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Land cover classification and change detection analysis of rawal watershed using remote sensing data

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Abstract

Changes observed in land cover/use parameters determine the hydrological and ecological processes taking place in a watershed. Hence, the present study was focused on analysis of the change detection in Rawal watershed, Islamabad using satellite data for the years 1992 and 2012 respectively. Land cover change was detected by applying a supervised classification-maximum likelihood algorithm. The findings indicated that there were accelerated land transformations among the five delineated land cover classes. Hence, there is a need for proper watershed management plans and conservation strategies to be designed in order to protect the forest, water and soil resources of this watershed.

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Introduction

Research on land cover and land use change is increasingly becoming important due to the fact that it is a primary factor for global change, reason being its interactions with biodiversity, biogeochemical cycles, climate, human activities and ecosystem processes (Xiao *et al.,* 2006; Zhang *et al.,* 2011). In order to develop any sustainable development program, where land cover and land use serves a major input criteria, continual, historic and accurate information regarding the land cover and use changes of the surface of the Earth is tremendously important. Therefore, analysis and mapping of the present land cover and land use situation along with the changes in land cover and use over time is essential to better comprehend and provide solutions for socio-economic as well as environmental problems (Lu *et al.*, 2004; Das, 2009; Pelorosso *et al.*, 2009).

Change detection is a process that observes a phenomenon or feature at different times to categorize the differences in its state. Change detection has various useful applications associated with land cover/use changes such as coastal change and urban sprawl (Shalaby and Tateishi, 2007), deforestation (Schulz *et al.*, 2010; Wyman and Stein, 2010), land degradation and desertification (Adamo and Crews-Meyer, 2006; Gao and Liu, 2010), landscape and habitat fragmentation, quarrying activities, shifting cultivation and landscape changes (Serra *et al.*, 2008), urban landscape pattern change (Batisani and Yarnal, 2009; Dewan and Yamaguchi, 2009), and other cumulative changes (Munroe *et al.*, 2005; Nagendra *et al.*, 2006).

Due to repetitive data acquisition, digital format and accurate georeferencing procedures, Satellite Remote Sensing (SRS) is most widespread data source for detecting, mapping and quantifying the land cover and use changes (Lu *et al.*, 2004; Chen *et al.*, 2005). SRS and Geographical Information System (GIS) can be integrated to detect and anlyze land cover and land use changes as Remote Sensing (RS) can enumerate the amount, location and type of land use change while GIS can provide a flexible environment for analyzing,displaying and storing digital data essential for change analysis (Wu *et al.*, 2006; Zhang *et al.*, 2011).

Over past years various GIS and RS based tools and algorithms have been used extensively both nationally and internationally to detect temporal, spatial, and land cover/ land use changes in different landscape elements of the world. In addition to this, land degradation patterns are also mapped to develop predictive models in order to ensure sustainable land use practices for the future. Furthermore, feasability of remote sensing is also assessed for the monitoring of different landscapes and recently various techniques have been used in combination to provide more accurate results (Koneff and Royle, 2004; Rao *et al.*, 2006; Baker, 2007; Bhandari, 2010; Xie *et al.*, 2010; Chengcheng *et al.*, 2011; Zhang *et al.*, 2011; Ahmad, 2012; Ahmad and Erum, 2012; Qazi and Ahmad, 2012; Ahmad, 2013).

Various methods have been developed over time by using satellite data to assess the variations in land cover/use (Singh, 1989; Coppin *et al.*, 2004; Lu *et al.*, 2004). Out of these, the most extensively used technique is pre- and post-classification comparisons (Coppin *et al.*, 2004). The pre-classification approach includes procedures like band ratioing (Nelson, 1983), change vector analysis (Johnson and Kasischke, 1998), direct multi-date classification (Li and Yeh, 1998), principal component analysis (Hartter *et al.*, 2008) and vegetation index differencing (Townshend and Justice, 1995) have been developed (Singh, 1989; Hardin *et al.*, 2007). The chief premise of these procedures is that land cover/use changes result in different pixel reflectance values between the time frames of interest. However, these techniques are good for locating the change but not very effective for indentifying the nature of change (Ridd and Liu, 1998). Post-classification comparison, on the contrary examine changes between independently classified land cover data over time. Regardless of the associated difficulties among these comparisons (Singh, 1989; Coppin *et al.*, 2004), it is the most extensively used technique for identification of changes in land cover and land uses (Jensen, 1996; Lu *et al.*, 2004), predominantly in urban environments (Hardin *et al.*, 2007). However, this approach has a disadvantage associated with it that the accuracy of land cover/use change maps created depends on the individual classification accuracies. Thus these techniques are subjected to error propagation (Yuan *et al.*, 2005). Nontheless, these post-classification techniques are chiefly useful for 'from-to' map generation (Jensen, 1996), which can clarify the location, magnitude and nature of changes shown (Howarth and Wickware, 1981). Furthermore, the technique can be employed to data which is acquired from sensors having different temporal, spatial and spectral resolutions (Alphan, 2003; Coppin *et al.*, 2004).

A historical analysis of water resources, for detecting the change in pattern of land cover and land use can help in the proper monitoring and management of the watershed area and is also required for the future planning and monitoring (Ashraf, 2013). Satellite imagery has been used as a major data source to detect or analyse the temporal changes in wetlands, coastal areas, watersheds, lakes, playas etc. since 1980's. Major sources for such analysis include Landsat (TM and ETM), Satellite Probatoire d'Observation de la Terre (SPOT), Radio Detection And Ranging (RADAR), and Advanced Very High Resolution Radiometer (AVHRR). Various studies have attempted to address land use and land cover change of watersheds through different methods. Nagarajan and Poongothai (2012) exposed the impact of land cover/land use changes in Manimuktha sub-watershed of the Vellar basin, Tamil Nadu. Hu *et al.* (2012) analysed land use change characteristics in the Jiuxiang river watershed from 2003 to 2009. Bazgeera *et al.* (2008) made an assessment of land use changes (1984 to 2003) and their implications on climatic variability for Balachaur watershed in Punjab, India.

The spatial and temporal dimensions of the land cover and land use changes in Pakistan and its different cities are not well explored. Although widespread and recent information on land cover and use changes is available in most developed countries, developing countries lack the geospatial database. For instance, no official statistics exist on land use patterns. Local governments make frequent use of census records to interpret land use changes due to the easy accessibility and recent nature of census records. Consequently, the dynamics of evolution are often misleading and unclear. Several factors account for the lack of past and present data on land use, including bureaucracy, financial constraints, lack of geospatial expertise in the planning agencies, and restricted access to data. Moreover these bodies face a general lack of coordination, which have worsened the planning and management of different resources. This empirical study utilized geospatial data in an attempt to identify the spatio-temporal patterns of land cover and use changes for the Rawal watershed in Islamabad so that both the decision makers and the scientific community can assess the various dynamics affecting land cover and use changes in this area.

The chief objectives of this study were therefore to explore the characteristics of land cover and use changes in the Rawal watershed area by using remotely sensed data. Specific objectives include: (a) to provide historical and recent land cover/use maps via integration of supