and the kind of interoperability that is fit for purpose in each scenario will be described.

2 User Scenarios and Interoperability

For information systems that include a spatial component, different types of high-level user scenarios exist where their dynamics, structures and relationships shape the architectures which are suitable for the 'system' (Beautement, pers.comm.; Allsopp, 2006). The four scenarios that will be presented range from process-driven at one end to event-driven at the other, each requiring a different type of interoperability to be enabled for effective information collection, analysis and sense-making to be fit for the context. In real-world applications and setups, overlaps between the different types described below can be found. However, overall, there are distinct differences regarding the nature of system ownership, behavioural dynamics, the degree of predictability of business processes, the use of standards, the life cycle etc. between the four user scenarios.

2.1 Self-contained, pre-defined

This type of user scenario represents systems for contexts that are well known and its mostly linear relationships of elements can be described. These systems have fixed, repeatable business processes that are 'certain' and largely predictable, for example in terms of the defined set of analytical operations carried out on spatial features. They can be characterized as follows:

▪ There is a single design authority responsible for design, development and implementation;

▪ The subsystem capabilities and data, regarding coordinate systems in use, spatial accuracy, data consistency, geographic feature identifiers, etc., are determined at design-time and sharing is enabled through pre-determined mechanisms;

▪ The relationships between subsystems are agreed in advance of any interaction;

▪ Any exchanges between subsystems are point-to-point and have pre-defined information exchange requirements; External exchange with other systems ('interoperability') is minimal;

▪ The systems and their subsystems remain linked over 'long' periods of time during which the configurations and overall relationships are largely static;

▪ Certainty and efficiency of these systems are high, but flexibility and robustness are low, as the system relies on the whole system working as intended;

Such self-contained systems are good for stable, well-understood and physically and virtually protected environments, but not flexible in the face of unexpected change.

2.2 'System of Systems' established institutionally

In this type of user scenario, 'systems' work with a common, agreed context, though each sub-organisation has its own sub-intent. Each of these intents is pooled with the others, following the formulation of a common intent, into a standardised system-of-systems where user interactions and processes are streamlined as well. For these scenarios it can be noted that:

- The systems 'participating' in a System of Systems are semi-independent entities who agree to share selected (spatial) information via agreed mechanisms;

- The design authority for the system is established by a committee of nominated design representatives;

- The participating systems may not join and leave as they please, as the agreements established through the System of Systems put obligations on them that they have agreed to at the outset;

- Interoperability is obtained using pre-agreed standards that can be open source or proprietary, based on the 'harmonization' of spatial data specifications regarding semantics, coordinate reference systems, temporal reference systems, scale etc.

- The overall relationships are firm and well defined between the systems, and reliable collaboration can be achieved under the agreements;

- The effectiveness, flexibility, certainty etc. can be modest because of collaboration overhead that can occur for individual systems; the robustness is medium as there are no common services involved;

Systems of Systems are good for partners working together in familiar, ongoing contexts over time.

2.3 Federations - federates join and share services in a 'plug and play' manner

In this case, events define the 'context' shaped by circumstances, the user needs are context-driven and fluid. Federations among entities operating in the spatial and non-spatial domain that are established are largely agreed 'on-the-fly'. In a federation, a number of collaborators have their own intent, parts of which are traded-off to achieve shared goals as circumstances require. This shared intent is formulated based on consensus and compromise between federates and owned by all federates. Shared federation resources are established and relied upon by the federates. Federations can be imagined as collaboration through and / or the provision of services in the 'Cloud'. These 'come-as-you-are' user scenarios are characterized as follows:

- Federations are context-driven groupings of pre-existing entities, with nested and overlapping memberships that have 'porous' boundaries between them;

- The federates explicitly join the federation and, whilst remaining 'independent', accept obligations from, and subordinate themselves to some aspects of the federation;

- The federates place obligations on the federation in return to provide common services;

- The relationships between federates are determined in the moment, and can be transitory or long-term – all exchanges between the federates are negotiated dynamically;

- The interoperability between the federates is based on open standards and relies on these standards being implemented among federates upfront and evolved over time;

- Overall, these federations are enduring and adaptive though they require a minimal 'critical mass' to be viable;

- The dynamic run-time effectiveness is high. Overall, certainty is high, but local levels of service may be lowered as federates may drop in and out.

Federations are good for real-world situations of all types where diversity enables effective, successful operations, as in cross-agency and cross-disciplinary working where federates work in flexible, complementary ways.

2.4 Independent 'Ad-hoc' 'Social Networking' activity built on whatever is available

This user scenario applies to contexts that are ever-changing and unpredictable. As such there are no pre-established user requirements and built-in assumptions are minimal – actual needs emerge with the dynamics of the situation. Each entities' individuality and integrity is retained and communities form on an ad-hoc basis in a

self-organized manner, following a transient shared purpose. The characteristics of this kind of setup are as follows:

- Independent entities share information and come together as they choose and / or as circumstances dictate;

- There is no design authority, other than that pre-existing resources and infrastructure are used if available;

- The interoperability is virtual and emergent - socio-technical. Interoperation takes place with whatever and 'whoever' is available, between 'entities' that offer spatial and non-spatial services;

- People and entities join and leave as they please – there are no obligations on anybody;

- The relationships that are formed are of a transitory nature and largely emerge by themselves;

- The ad-hoc collaboration is enabled and achieved via wikis, social networking etc.;

- For such a setup, effectiveness, timeliness and flexibility can be high. These ad-hoc communities can also spontaneously disperse, so the robustness in this type of user scenarios as such is low, but resilience   in the face of unexpected disruption is high, as there are no single points of failure;

In summary, ad-hoc, collaboration is good for disasters and high-tempo activity in the face of uncertainty and dynamically changing circumstances in which flexibility and adaptation are required and / or essential.

Migration and transition between these four types of user scenarios over time may occur as either institutional forms become firmer or as greater agility is required. From any transition or migration follows a different set of appropriate capabilities required, including the kind of interoperability.

3   Appropriate ways of working: Discussion and Outlook

Given the description of contexts, actual experiences and an indication of what constitutes appropriate ways of working in the previous sections, it has become clear that in complex emergency and conflict contexts, it is not sufficient just to, in interoperability terms, achieve the technical software interoperability as described at the outset alone - attending to the social aspects is also key to success.

Hence, appropriate ways of working, underpinned by geography, in complex crisis response situations involves the formation of federations or ad-hoc communities of interest from heterogeneous actors with different skills and equipment that work with a shared operational understanding. This requires that a degree of socio-technical interoperability can be achieved which transcends the merely technical. That extended capability is part of the so-called 'complexity-worthiness' [*] of entities that is needed to work with an ever-changing complex emergency context.

The ability to judge the relevance of various interoperability capacities to emergency and conflict environments has been defined in a set of indicators which are described by Beautement & Broenner (2011). These include, for example the degree to which:

- tools and techniques can be demand-driven and flexible enough to have their mode of employment changed on-the-fly;

- the applications provided enable users to collect information and indicators from a variety of sources, to weigh up hypotheses of possible futures and use contradictory information for sense-making;

- the operational dynamics of contexts can be accommodated through socio-technical interoperability which enables the formation of federations, agile groupings and communities of interest using flexible sets of procedures and ontologies that can be 'morphed' as required;

- the assessment of requirements, in the light of changing stakeholder values, needs, interests and viewpoints in dynamic contexts, leads to the development of demand-driven user-centred services; and

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[*] Complexity worthiness: i.e. being able to access, deploy and employ capabilities which are appropriately matched to the nature of things being worked with - and being able to adapt them dynamically as circumstances change.

▪ system engineering is able to provide elements which can be adapted real-time within an architecture that is able to be part of and adapt to federations' needs and ad-hoc demands as required.

Deriving socio-technical interoperability criteria from these indicators is a requirement for the design and development of systems and geospatial applications that can effectively support collaborative sense-making and diverse operations in emergency contexts.

A systematic analysis of these criteria for judging appropriateness against the four types of user scenarios described above will be carried out in a workshop during the AGSE 2012 conference and participation is invited.

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Enabling Interoperability: Data models for humanitarian emergency situations

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KEYWORDS:
Interoperability, Crisis Mapping, OpenStreetMap, Humanitarian Data Model, Humanitarian eXchange Language, HXL

EXTENDED ABSTRACT

People throughout the earth are facing natural hazards as earthquakes and tsunamis or extreme weather conditions as well as man-made crisis situation,

Dealing with such situations needs communication, as well between people involved, as well as between governmental and non-governmental organizations to ensure a coherent response to emergencies (OCHA 2012). For the digital exchange of geospatial information between organizations several data models have been developed and published, often coined by the needs of the environment they were developed (Dilo and Zlatanova 2010). In this presentation the focus will be given to two models, the first originating in the context of the OpenStreetMap project, the second a more general model, using approaches of the Semantic Web.

The OpenStreetMap (OSM) project in general is one of the most successful examples of Volunteered Gepgraphical Information (VGI). OSM is based on a surprisingly simple data model consisting of just four data types: Nodes, representing points of interest (POIs) and acting as vertices, ways, representing linear and areal features, and relations which aggregate nodes, ways and other relations to larger units. Although historically geared for (road) mapping in developed countries, for non-emergency situations, it has been extended to emergency situations based on its tag-value concept in the underlying XML encoding language (Humanitarian OSM Team 2012b).

The Humanitarian Data Model (Humanitarian OSM Team 2012a) itself is defined by a tabular description of feature classes related to handle logistic issues in emergency situations. It comprises the several feature classes (Humanitarian OSM Team 2012a):

- Highway/ Road, Obstacle, Bridge, Aerodrome, Port, Warehouse Compound, Fuel Point,
- Health Facility and
- Internally Displaced People (IDPs) camp site.

Regarding the encoding, theses classes rely on the OSM data model, i. e. node, lines, and relations. The non-geometrical attributes are claimed to be a subset of the UN Spatial Data Infrastructure for Transport (UNSDIT, LogCluster 2008) tailored to match operational requirements derived from the humanitarian efforts in the context of the Haiti earthquake in 2010. The feature classes are supported by a number of common tags, i. e. for addresses spatial signatures etc.

Based on these definitions an XML Schema Definition was developed at Stuttgart University of Applied Sciences. For the geographical properties, it is based on the Geography Markup Language (GML) application schema, a worldwide accepted ISO and OGC standard (Lake 2004, Portele 2007). This approach supports compatibility with Geographic Information Systems with GML import and export functionality. Furthermore XML related technologies like XSLT can be applied to suche data.

Another approach is given by the Humanitarian eXchange Language (HXL) Situation and Response Standard (Keßler et al. 2012) which is based on the Linked Data Approach (Berners-Lee 2006). Basic architectural principles and standards are used in the Web to create typed links between data from different sources (Bizer et al. 2009). Some basic principles can be summarized as follows:

- Objects are identified by and can be accessed using HTTP URIs.

- The basic format is RDF/XML.

- Links are based on statements using the "Subject – Predicate – Object" syntax.

Accordingly the modeling in HXL works with this "Subject – Predicate – Object" syntax where each of them c an be expressed through an URI (for examples see http://hxl.humanitarianresponse.info/ns-2012-06-14/hxl.n3).

Figure 1 Example of a subject - predicate - object triplet (Source: Keßler et al. 2012).

In the definition of HXL there are classes available, which can be used as subjects or objects. Well defined properties can be used as predicates. Predicates can express a relationship between a subject and an object or define values for attributes. Domain define the types of subjects; the range defines the types of objects which can be used:

Description	Relates a feature to its geometry.
URI	http://hxl.humanitarianresponse.info#hasGeometry
Domain	hxl:Feature
Range	hxl:Geometry

Figure 2 Example of HXL predicate definition: hxl:hasGeometry (Source: Keßler 2012).

Due to the fact that HXL is based on the RDF structure, HXL can be published in the "Linking Open Data" (LOD) cloud diagram.

The HXL standard is continuously evolving based on inputs from various people and organizations. It can be subdivided in the following sections:

1.   Date/Time Section - Describes how to refer to dates, periods of time, etc using theW3C profile of the ISO 8601:2004 standard for representation of dates and times.

2.   Geolocation Section - Describes how to reference locations (p-codes, custom geography, etc.), using OGC WKT (Herring 2010) for geometry. This section ontains classes for geographical dimensions for example the administrative unit like country or region, a bounding box, a feature, a geometry, a LineString or just a point. For this section there are again some properties available. Geolocation properties can define the location, the option to handle the data as WKT or information about geometries crossing each other. There's also a property to identify equal geometries.

3.   Humanitarian Profile Section: The classes of this profile can be used to give information about the affected population in an emergency, for instance which population is affected, the age of the people and their condition.

4.   Metadata Section - Defines the metadata components (source, provenance, etc.), using DCMI Metadata Terms (Dublin Core Metadata Initiative 2010). This section contains classes for the approval level and a data container. There's always existing exactly one container which includes all metadata. Properties can be information about who has approved something or if the metadata set contains primary data.

5.   Response Section - Defines high level elements that comprise a humanitarian response (camp, organizations, activities, clusters, objectives, outputs, outcomes, etc.). The response section contains classes for camps, organizations and for the response in crises. Properties can be used to give more detailed information about the organizations like the name or the homepage.

6. Situation Section - Defines high level elements that comprise a humanitarian emergency. It contains properties for example for the common title of an emergency for all organizations and the description of a situation.

According to Hendrix (2012), HXL is widely supported by several institutions, i. e. UNDP supports it (https://www.undpegov.org/node/35), and UNHCR has made HXL a component of their information management strategy.

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Analysis and Integration of Open Access Geoinformation in the Spatial Data Infrastructure for Emergency Response and Disaster Preparedness

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KEY WORDS:

Rapid Mapping, Participatory Mapping, Spatial Data Infrastructure, Crowd-sourcing

ABSTRACT:

The occurrences of disaster all over the world trigger the awareness of many corresponding institutions all over the world to generate and use spatial information in order to strengthen the capabilities to cope with disaster and to minimize human casualties. Time constraint, reliability and data bureaucracy are always problematic moreover in the emergency situation. The massive development of remote sensing technologies enhances both spatial and provides refined spectral resolution to develop the spatial data infrastructure in the relatively restricted access. In the meantime, the worldwide development of open source GIS and geodatabase initiates open access geoinformation nowadays as an instant solution for delivering the spatial data to the public. Bridging the distance from those two sides of spatial data development has the potential to provide powerful tools in disaster management where the quick response and high accuracy can be integrated. This research aims to evaluate and to develop a prototypical solution to integrate open access geoinformation into an existing spatial data infrastructure.

Monitoring Land Subsidence in Bandung, Indonesia with Differential Interferometric Synthetic Aperture Radar (DInSAR) Technique Using ROI_PAC Open Source Software

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ABSTRACT:

The main idea of this study is to measure and analyze land subsidence in Bandung City by processing ALOS PALSAR satellite images using the DInSAR technique. DInSAR technique is an effective technique for measuring crustal deformation. We processed eight ALOS PALSAR images (at level 1.0) acquired from September 2007 to November 2011. For time series of interferogram analyze, we analyzed 18 pairs possibility of DInSAR interferogram from eight ALOS PALSAR images. To get better result, we computed the best baseline estimation to reduce fringes from baseline between master and slave data. The 3-arcsec (90 m) Shuttle Radar Topography Mission (SRTM) used to remove the topographic contribution as Digital Elevation Model (DEM) reference. The observed of land subsidence deformation rate from this DInSAR technique averagely 0.2 m/year up to 2.5 m/year. This study will help create a land subsidence map in Bandung city in order to measure and analyze the pattern of the rate land subsidence. Finally, the result shows the potential use of DInSAR technique using open source program (ROI_PAC) to analyze and measure land subsidence rate in Bandung city.

1   Introduction

1.1   Land Subsidence in Bandung City

Bandung city is located in western Java Island-Indonesia at longitude of 107010'48"-108013'12" and latitude of 6010'48-7044'24" as shown in Fig 2. The compaction in alluvial sediments containing clay causes land subsidence in Bandung. Compaction is a natural process that it happens by uncontrolled usage and over-exploitation of ground water, especially in Bandung's industrial area. This over-exploitation of ground water is leading to a rapid decline of water levels, drying out clay layers that finally results in land subsidence (Abidin et al, 2009) as shown in Fig 1. The DInSAR technique is used to derive long-term consecutive volume changes at the surface. We implemented the phase information of two complex data as DInSAR data to retrieve the volume change caused by long-term consecutive land surface deformation especially subsidence or uplift. Figure 3 shows the geometry of the DInSAR for land deformation.

1.2   Related research

Land subsidence is not a new phenomenon for Bandung city. Several researchers were studied this phenomenon using a variety method and technology. There is a several research related land subsidence in Bandung City. Based on four GPS (Global Positioning System) surveys conducted on February 2000, November 2002, July 2002 and June 2003, it can be concluded that in the period of 2000 to 2003 several locations in Bandung basin have experienced land subsidence. The GPS survey results show land subsidence in Bandung has rates of

subsidence about 2-20 mm/month, or 2-24 cm/year (Abidin, 2008). In other research, some researchers were used DInSAR technique to investigate rates of subsidence in Bandung City by commercial DInSAR software (SIGMA SAR). Using JERS-1 SAR and ALOS PALSAR images during the periods of 1993-1997 and 2007-2010, the result reveals significant volume of subsidence occurred at industrial complexes of Bandung city, especially in the Cimahi, Dayeuhkolot and Baleendah districts around 4.5 up to 11.0 m3 per year (J.Tetuko.S.S. et al, 2009). Also the largest subsidence was observed to occur at the Cimahi area around 57 cm between 28 January 1995 and 15 January 1996. The other technique in land subsidence research was used geographic information system (GIS) method. This research was combined several spatial and vector data to determine the priority site for land rehabilitation at Bandung Basin (Narulita et al, 2008). The rehabilitation priority site in Bandung basin was determined using overlying the critical level of water recharge map, groundwater modelling, land use map and geology map during 2004-2006. The result revealed that significant land subsidence and critical landslide occurred in six locations (Soreang, Lembang, Tanjungsari, Batujajar and Gununghalu area) around 20-50 cm per year.
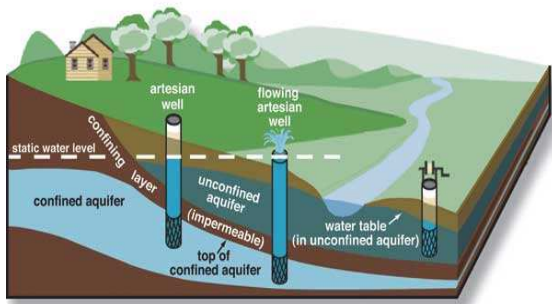

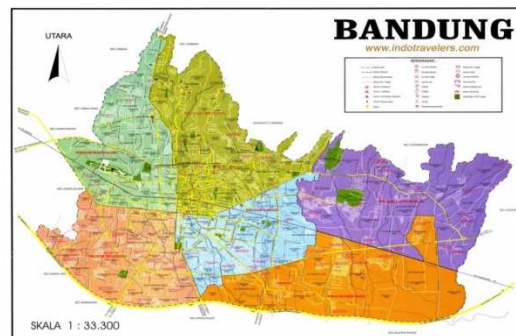Fig. 1: Land Subsidence in Bandung City
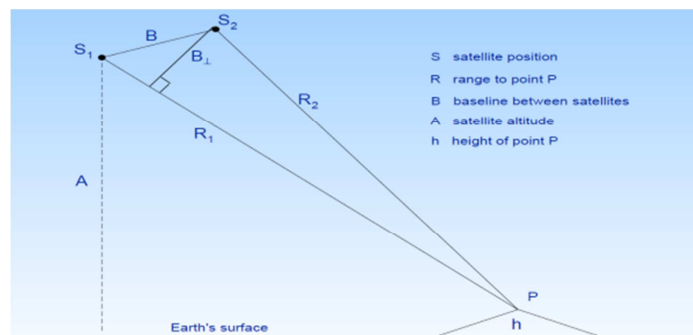

Fig. 2: Bandung City Map

Fig. 3: Geometry of DInSAR Technique (Ismullah, 2011)

1.3 ROI_PAC Open Source Software

ROI_PAC (http://www.roipac.org/) is available for non-commercial use. The first release of ROI_PAC was published quietly in 2000 by a scientist group It allows researchers in the area of topography and surface change to apply InSAR and DInSAR method. ROI_PAC was developed primarily to work with ERS data, JERS, Envisat and ALOS PALSAR data and allows researchers in the area of topography and surface change to apply InSAR and DInSAR method. It uses raw radar, ancillary information from telemetry and navigation solution and digital elevation model (DEM) to produce a variety of derived products, including the full resolution image, interferogram, phase image and error estimate (Open Channel Foundation, 2012). This software simulates an interferogram from the orbit data and the DEM in order to get deformation phase. ROI_PAC implements its fundamental algorithms in C, Fortran 90 and drives each excutable module with a PERL control script, running on SGI, SUN, Mac OS X and LINUX platforms.

2   Methodology

2.1   ROI_PAC Installation

After download ROI_PAC program from Internet, we can process and setup binaries in LINUX environment. Therefore, viewer compiler must be installed in order to visualize the result of ROI_PAC program. Finally, we can use ROI_PAC to process DInSAR technique like image matching, interferogram generation, fringe removal, unwrapping method and visualize the results, as shown in Fig 4.
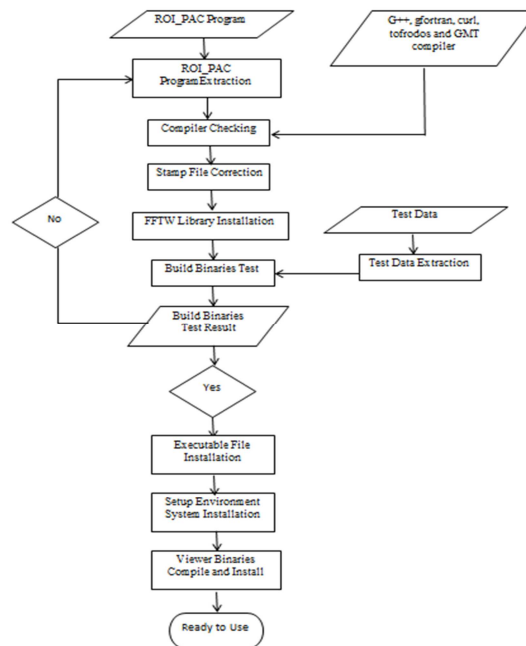

Fig. 4: ROI_PAC Installation

2.2   DInSAR Processing

The raw SAR data were processed using ROI_PAC to derive the interferogram or phase difference and the parameter as shown in Fig 5.
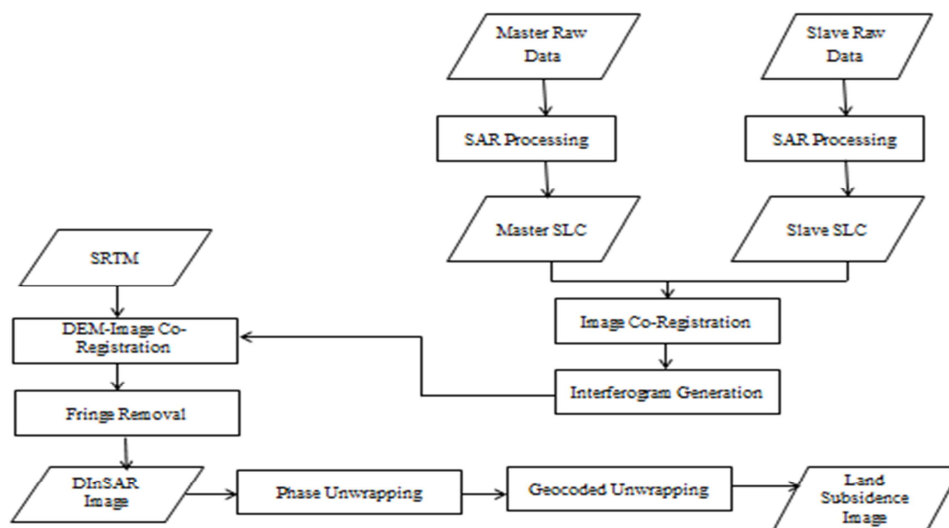

Fig. 5: DInSAR Technique Processing

Disaster and Risk Management

3 Case study

3.1 Objective

DInSAR technique is applied in a long duration measurement ALOS PALSAR data and is used to investigate the land subsidence rate in Bandung City. Eight ALOS PALSAR images are used observed from the period 10 September 2007 through 03 November 2010, as shown in Tab 1. In order to get and visualize the subsidence rate in study area and combine with the other data like geographic and geodetic data. The earlier observed image is used as the master and the most recent image is used as the slave. Based on this rule, we can get 28 combination between master and slave image. From 28 combination of ALOS PALSAR image pairs, we must analyze the critical baseline and normal baseline. We put five ALOS PALSAR image pairs that it have minimum critical and normal baseline value, in order to get good coherence between master and slave image combination as shown in Tab 2.

No.	Satellite Image	Acquisition Date	Level
1.	ALPSRP086653760	10-09-2007	1.0
2.	ALPSRP106783760	26-01-2008	1.0
3.	ALPSRP133623760	28-07-2008	1.0
4.	ALPSRP153753760	13-12-2008	1.0
5.	ALPSRP160463760	28-01-2009	1.0
6.	ALPSRP187303760	31-07-2009	1.0
7.	ALPSRP207433760	16-12-2009	1.0
8.	ALPSRP254403760	03-11-2010	1.0

Table 1. ALOS PALSAR Images Used in The Present Study

No.	ALOS PALSAR Pairs	Acquisition Date	Level
1.	ALPSRP153753760- ALPSRP160463760	13/12/2008-28/02/2009	1.0
2.	ALPSRP086653760- ALPSRP106783760	10/09/2007-26/01/2008	1.0
3.	ALPSRP160463760- ALPSRP207433760	28/01/2009-16/12/2009	1.0
4.	ALPSRP133623760- ALPSRP160463760	28/07/2008-28/01/2009	1.0
5.	ALPSRP133623760- ALPSRP207433760	28/07/2008-16/12/2009	1.0

Table 2. ALOS PALSAR Images Pairs selected

3.2 DInSAR Results

The interferograms of ALOS PALSAR image pairs are resampled to a resolution of 12.5 using the same Doppler centroid and the individual Doppler chirp rate, where the starts address for the slave image is selected to use the satellite telemetry to overlay onto the master data to the greatest degree possible. The master and slave image were coregistered using two processing step: coarse registration and fine registration. In the differential interferometric SAR process, the simulated flat earth is generate to correct the fringe using a SRTM digital elevation model (DEM) with a resolution of 90 meters (SRTM 90 m DEM) and the orbital data, as shown in Fig 6.
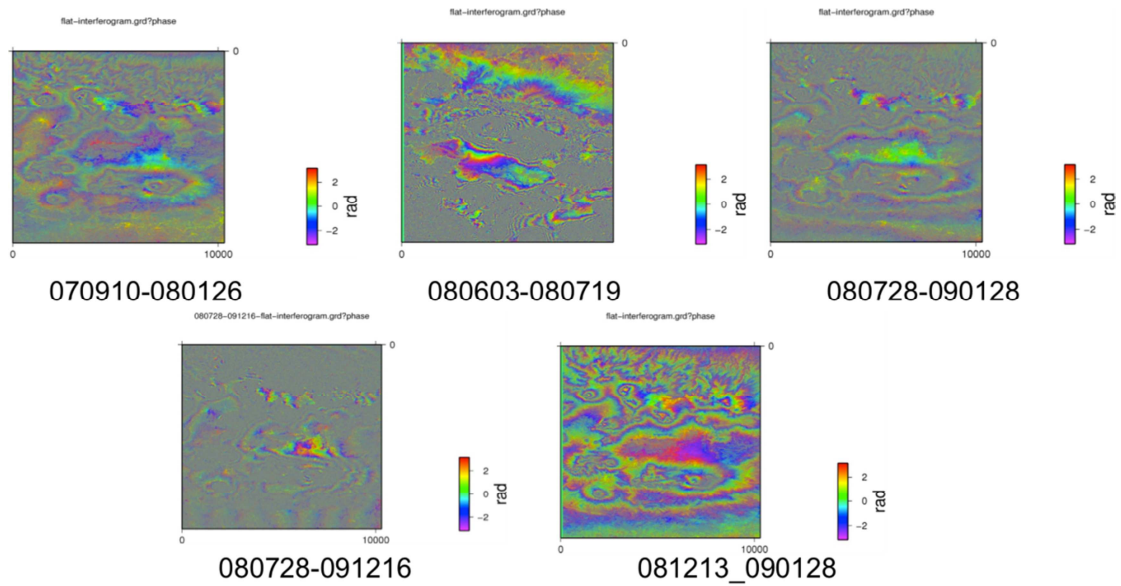
Fig. 6: Flattening Interferogram Images

The flattening interferogram image, which is then wrapped, normally contains the high-frequency parallel component generated by the horizontal baseline distance. This component should be eliminated using the orbital data, where orbit tuning is conducted by unwrapping the flat-earth corrected fringe. Finally, it can result DInSAR images, as shown in Fig 7.
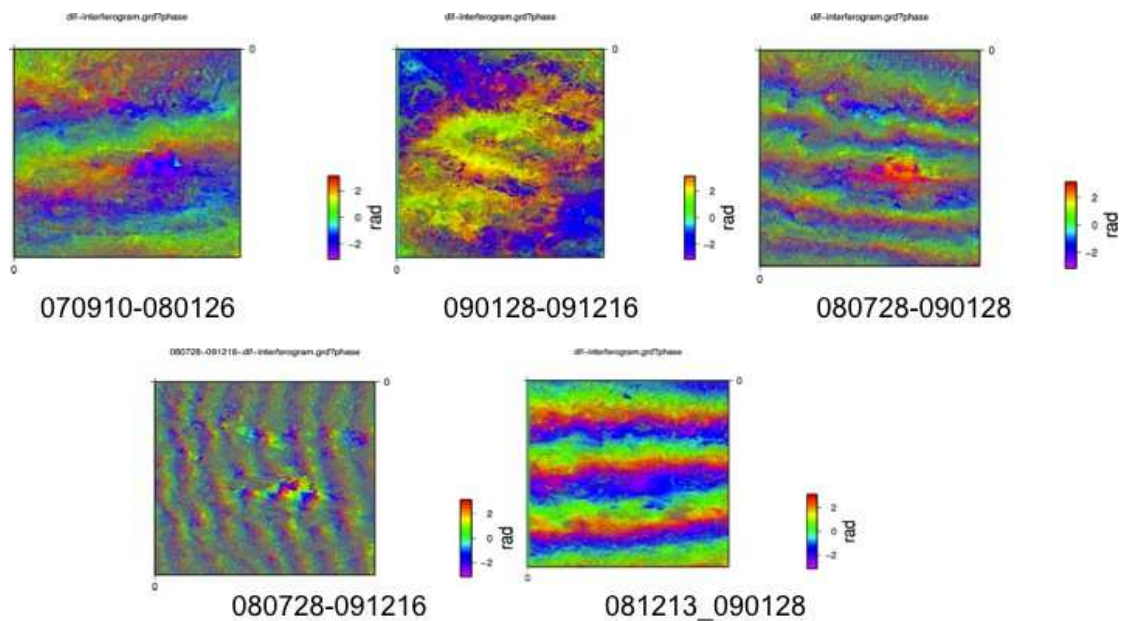

Fig. 7: DInSAR images

Finally, the interferogram or phase difference image was obtained and geocoded with RST (rotation, scaling and translation) of a World WGS 1984 projection. Geographic Information System (GIS) has been used to process in order to investigate the subsidence and its impact on the study area as shown in Fig 8.
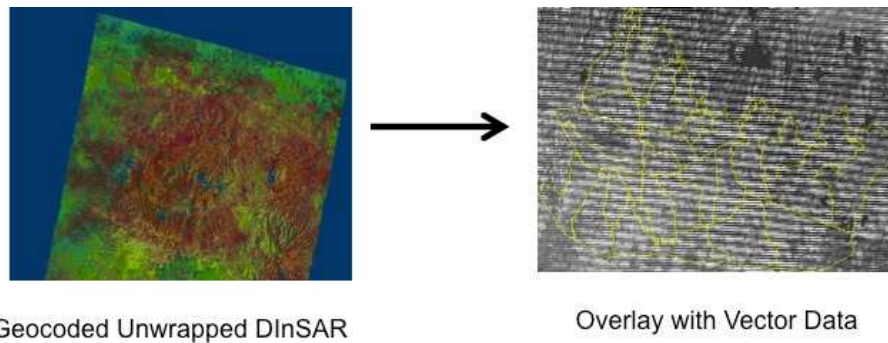
Geocoded Unwrapped DInSAR

Overlay with Vector Data

Fig. 8: Overlaying of geocoded unwrapped DInSAR data with GIS Vector Data

3.3   Statistical Computation and Data Comparison

After process geocoding and unwrapping, we can continue with GIS processing such as overlay, subset and ROI (region of interest) to select specifically the district of Bandung city. We can process statistical computation in every district in Bandung city. From statistical computation, we get several value of land subsidence rate in every district. There is a minimum, maximum, mean and standard deviation value for each district in Bandung City, as shown in Tab 3.

No.	District	Min	Max	Mean	StdDev
1	Andir	-16.6	212.6	22.4	25.9
2	Astana Anyar	-1.2	149.6	28.8	30.8
3	Babakan Ciparay	-8.4	167.9	23.9	22.8
4	Batu Nunggal	-8.2	206.4	24.5	33.6
5	Bojongloa Kidul	0.3	217.4	27.8	26.9
6	Bojongloa Kaler	-7.2	231.3	28.8	30.1
7	Cibeunying Kaler	-12.4	106.9	18.9	27.7
8	Cibeunying Kidul	-13.2	214.9	18.8	29.9
9	Cibiru	-16.2	174.1	12.9	22.6
10	Cicadas	-15.1	169.2	17.9	30.5
11	Cicendo	-5.4	143.7	17.4	21.3
12	Cidadap	-13.1	239.9	15.9	28.7
13	Coblong	-13.1	199.2	17.6	29.1
14	Kiaracondong	-12.9	241.8	22.1	31.5
15	Bandung Kidul	-17.7	343.5	25.6	32.6
16	Bandung Kulon	-4.2	173.0	21.2	18.4
17	Lengkong	-9.3	206.4	25.2	29.6
18	Margacinta	-14.0	371.2	25.3	35.7
19	Rancasari	-19.1	302.3	18.2	27.1
20	Regol	-0.6	120.4	27.5	27.6
21	Sukajadi	-9.9	133.7	19.6	26.9
22	Sukasari	-11.6	132.5	16.1	24.8

23	Sumur Bandung	-6.8	102.3	19.9	23.3
24	Ujung Berung	-30.8	322.6	16.0	30.0
25	Bandung Wetan	-18.7	198.1	18.4	26.1
26	Arcamanik	-15.4	194.5	16.5	31.9

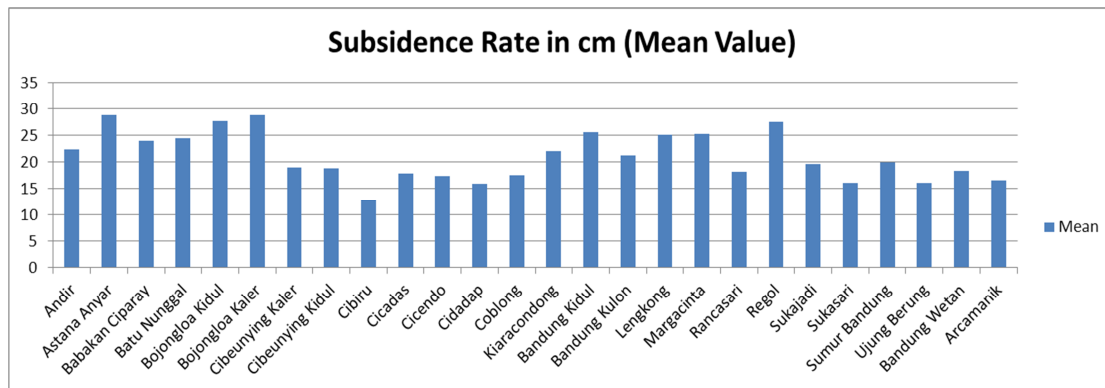Table 3. Value of Estimated Subsidence of Bandung City (in cm)

Fig. 9: Estimated Subsidence of Bandung City (in cm)

In order to confirm the DInSAR derived phase difference that will be used for the calculation, we compared the vertical deformation or subsidence obtained by DInSAR and GPS observation. Five sets of GPS observations are prepared to investigate the subsidence in the study area. The results reveal that serious subsidence occurred at six districts, Astana Anyar, Bojongloa Kidul, Bandung Kidul, Lengkong, Margacinta and Regol, as shown in Fig 9. Table 4 shows the subsidence at each DInSAR observation point obtained by DInSAR for observation periods from 13 December 2008 to 28 January 2009 (ALOS PALSAR). This observation shows that the total subsidence of Astana Anyar, Bojongloa Kidul, Bandung Kidul, Lengkong, Margacinta and Regol areas are 28.80, 27.76, 25.60, 25.12, 25.36 and 27.47, as shown in Fig 10.

No.	District	Mean	Coordinate (degress)		Height (h)	DInSAR	Observation GPS	Error
			Latitude	Longitude	Ellipsoid (m)	081213-090128	(20050624-20080823)	(cm)
1	Andir	22.3712	6.91	107.576	-	2.8	-	-
2	Astana Anyar	28.8025	6.936	107.601	691.571	3.6	3.6	0.0
3	Babakan Ciparay	23.9465	6.94	107.577	-	3.0	-	-
4	Batu Nunggal	24.5047	6.923	107.641	682.1178	3.0	2.8	0.2
5	Bojongloa Kidul	27.759	6.948	107.596	-	3.5	-	-
6	Bojongloa Kaler	28.8752	6.93	107.592	-	3.6	-	-
7	Cibeunying Kaler	18.9602	6.93	107.592	-	2.4	-	-
8	Cibeunying Kidul	18.8444	6.895	107.632	-	2.3	-	-
9	Cibiru	12.865	6.924	107.715	-	1.6	-	-
10	Cicadas	17.8704	6.912	107.661	-	2.2	-	-
11	Cicendo	17.4495	6.902	107.604	-	2.2	-	-
12	Cidadap	15.8682	6.891	107.604	-	2.0	-	-
13	Coblong	17.5758	6.891	107.614	-	2.2	-	-

14	Kiaracondong	22.1271	6.93	107.652	-	2.8	-	-
15	Bandung Kidul	25.6016	6.956	107.629	691.5718	3.2	3.6	-0.4
16	Bandung Kulon	21.2363	6.937	107.063	-	2.6	-	-
17	Lengkong	25.1073	6.931	107.628	-	3.1	-	-
18	Margacinta	25.3556	6.948	107.66	-	3.2	-	-
19	Rancasari	18.2441	6.953	107.694	-	2.3	-	-
20	Regol	27.4684	6.938	107.614	683.4918	3.4	3.5	-0.1
21	Sukajadi	19.6533	6.886	107.614	-	2.4	-	-
22	Sukasari	16.0958	6.871	107.585	-	2.0	-	-
23	Sumur Bandung	19.905	6.915	107.613	-	2.5	-	-
24	Ujung Berung	16.0509	6.91	107.704	702.2434	2.0	0.2	1.8
25	Bandung Wetan	18.3979	6.91	107.621	-	2.3	-	-
26	Arcamanik	16.5259	6.91	107.576	-	2.1	-	-

Table 4. Comparison of DInSAR and GPS Observation-Subsidence Rates (cm/years)

Based on the GPS and DInSAR results, the rate of subsidence of every district in Bandung city in cm/year determined from the DInSAR and GPS observations for the period from 13 December 2008 to 28 January 2009 and 24 June 2005 through 23 August 2008. Direct comparison of line-of-sight (LOS) deformation from DInSAR with the GPS vector deformation is used to investigate the accuracy of DInSAR measurement. From comparison of the GPS and DInSAR results, we get result the maximum value of DInSAR-GPS difference is Ujung Berung district (1.8 cm) and the lowest value is Astana Anyar district (0.0 cm) as shown in Tab 4. The result of maximum value from subsidence rate per year is Astana Anyar and Bojongloa Kaler (3.6 cm/year) and the minimum value is Cibiru (1.6 cm/year) as shown in Fig 10.
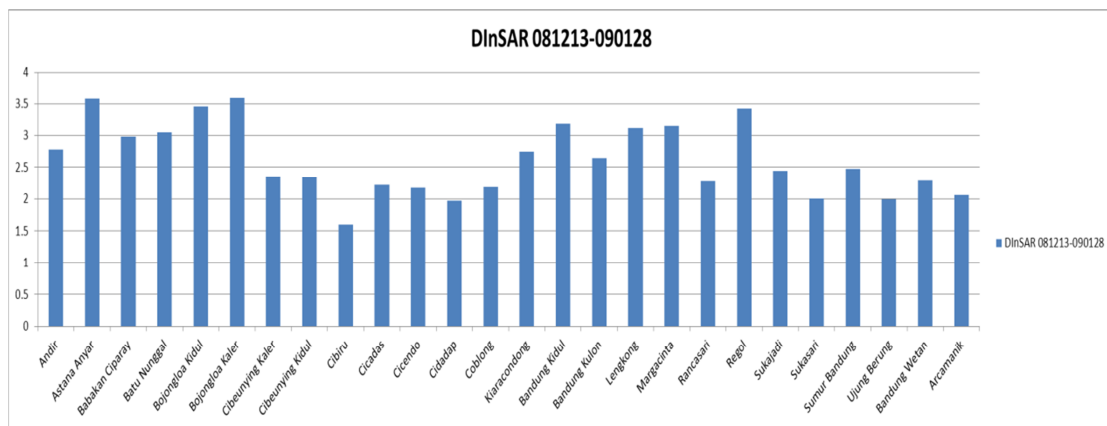

Fig. 10: DInSAR -Subsidence Rates (cm/years) per District

4   Discussion and Conclusions

The DInSAR technique was used to derive long-term consecutive volume change at the surface of the Earth caused by land deformation (uplift or subsidence). In order to confirm the role of the DInSAR technique to investigate the subsidence in Bandung city-Indonesia therefore using Japanese L band Spaceborne SARs (ALOS PALSAR) during the periods of 13 December 2008 and 28 January 2009. The results reveal that significant subsidence occurred at industrial complexs of Bandung city, especially in the Astana Anyar, Bojongloa Kidul, Bandung Kidul, Lengkong, Margacinta and Regol districts. The analysis result of ALOS PALSAR obtained using the proposed technique reveal new subsidence areas in industrial and residential areas of Astana Anyar, Lengkong and Marga Cinta districts. GPS observation of the study area has confirm these result. They also

allow the accuracy of the DInSAR measurement that it is determine direct comparison of line-of-sight (LOS) deformation from DInSAR with the GPS vector deformation projected into the DInSAR LOS. The errors result data shiftting approximately ±0.5 cm or ±0.75 m3/year/pixel. This error affects the subsidence rate estimation and it must consider when using the proposed method.

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Geoinformatics and Health

School Water, Sanitation and Hygien (School WASH Mapping) - Seeing is Believing – Tanzania Experience

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ABSTRACT:

Water, Sanitation and Hygiene briefly termed as WASH play a critical role in any school. Without water and sanitation facilities, hygiene promotion and education in schools is difficult and has minimal impact. The provision of safe water and sanitation facilities is a first step towards a healthy learning environment. However, provision of infrastructure alone is not enough to guarantee the adoption of positive hygiene behaviour changes by school children without taking care of the exact location and distance of the infrastructure from school site.

The combination of facilities and their location, good behavioural practices and education aims to a positive impact on the health and hygiene conditions of the school children. Given the fact that many schools are currently far from achieving acceptable levels of water, sanitation and hygiene, and may have no suitable facilities at all, or wrongly located because they lack resources, skills or adequate institutional support; achieving appropriate targets will often not be possible in the short term.

To address the problem, facts findings was the first step whereby GIS was used to put everything in black and white on the table for discussion based on the minimum standards set out by government authorities for School WASH. The background, the various parameters, methodologies and technologies to produce "School WASH mapping" are described. The outcome proves that "Seeing is believing".

1   Introduction

Water, Sanitation and Hygiene (WASH) play a critical role in any school. The most obvious example is school latrines, though water supplies and hygiene education are also very important. Schools that do not have such services present a number of risks to pupils, including the risk of contracting diseases associated with poor sanitation, lost school days due to illness or for girls while menstruating. Further, schools have a key role to play in providing hygiene education which can have wider influence to families and communities and a long term impact including on future generations.

Main objectives of School WASH mapping was to gain an insight in the current WASH status at pre/primary and secondary schools and in a later stage support the development of good practice, capacity building, awareness raising, and infrastructure development in selected districts within the United Republic of Tanzania. The school WASH mapping project has been carried out in different style in several developing countries including Tanzania, Kenya, Zimbabwe, Zambia, India, Burma, Vietnam, Indonesia, Nepal, Bolivia, Paraguay, etc. In Tanzania GIS and mapping technology was used to show existing situation in terms of location and sitting of WASH facilities by presenting correct and clear information to water and sanitation actors and decision makers and hence to establish the actual gaps.

1.1   The importance of water, sanitation and hygiene (WASH) mapping in schools

It was observed from the district health facilities information that diseases related to poor hygiene and lack of access to sanitation are among the top ten inpatient and outpatient attendances. There is a close link between water supply and waterborne diseases such as cholera, water-based diseases such as malaria and water-washed diseases such as scabies and trachoma in areas with poor sanitation facilities. Poor water and sanitation have a great impact on health of children and ultimately on quality of education and pupils performance. Sanitation related illnesses, such as diarrhoea, are a major factor for low school enrolment, absenteeism, poor classroom performance, and early school dropout/truancy. BUT, having all WASH facilities at school without looking at

their location, sitting, distance from the targeted audience and functionality status it does not making sense. That is why mapping of the facilities to obtain their actual location and sitting within the school premises or outside was vital important and has raised great concern to decision makers.

1.2   Project location area

Tanzania is located in Eastern Africa between longitude 29o and 41o East, Latitude 1o and 12o South of the Equator. Tanzania has a surface area of 94.3 million hectare subdivided into 29 regions. Each region is also subdivided into districts and local government authorities (LGAs) which are 135. Tanzania is the home of the famous Kilimanjaro mountain which is the highest point in Africa. (See Figure 1)

2   Parameters and technology used in mapping school WASH in Tanzania

The collective name that was used for mapping school water, sanitation and hygiene is "School WASH mapping". There were different parameters, methodologies and technologies which were combined and therefore function together to produce results. These methodologies were applied together and transformed into a GIS language to prove **seeing is believing**.

Figure 1: Location of Tanzania in Africa

A detailed questionnaire about the school ownership, teaching facilities, water and sanitation facilities including number of drop holes per toilet, hand wash and cleans materials were administered per school. Others include type and functionality status of the latrine, location of existing water source and water point type, school roofing material and structure, classroom set up and number of pupils and teachers per school.

As part of office work, the survey questionnaire was transformed into digital form based on ASCII format which later on a data dictionary was developed and uploaded into a GPS device. The GPS equipment run Windows CE for mobile device and can be used as a field computer. With this device we were able to capture all questions as addressed into the survey questionnaire with additional information of location in terms of X and Y coordinates as well as altitude (height above ellipsoid). This means no any paper work was needed any more. Figure 2 is the

part of survey questionnaire and the developed data entry form which was uploaded in the GPS device for the school WASH mapping data collection project.

2.1 Field work

Field work team used a "Top Down Model" for data collection at district level. Normally GIS and Mapping experts' reported to district education officer (DEO) who assigned one person from his office and who is familiar with the district infrastructure to join the team for the realization of the school WASH mapping. This person was responsible to guide the team to ward executive offices (WEO's office). At WEO's office, the team normally conducted a very brief interview with the WEO with an intension of knowing education status in his/her ward and if necessary how many village which have no any school. At this level the team obtained guidance to contact village executive officers (VEOs) or village headmen. At VEO's office an interview was conducted to collect the basic information about the school including management type and available master plan for education purposes. At this level a process of visiting each school started. The team travelled from one school to another in the villages using available means of transport to conduct interview with responsible personnel. Most of the interviewees were school head teachers. This helped to acquire non-spatial data that is later on subjected to analytical considerations using GIS.

School WASH survey questionnaire – 2012   **School WASH GPS data entry form - 2012**

Figure 2: Section of survey question and the data entry form on the right which is uploaded in the GPS device

A school was recorded as a point. Location data was recorded in a GPS in the form of X and Y coordinates, way point number and altitude. However all questions which were asked about WASH facilities which were inspected were recorded in the GPS instrument which later on acted as attribute information for particular school point.

A digital camera was used to capture photographs of the school showing the overall school appearance, roofing style with respect to rain water harvesting point if any, any available water points/source and toilet structure. A serial number of each digital photograph captured was recorded in a GPS. The serial numbers of each photograph was used for reference purposes when accessing school situation and WASH status.

The photographs presented actual field situation of school, toilets/latrine and water points during the time of the study. They could also be used in the future for monitoring the conditions of school WASH. This compliments the "Seeing is Believing" vision.

2.2   Data processing

Data processing involved two aspects; spatial data processing in a GIS and non-spatial data in the MS Excel application software. In principle, since all data were concerned with land based components and the involved technology was basically dealing with data acquisition and automation with respect to land information systems, the integration of these components was based on what we call a geospatial database.

2.3   Analysis of data and feed-back

The most influential type of analysis was the correlation between the availability and location of WASH facilities and pupils population density at Ward level, which illuminates inequity in distribution at the lowest administrative level. This allowed for a comparison between clusters of wards as opposed to collected statistics masking differences in distribution below the district level. In addition, the wealth of the dataset provides the basis for additional types of analysis.
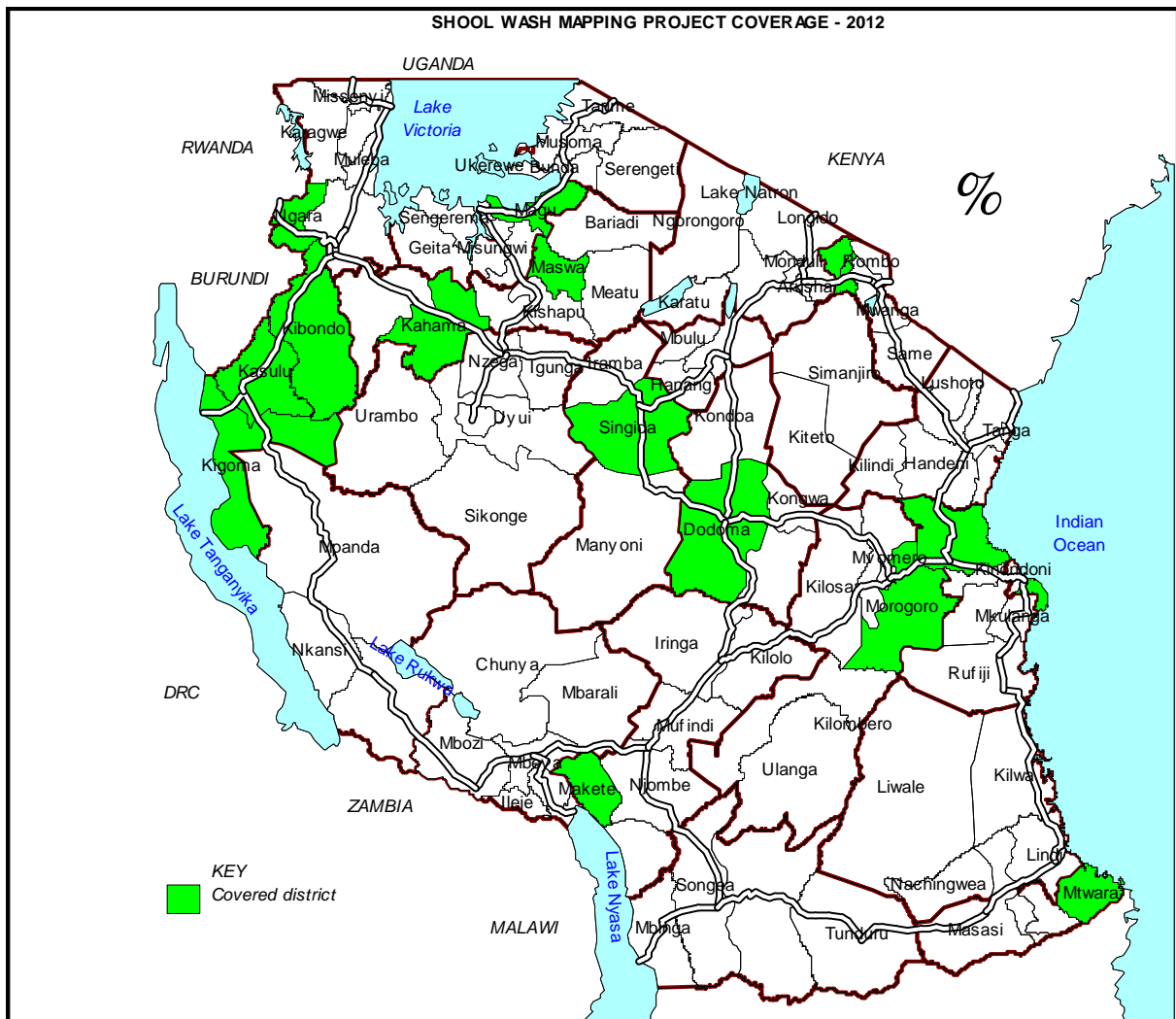

Figure 3: Distribution of districts covered during school WASH mapping project in Tanzania mainland

Based on school and pupils distribution by ward, a link/statistical formula was applied to monitor the service delivery based on data collected as illustrated here below.

- ▪ **Drop Hole coverage per gender** - Density of existing school WASH facilities in correlation

with population density of pupils per ward against the Ministry of education and vocational training target of one (1) drop hole of toilet per 20 pupil girls, and one (1) drop-hole of toilet per 25 pupils (boys). This was calculated as follows,

▪

$$Drop\ hole\ coverage = \left[\frac{No.\ of\ Drop\ Hole}{Number\ of\ Pupils} \right] \times 100$$

This is delivered from: 1 Drop hole = 25 pupil boys, which means 4 drop holes serves 100 pupil boys.

The map below present results of the analysis for the drop holes coverage for pupil boys in Kahama district one of the area covered by the project in North West Tanzania (See Figure 3). Based on National Ministry of education and vocational training target that 1 drop hole should serve 25 pupil boy, wards with red color indicate that 100 pupil boy share 1 or less than one drop hole while wards with orange color indicate that 100 pupil boys share between 1 and 2 drop holes. Green color wards, 100 pupil boys share between 3 to 4 drop holes while the deep green color which no any ward attaining that category have managed to attain the target that at least100 pupil boys should share 5 and above drop holes.
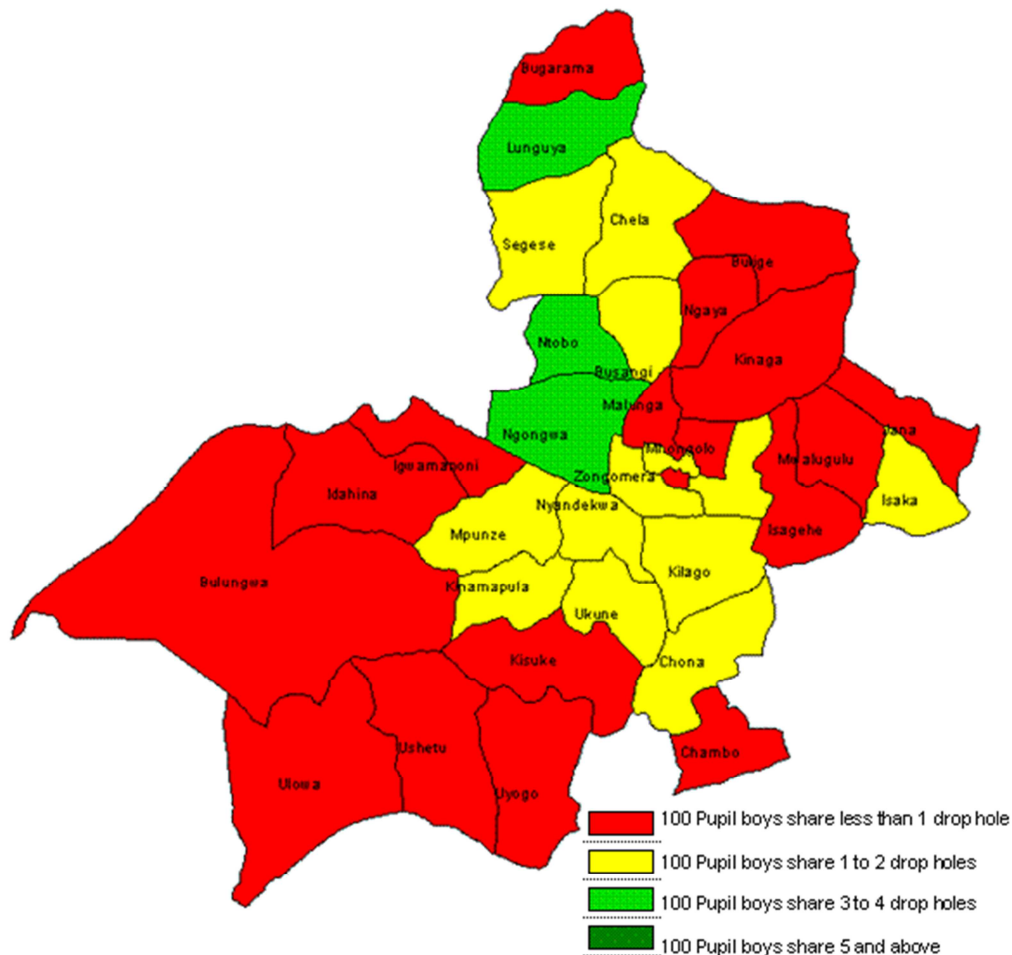

Figure 4: Drop hole coverage for pupil boys per ward in Kahama district.

3   Feedback to target groups

After the processing of the data and analysis, outputs were presented to key stakeholders at the district level. These include district technical committee which is formed by local councilors depending on the size of the district, head of departments and district executive director. Main aim of the feedback at this stage was data verification and gaining an insight of existing situation within the district before submitting to full district councilors for blame storming and implementation.

Outputs from the school WASH mapping projects were GIS data, maps, and analyzed dataset in MS Excels. Maps show existing situation, coverage and investment level across the district in relation to the national WASH target. In order to present various types of analysis; decision-making processes were also discussed in relation to the maps.

As discussed earlier, school WASH mapping was introduced in order to support the Local Government Authorities in planning and monitoring processes under the framework of decentralization. The ultimate target groups of school WASH were the councilors who represent local communities at the district, the communities themselves, local NGOs and service providers operating at district level, and national level decision makers. The intention was to enable those groups to demand better service delivery based on depth and quality of data throughout the sector.

Is seeing believing? What do we get from the maps? One councilor rose concern on the distribution and effectiveness of the WASH facilities and allocation of resources e.g. teachers, latrines and classrooms in the district. Before this project councilors were not able to rise concern and comments as they had no basis, nor they didn't know what is taking place within their wards. A good example was several schools operating with temporally latrine structures in Kahama district while others had good structure but very poor sanitation (Figure 5 below). "It is the shame, but that is how it works" he added.

Figure 5: Existing situation to some of schools in Kahama district. Photographs are taken to each action as supporting evidence to decision makers.

From the maps he was able to ask why school WASH facilities are better within and near township while is getting poor and poor as you move to peripherals. Why big number of teachers is found in township schools while many schools in peripheral villages have no teachers. It seems there is an element of corruption in allocating resources. He said, this is true evidence showing discrepancies in service delivery while we belong to one district and we are paying same taxes.

Although the answer was quite clear that all decision makers and good infrastructure surrounding the township were the major causes for better service delivery as administrators were able to move and do inspection to nearby schools, still it was not clear why school headmen/teachers working in peripheral areas don't bear their responsibilities.

District planning officer supported the evidence that, having photographs and maps showing reality during planning processes will enhance the process by channeling resources to proper location and even the way we perform our duties.

4   Situation analysis in relation to other countries

The school WASH mapping project has been carried out in several countries including Kenya, Zimbabwe, Zambia, India, Burma, Vietnam, Indonesia, Nepal, Bolivia, Paraguay, Democratic Republic of Congo (DRC), Mali etc. The only approach that makes Tanzania unique was its approach on the application of Mobile GIS technology during data collection and presentation.

In Tanzania, school WASH mapping project was conducted in two parts. The first is a comprehensive quantitative data obtained using GIS and mapping exercises which was later on complemented by the second component of the study – a qualitative exercise to validate the survey data and collect further narrative information on governance aspects of school WASH briefly known as VIP (Validation and Intervention Process).

Most of the countries mentioned above conducted the second part of study without taking much concern of the spatial component which advocates the seeing is believing approach.

5   Conclusion

Technology involved on school WASH mapping was rated the best and considered to be the useful ones since it has placed everything on black and white enabling decision makers to comment on service delivery to the public. It was shame and blames sighting to education centres as sources of sanitation and hygiene while it was opposite. How could we know that, this is a real situation to our schools? Ward councillors commented to school head teachers while demanding change in management based on GIS data.

As we speak, school WASH mapping is very important tool as it enhances development plans through proper planning with real data. It helps the district management to monitor the effectiveness of its investments in service delivery as well as strategic planning and advocacy at local government level and at times at higher governmental levels. Finally it enhances collaboration among the district stakeholders and the three ministries (Health, Water and Education) to develop a joint action plan to address WASH at schools.

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Urban and Regional Planning

GIS in Logistics and Transportation for a Dairy Co-Operative Society in Kenya

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ABSTRACT:

Logistics has gained popularity among many business and production companies as a strategic function to gain competitive advantage. In agri-business such as dairy farming logistics tools are also being applied to their supply chain to address the chain costs and more importantly to improve their business efficiency as a whole. This is especially so in the area of transportation which comprises a large share of the companies' costs. The collection of raw milk is a critical sector of the supply chain that needs to be addressed in order to improve the overall performance of the company. This study was carried out to address milk collection challenges of a local rural dairy company in Kenya. It involved the determination of optimal routes in a milk collection chain involving 10 routes and 40 collection centres. The milk processing factory, collection centres, road network, trading centres were mapped from both primary and secondary data sources. A topologically clean geometrical network dataset of the roads was created, together with vehicular information from the milk company, the most economical and efficient routes were determined through the application of vehicle routing problem (VRP) solution in a GIS environment. A comparison was undertaken to compare the current costs in terms of time and distance with those generated, which revealed a substantial saving in time and distance if the dairy could adopt the VRP solution. This is quite significant in light of the high fuel costs being experienced globally.

1   Introduction

1.1   Background

Geographical information systems and logistics have been used by numerous businesses across the globe in varying areas such as refuse collection and disposal, fleet management, parcel deliveries, among others. The management and enhancement of the logistics activities has been undertaken with the aim of decreasing production costs while increasing performance through improvement in the efficiency and effectiveness of the companies' operations (Stock & Lambert, 2001). The fundamental aim in application of logistics is to gain competitive advantage over other key players in the same industry. The use of GIS and logistics has also started gaining ground in the dairy industry where it can also be applied in various key areas such as asset management, mapping, vehicle tracking, facility siting, network analysis, among a myriad of other activities in the sector.

The fundamental activity of a dairy is   collection and delivery of milk to the processing plant. This activity is as complex a chain as any other in the field of logistics. The distribution and collection of milk is one of the problems that bring concerns for dairy companies, especially when considering transportation. A dairy society's success and competitiveness in the market deeply depends on transportation cost. Challenges and problems in transportation are experienced right from collecting the raw milk from the farms to the factories, and in the delivery of the processed products from the factory and depots to the final consumer. Logistics costs, especially the ones related to transport can represent an excessive fraction of the business total production cost, and can range from 5% to 35% of the product's final value, depending on the sector to which the company belongs and the geographical location. Therefore it is essential to address the issue of logistics, especially in milk collection for the dairy societies, as it eventually influences the amount of income the farmers earn from their produce.

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Studies by the International Monetary Fund show that logistics costs account up to 12% of the GDP of a nation (Stock & Lambert 2001). Improvements in logistics have positive effects on prices of goods and services, the balance of national payments, currency evaluation, the ability to compete effectively in global markets, industry profits, the ability to raise investment capital, economic growth – leading to higher level of employments (Bowersox & Closs 1996). In Kenya, logistics is complicated due to the lack of modal options and poor road conditions. Transportation costs therefore form a significant component of total cost for companies, especially those that engage in the movement of raw materials or products. The major components of this cost include labour cost on the drivers, the cost of fuel, and the cost of the trucks. These costs are especially important where perishable products such as milk are being transported and specialized handling is required.

In most countries, milk is a scarce commodity. This has led to dairy companies attempting to attract as many farmers as possible through attractive inducement of competitive price per litre. Rival dairy companies regularly attempt to "poach" farmers from other dairy companies through much publicised increases in price per litre. The history of the dairy industry contains many examples of so called "Milk Wars". Marketplace competition for dairy products, and similar levels of efficiency in modern milk processing plants, ensure that the dairies cannot profitably operate if the cost of a litre of milk arriving at the processing plant is out of line with others in the industry (Gonzalez & Machin, Undated). This is not different in Kenya where small dairy cooperative societies are expanding at a high rate to compete among each other and against some large country-wide milk companies.

1.2 Logistics in the dairy industry in Kenya

Dairy production in Kenya forms a significant part of the rural economy, accounting for 33% of agricultural Gross Domestic Product (GDP), and is the primary source of livelihood for over 600,000 smallholder farm families (Omore et al.1999). Smallholder dairy production is a widespread and growing activity in the Kenyan highlands, and a potentially important source of livelihood for many poor farmers with road access to urban areas of East and Southern Africa. Currently over 80% of the estimated 1,500 million litres of milk produced annually in Kenya comes from smallholder dairy units (Waithaka, 1993). This contrasts with the structure of production in earlier decades, when most of the milk was derived from large-scale producers. Smallholder dairy production is concentrated in the high potential areas of Central and Rift Valley Provinces. Smallholder dairy farmer co-operative societies have played an important role in the adoption of market-oriented dairying by smallholder farmers, by providing them with often the only reliable milk marketing outlet (Raikes 1981).

Barriers to smallholder participation in the milk industry nevertheless remain; market factors are among the most important constraints for this highly perishable commodity, poor roads and long distances, high costs for transport, affecting both the reliability of markets and prices available to farmers. Nonetheless, with growing populations, urbanisation, economic growth, and rapid increasing middle class, the demand for milk is expected to grow by 30% in the next 10 years, (TetraPak 2011)), making the milk industry an important venture to invest in. Logistics, therefore, is an important area for the dairy companies or society in Kenya to improve, owing to the characteristic of the dairy farming where the small-scale farmers are scattered across large geographical areas.

1.3 Problem statement and study objectives

GIS and logistics is a new technology that has not been in use in Kenya until recently. The technology is yet to be embraced by the dairy industry. Vehicle routing and scheduling of milk collection activities are done manually through experience and as per demand, resulting in high transportation costs. The situation has been worsened further by the rising cost of fossil fuels globally, which calls for use of other means of reducing transportation costs. There is, therefore, a tremendous capacity for growth if the companies embrace these new technologies in their operations.

The study took a case study of a fast-growing dairy company operating in Githunguri District in, Kiambu County, lying 50 kilometres northwest of the capital city of Nairobi (Figure1). The dairy company, popularly referred to by its marketing trade name "Fresha", is owned and managed by Githunguri Dairy Farmers Co-operative Society (FCS). Githunguri FCS was registered in August 1961 with a membership of 31 and one milk collection centre, but has had a tremendous growth with membership rising to 17,000 members and 58 fully-computerized milk collection centres to date. an annual turnover of Ksh 3 billion, and an average of 170,000 litres of milk per day ((Fresha Dairy Products). The catchment area for the dairy society is mainly Githunguri District, where most of the members reside.

The milk society cites high operational costs in their milk collection activity as one of its biggest challenges. This is exacerbated by the roads which are not all weather, especially during rainy seasons. This has led to the increases in the cost of transport through use of long routes in addition to other factors such as time spent during milk collection, capacity of the trucks, and scattered milk collection points. The lack of a logistics system contributes to a complicated process in proper milk collection, delivery and distribution, and suitable routes assignment for trucks, besides the routes and the collection points not being mapped. In general, there is lack of skills and knowledge on the adoption and use of modern technology such as GIS in milk collection and delivery system. For the dairy to be productive, proper planning is a must especially on

the milk collection routes. Considering that the milk is transported in churns carried by trucks, the distance travelled needs to be minimized, so that the delivery to the processing plant is achieved in optimal time when the milk is still fresh.
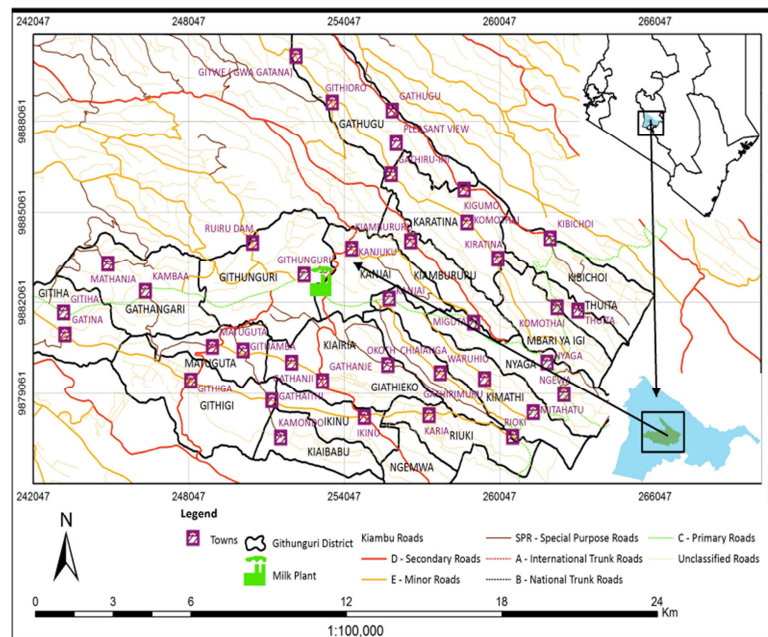

Figure 1: The dairy milk collection catchment area in Githunguri District, Kiambu County, Kenya.

Dairy farming in Githunguri is mainly carried out by small scale farmers who own 3 to 10 dairy cows. The production per farmer ranges from 60 litres to 300 litres per day, with most selling their milk to the dairy. The members deliver the milk at small collection centres where it is measured and transported to main collection centres. The dairy collects milk from these collection centres by use of trucks twice a day, and delivers it to its single processing plant at Githunguri town. There are 58 collection centres spread across the District and beyond. The dairy uses 10 routes and 17 trucks to collect the milk and transport it to the processing plant. The trucks have an approximate capacity of 10,000 litres.

Milk is collected twice a day; in the morning and in the evening. The morning schedule starts at 5.00 am to 9.00 am, while the evening one begins at 2.00 pm to 7.00 pm. The collected milk is then transported to the plant within two hours of milking. At the collection centres, the milk is weighed using digital weighing scales, which then transmit the data to the dairy's head office in Githunguri town. Despite the use of this digital weighing system, the dairy has no software to handle routing, scheduling and location of collection centres. This is achieved manually by schedulers where they consider the number of farmers in a certain locality and also the distance from one centre to another. The main problem affecting the dairy on aspects of milk collection remain the poor state of most of the roads and the high cost of fuel. However, there has been an improvement and several roads are fairly well maintained and in good condition. The dairy has indication that it possesses a dire need for routing software to enable in scheduling and routing.

The general objective of the study therefore was to explore the use of GIS and logistics in improving the milk collection and delivery service for Githunguri Dairy FCS. In specific, the research aimed to map out the milk catchment area served by the dairy, map the collection centres, service areas, and the processing plant in the catchment area, establish optimal travel routes, and compare the derived routes with those in use by the dairy.

2   Materials and Methods

2.1   Materials

The data used in this project included administrative boundaries, road network data, milk collection centres location data, location of the dairy's processing plant, and trucks data. The roads data was compiled from existing vector data from the Kenya Rural Roads Authority. The spatial location of the collection centres, as well as that of the processing plant, were collected with the aid of Android GPS-enabled mobile phone, and while the attributes were updated with the aid of the company's staff. All the spatial data was integrated in ArcGIS software under the Universal Transverse Mercator (UTM) Zone 37S map projection system.

The most essential data was the road network data. This was checked for consistency, cleaned, and topology created to facilitate the creation of a network dataset. It was then classified into four surface types: premix, earth, gravel and surface. Other attributes included were: the number of lanes, road class, lengths, and its condition. Additional attributes introduced were design speeds for various road classes, and the time to cover each road segment. Additional data and information relating to milk collection such as the routes, average milk obtained from each milk collection centre, and the schedules of the milk collection were also obtained.

2.2   Methods and Analysis

The situation of the dairy in addressing the logistics of milk collection and delivery is one that needed the assignment of vehicles to routes and minimizing the individual as well as the total distance and time taken by the vehicles through the collection centres and back to the processing plant. Such a scenario belongs to the problems in logistics known as vehicle routing problem (VRP), whose algorithms have been implemented in major geographical information systems software such as ArcInfo of the ArcGIS software family. The VRP class of problems relates to servicing customer demands from a single depot, with the customers locations, depot location, and customer demands being known (de Smith, Goodchild, & Longley, 2007).The solution to VRP seeks to minimize the overall length of the routes, subject to some constraints such as pre-defined time windows for deliveries, problems involving pickups and deliveries, problems involving a series of depots, problems where demand is dynamically variable, among other constrains.

ArcGIS 10 was used in this study to view and manipulate the geographic data. The software was used specifically to query, explore and analyse data from a statistical and spatial perspective. The logistics analysis was achieved via the Network Analyst extension, where the algorithm to perform Vehicle Routing Problem (VRP), has been implemented. The solution presents the 'least cost impedance' path on the network from one specified stop, in this case the processing plant, to one or more stops, the milk collection centres. VRP relates to servicing customer demand from a single depot; the customer locations, depot location, and customer demand levels are assumed to be known.

The study started with the identification of all the milk collection centres. A GPS-enabled Android mobile phone was used to collect the spatial coordinates of most of the collection centres; others were identified from Google Earth and their coordinates digitized. All these were then imported into a personal geodatabase. Attribute information of the collection centres necessary in solving the VRP for the daily were then added. Of the 58 collection centres whose spatial locations were mapped, only 40 had complete information that could be used for further analysis.

A network dataset was then created from participating feature classes: the road data, milk collection centres, and the milk factory. Of great importance in the network data creation was setting the hierarchy of the road links. The hierarchies were set to match the surface type of the road, with the highest being gravel, followed by surface dressing, then premix, and the lowest being the earth surface. From the network dataset created, routes that were used by the dairy were then mapped, and from it, the time and distance taken per route were determined. The total time and distance covered by all the routes were also derived. The logistics solution of VRP was then solved to derive the optimal paths to serve the 40 collection centres, and similarly the time and distance taken per route determined. A comparison of the currently used routes by the dairy and those derived by the VRP solution was done.

2.2.1   Vehicle routing problem solution explained

The solution to vehicle routing problem involves how to best assign a group of customers to a fleet of vehicles and to sequence and schedule their visits. The objectives in VRP solutions are to provide a high level of customer service by honouring any time windows while keeping the overall operating and investment costs for each route as low as possible. The constraints are to complete the routes with available resources and within the time limits imposed by client demands, driving speeds, and workloads.

When a network dataset has been generated in ArcCatalog, it's added in ArcMap (the graphical user interface for ArcGIS) for network analysis. A VRP layer, generated via the Network Analyst is loaded in ArcMap together with its 13 network analysis classes. The classes are: *orders, depots, routes, depot visits, breaks, route zones, route seed points, route renewals, specialties, order pairs, point barriers, line barriers, and polygon barriers.*

Order feature layer stores orders of the VRP analysis layer. For this case it refers to the collection centres. Milk is picked up from these centres twice a day. The approximate milk quantity to be picked up at each centre in kilograms is of different capacities. These orders have a service time of 20 minutes, which is the time needed to complete the work at the order. Milk collection is done in two time windows; that are 06:00:00 to 09:00:00 and 15:00:00 to 18:00:00 hrs.

Depot feature class stores the depots. The dairy has got only one depot which is the processing plant which is located at Githunguri Town where all milk collected is transported to. The plant has open and close times and vehicles cannot arrive outside the time windows.

The route network analysis class stores the routes. Route refers to vehicles, routes and drivers. The dairy has a total of 10 routes used in milk collection. The time spent at the dairy plant after the milk collection for purpose of unloading is referred to as *end depot service time*. The route starts at a fixed time, therefore has no latest start time. **Operation cost** for each route is made up of time-based cost, distance-based cost and/or fixed-cost. Fixed cost are incurred when additional vehicles are rented to handle high-workloads, time-based cost includes cost of paying the driver for hours worked, overtimes and lunch breaks, while fuel-cost determines the distance costs. The dairy makes use of trucks that have a capacity of 8, 000 litres per collection.

Depot feature class layer is created when the route starts and ends at the plant. This provides information regarding why a route visited a depot and what happened there. The amount of milk unloaded by a route at the plant is recorded in the properties of a depot visit. This layer is an output-only network analysis class because the features are created strictly during the solve operation.

2.2.2 Vehicle routing problem analysis parameters

The parameters are set on the properties dialog box of the Vehicle Routing Problem layer. The parameters are: *time-cost attribute, distance-cost attribute, default date, capacity count, time and distance field units, output shape type, and hierarchy attribute* among other availed parameters.

The **time-cost attribute** defined while creating the network dataset is used to define the traversal time along the elements of the network. The **distance cost attribute,** also defined while creating the network dataset, is used to determine the length along the elements of the network. The **default date** is set to 'Day of the week'; this helps to configure an analysis layer that can be reused without having to remember to change the date. Capacity count refers to the number of capacity constraints dimensions required to describe the relevant limits of the vehicles. For the case of the dairy, it has a capacity of one (1) because only the volume of milk is considered and not weight which would make the capacity to be two (2).

The **time fields and distance field units** are set to minutes and metres respectively. These units are used by the analysis layers, sub layers and tables. The **output shape type** is set to '*True Shape with Measures'* because it gives the exact shape of the resulting route. The output includes route measurements for linear referencing. The measures increase from the first stop and record the cumulative impedance. The **hierarchy attribute** created during the network dataset creation is used resulting in the solver preferring higher-order edges to lower-order edges. This will determine the choice of route that a driver should choose to optimise in delivery of the milk.

2.2.3 Solving the VRP

The VRP is solved after creating the vehicle routing problem analysis layer, populating the required analysis objects, and setting appropriate analysis properties. This generates the routes along the road network connecting centres served by the same route. The vehicle routing problem solver then computes an internally-managed origin-destination (OD) cost matrix between each of the orders and depot locations using the *time attribute* as impedance and *distance attribute* as an accumulated attribute. If some constraints are violated, the solve process fails and if a route is not used in a solution then its output field is set to null. After successfully solving the vehicle routing problem analysis layer, the time spent and distance travelled in each route were obtained, and could therefore be compared to those in use by the dairy.

3   Results and Analysis

3.1   Mapping out the milk catchment area

The dairy society serves members who reside mainly in Githunguri Division, which currently has been elevated administratively to form Githunguri District. A geodatabase with all the milk collection centres, administrative boundaries, roads, major shopping centres was compiled from which necessary maps such as the dairy's catchment area could be easily retrieved and printed for spatial awareness and empowerment of the dairy staff in its operations and planning. This database could easily be expanded to accommodate other milk collection centres, and for planning further expansion of the dairy activities. The mapping also demonstrated the applicability of GPS-enabled Android phone   for application in mapping.

3.2   Vehicle routing problem results

A total of ten (10) routes were generated from the Vehicle Routing Problem analysis (Figure 2). The routes serve a total of 40 collection centres. The collection centres were assigned to routes based on several factors such as; vehicle capacity, maximum distance that can be travelled, total time spent, the number of centres visited and pick up volume of each centre. Similarly, the routes being used by the dairy were simulated and a similar report generated. Both routing problems were

generated under the same conditions, i.e. same roads, same vehicle capacity, maximum distance travelled per day. A comparison of the two revealed that the dairy could efficiently and effectively collect the milk using only 8 routes.

Of the 10 routes, the results (Table 2) revealed that two routes had zero time and distance, which implied that eight routes were adequate to serve the 40 collection centres effectively and efficiently. The results show that the total distance travelled currently was far much greater than the optimal routes generated via VRP solution by 52, 424.29 metres, and time-wise by 8 hrs 45 minutes (525.59 minutes), for the morning shift. See table 3. However, simulation of both morning and afternoon shifts with the 8 routes, showed that the generated optimal routes were more costly in distance by 6,235.76 metres, but saved on time by 1 hour 26 minutes (76.79 minutes). This is because time windows were considered, where the vehicles travel a longer distance but are able to achieve the same results. This helps to optimize the work done by each truck, while ensuring that no single truck was overworked.
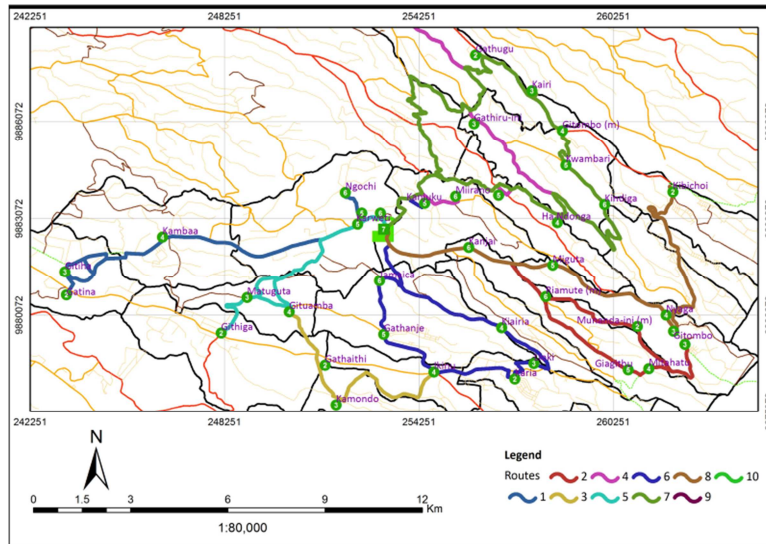

Figure 2: The optimal routes generated by the VRP solution.

Table 1. Comparison between routes used and those generated

Route	A: Current Total time (min)	B:Current total distance (m)	C: VRP total time (min)	D: VRP distance (m)	Difference in time (min) (A-C)	Difference in distance (m) (B-D)
1	212.52	30,495.53	205.39	29,310.23	7.14	1,185.30
2	216.92	34,514.99	202.30	26,015.58	14.61	8,499.41
3	211.97	18,400.83	198.86	20,564.96	13.12	-2,164.13
4	192.56	24,963.69	209.99	37,092.43	-17.42	-12,128.75
5	218.32	31,676.39	199.08	17,808.19	19.24	13,868.21
6	182.13	5,089.71	182.97	23,421.23	-0.83	-18,331.52
7	235.43	34,328.72	206.76	35,626.24	28.67	-1,297.52
8	215.30	39,226.97	203.03	35,093.72	12.27	4,133.25
9	214.88	30,989.54	0.00	0.00	214.88	30,989.54
10	233.91	27,670.50	0.00	0.00	233.91	27,670.50
Total	2,133.96	27,356.87	1608.37	224932.58	525.59	52,424.29

4   Conclusions and Recommendations

In light of the analysis and simulations performed, and, it is evident that if the use of   GIS and logistics in route planning and scheduling would bring benefits to the dairy company. The mapping of the dairy's catchment area with all the milk centres, roads, trading centres and towns, and other important facilities, provides a fundamental base map for not only the management but also for the operations staff in planning their activities. GIS provides an essential tool which can aid in the improvement of milk collection and delivery of other extension services to the farmers. A GIS may be adopted because it is capable of handling both spatial and non-spatial data necessary for the management of the dairy company's activities. A GIS system will enable the dairy to use short and cheaper routes during the milk collection, with high rate of return within a short period, a decision that the traditional methods of handling data are incapable of providing. The dairy can therefore save in time, mileage and labour.

As a recommendation, the dairy company should map all their facilities to enable easier management; besides the milk collection centres, the dairy has other facilities such as outlet stores that they use for extension services for the farmers. The dairy may also need to map out the location of the farmers who supply them with the milk in order to utilize more functionality of GIS such as optimal location of the milk collection centres. In addition to network analysis, GIS has other uses such as asset management, fleet management, and marketing. The implementation of GIS in the milk collection and delivery scheduling should be institutionalized in order to ease information management for both spatial and non-spatial data. The benefits would however be more seen when all the concerned stakeholders such as the management, quality assurance staff, schedulers and planners, and marketers are trained in the use of GIS as a tool for planning in milk collection and delivery, and in other necessary application areas in the dairy.

Acknowledgment

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Landuse / Landcover of Sialkot Using RS & GIS - An Urban Sprawl Perspective

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KEY WORDS: Urban Sprawl, Urban Remote Sensing, Urban/Sialkot GIS, Mapping, GPS

ABSTRACT:

In search of job opportunities, civic facilities and due to rapid growth in population, there is a huge trend of urban sprawl especially in developing countries like Pakistan. In absence of organized records, it becomes extremely difficult to control the urban sprawl in accordance with the available civic facilities/resources and ultimately people suffer from unavailability of basic civic facilities (e.g. water, sewerage, electricity, burning gas, and hospitals etc) in bigger cities. The situation becomes worst when house-hold industries penetrate into and keep on enrooting inside a city along with urban sprawl. This results not only in uncontrolled urbanization with extremely meager civic facilities but also increases crime rate. Sialkot is one of the similar types of cities in Pakistan. A comprehensive Landuse/Landcover of Sialkot has been developed using RS&GIS to facilitate all city administrative agencies for their current and future decision-making. The base-map has been developed using various historical drawings/maps, satellite images, and house-hold datasets obtained through GPS surveys. Various analytical maps/reports have been generated and interesting results have been deduced. In Sialkot, as in other intermediate cities of similar sizes, industrial, commercial and housing developments are expanding and radiating out generally all along the major transport corridors. Although Sialkot is expanding in all directions, but the major flux is towards north-west, west and south sides of the city. The expansions towards north and east directions are restricted because of the Cantonment and the Indian border. The current work will provide a basis for future urban planning of the city.

1   Introduction

Urban sprawl is one of the problems in the cities nowadays. In the past decades cities had define and specific boundaries, but they have missed their realms by excessive growth today. The word 'Urban Sprawl' means more growth than the usual and what makes it different from urban growth is this excessive nature. Cities tend to growth and planned growth is reached while there is an appropriate proportion between urban growth and urban organism. But when the growth is more than usual, its pressure on the boundaries, city will face new major problems. Until about three decades ago, Pakistan's cities were compact and cantered upon a civic administrative or commercial core. Now in Sialkot (Figure 1), as in other intermediate cities of similar sizes, industrial, commercial and housing developments are expanding drastically. What were previously small rural

Figure 1

Source:

MODIS Image of Pakistan

settlements are becoming engulfed as contiguous areas to the cities built-up areas and the interstitial areas between the radials then coalesce to form extensive areas of urban sprawl. The predominance of central place functions becomes less dominant as mobility and spending power increase, economic linkages strengthen and
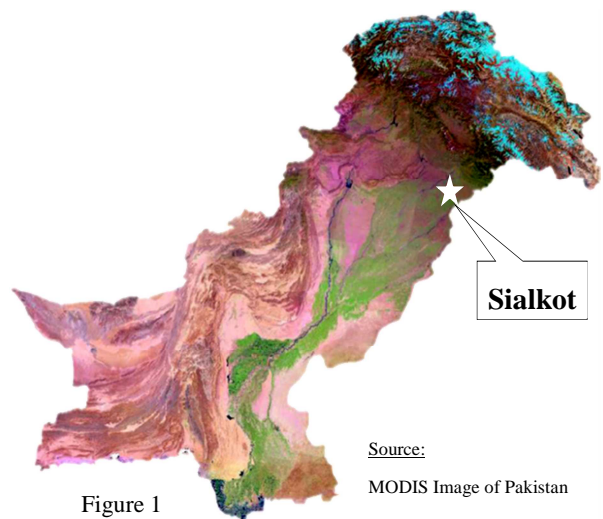
newly emerging commercial, institutional and servicing functions emerge; incrementally making the urban form less cantered and more multi-nodal and metropolitan in character. Sialkot District comes under Gujranwala Division and is one of 36 districts within Punjab Province. The total population of Sialkot District, which was 2.7 million in 1998, is estimated to be about 3.6 million in 2010, growing at 2.66% per annum. In 1797, Sialkot was a small settlement centered on a Fort just north of AikNullah. Over the next 100 years it expanded slightly towards north, and a railway station was constructed which crosses the city from east to west. Present population of Sialkot Tehsil is estimated to be around 0.912 million, about 27% of the entire District. The population of the Sialkot city (Ex Municipal Committee area and Cantonment) is estimated to be about 550,418 with an average population density of around 1160 per Sq Km.

2   Methodology

2.1   Conceptual Workflow

Population estimates and projections have been prepared for Sialkot using the following conceptual workflow:

1. A comprehensive review was made of all the available / relevant documents and information sources including 1981 and 1998 Censuses, the Vision 2030 Pakistan document, various reports and studies of Sialkot.
2. Maps were prepared identifying the present boundaries of the urban agglomeration, and these were overlaid on maps of administrative (Union Council) boundaries.
3. From these maps and related 1998 Census data, the 1998 functional urban population of each Sialkot urban population areas was determined.
4. A database was developed for Sialkot comprising of the population of District, Tehsil, pre-2001 city, cantonment and the peri-urban areas.
5. Analyses were generated of the population growth trends for each administrative area.
6. Population projections of Sialkot were made based upon national urban growth trends, the growth trend of the surrounding region, and the economic base.
7. Google Earth Image has been used for showing Urban Growth Patterns.

2.2   Schematic Diagram

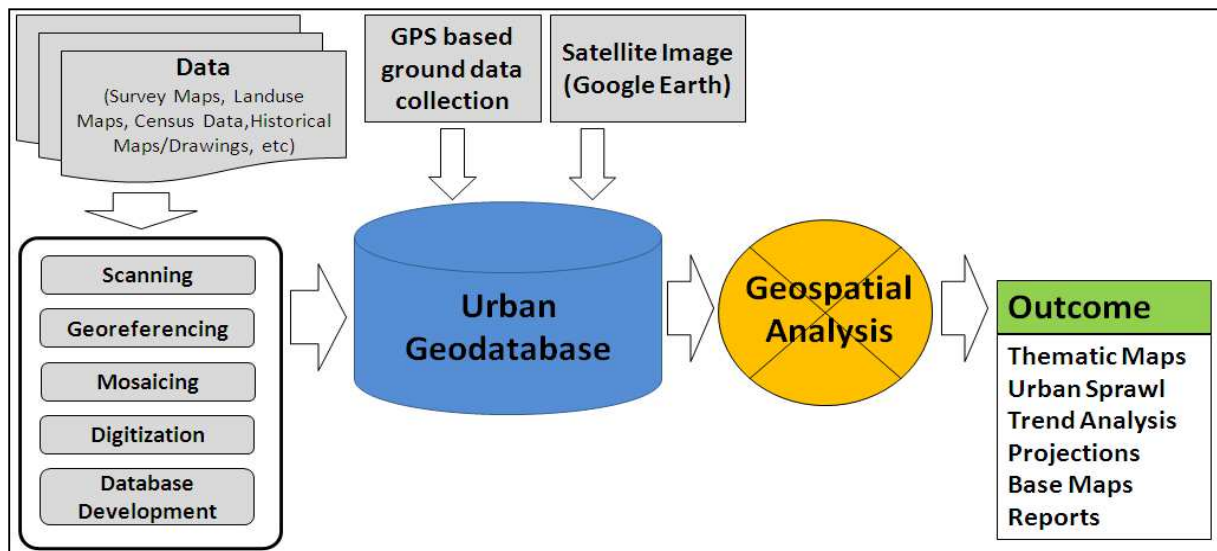The above conceptual work flow was quantified and implemented using the following schematic diagram, Figure 2:


Figure 2 Schematic Diagram

3   Monitoring Sialkot Urban Sprawl

Based on historical maps/drawings/data, it is found that after Pakistan partition in 1947, the city began to expand, mainly towards the north, as the Cantonment became more significant, and also towards north-west, in the direction of BhedNullah. In 1970s, the city had significantly densified and expanded up to Bhed Nullah, and substantial development of the areas of north of Bhed Nullah, centered around the Cantonment, had become much more pronounced. Recently, the city has grown in a westward direction along the major inter-city roads radiating out of Sialkot and along Defense Road. Figure 3 shows historical maps showing Sialkot growth patterns.

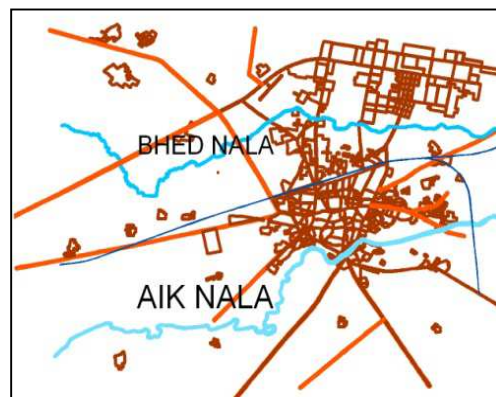**Sialkot in 1797**
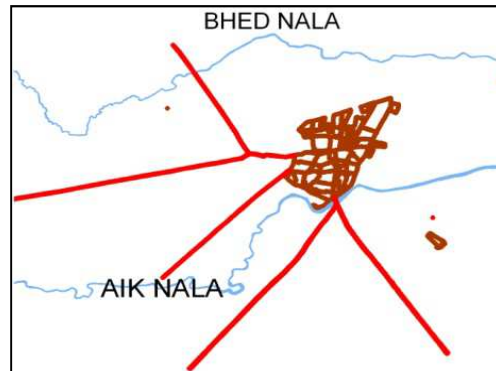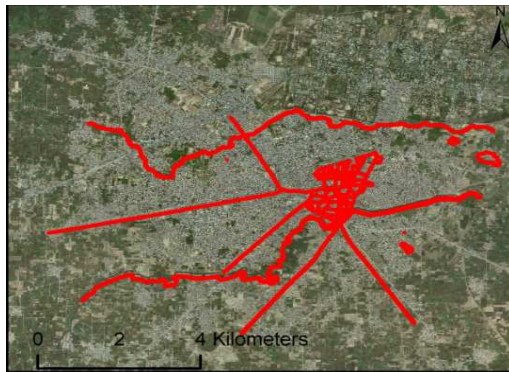
Sialkot in 1847
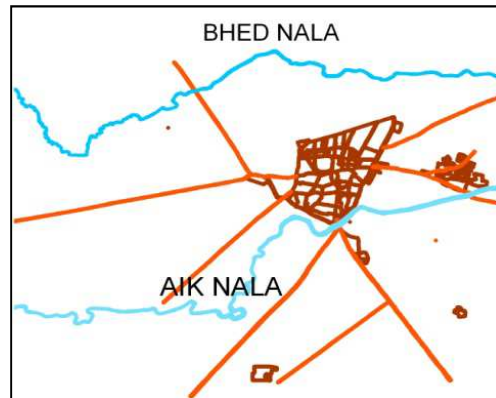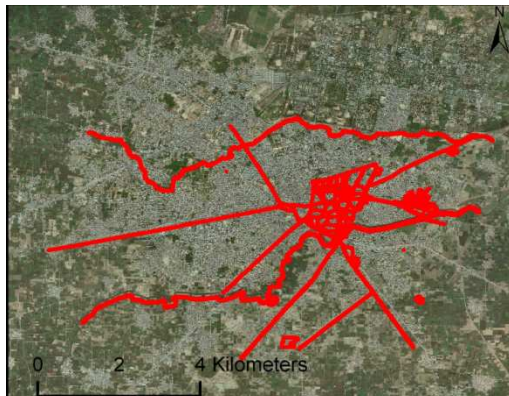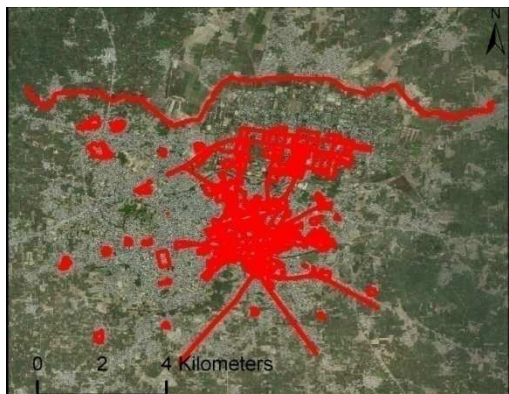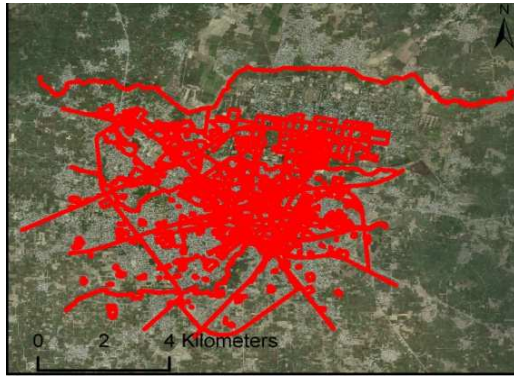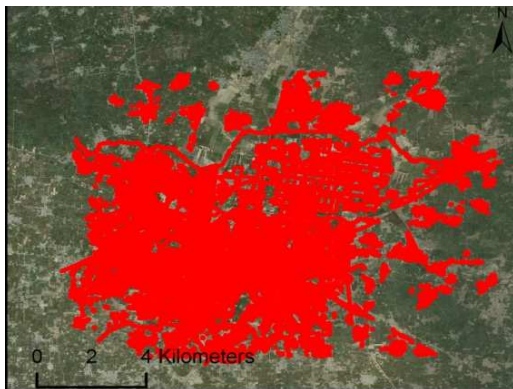

Sialkot in 1947

Figure 3 Sialkot Urban Growth Patterns (continued on following page)

Source: Sialkot Outline Development Plans, Urban Unit base maps and Google Earth.

Sialkot in 1972

Sialkot in 2010

4   Results and Discussion

4.1   Corridor-wise Expansion

The present growth trend of Sialkot is likely to continue, expanding more towards north-west and south-west. The 'pull and push' forces created by the proximity to the Cantonment and the Airport will encourage this trend to continue in future as well. Most of the sprawl has been absorbed in the following westerly corridors as shown in Figure 4:

Corridor-A: KotliLoharan Road – Marala Road

Corridor-B: Marala Road - Airport Road

Corridor-C: Airport Road – Wazirabad Road

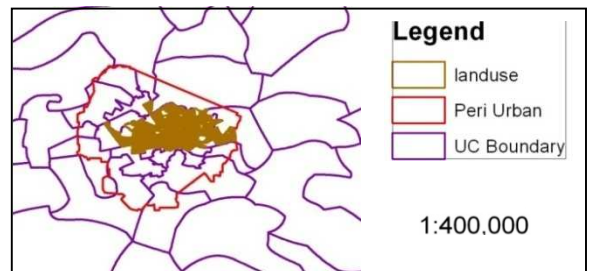Corridor-D: Wazirabad Road and Gujranwala Road.

Figure 4: Landuse of Sialkot (Urban Area)

Although to a lesser extent than west, additional growth will also take place towards south in areas falling between the following roads: An overall road network map of Sialkot city is shown in Figure 5.

1. Gujranwala Road-Eminabad Road

2. Eminabad Road-Pasrur Road
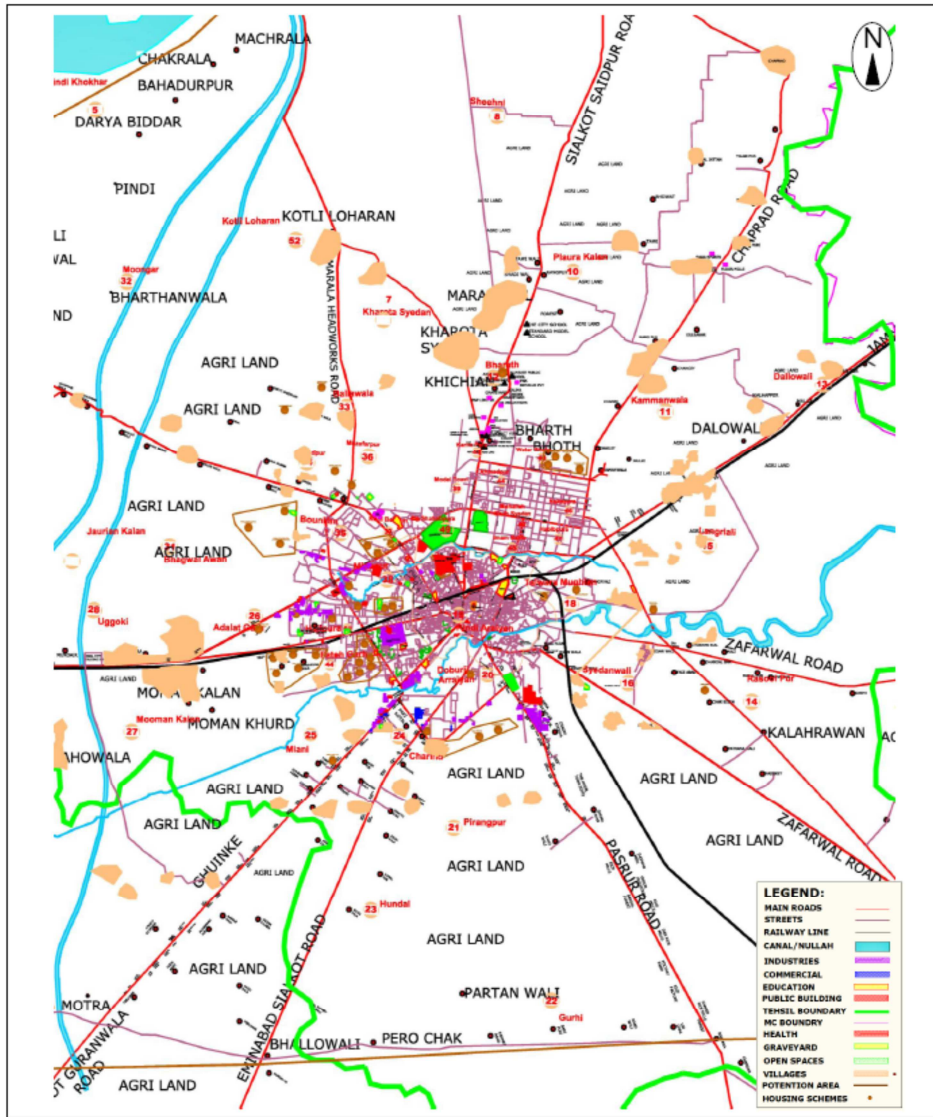
3. Pasrur Road-Zafarwal Road.

Figure 5: Sialkot City Land Use Patterns

Source: Sialkot city land use patterns adapted from Urban Unit base map.

4.2 Private Sector Housing Schemes

Data obtained from Tehsil Municipal Administration (TMA) Sialkot shows that 56 private housing schemes are currently under development in the city. An aggregated area under these schemes is 3,575 kanals (447 acres), while the average area per scheme is about 64 kanals (8 acres). Most of these Schemes are located towards west of the existing city, along roads heading southwest, west and northwest of the city. They extend up to the airport area. Assuming a gross density of 50 persons per acre, these schemes would only provide housing for 22,350 persons, about half of one year's growth of the city. Since the full development and occupation of these schemes will take 5-10 years, it may be judged that they will provide housing for only about 5-10% of the growth that is occurring. Most housing schemes in the city are built individually, by the private individuals who will later occupy it. Private Sector Housing Schemes are shown in Figure 6, and list of Housing Schemes is given in Table 3.
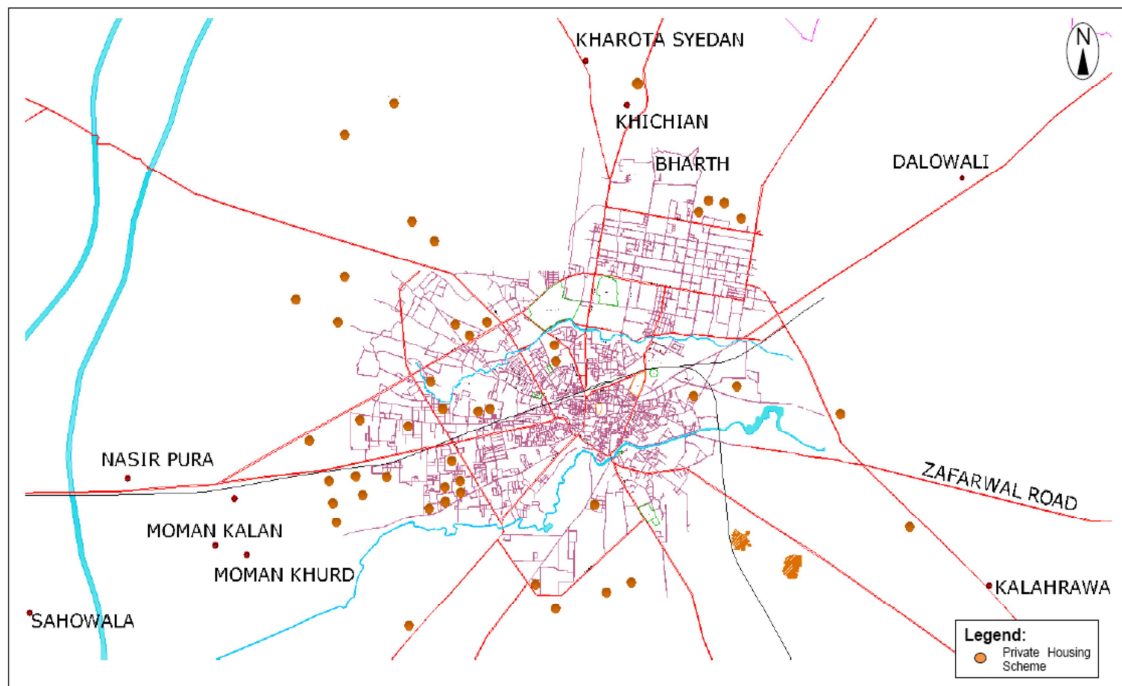
Figure 6: Private Sector Housing Schemes in Sialkot

Source: Urban Unit Sialkot base map and private housing schemes data obtained from TMA Sialkot (Scanned Maps)

Sr. No.	Housing Scheme	Area[*1]	Sr.No.	Housing Scheme	Area[*1]
1	Madina Colony Ura	89	11	GulshanAzeem Town Buttar	80
2	Cannt Model Villas Bharath	99	12	Happy Valley KotlaAmbanwala	18
3	Canal View Colony, Bharth	102	13	Model Avenue Ugoki	17
4	Defence Homes Colony, TalwaraMughlan	57	14	Aziz Town, JairamPur	48
5	Azeem Colony, Bhoth	75	15	Canal City RaiPur	273
6	Cantt Avenue Bhoth and Chak Rani	143	16	GulshanToheedShatabGarh	64
7	Defence Homes	115	17	Toheed Town ShatabGarh	5
8	Gohadpur Model Town	18	18	Kashmir Villas PaccaGarha	26
9	Gulshan-e- Ahsan	48	19	Mag Town PaccaGarhah	421
10	Osman Town	50	20	RehmanPurKhetchian	50

Table1: List of Housing Schemes in Sialkot

*1: Area in Kanals(Rounded off)   Source: TMA Sialkot

4.3   Planning Area - City Administrative Area

On the assumption that densities will decrease, as the city grows and expands during the next 20 years, it will triple in size, with most of the expansion occurring to the West and Southwest. Urban development will extend along Gujranwala Road to Daska, and along Wazirabad Road to Sambrial. Other major growth corridors will include to the Northwest, toward Kotli Loharan, and to the South, toward Pasrur. The contiguous urban area will cross the Tehsil Sialkot boundary between Daska and Sialkot and Sambrial and Sialkot Shown in Figure 7 below.
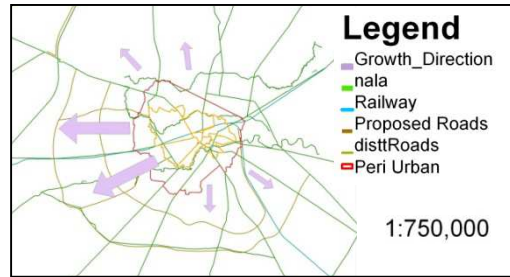
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Figure 7: Planning Area

5   Population Projections & Recommendations

In Sialkot, past efforts have been failed at their initial planning stage, and present capacity for planning and development control is limited and ineffective. The new growth pattern trends are well underway and present both positive potentials and negative challenges.

5.1) A necessary precondition is to define of what the most appropriate 'Sialkot Planning Area' should be future planning purposes. This will, in-turn, determine the urban population catchment area as the basic parameter for forecasting the future populations that need to be planned for.

5.2) Within the context of preparing this urban development framework, it is a fundamental pre requisite to redefine the 'Planning Area' concept within the context of a more strategic approach to urban planning and growth management. The consultants (HGK – Government of Hong Kong) for the development of Sialkot recommend that the new 'Sialkot Planning Area' definition should be set within an overarching district-wide context that relates more to a poly-centric metropolitan concept of development. The total population of the entire Sialkot District, which was 2.7 million in 1998, is estimated will be nearly 3.4 million by 2010, growing at 2.46% per annum. The present 2010 urban population of Sialkot District is estimated to be around 1.32 million, about 38% of the total District population, living in 10 urban centers including 'Sialkot City'. By 2020 it is forecast that the urban population of Sialkot District will increase by more than 1.2 million to reach almost 1.6 million and that the other urban centers (excluding Sialkot) will account for nearly 25% of this growth. Therefore, it is evident as Sialkot itself expands to coalesce with many of these towns, the nature of the growth and change synergies with the other settlements will play a significant role in determining the socio-economic performance of each urban center and the district as a whole. To this end, it is important that this poly-centric metropolitan area is understood to be an integral part of the strategic urban development framework for Sialkot.

6   Conclusions

The dynamics of Urbanization for the next 20 years cannot be understood or simulated within the confines as described by restrictive administrative boundaries. There will be drastic ribbon urban sprawl in Sialkot requiring expensive civic and administrative planning for which continuous updating of GIS based maps, geospatial database and household datasets for the study area are essential.

An overarching geospatial (district-wide poly-centric metropolitan) urban policy needs to be established to compliment the Sialkot Strategic Urban Development Framework.

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GIS Application in Water Distribution Network Modelling in context of a Small Town in Bangladesh

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KEYWORDS: GIS, Water Distribution Network, Water Demand, Nodal Demand, Land Use, Built-up Area

ABSTRACT:

Water distribution network (WDN) modelling requires various spatial and non spatial data input. Most of the WDN simulation software utilize the analytical abilities of Geographic Information System (GIS) to process and incorporate such information into the model. This paper presents a methodology of adopting GIS in WDN modelling involving pipe network digitization, water demand calculation, nodal demand allocation, topographic data extraction from Digital Elevation Model (DEM) and demographic data input. Alamdanga municipality of Chuadanga district of Bangladesh has taken as the case study area where currently no pipe network for water supply exists. The land use map produced from topographic survey and satellite image is used for demarcating the primary built-up area. A GIS based analysis is performed considering some parameters which affect the growth trend; in order to identify the potential future development area as an increment to the primary built-up area. Thiessen polygon method is adopted to delineate the command area of each node. Projected population density inside each administrative boundary is directly incorporated into the GIS database. All spatial information is integrated to non spatial information to compute the nodal water demand. The developed GIS database can be utilized in any suitable modelling tool for WDN simulation.

1 Introduction

A model input file of a WDN usually consists of node label, node coordinates, nodal elevation, nodal water demand etc. as design parameters. Some design criteria are also set like pressure, head loss, velocity etc. The accuracy of the developed model mostly depends on the input file. Therefore, preparation of a database of design parameters is a matter of paramount interest in WDN modelling. This study illustrates the preparation of a nodal water demand database, based on entirely GIS platform.

Various researchers depicted various methods for nodal demand computation; linear method (Walsky et. al., 1988, Quinary et. al., 1981, Swamee et. al., 1990), non-linear method (Watanada, 1973, Chilpunkar et. al.1986, Gupta et. al. 1993) Lagrangean Multiplier (Lancey & Mays, 1989), dynamic, mixed integer, gradient search, enumeration method etc. to analyze WDN network. We have used Thiessen polygon for nodal area delineation. Raster maps of input files are used mostly, because of large data storing capability of raster in small files. The prepared database has been created in the form of shape files, therefore can be exported as dbf file and also any of the input parameters can be projected in maps to create visual impact and to enhance the data analyzing capability of the modelers.

2 Methodology

The future built-up area is to determine first in order to find out the actual water demand in each individual node. Therefore, an urbanization potential map was prepared. Future built-up area was then extracted from the urbanization potential map. Commanding areas of the nodes are integrated with the built-up area map to prepare the intended GIS database for nodal demand computation.

The used spatial data input for the study are-

- Study area boundary polygon,
- Land use category polygon,

- Water body polygon,

- Road network line and

- Digital Elevation Model (DEM)

Demographic data (population data) is the only non-spatial data input for the study.

2.1   Urbanization Potential Mapping

An urbanization potential map was prepared considering the following parameters- present land use category, land topography (represented as DEM), access to road network and access to water bodies. Raster maps of the aforesaid parameters were prepared from topographic survey data, adopting 20 m cell size. The maps were then reclassified into 10 base scale. Weighted sum of the reclassified maps was produced to get the urbanization potential map.
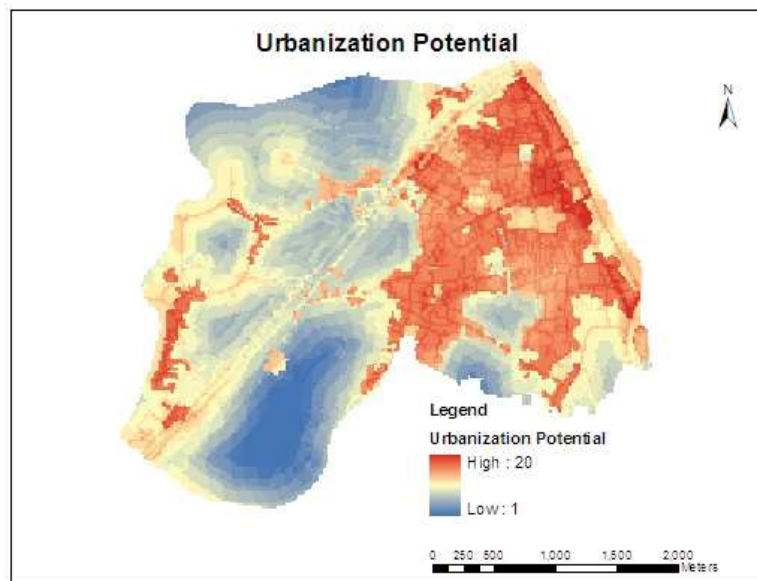
Figure 1 Urbanization Potential Map of the study area

2.2   Assessment of Built-up Area for Design Years

From United Nation's report (World Urbanization Prospects, the 2011 Revision), projected urbanization rates for every 5 years up to design year was extracted. Count of cells representing the built-up area was computed from the land use map of the year 2010. Using the urbanization rates and count of urban cells in 2010, future count of urban cells was determined up to the year 2025 (Table 2). The urbanization potential map produced in the previous section was reclassified into 20 distinct classes so that future built-up area can be extracted with high accuracy. By random iteration, the 20 classes are grouped into built-up and non-built-up area so that count of cells in built-up area (17,104) is close to the future count of urban cells (17,183) computed in Table 2. Urbanization Potentiality class 9 to 20 represents the built-up area of 2025. Figure 2 and Figure 3 represents the baseline built-up area and design year's built-up area respectively.

Years	Urbanization Rate	Count of Cells	Area in km2
2005-2010	1.69	14266	5.71
2010-2015	1.7	14507	5.80
2015-2020	1.71	15784	6.31
2020-2025	1.7	17183	6.87

Table 1. Showing Urbanization and corresponding cell count of raster map
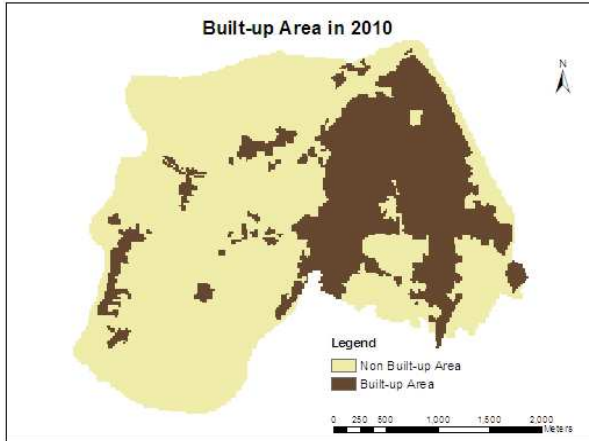
Figure 2 Baseline built-up area
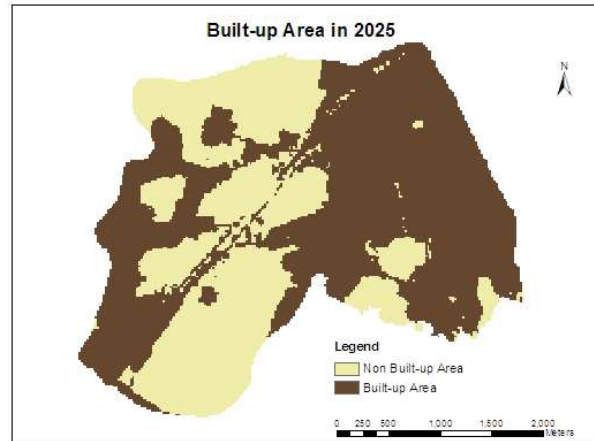
Figure 3 Built-up area for design year

2.3   Nodal Area Delineation

The proposed pipe network was digitized along the road network. Nodes were placed at each intersection, confluence and pipe end. For water distribution network modelling purpose, water demand in each node has to be computed. Command area of each node was delineated using "Thiessen Polygon". The produced Thiessen Polygon map is shown in Figure 4.
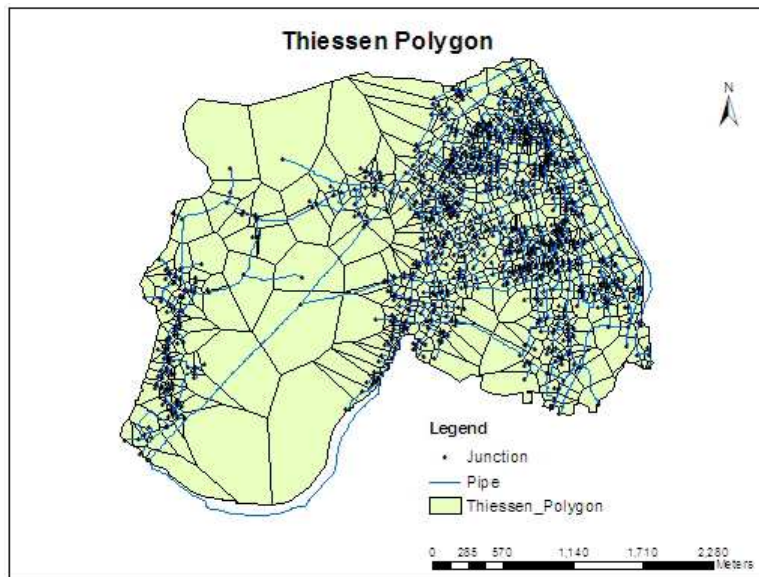
Figure 4 Nodal area delineation using Thiessen Polygon

2.4   GIS Database for Nodal Demand Computation

The built-up area map for 2025 was converted from raster to polygon. Thereafter, the built-up area polygons were integrated with the Thiessen Polygons by 'Union' method. The produced feature contains build-up area and non build-up area of each Thiessen. 'Pivot Table' function was used to arrange the dataset according to Thiessen label. Therefore, the table was again joined to the original node shape file. Elevation value of each node was extracted from the DEM using 'Extraction' toolbox. Thus the GIS database for nodal demand computation has been prepared. The attribute table of the node shape file contains all necessary data for nodal demand computation. Some calculation in the table was done to produce a typical water distribution network model input format. A typical output table was produced in Appendix E.

3   Discussions

The baseline (2010) built-up area was 5.71 km2, and the projected built-up area in 2025 was 6.87 km2; which indicates 20.71% increase of built-up area. For assessment of urbanization, linear growth pattern is adopted using United Nations' predicted urbanization rates. But in case of population projection, exponential growth rate was considered. Therefore, population density in built-up area varied significantly from 6081 person per km2 to 8692 person per km2. Corresponding nodal water demand was also increased as consequence.

4   Limitations of the study

While assessing future urbanization, local urbanization trend could produce more accurate results than using United Nations' predicted urbanization rates. Same population density in the build-up area was assumed. But the developed method has the capability of assigning different population density in different class of built-up area. Proper function should be developed for computation of different population density in different class of built-up area. Similarly different per capita water consumptions could be considered for different income group of people.

5   Conclusions

This study depicts an entirely GIS based method for nodal water demand computation and storing the computed results in GIS shape file. The database can be used as input parameter's file for water distribution network modelling. Since the input parameter file is stored in a shape file, modelers can easily interpret and analyze the parameters in maps. Further study should be continued regarding this study to explore the methodology for entire WDN modelling in GIS platform.

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Appendices

Appendix A   Adopted Urbanization Index for Land Use Map

Land use Category	Urbanization Potential Index for land use
Grave Yard, Crematorium, Cemetery	1
Dense Tree Plantation, Forest	2
Open Space, Park, Play Ground	3
Agriculture	4
Education & Research, Religious Institution	5
Admin. Services, Health Services and others.	6
Transport & Communication	7
Homestead & Residential	8
Trade & Commerce	9
Manufacturing & Industry	10

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Appendix B   Adopted Urbanization Index for DEM

Land Level Range (m)	Urbanization Potential Index for DEM
8.96-.80	1
9.79-10.63	2
10.63-11.46	3
11.46-12.30	4
12.30-13.12	5
13.12-12.96	6
13.96-14.79	7
14.79-15.62	8
15.62-16.46	9
16.46-17.29	10

Appendix C   Adopted Urbanization Index for Access to Road Network

Road Distance Range (m)	Urbanization Potential Index for Road Network
0-28.28	10
28.28-84.85	9
84.85-145.60	8
145.60-212.60	7
212.60-282.84	6
282.84-354.40	5
354.40-425.21	4
425.21-501.59	3
501.59-594.64	2
594.64-749.67	1

Appendix D   Adopted Urbanization Index for Access to Water body

Water body Distance Range (m)	Urbanization Potential Index for Road Network
0-101.98	10
101.98-20.91	9
220.91-345.25	8
345.25-483.74	7
483.74-635.61	6
635.61-807.22	5
807.22-1003.19	4
1003.19-1229.31	3
1229.31-1516.44	2
1516.44-2030.66	1

Appendix E   Typical Database of WDN Modelling Input

Label	Elevation	BA10	NBA11	X_BTM	Y_BTM	PopDen12	Population	LPCD13	Demand (L/day)
N-1	13.31	0.01689	0.00040	392812	628712	8697	147	100	14700
N-2	14.76	0.00160	0.00000	392858	628652	8697	14	100	1400
...									

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[10] Built-up area in km^2

[11] Non built-up area in km^2

[12] Population Density in person per km^2

[13] Per capita water demand in liter per day

Application of GIS for urban management

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ABSTRACT

Thimphu Thromde (Municipality) is the national capital and the largest urban centre in Bhutan. The last topographical base map of the Thromde was prepared through UNOPS in 2000 using photogrammetry. Afterwards, it was neither validated nor updated. Ever since Thimphu city has grown significantly in both content and extent, numerous infrastructures have been added and even the extent of the Thromde has been increased by additional territory. The current base map has become obsolete as it fails to represent any new features and details that have developed all over the city. The value of this map has turned out to be very trivial resulting into impractical for most applications. Therefore, Thimphu Thromde has decided to carry out the topographical base mapping through high resolution satellite imagery to update both the content and extent.

The intend of the presentation is to illustrate the process of base mapping using GeoEye-1 satellite imagery as the primary data input and its associated application in utility mapping and city address system using photogrammetry and GIS technology.

GIS in Education

Geographic Information System (GIS) Development at the University of St. La Salle, Bacolod City

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ABSTRACT:

In accordance to the vision of the University of St. La Salle (USLS) to produce students responsive to global technology changes, the College of Engineering got involved with the GEOTEACH Project funded by the European Union Asia IT&C Programme. This was a collaboration between the University of Applied Sciences (Karlsruhe, Germany), University of Our Lady of Peace (Namur, Belgium) and three (3) partners in the Philippines, namely, Xavier University (Cagayan de Oro), Environmental Science for Social Change (Manila) and University of St. La Salle (Bacolod City). As a result, the Geomatics Laboratory was set up in the USLS College of Engineering in 2005. Its main purpose is to be a venue for capacity building of the faculty and students through the integration of Geomatics technology into the curriculum of the Engineering students. This involves the training of the faculty, gathering of relevant data, development of lecture and hands-on manuals and doing research related to the course. Through the years, GIS development has been consistently pursued in the University. Additional workstations were acquired and more researches have been done. Also, the continuing training of the USLS faculty and students has led to greater awareness and appreciation of the technology. GIS has also been successful integrated in some Engineering classes and have been used for service learning projects, focusing on environmental studies. Various environmental management projects with local communities have also been done using Participatory GIS techniques.

This paper gives an overview of how GIS development was done at the College of Engineering of the University of St. La Salle. It aims to present the experience of the university of GIS utilization in the context of a developing country such as the Philippines. It will enumerate the different activities done by the college to build up the utilization of GIS technology in the academic sector, specifically to the students, faculty and partners. A review of the major success indicators and challenges of each activity will also be discussed.

1   Introduction

Through the years, Geomatics technology has gained much interest in developing countries like the Philippines. Its wide range of applications has opened its use by different sectors such as the government, private companies, non-government organizations and academe. As one of the premier universities in the province of Negros Occidental, the University of St. La Salle also embarked on the development of this technology through its involvement with the GEOTEACH Project funded by the European Union Asia IT&C Programme in 2005. This 2-year project was a collaboration between the University of Applied Sciences (Karlsruhe, Germany), University of Our Lady of Peace (Namur, Belgium) and three (3) partners in the Philippines, namely, Xavier University (Cagayan de Oro), Environmental Science for Social Change (Manila) and University of St. La Salle (Bacolod City).

Through this endeavour, the Geomatics Laboratory was set up at the College of Engineering, the center of technology-based applications in the university. Primarily, it aims to be a venue for capacity building of the Engineering faculty and students through the integration of Geomatics technology into relevant courses. It also seeks to increase use of geomatics methodologies by other sectors of the university through research and outreach programs. Furthermore, it is also intended for access by GIS practitioners of the government, non-government and private partners of the university.

This paper gives an overview of how this development was done at the College of Engineering of the University of St. La Salle. It aims to present the different activities done by the college to build up the utilization of GIS

technology in the academic sector, specifically by the students, faculty and partners. A review of the major success indicators and challenges of each activity will also be discussed.

2   Methods and Processes

Geomatics development in the university was viewed as the synergy of three major components, the 3Cs, namely (1) Capability building (2) Curriculum integration and (3) Community-based research. Each component plays a very important role in ensuring the spread of the technology to as many people as possible, the increase of the awareness and appreciation of the tool and the generation of funds to support the development. Consequently, these will result in the sustainability of the program in the institution.

2.1   Capability Building

One (1) faculty member was trained at the University of Applied Sciences in Germany for 5 months through participating in Masters in Geomatics courses and personalized GIS tutorials and trainings by the German university staff. The use of GIS in an action-based research was also part of the capacity building and spearheaded by the University of Our Lady of Peace, Namur, Belgium.

Upon completion of these activities in Europe, the technology was then transferred by conducting training of identified faculty members in the Philippines. Training modules and hands-on manuals were developed with the supervision of the German university. In order to facilitate the learning process, lectures were accompanied with hands-on exercises and evaluation tools at the end of each session. Topics comprised of introductory concepts of GIS and are focused on the ESRI ArcGIS 9 software. Lectures were on (1) What is GIS (2) Basic Concepts (3) Hardware and Software (4) Data Acquisition (5) Visualization and May Lay-out and (6) Spatial Analysis. Hands-on exercises covers the topics (1) Introduction to ArcCatalog (2) Introduction to Arcmap (3) On-screen Digitizing and Editing (4) Digitizing Tablet (5) Attribute Data Acquisition using GPS (6) Symbology and Map Lay-out and (8) Overlays and Buffers.

2.2 Curriculum Integration

As an academic institution, the main thrust of the university is to produce students which are globally-competitive and this means that they must be competent in the use of emerging technologies such as the GIS. This is the reason that a major focus of Geomatics technology is to develop an appreciation and knowledge of the technology in the students. In order to do this, the following activities were done.

2.2.1   Set up of GIS laboratory.

Initial funding of the laboratory was sourced from the GEOTEACH project of the university. During its inauguration at the end of the project in 2006, the laboratory had a network of 8 licensed ArcGIS workstations with significant peripheral hardware such as 8 GPS units, 1 server computer, 1 digitizing tablet, 1 plotter, 1 scanner and 1 printer. For the sustainability of the laboratory, funds were then generated from the tuition fees of the students. The amount generated was used to expand and maintain the laboratory facilities as well as finance the GIS activities of the college. GIS workstations and softwares were purchased and now, the laboratory has grown to a work area of 16 licensed ArcGIS workstations with an adjoining lecture room for 30 students. Replacement of computer hardware was also done in 2011 by purchasing 4 additional computers.

1.2.2   Customization of training materials for students.

The training materials were customized for integration into the Engineering courses. The entry subject was identified to be the Environmental Engineering class which was taken by all 3rd year Engineering students, prior to their entry into the major courses. This will pave the way for further application of Geomatics into other applications upon the specialization of the students in their 4th and 5th year in the fields of Chemical Engineering, Computer Engineering, Electronics and Communications Engineering and Materials Engineering.

1.2.3   Service Learning Projects

One program introduced by the university in 2003 is the Christian Service Learning Program. Through this program, the university aims to introduce a different method of teaching wherein instruction is coupled with community service activities.

In accordance to the Christian Service Learning Program, GIS was also utilized in the Environmental Engineering classes. This involves allowing the students to learn and reflect on environmental management concepts by letting them serve the local community through interactions with the local community and analysis of their environmental conditions.

Two case studies were developed in relation to this. First, as a module on the assessment of water quality of Bacolod City, the ES10 students studied the water supply of all public schools in the City. This involves identification of their location using the GPS, collecting samples, analyzing relevant water quality parameters and mapping this using GIS. The identification of the most vulnerable areas, possible causes and mitigation measures were connected to water management plans of the community. Second, a project was done in relation to mangrove reforestation in a partner community of the university. Using GIS and in relation to the learning ecological concepts, students were asked to map out the mangrove area in order to spatially analyze the distribution of the mangrove species and identify improvements in the mangrove reforestation project. This map was also used to estimate carbon dioxide uptake in relation to climate change assessment.

2.3 Community-based Research

To further develop awareness and appreciation of the technology, Participatory GIS (PGIS) was adapted into the socially relevant researches of the university. USLS first used PGIS methods in defining a Community-based Solid Waste Management Program for an urban barangay of Bacolod City, Barangay 7 wherein information was gathered on the local perceptions and social acceptability of dealing with the solid waste problem in the community. Then, the PGIS method was replicated in a coastal barangay of the same city, Brgy Punta-taytay also dealing with their solid waste program. However, analysis and some methods were innovated to be more responsive to the needs of the barangay. Due to the favorable response of the community, GIS application was further expanded into another research involving basic needs assessment and poverty mapping of the area in 2009. Furthermore, in 2007, USLS applied PGIS methods to a rural mining community in the southern part of the province. This is in relation to resource management mapping in the area.

In Barangay 7, Bacolod City, community mapping was done in order to define the local knowledge and perceptions of the community regarding solid waste. Local leaders and key informants were asked to draw their community with the objective of defining the solid waste interventions that can be introduced by the local government units such as (a) materials recovery facility (b) collection points (3) compost gardens and (4) hazards. In the GIS technique, local leaders were involved in data gathering procedures and validation in the area. From here, a community-based program was developed.

Taking the learnings from Brgy 7, in the project of USLS with Barangay Punta-taytay, the involvement of the community was improved. As an understanding of the participatory nature of GIS was increased, community mapping procedures were enhanced and the appreciation of the GIS was first ensured. Furthermore, GIS analysis was developed such that constant consultation and validation of the parameters were done with the community. All results were also shown for review in every step of the process. Because of the reception of

For the mining community, Sitio Dung-i in Sipalay City, more focus was given to the social preparation and integration of the local community to the process. This was done by (1) training a member of the community in Geographic Information System (GIS) (2) letting a local explain and facilitate the community mapping activity (3) doing validation activities with the community and allowing them to use the Global Positioning System (GPS) (4) conducting Focus Group Discussions (FGDs) to finalize the map and (5) being in constant dialogue with the community to ensure the accuracy and acceptability of the map.

3   Discussion

Each component of the program has produced major results. However, there are still a lot of challenges which should be addressed and improvements in the program are needed.

3.1 Capability Building

As of 2012, around 100 professionals from the USLS faculty and staff, LGUs and NGOs have already been trained. The utilization of the technology is not confined to the College of Engineering anymore but has been used by the University Research Center and the outreach office of the university. This indicates that the acceptance of technology has been established and can be viewed as preparation for the wider utilization of GIS in the university. Also, linkages with other sectors in the university support the multi-disciplinary nature of geomatics technology, paving the way for further applications of the tool.

However, in order to encourage this spread of the technology in the academic community, continuous training of the GIS practitioners is needed. The technology is developing rapidly and versions of the software are being changed constantly and consequently, new functionalities need to be learned. Training modules need to be constantly updated and this requires time and costs for the university. With the advent of increased internet access, GIS data sources have also greatly advanced. Although this is a welcome change, efforts must be made in ensuring that data and methodologies which are incorporated in the courses are accurate. A lot of work is required to keep up with the technology changes and to transfer these changes to GIS users and specialists. In the universities of developing countries, this is a major challenge since capability building involves a lot of manpower and costs.

3.2 Curriculum Integration

Currently, six (6) members of the Engineering faculty are directly involved in curriculum integration of GIS in courses. Since 2006, The Geomatics Laboratory has already taught GIS to approximately 1300 students as part of their Environmental Engineering subjects. Starting 2007, GIS was used in a major Electronics and Communications Engineering subject to define microwave site location employing the open laboratory set-up. In this course, approximately 150 students have already participated. Although this is considered as a major achievement, there is still a need to identify more subjects wherein GIS applications are employed. This is one concern of the college and strategies are being employed to accomplish this,

Integration of GIS into courses of the College of Arts and Sciences are also being developed now, in relation to the study of Environmental Science. Further, in line with increasing the application of GIS to other academic institutions, the laboratory has also provided maps to students from other universities in Bacolod City, specifically, University of Negros Occidental-Recoletos and Colegio de San Agustin. This increased interest in the technology is a sign of the readiness of other sectors for more GIS-related involvement in the future. Comprehensive planning is needed in order to ensure that there are sufficient human and financial resources to implement this.

In terms of the Christian Service Learning Program, initial GIS activities have fostered interest in the tool but improvements have to be done in the implementation, specifically in social preparation and evaluation of the students. Utmost care must be taken so that the interaction between the students and community will not have negative effects. As a result, incorporation of GIS into the CSLP has been temporarily suspended in the college. Future projects in relation to this will be pursued when the CSLP program and community relations have been fully established.

3.3 Community-based Research

This component served to develop the GIS expertise of the GIS practitioners in the university. This better understanding of the tool will be translated into a more holistic approach when transferring this technology in the classroom and training venues.   Through these researches, important lessons were gained, most especially in the need to truly focus on social relationships in the conduct of the process. Although the tool has proven to be of great value to the community, the involvement of technical people must be confined to assisting the community in facilitating information and not on controlling the use of the tool. The sustainability of the program is dependent on the initiative of the community and so, planning tools must be consistent to their present needs and conditions. A great challenge for GIS use is in attaining the balance between technical soundness and social acceptability and this can only be gained by GIS practitioners by constantly working with communities.

Another benefit gained from this component is the increased awareness and application of GIS in the community. Their exposure to the technology helped them to accept the technology and identify more ways in using them. The process truly empowered them and facilitated their involvement in the process of decision-

making and communicating. PGIS gave them a sense of power, authority and control over their knowledge and aspirations for themselves and their community.

One challenge in this component is how to involve the students and sustain the use of GIS in social development projects. One way is by coupling this with the CSLP component of curriculum integration. Another way is by identifying research grants and linkages with other universities involved in GIS practice. These, however, requires a lot of planning and is not yet part of the immediate plans of the college.

4   Conclusions

The implementation of Geomatics development in the University of St. La Salle presents a plausible way of technology transfer. The three components, namely, capability building, curriculum integration and community-based research complement each other and have proven to be very beneficial in the advancement of the GIS program of the university.

The building up of geomatics technology is not an easy task especially in developing countries since human and financial resources are limited. Thus, involvement in an international project such as the GEOTEACH project was a major key to the start-up of Geomatics development in the university since capability building and acquisition of equipment were provided by the project. Also, the linkages established with other universities were an important factor in the attainment of the goals since the European universities served as mentors and guides for the universities in the Philippines.

However, development was not confined to the project and a more critical concern was the sustainability of the GIS utilization. This was addressed by the university by putting in mechanisms in the conduct of GIS activities such as defining a business plan, setting curriculum integration goals and continuous implementation of capability building activities. Existing linkages were also further strengthened. Constant strategic planning was also done so that implementation is responsive to technology changes in the world.

One contribution of the university is its focus on community-based GIS application. One vision for GIS is that it is a technology which must not be confined inside the academic community and its potential can fully be harnessed if it is used and appreciated by the local community.

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Evaluation and Development of Elearning Tools and Methods in Digital Photogrammetry and Remote Sensing for Academia and Industry

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ABSTRACT:

There exist already a wide variety of tutorials and on-line courses on Photogrammetry and Remote Sensing very often used in academia. Many of them are still rather static and tedious or target high-knowledge learners. ELearning is, however, increasingly applied by many businesses and training centers for life-long learning (e.g. the EduServ courses of EuroSDR[14]), with the target of saving time and cost, as well as expand their offerings to trainees living in distant areas. Moreover, a specific scenario is taken into account in some countries, like Saudi Arabia, where separation of the genders in all institutions in imposed, resulting in providing twice the number of educational workshops and courses. This paper will focus on these issues and present experiences gathered from a Master Thesis on "ELearning in Digital Photogrammetry and Remote Sensing using Moodle" at HFT Stuttgart and experiences from a current European Tempus IV project GIDEC (Geographic information technology for sustainable development in Eastern neighbouring countries).

The aim of this research is to provide an overview on available methods and tools, classify and judge their feasibility for the above mentioned scenarios. A more detailed description is given on the development of eLearning applications for Digital Photogrammetry and Remote Sensing (DPRS) using the open source package Moodle as platform. A first item covers the experiences from setting up and handling of Moodle for non-experts. The major emphasis is then on developing and analyzing some few case studies including lectures, exercises, and software training. Feedback from students and company staff will be evaluated and incorporated in an improved design and sample implementation. A further focus is on free software and tools to allow an easy integration of dedicated methods as audio and video flashes, quizzes for self evaluation, dynamic training, web-conference, etc. into the eLearning platform. The overall objective is to evaluate the possibility of allowing learners from academic and non academic sectors to get the initial experience and knowledge in DPRS in a modern, flexible and economic way. The time and the skills required for developing web-based materials will thus be investigated in more detail. Additionally, the quality of the developed eLearning application will be assessed based on a developed criteria list.

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[14] European Spatial Data Research Network (www.eurosdr.net)

Planning and Analysis of Educational Facilities using GIS: A Case Study of Busia County, Kenya

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ABSTRACT:

The educational sector in Kenya as in many other third world countries is faced with numerous challenges such as lack of infrastructural and human resources, poor accessibility, imbalance between demand and supply, among others. A spatial analysis on the situation of the sector for a better understanding is essential at various geographical levels in order to evaluate the extent of these challenges. The purpose of this study was to illustrate how GIS can be used in addressing the educational planning problems through a case study of educational facilities in Busia County. The study involved inventory mapping of all the educational facilities in the County in the backdrop of existing road networks, analysis of the regional distribution of educational facilities, and evaluation of spatial accessibility to the facilities. Demographic data were used in demand analysis for various educational services within the county. Using the demand ratios such as school age population to primary schools, Secondary schools to primary schools, teacher to student ratio and student to toilet facility ratios demand maps and graphs were generated in GIS environment that clearly illustrates the challenges facing parents and other stakeholders as well the disparities in provision of quality education within the County. In addressing the spatial distribution challenges especially in the imbalance in demand and supply, Centres of Excellence are proposed, and suitable public primary schools are identified for expansion to secondary schools, based on certain criteria such as number of facilities, land size the school is located, and topography.

1 Introduction

1.1 Background and problem statement

Education is the process of learning and acquiring information. It can be classified into two: formal learning through an institution such as a school, and self-taught learning or what is often termed as life experience. In recognizing that quality education is a prerequisite to socioeconomic development, the Kenya government has committed itself to the improvement of the educational facilities in the entire country since independence. However challenges still exist in ensuring access to quality education for all school age children especially in the rural areas. Despite the government's efforts in expansion and delivery of educational facilities since independence, it is widely recognized that increasing population and demand for quality education far outstrip the ability of the Government to provide effective quality educational services in Kenya.

With the promulgation of a new constitution in 2010, the management of the country's resources and infrastructure will drastically change; revolving at two levels of governance: the Central government and the County government. This, it is presumed, will address issues of distribution of the country's resources equitably. The central government still retain most of the roles such as policy formulation, coordination and implementation as well as management of educational facilities, while the county governments will oversee the supervision and management of the facilities. It is therefore of essence for each county government to understand and enumerate its resources in order to better its service delivery to the people.

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Busia County, located in the western region of the country, was taken as a case study in this research. According to the 2009 census, the County had a population of 736, 942, rising at the rate of 34% from that of 549,644 ten years earlier. Despite the rising population, the county's educational facilities have remained unchanged, with statistics from the Ministry of Education showing that it has 417 primary schools, 92 secondary schools, 2 middle level colleges and 3 University Colleges. The situation on the ground generally reveals disparity in the distribution of these educational facilities, especially at the primary school level where some children walk quite long distances to access educational facilities and others walk quite short distances. Nonetheless, there exists no study to document either the spatial characteristic or accessibility to these facilities. This paper presents an effort of a geographical analysis on Busia County's education facilities. In specific, the study sought to map all educational facilities of the county in the backdrop of population distribution, topography, and the transportation network; elucidate on the capacities for the education facilities, as well as suggest ways of improving on equitable spatial distribution of the education facilities within the county.

1.2   The Study Area

Busia County is located in the Western Region of Kenya. It is border by the republic of Uganda in the north, and Siaya, Kakamega, and Bungoma Counties in the south, east, and north-east respectively. It is comprised of ten administrative divisions namely: Bundalangi, Funyula, Butula, Matayos, Township, Chakol, Amukura, Nambale, Amagoro and Angurai(Figure 1). The County covers an area of approximately 1,683 square kilometres and is located between latitudes 00° 01' and 00° 47' north of equator and longitudes 33° 57' and 34° 26' east of Greenwich meridian.

The county has moderate climatic conditions with temperatures ranging between 20 to 28° C. The main economic activities include agriculture at both small and large scale, fishing especially along the areas bordering Lake Victoria in Bunyala district, and dairy and livestock farming at small scale. Land in this county is privately owned, with individuals mainly having absolute rights as recognised by existing registration systems. The County has a quite a heterogeneous landscape that varies from flat and flood-prone lowlands of Bundalangi and Funyula to the hilly and steep Amagoro and Angurai divisions on the slopes of Mt. Elgon. The county is traversed by an expansive road network that links the administrative divisions as well as the county with its neighbours. It has also a varying population distribution, with Township division having the highest density, and Bundalangi and Funyula divisions that border Lake Victoria having the lowest.
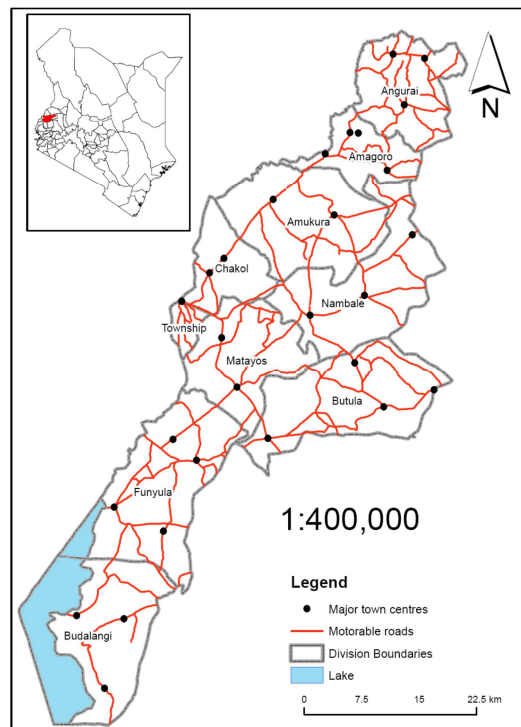

Figure 1: The study area: Busia County

1.3   Use of GIS in education planning

School mapping originated in France in 1963 (Caillods 1983; Da Graca, 1998; Galabawa et al. 2002; Govinda, 1999 as cited in Hite, 2008). School Mapping is a normative approach to the micro-planning of school locations and is also used to investigate and ensure the efficient and equitable distribution of resources within and between school systems especially when large-scale reforms or significant expansion of an educational system takes place (Calillods, 1983). Such reforms could be in form of government policies, such as the policy for free and compulsory primary education in Kenya that was introduction in 2003.

An educational system is inclusive of all supportive facilities, teaching staff, and an environment that is conducive for learning. Access to educational does not only mean attending school but also the proximity to the transportation network such as roads, sufficient number of teaching staff, adequate classrooms, good playing facilities etc. Access to quality educational facilities is therefore a critical determinant of the economic status of the populace. It is concerned with the ability of a population to obtain reasonably specified quality educational services. In general, access to quality education is an important concern for developing countries as is a significant factor that contributes to the economy of a given country. With its spatial analytic capabilities, GIS provides a good platform for a deeper geographical analysis of education accessibility.

To improve access to educational facilities, it is crucial to monitor how access varies across geography and sub-populations. Maps can be used to explore issues such as utilization and location of educational services and the difference levels of facilities. However the issue of access to educational facilities is in many respects a geographical one and thus spatial display of data is, in many ways, essential. The results are intended to empower researchers, policy makers, decision makers, practitioners, and donors to develop educational-related policies that achieve the highest benefits. GIS systems are therefore well suited to measuring spatial accessibility to educational facilities as they contain the core components needed for analysis such as data capture, storage, management and manipulation tools for both spatial and attribute data, core analysis algorithms such as buffering, overlay, suitability, proximity analysis, shortest path and raster cost-distance analysis, programming environments to customize and extend existing algorithms and create new analysis tools and mapping and visualization tools to communicate the results of analysis (Bazemore et al, 2003).

GIS can still be used in educational sector in many other ways such as conducting market studies and documenting educational needs of a community and to manage materials, supplies, human resources, and logistics, to forecast future enrolments and to predict future school requirements and appropriate locations so as to enhance accessibility to quality education and in the end improve the quality of life among many other areas (Attfield et al. 2002).

2   Methods and Materials

2.1   Overview and Materials

The problems that are experienced by the education sector in Busia County are mainly related to the spatial distribution of educational facilities and lack of balance between demand and supply in the provision of education to school age population. This study attempts to address these problems through inventory mapping of the education facilities, geographical analysis of demand-supply, facility analysis, staff-allocation analysis, and spatial accessibility and suitability analysis. Spatial accessibility in this research was based on straight line distances from the existing road networks. Demand analysis for the school facilities was carried out by computing the various indices such as, the ratio of school age population to existing facilities such as schools and classes, ratio of teachers to students, the ratio of secondary schools to primary schools, ratio of private schools to public schools, as well as ratio of number of facilities to the population density; all these were calculated and aggregated for analysis at the administrative division level.

Data used for this research work included scanned topographical maps, administrative boundary maps, demographic data of the county, school locations and related attributes. Data relating to the educational facilities was obtained from the Ministry of Education. The data comprised of the spatial location of the education facilities together with various attributes. The attributes of the data included facility classification. i.e. whether a primary , secondary or tertiary institution, total enrolment, number of teachers, school land area (acreage), number of toilet facilities for both boys and girls, number of laboratories, ownership of the school, whether the school was mixed. However, the dataset that was acquired had several missing values, necessitating only limited analysis to be undertaken, and forcing the analysis to be aggregated to the division level. This was particularly so for the primary schools data where the only analyses possible were on the spatial distribution per division in

the county, their ratio to that of secondary schools, accessibility, and for identifying suitable primary sections that could also allow expansion to accommodate secondary wing.

Additional spatial data for vocational training centres, middle level colleges, the three university colleges in the county, as well as important town centres, was collected using hand-held Global Positioning Systems (GPS) receivers. The GPS receivers were also used for verification of the spatial location data of the school data from the Ministry of Education and for the location of additional schools whose data had not been captured in the ministry database. All these were then assembled in a GIS geodatabase for further manipulation and analyses.

2.2   Methods

A total of nine topographical map sheets at a scale of 1:50,000 covering Busia County were used. All the topographical maps were   scanned and then georeferenced in Arc 1960 datum. The georeferenced map sheets were then converted from Arc 1960 reference spheroid to the WGS 1984 for harmonization with the position data of the schools that was already pre-collected. From these scanned maps, information as such rivers, streams, contours, road networks and railways were extracted through on-screen digitizing and stored as feature classes. The feature classes were then edited and to remove the errors that occur during the digitizing such as dangles, overshoots and undershoots. These feature classes were then used as basemap elements of the County educational facility map and also in the analysis of accessibility to these facilities.

The roads were originally classified into three: tarmac roads, dry weather roads, and loose surface roads. The dry and loose surface roads formed the main access to the educational facilities, while the tarmac roads formed only a small percentage of road networks. In analyzing accessibility, the tarmac and dry weather roads were considered as motorable, and used in the selection of suitable public secondary schools that could be expanded to educational *Centres of Excellence* for each division. The schools selected for expansion were those which fell within a buffer of one kilometre from either the tarmac or dry weather roads (motorable roads). Further buffer analyses were undertaken by setting several 1km buffer bands in order to facilitate discussions on levels of accessibility from the roads.

Information from informal interviews from education officers and other administrators showed that it would be more expensive to bring equitability in education by building new secondary schools. Furthermore it would be quite a task to find any land on sale for such project, as the demand superseded supply due to high population. Therefore it was suggested that public primary schools that were located on large parcels of land could be expanded to have a secondary wing. Therefore, spatial selection based on attributes was done, and further those identified had to be within the 1km buffer zone of any road.

A digital elevation model (DEM) was created from contours digitized from scanned topographical maps. The DEM generated was used during the suitability analysis to locate public secondary schools, which had enough areas of land (more than 7 acres) and on suitable grounds that were neither very flat (as the area is prone to flooding) nor too steep, to be expanded to *Centres of Excellence,* and also in identifying primary schools which could be expanded to have a secondary school section.

3   Results and analysis

3.1   Spatial distribution of education facilities

Aggregating the obtained data at the division level revealed the spatial distribution of the various educational facilities of Busia County (Table and Figure 2). Funyula division has the highest number of public primary schools, followed by Butula while Township division has the least. However, Butula lead in the number of public secondary schools while Townships still had the least. Amagoro and Nambale Divisions, however, had the highest number of private schools.

Table 1: Distribution characteristic of education facilities in Busia County

Division	Pop. Total	Area in Sq. km	Density	College	Public Sec.	Private Sec	Public Prim.	Private Prim	VTC	Total
Township	35,663	22.3	1,599	1	2	1	8	5	1	**18**

Matayos	75,682	173.9	435	0	13	0	38	6	1	**58**
Nambale	94,637	237.8	398	2	13	2	41	6	3	**67**
Butula	121,870	247.1	493	0	16	1	57	9	2	**85**
Angurai	59,740	146.9	407	0	9	1	38	2	1	**51**
Amagoro	58,207	114.1	510	0	3	1	19	11	0	**34**
Funyula	93,500	265.1	353	1	11	1	64	3	2	**82**
Budalangi	66,723	188.3	354	0	7	0	34	3	1	**45**
Amukura	61,536	159.0	387	0	6	0	43	1	1	**47**
Chakol	76,388	140.6	543	1	5	0	24	5	1	**36**
Total	**743,946**	**1695.1**		**5**	**85**	**7**	**366**	**51**	**13**	**527**

*Sec. – Secondary Schools; Prim.- Primary Schools; VTC – Vocational Training Colleges;

3.2   Accessibility analysis

The use of buffer analysis showed that 84% of the primary schools and 89% of the secondary schools were within 1km travel distance from motorable roads. This means that majority of educational facilities could easily be accessed by educational administrators. Except for a single primary school in Chakol division, all the other remaining schools lay within 4 km from motorable roads.
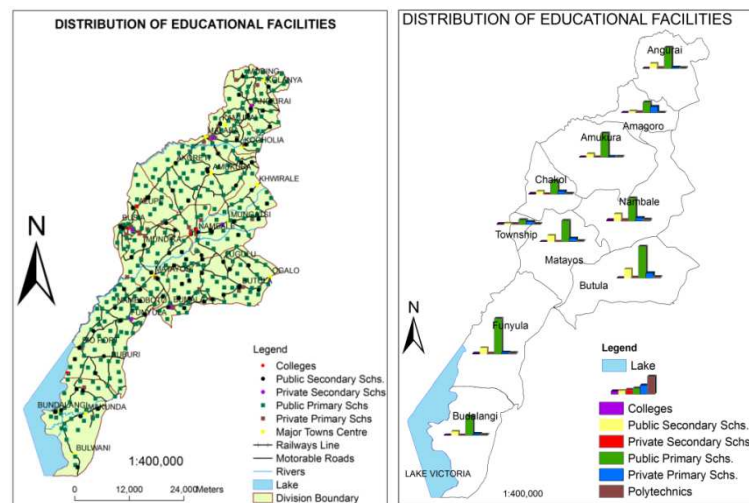

Figure 2: Spatial distribution of education facilities in Busia at the division level
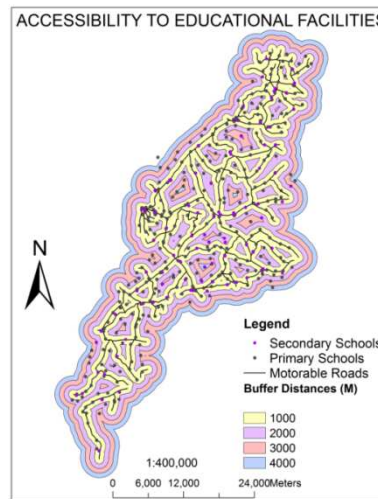
Figure 3: Schools distribution in relation to the road network.

3.3 Demand Analysis

The demand analysis was carried out at the division level. On the assumption that 65% of the population was school-age going, and that the secondary schools pupils was known from the collected data, several demand indices were calculated. With the primary school data, the indices were: school age population to number of primary schools, number of pupils per class, and the ratio of secondary schools to primary schools. Other geographical analyses carried out at the division level included: teacher-to-student-ratio for public primary schools, private-to-public schools, student-to-toilet ratio.

The results in general highlight the demand for and on education facilities at the division level. They reveal the spatial heterogeneity in demand as well as the disjoint in secondary to number of primary schools, ration of teachers to students, and also the number of pupils per toilet at the division level. Busia Township division and Amagoro have over 2,000 pupils in a primary school (see Table 3), and of the ten divisions of Busia County, only two had a demand of less than 1,000 pupils in a primary school. This shows that there is overpopulation in schools, calling for expansion of the primary school facilities or the creation of new schools. The analysis also show the ratio of secondary schools to primary schools being quite high, which indicates the necessity to have more secondary schools. The indices were mapped in the GIS environment in order to improve on the spatial analytic perspective.

Table 2: Education facility demand analysis

DIVISION	School age pop.-to- primary schools (n:1)	Secondary-to- primary schools (1:n)	Teachers-to- students (secondary) (1:n)	Students- to- Toilets (n:1)
Amagoro	2,042	8	37	44
Amukura	1,088	7	21	30
Angurai	952	4	18	28
Budalangi	1,204	5	19	39
Butula	1,313	7	35	37
Chakol	1,504	6	20	35
Funyula	895	6	34	31
Matayos	1,381	3	17	37
Nambale	1,297	3	18	34

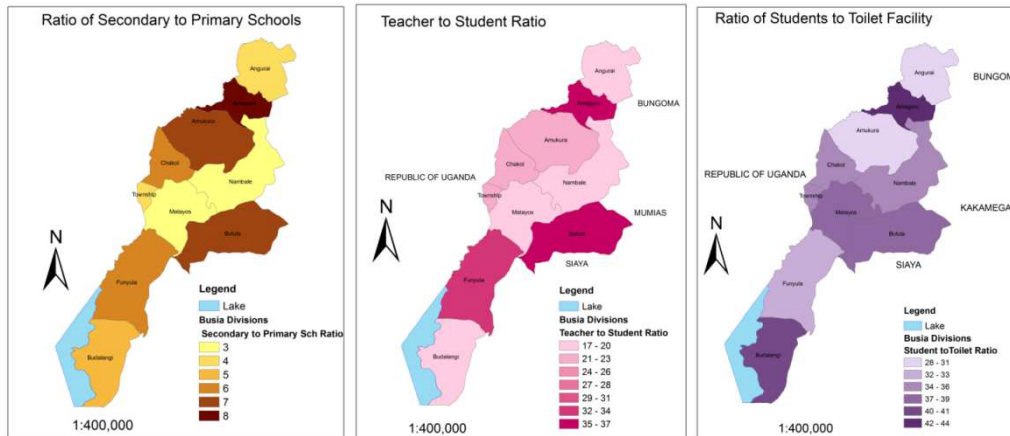| Township	2,814	4	20	34

Figure 4: Spatial visualisation of the education facility demand analysis

3.4 Suitability analysis

3.4.1 Suitability analysis for primary schools for expansion

Further geographical analysis was undertaken to select the public primary schools which could be expanded to accommodate a secondary section, based on the demand analysis for form one places for each division. The assumption was that a division with a higher number of pupils in a given class will most likely have more pupils sitting form standard eight examination and hence a higher demand for secondary schools. Also the ratio of existing secondary schools to primary schools is considered in this analysis. The existing public schools were targeted because most of the land within the County is privately owned and not many people would be willing to sell their small portions. The factors considered in selection of suitable primary schools were: the selected schools should be located in divisions where the ratio of school age population is equal or greater than 1,300; the ratio of secondary schools to primary schools should be equal to or greater than four; the distance of the primary school from the existing public secondary school must be greater than or equal to 3.0 kilometres; the school must have area of land equal or greater than seven acres((2.8 hectares); and the location of the primary school must be in an area with a slope of between 2 and 20 degrees(so that hilly and very low-lying areas would be avoided).

The selection resulted in eight public primary schools for expansion located in the four divisions that had high demand for secondary school spaces; three schools were in Chakol division, Butula and Township had two schools each, while the remaining was found in Amagoro division (See Figure 5).
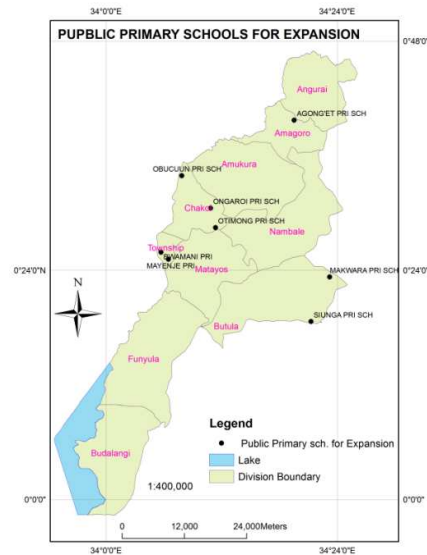
Figure 5: Public primary schools selected for expansion to include a secondary section

3.4.2 Suitability analysis to locate " *Centres of Excellence*"

The selection was based on divisions since the divisional boundaries separated small sub-tribes with conflicting interests especially when deciding on locality of important facilities like County headquarters or recently the location of national secondary schools where each sub-tribe demanded that the national school be located in their division. Therefore from the existing public secondary Schools in each division in the County, two schools were selected where possible so that the existing infrastructures could be improved and the schools expanded to become Centres of Excellence in education provision so as to improve quality and ensure equity.

The factors considered in selecting schools earmarked for expansion were: the school's total enrolment of students was set at greater than or equal to 350 students; the existing number of laboratories should be greater than or equal to two (at least 2 labs), the school must be located at a distance of less than or equal to one kilometre from motorable road, the school must have an area of land greater than or equal to fifteen acres (15 acres), and the school must be a boarding school of either boys or girls only respectively. Looking at the distribution of the schools that met the set criteria, one realizes that three divisions (Chakol, Amukura and Amagoro) have only one school each while Busia township division has none at all. The analysis of mixed schools in the four divisions that had deficit was then carried out but still none met the set criteria. It is therefore proposed that other criteria be set to identify one more school each in Chakol, Amukura and Amagoro divisions to be expanded.
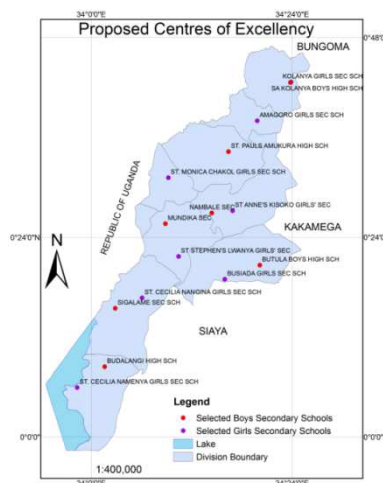

Figure 6: Secondary schools that met the criteria for expansion to Centres of Excellence.

4   Conclusions and Recommendations

The study demonstrated the use of GIS in analyzing positional related data and its enormous potential in solving educational planning problems. Using simple GIS tools like selection by attribute and location, it was seen that GIS can assist in addressing problems of disparity and lack of balance between demand and supply of educational facilities. Additionally, the visual display of the various demand maps and graphs availed in GIS, provides powerful support tools to aid decision making on what action to take. Parents can also make informed decisions when choosing schools for their children using these demand maps, charts, graphs and the database management system.

The results on accessibility analysis of the educational facilities show that most of Busia county education institutions to be well-accessible. However, mapping of the roads in different surface categories reveal that bitumen-covered roads to be quite few, calling for an upgrade of most of the roads. Prioritizing the roads to be improved to bitumen standards can be decided upon by spatial queries of facilities and centres that the road serves in combination with other spatial factors such as topography.

The proposal to expand some primary schools to have a secondary school section, and also the expansion of the proposed public secondary schools to Centres of Excellence in education provision will not only ensure quality, equity and gender balance but also promote harmonious co-existence amongst the sub-tribes in the county. Unfair competition for form one places, among the divisions with high demands and high enrolments rates will also have been addressed. Further analysis of facilities such as toilets, laboratories, and staffing, provides an opportunity to understand not only the spatial distribution characteristic of the education facilities across the county, but also on the quality of these facilities, and ability to address education needs.

As the study utilised projected data from the national and housing census of 2009, a more detailed study within actual survey data within the county is so that the actual situation on the ground can be well represented. Other non spatial factors like literacy, age, sex, religion, economic status and ethnicity could also be incorporated to check their influence on education sector.

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Role of Geospatial Literacy in sustainable development decision making

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ABSTRACT

Sustainable development is a multi actor process which requires involvement of all stakeholders of society at different levels. (Olaleye, 2004) states that sustainable development brings about progressive reduction of material deprivation and social inequalities and also promotes the development of human capabilities and potential. Citizen's participation is considered as a mean to achieve democratic decision making through transparency of public administration. The active engagement of individuals and groups to change problematic conditions and to influence policies and programs that affect the quality of their lives or the lives of others" (Gamble and Weil, 1995).

The decision making process is inherently collaborative and participating in its own nature and it may involve key interest groups at national, regional or local level along with organizations, policy makers, entrepreneurs, educators, managers. Recent developments have also witnessed the emergence of new strategic approaches to spatial planning at local, regional, national and transnational scales, which have sought to broaden the scope and enhance the governance capacity of spatial planning in practice (Healey et al., 1997; Albrechts et al., 2003).

Information and communication based society is rising at a faster pace than ever. This is evident from that fact that number of internet users per hundred inhabitants are constantly rising. This trend is giving rise to so called digital culture and social consensus based collaborative planning in which a digitally literate citizen is involved at local, regional and national level development processes. (Healey, 1997) elaborates governance as the formal government entities and informal alliances and networks through which business groups, environmental groups, neighborhood groups and amenity societies interlace with the formal government in order to manage collective affairs.

Diverse economic, social and environmental processes are inherently spatial and can't be understood without taking into account their spatial dimensions. The benefits of spatial planning depends on natural or built environment, also the spatial location of the intervention area and are dependent on characteristics of the area of interest like physical development opportunities, population, etc. In the context, Geospatial technologies have become the driving engine of spatial reasoning, socio-organizational problem solving, performing informed analysis, collaborative problem solving.

Many stakeholders like developers community groups, urban planners, Government officers and citizens represent their own interest and at times its the process becomes very complex. A consensus is necessary in order to reach economically, sociologically and environmentally viable solution. Typically text based documents, verbal communication and images are being used to communicate the ideas which at times can be misleading and may lead to low quality decision making. There is a loss of information too when we translate the complex visual forms through inadequate communication. (Campagna, 2006)

Our world is increasingly geospatially-enabled and there has been a drastic increase in geographic interest and awareness. Whether for personal, social, professional or academic use, people are using Geographic Information System technology to communicate information in a map format. Whether it's using Google Earth to study urban change or finding shortest path to reach destination. There is a need to study the response of the diverse communities as how effectively they communicate with evolving spatial technologies and relate themselves in describing phenomena, use spatial information and maps in navigating, in problem-solving, and in artistic expression. This also includes the ability to create and utilize information, viewable in place, directly associated with physical reality.

This so called locative understanding or in other terms Geospatial Literacy may become the key to help effective decision making especially in democratic structure of society where involvement of citizen is crucial.

There have been experiments done such as in South Portland to hold a Virtual Forum in which residents were asked to fill out a virtual survey and residents could watch a video presentation by Planning Decisions. As facilitations attendees participants were given an option to type questions online, which could be answered verbally at Virtual Forum. This proved to be very effective to allow public to enter feedback online at their leisure as opposed to asking the public to meet at a specified date and time for a virtual forum.

In developing countries, where number of internet users is inching closer to that of developed world, Geospatial literacy exists only among a small portion of highly qualified technocrats. There is a need to develop the idea of geospatial literacy blended learning further to encourage effective bottom-up communication.

Further, there is a need to explore the role of geospatial literacy in effective decision making, analyze the trends in developing countries and summarizes the citizen's response to various initiatives for geospatial literacy, which ultimately leads to sustainable development.

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eLearning in Digital Photogrammetry and Remote Sensing

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KEYWORDS:

eLearning, Developing countries, Asynchronous learning, Synchronous learning, Moodle, Digital Photogrammetry and Remote Sensing (DPRS)

ABSTRACT

Digital Photogrammetry and Remote Sensing (DPRS) disciplines have being integrated into many study programs such as geographic, environment, agriculture, civil engineering, etc. However, the available tutorials and online courses either are very static and tedious or they target the high knowledge learners. On the other hand, teachers don't have the programming skills required to create learning materials that grab learners' interest and encourage them for further study. In this regard, creating contents that motivate students to learn effectively using easy and affordable production tools has become a big demand not only for universities, but also for businesses and training centers.

In this workshop, four authoring tools will be explored and used for creating different learning materials in DPRS including self assessment excercises, interactive presentaions, flashes, web pages contents and vodcasting without the need to be a programmer or good trained in html language. The tools are:

- *eXe software: Open source software from eXelearning.*

- *Lectora® Inspire: Commercial software from Trivantis.*

- *Camtasia® Studio: Commercial software from TechSmith.*

- *iSpring Pro: Commercial software from iSpringSolutions*

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Experiences and Business Development

MPG Alumni and Knowledge Management – a Recent Encounter

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ABSTRACT

Germany and the developed countries in general are well known for best practice and advancement in science and technology. Opportunity to study in Germany for most students from developing countries has proofed to be one of the best events to adhere, absorb and embrace as much of these strong points which then later can be used to contribute to the community and environment in home country. Beside technical or specific discipline to master in Germany, students are also introduced and trained more in the area of knowledge management where knowledge sharing is encouraged at every level of study and access to resources (including other people's knowledge) is widely open. This equips them to absorb the knowledge and then later apply the knowledge in the future. Some important aspects in knowledge management (sharing, accessibility assimilation and application) as alumni, based on recent experience are collaboration, flexibility, stay connected, and maximum use of current trend and technology.

Collaboration inside and outside the institution is very important. Many institutions are now very serious in knowledge management aiming at inter-unit knowledge sharing that is beneficial with ultimate goal of creating prosperity. Relatedness in knowledge content can bind units or disciplines into collaboration. Alumni can play a role in this collaboration for example by coordinating regular meeting and presentation of recently gained knowledge by staff from different departments.

Affiliation to organisation including professional organisations such as Indonesian Society of Economic Geology (MGEI) can be the vehicle for involvement of alumni which can have a wider impact. MGEI, a commission under Indonesian Association of Geologists, is strongly dedicated to knowledge management within the organisation, and contributing to academic world, industry as well as environment and society. Alumni's Master Degree in Geoinformatics and Photogrammetric at HFT Stuttgart serves as a bridge between the two disciplines: Geoinformatics and Geology. Knowledge on Data and Database was shared recently by alumni on MGEI Goes to Campus Program to geological students at two universities in Indonesia. The fundamentals were emphasised that is "got it right in the first place", in an introduction to best practice in data and database.

These opportunities of knowledge sharing session at the universities came in a good timing. There are advantages in the involvement with knowledge management program through organisation because programs are set, managed by a bigger team and commonly is more secure in terms of resources including timeframe; as compared to self motivated and self-organised knowledge sharing event(s). Hence flexibility and snatching opportunity to manage knowledge whenever available is important for alumni, especially due to priority list such as work commitment or assignment.

Knowledge management including knowledge access until application is enhanced when alumni is stayed connected. This is the case recently in Zambia where alumni were able to support each other with not just professional advices and resources on Geoinformatics, but also socio-cultural information and links. Finally alumni connection can not be separated from the use of trend and technology such as e-newsletter, alumni page, social and professional networks on the internet and other platforms. These all contribute well to one's personal and professional development which in turn will give positive impact also to institution where alumni is attached to and society in general.

GIS solutions for the public participation in social and environmental activities: examples from Lithuania

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KEYWORDS:
GIS, e-democracy, public participation, environment

ABSTRACT

The presentation gives several examples of GIS application in the public sector that build public awareness and encourage the public participation both in social and in environmental activities. The presented GIS solutions have been implemented in the local and state government or environmental institutions of Lithuania. Several municipalities of Lithuania have implemented so called e-democracy solutions that provide means to local inhabitants to actively participate in the decision making by following online municipal council meetings, expressing their opinion on proposed legal acts, submitting complains and suggestions on painful issues of their living environment via the Internet. A Problem map as a part of the e-democracy solution allows the public to relate the issue to the location on the map, submit it to the municipality, and follow its status online. The same map serves to the municipality as room to inform the local and visitors about public works that might affect them, for example, a road construction. The national government initiative to present a crime map to the public is one more example of GIS in building the public's awareness of their living environment. Such information might stimulate the public to take an active role in crime prevention and address related questions to the government based on the crime map information. Besides the local and national GIS initiatives, GIS solutions by NGO's that focus on environmental issues conclude the presentation.

The Use Geo-Information in Advocacy and Coordination of Humanitarian Assistance in Somalia

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ABSTRACT

I would like to share my experience in a humanitarian coordination office on how Geo-information is applied both for advocacy and coordination support for humanitarian assistance in Somalia.

The Information Management Unit is in charge of Data collection, analysis, reporting and management. To enable effective humanitarian coordination and disaster preparedness, the unit is also responsible to the management of all baseline data for preparedness and these include Common Operational and Fundamental Operational datasets (COB & FOD's), this data is about the geographic area of concern such as topography, Populated areas, Transportation network, Administrative structure, Livelihoods, climate etc. In additional to the thematic data the unit manages other information on the emergency and Hazards vulnerability of the geographic area based on historical and scientific documentation.

The IMU unit has developed Geo-informatics tools for programming and advocacy. The 3 W matrix "Who is doing, What, Where" is used to map out Clusters/Sectors interventions based on their specific locations. This offers the numerous humanitarian actors the means to access the available information in a standardized format and a common frame of reference. This applications improves data coverage, reduce duplication of activities, and identification of GAPs whereby some areas in need are not reached in good time to save lives.

The Geo-information technology has proved to be a critical tool for analysis and advocacy among humanitarian actors in Somalia.

Workshops

Because the main business of government - to make
decisions in the public interest - involves geographically related issues,
Geographic Information Systems (GIS) provide incomparable power
that can play critical roles in all dimensions of good governance.

Peter Kuntu-Mensah, Accra, Ghana, 2006

Production Workflow from AT to DTM and Orthophoto Mosaic Generation using Inpho Software

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KEYWORDS:

Aerial Triangulation, DTM Generation And Editing, Orthophoto Generation, Seamline Editing, Orthomosaicing, Radiometry Enhancement, Inpho, Trimble

ABSTRACT:

Digital orthophoto production workflows vary in different geoinformatics environments. This workshop presents a flow line based on exclusive use of inpho photogrammetric software. The advantages of having a single project and interoperable data formats for all digital orthophoto production steps will be presented. the introduction to project set-up, georeferencing images, DTM generation and editing, orthophoto generation, radiometric enhancements and mosaicing will be shown during the theoretical presentation followed by the demonstration of a sample project.

Implementing OGC conformant Web services using PostGIS and GeoServer: Requirements for Replacing Local Data by Web Services

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KEYWORDS:
SDI, OGC, WMS, WFS, data harmonization, data interoperability

ABSTRACT

Standards are necessary for using geodetic data interoperably in heterogeneous environments. Such standards are developed and published by the Open Geospatial Consortium (OGC), e.g. Well Known Text (WKT), Well Known Binary (WKB), Web Map Service (WMS) and Web Feature Service (WFS). In Open Source Software the OGC standards are usually adopted as standard interfaces to spatial data beside interfaces to propriarity or industry standard data stores.

PostGIS and GeoServer are two Open Source software products that are serving OGC standards perfectly. PostGIS is a powerful data base for spatial data and GeoServer is an easy to use data server that can access various spatial data formats, among them data in PostGIS can be accessed directly by GeoServer.

The workshops will show how easy it is to set up a PostGIS datastore and to populate it with data from ESRI shape files. It also will show the easyness of installing GeoServer and configuring Web Map and Web Feature Services. Thereby the OGC Styled Layer Descriptor (SLD) definitions for WMS will be mentioned as well as the OGC Filter Encoding Standard for WFS.

Interface standards are necessary to use spatial data in an interoperabel way, but the use of such standards is not sufficiant for an efficiant integration of data in Spatial data infrastructures (SDI) and in workflows on users side. Problems still will occur when data from various vendors has to be integrated into existing workflows or combined for individual purposes, especially when web services are used in desktop GIS.

The workshop will not only show how to produce WMS and WFS. It will also focus on additional needs for controlling access to data and data harmonization. These two factors can not be covered by general standards. They have to be worked out within a community of data providers and users.

The author is member of the committee for the SDI of the German state Baden-Württemberg (GDI-BW). At Stuttgart University of Applied Sciences he is the head of the laboratory for Geoinformatics, which focuses on data interoperability. From this experience his statement is: "Working with web services shows that standards are necessary but not sufficient for efficient use of data in dayly workflows".

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Workshop: Spatial Analysis with Open Source - gvSIG and SEXTANTE

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ABSTRACT:

The gvSIG project was initiated by the regional government of Valenciana in Spain in 2003. The software is developed by the Spanish company IVER Technologías together with the Jaume I University of Castellón based on Java. Though the original language is Spanish, localizations for many languages are available. The system is targeted at professional users of geographic information from the public sector, private industry, sciences and education. It supports a wide range of data formats and databases, including proprietary ones. Meanwhile the software has matured, thus it may be used for professional applications.

Very well integrated into gvSIG is the plug-in SEXTANTE, which offers more than 700 tools for raster as well as vector analysis by integrating GRASS as well as SAGA tools. These tools can be chained for more sophisticated workflows using an integrated visual model builder or by using a scripting language.

In this hands-on workshop the gvSIG user interface will be discussed as well as in introduction into the SEXTANTE toolbox will be given.

LIDAR Point Classification – MICROSTATION and Terrascan

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KEYWORDS:

LIDAR, Microstation, Terrascan, DEM, Point Classification

ABSTRACT

LIDAR data filtering and classification are the most important steps of the LIDAR data processing, which requires efficient data processing software. This paper introduces LIDAR data processing software named Terrascan. Terrascan was developed to be used on MicroStation. In data classification, the software provides extended mathematical morphology algorithm and robust estimation algorithm and has some adaptive capability.

1   Introduction

In the past 20 years, the airborne LIDAR has been extensively used as a tool for accurate and fast acquisition of ground 3D data. An airborne LIDAR system is consisted of High-Precision Position & Orientation System (POS), laser scanner, digital camera and center control unit. The POS is a key component of airborne laser detecting and measuring system. It uses Dynamic Difference Global Positioning System (DGPS) technology and Inertial Measurement Unit (IMU) to determine the position and attitude of sensor in the aerial flight. Laser Scanner is core of the LIDAR and usually consists of laser transmitter, receiver, time interval measurement device, gearing device, and a micro-processor. Digital camera is used to receive the image information of an object. The center control controls and coordinates the other hardware to ensure high levels of synchronization of all instruments (Ackerman F, 1999).

The data processing of Airborne LIDAR generally includes several steps as follow (Xiaohong Zhang, 2007):

1. Determine flight track by joint analysis of the differences of data from the ground GPS reference station and the airborne GPS data.

2. Calculate the 3D space coordinates of laser points. The soft-ware provided by equipment maker processes the GPS flight track data, airplane attitude data, ranging data measured by laser and swing angle data of laser scanning mirror and then gained 3D coordinates (X, Y, Z) data of objects called Point Cloud.

3. Filter and classify point cloud. Because of various reasons, there are some noises in the point cloud, and they must be removed by filtering. At present, most Airborne LIDAR data filtering methods are based on the height break of pin point, such as morphological filtering method (Lindenberger J, 1993), mobile windows method (Petzold B, 1999), iterative linear least squares interpolation method (Pfeifer N, 1999) and terrain slope based filtering (Vosselman G, 2000). The aim of filtering and classification is to improve the ac-curacy and applicability of point cloud as well as accurately distinguish information of other objects.

4. Point cloud switching: For data collection of a large area, airplane must fly multiple routes due to the limit of flight height and scanning field angle. A certain degree of overlap must be maintained and the system error should be removed as much as possible.

5. Coordinates transmission: The coordinates should be transmitted according to user's requirement.

6. Generate the digital elevation models (DEMs) and digital terrain models (DTMs) from the ground points gained after classification.

7. Digital Orthophoto Maps: The high-resolution images gained from digital camera are processed by aerial triangulation measurement method with internal and external orientation elements. Then the data is oriented and mosaic with the DTM data based LIDAR and form digital orthophoto maps (DOM).

2. Terrascan

TerraScan is a dedicated software solution for processing laser-scanning points and creating fully-featured terrain models. TerraScan can easily handle tens of millions of points as all routines are tweaked for optimum performance and its versatile tools prove useful whether you are surveying transmission lines, flood plains, new highway bases, stockpiles, forest areas or urban environments.

Terrascan Features

TerraScan is a recognised processing product within the laser-scanning industry. Using advanced algorithms and a simple user interface, TerraScan provides greater control over laser scan projects whilst also increasing processing productivity. Its key features are as follows:

1. Recognises multiple file formats
2. Automatic or manual creation of project blocks
3. Advanced point classification tools
4. Effortless viewing tools
5. Point data management

3. Microstation

Microstation was developed by the Bentley System of the United States. It is a general Multi-Platform Computer Aided Design (CAD) software system. It is a professional software system originated from minicomputer, but offers many advantages over other PC CAD software systems:

1. Microstation is better in software function, structure and performance efficiency
2. Microstation supports multi-hardware and operation systems. It is compatible in different operative systems and the function and structure are totally the same in these.
3. Microstation has led the technology advancement in the area for a long time
4. Microstation provides five programming languages that could be used by different programmers. Development of Terrascan is used MDL language.
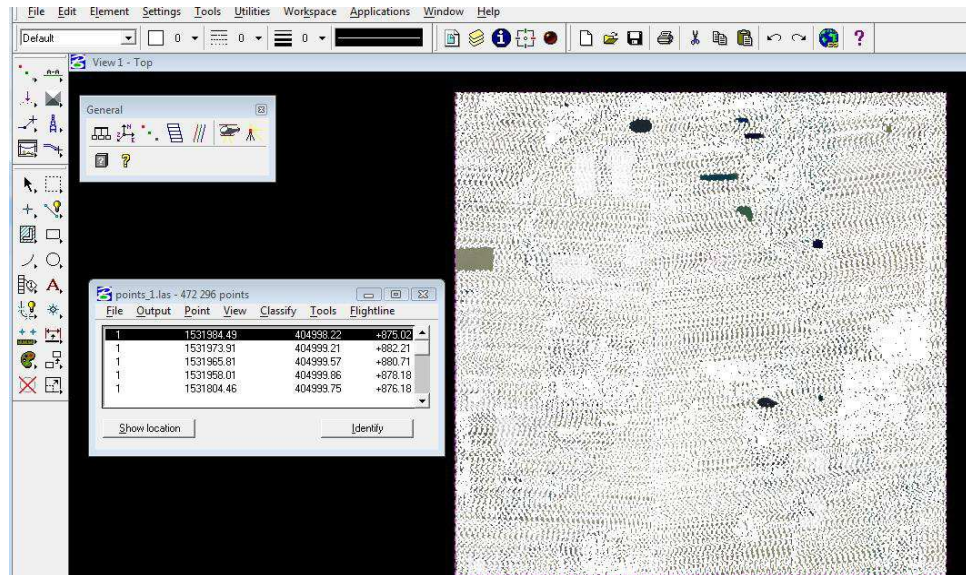
Figure 1

Terrascan system

Terrascan could be run after opening the MicroStation and creating a new 3D workspace. The main interface is shown by

selecting Terrascan.ma in MDL Application menu of Microstation and is divided into menu area and data display area (Figure 1). The data display area is for data display and point positioning processing. View of the Microstation displays the read of point cloud.

Point cloud Read and Display

For the large amount data of LIDAR, Terrascan employs the data format provided by MDL language. Therefore the embedded formats can be processed better and multifarious operations can be performed by Microstation.

In the aspect of data format, Terrascan currently supports input and output of ASCII, BIN and LAS format files. The system automatically gives the points default color and centrally displays in Microstation View. The system provides several display modes, including the modes based on height (Figure 2), intensity and class.
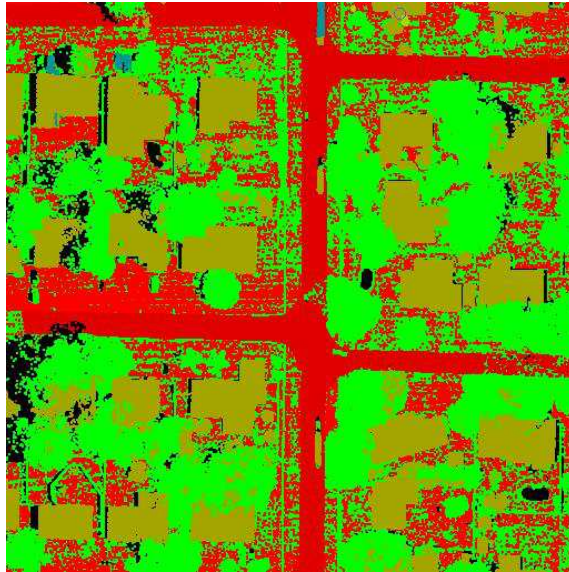
Figure 2

Classification

Filtering of ground points may be one of the most important routines of TerraScan. Many other classification tools compare the elevation of other points to the ground surface created from ground points.The classification routine consists of two phases. At first TerraScan searches the initial points and builds an initial temporary TIN model from the searched points. Triangles in this initial model are mostly below the ground with only the vertices touching ground. Before starting this process the real low points must be searched by some different routine of TerraScan. Often some of these "*Low points*" are lower than the other points in the ground vicinity and they must be removed.

In the second phase of classifying ground points, TerraScan starts to lift the model upwards and by iteratively adds new laser points to it. Each added point makes the model to follow the real ground surface more and more closely. The system provides routine for classifying the features semi automatically. Routine can be useful to classify ground, building, vegetation and so on. In the figure (3) ground points and buildings are classified using the routine. Routine is speed up the classification. Manual classification is also possible in Terrascan using built in tools such as classify fence, classify using brush.
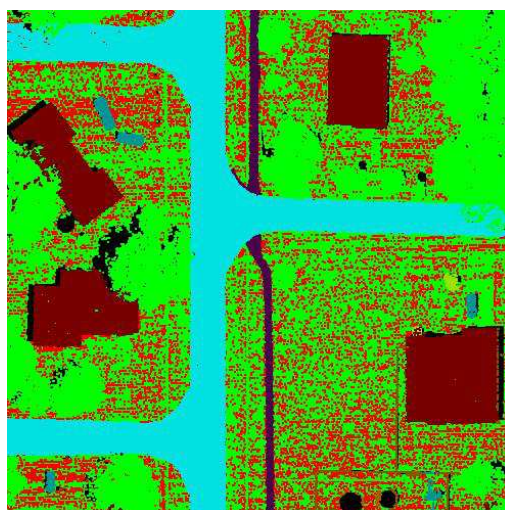

Figure 3

Create editable model and display shaded surface

Create Editable Model tool creates a surface model which can be visualized in TerraModeler and which is actively linked to loaded laser points. You can visualize the surface model to identify classification problems and assign correct classes to those points. The surface model together with display methods will be updated immediately to reflect the change.

This tool is particularly useful when you want to validate ground classification and remove possible remaining low points. The best display method for that purpose is Display Shaded Surface tool in TerraModeler's **Display Surface** tool box.
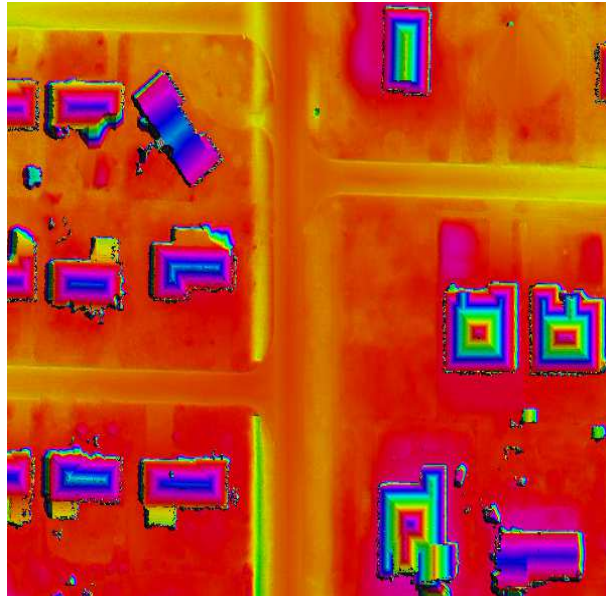

Figure 4

4. APPLICATION

LIDAR with digital imagery is an ideal technology for the rapid and accurate airborne survey of dam sites, flood areas and transmission line data.

The construction of dykes, dams and transmission lines requires a precise knowledge of the topography. Using airborne lidar. Digital terrain models produced using this technology has been used for detailed planning and engineering during construction projects.

LIDAR technology is ideal for many forestry applications. Airborne LIDAR is a methodology of using light detection and ranging systems to produce detailed maps of the ground more speedily and, in many cases, more economically than almost any other method. LIDAR results in bare earth as well as the height of the vegetation, other features can also be determined, especially in conjunction with standard or small frame aerial photography (such as access roads, structures and water courses). The result is these data can be used to help assess stands and timber volume, plan roads, review slope stability, run-off and other critical data about any area.

5. CONCLUSION

The other methods of topographic data collection are land surveying, GPS, and photogrammetry. LIDAR technology has some advantages in comparison to these methods, which are higher accuracy, fast acquisition and processing, minimum human independence, weather/ light independence, canopy penetration, higher data density, GCP independence, and also cheaper in many applications.

The main advantages of LIDAR are accuracy of measurements, high automation and fast delivery times. Due to its typical characteristics, both in data collection and data type, LIDAR has opened up several new applications that are not economically feasible with the conventional techniques. In India the technology is yet to make its way and has still a long way to go.

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Interoperability in Disaster Management

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KEY WORDS: Interoperability, Emergency, Crisis, Capabilities, Ways of working

ABSTRACT:

Recent major disasters like the earthquake in Haiti in 2010 have provided valuable insights into some issues surrounding interoperability in ad-hoc, event-driven situations. In the 'Interoperability in Disaster Management' workshop participants will reflect on ways of working that are appropriate to the complexity of the situation at stake and on how that affects the interoperability required given the specific contexts of crisis and disaster events. In group work, participants will populate a framework that provides a structured analysis of the different types of technical (and social) interoperability needed for different kinds of user scenarios that involve spatial information and their applications, ie. from self-contained systems to ad-hoc collaboration in disasters.

The workshop intends to expose and explore research questions and potential development opportunities that follow. It will deal with 'appropriateness' in types and characteristics of interoperability in disaster management and with the transitions between different phases of operation.

Hands-on Workshop on Quantum GIS Advance Cartography Style and Webmapping

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KEYWORDS:
QGIS, free and open source, education

ABSTRACT

The most common criticism in the use of free and open source geospatial desktop applications is the lack of advanced cartographic design features. In the past iteration of development of Quantum GIS (QGIS), new features are added to enable designing beautiful cartographic output. This workshop is a technical demonstration and hands-on tutorial in the use of QGIS using the advance cartographic styling features of the application. At the end of the 3 hour workshop, participants will be able to:

1.   Prepare advanced styling of data layers using the New Symbology,

2.   Prepare beautiful paper-based maps with Map Composer and,

3.   Publish simple webmaps using QGIS Server and OpenLayers.

Networking Implications for Students, Alumni and Young Researchers

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ABSTRACT

Networking is of increasing importance in our professional lives.This workshop addresses the science and art of networking, introduces the philosophy of successful networkers, shares basics of how to tie networks and introduces successful networks, yesterday, today and tomorrow. As the last topic, the differences between current networks for women and networks for men are treated. The workshop comprises a slide presentation combined with practical exercises with active student participation, and provides the attendees with a toolbox of proven approaches for successful networking.

It is important what you know.

But it is also important whom you know

– And who knows about you.

Stragetic process management for introducing GIS

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KEYWORDS:
Strategic Planning, Management, GIS introduction, System evaluation, Cost-Benefit-Analysis

ABSTRACT

In this workshop a concrete path for the introduction of Geographical Information Systems (GIS) in public agencies or private companies will be intrduced.

The whole process consists of ten different phases, starting with the initalization and ending with the productive usage of the system. Aspects of the strategic planning of the institution are presented, as well as requirement analysis, and conceptual database modelling and conceptualization of the IT infrastructure. Based on these findings information products are described and assigned to specific organisational units. In a cost-benefit-analysis different categories of benefits which can be accrued by introducing GIS are taken into account. A methodology of assessing monetary benefits for all information products is presented.

By a call for tender the system introduction is announced to possible vendors. Further steps like evaluation of submitted offers and testing of offered systems prepare the final decision.

By data import and usage of interoperable services the GIS starts its operational use.

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Fuzzy Logic Analysis using MapWindow

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ABSTRACT

Site selection process is a screening technique, used to select appropriate sites for dumping waste. Screening is done by considering the restrictions that have to be met when selecting a site. Two Screening methodologies i.e. Boolean and Fuzzy were used for delineating dumping zones. Boolean defines a two valued logic with sharp delineation of boundaries where as fuzzy provides a smooth transition between the boundaries to handle the concept of vagueness.

This workshop assesses fuzzy logic information content to find landfill zones for dumping waste using MapWindow. It follows three stage analysis processes. After identifying the landfill siting constraints, the first stage is initiated by formulating the membership functions. After identifying the variables, the second stage is to perform the manual fuzzy logic analysis. The final stage involves demonstration of a user-friendly generic tool that automates manual fuzzy process.

3D Building Generalization

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ABSTRACT

This workshop attempts to discuss various aspects of 3D building generalization for example data reduction, simplification of smaller features attached with 3D buildings models. Different task-specific applications or users demand different abstractions (generalized) 3D scenes of 3D models as appearance properties, textures and materials attached with these models drastically increase loading time in visualization and spatial analysis. So, generalization operations such as simplification, aggregation, etc. are applied to reduce data but main characteristics of the building are preserved. Reduction of data from higher LoD is one of the components of generalization process. Other components for automatic generalization include: generation of different LoDs; simplification of data models; representation of generated and simplified LoDs in multiple data structure; and automation of application's or user's requirements. The resulting generalized or abstracted models of generalization process can be analyzed and visualized in different scales efficiently. Simplification operation for generalization is carried out based on generalization accuracy specified by CityGML. This workshop also will highlight the research outlook and the near future work.

3D City Modelling

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ABSTRACT

Semantic information and database are vital in GIS for analyzing data and 3Dobjects characteristics within a virtual urban area. Web-based applicationssuch as Google Earth and Microsoft Virtual Earth are suitable for visualizationpurposes but not for spatial data infrastructure. The concept is to address 3Dmodeling of any objects within the city along with semantic database such asterrain, road network, building wireframes and street furniture. In this workshop, CAD data (DWG files) along with terrestrial photos will be used to generate 3D models of buildings in SkechUp. Using CityGML plugin conversion process will be done and the model will be imported to CityServer3D for semantic information. Different methods will be applied for texturing andgenerating intricate elliptical and dome form geometries along with streetfurniture. Introduction to VRML, XML, CityGML andsolid model generalization and texturing will be covered during the workshop along with texture generation viaphoto editing software such as PhotoShop.

Atlas making and atlas reading – With insights contributing to the skills required

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ABSTRACT

Atlases form a suitable means for communicating complex and large amounts of spatial information and are generally considered a higher form of cartography (Kraak & Ormeling, 2001). As a final product of the BIOTA East Africa project such a printed atlas was produced with two thirds of its 1000 copies having been distributed in Kenya and Uganda.

The introduction of the workshop reflects on what is generally known about atlases. The first part then summarizes the atlas making process covering the various steps from the first atlas concept to the final printing. The second part provides insights into the making of The BIOTA East Africa Atlas – Rainforest Change over Time. By studying the atlas we learn what kind of questions it is able to answer and how it thus contributes to environmental education, decision making, and research. The third and final part finally highlights the challenges encountered during map production and those following map production.

With a different emphasis this time, the workshop is suitable for both participants being new to the topic and those who followed the workshop at AGSE 2011.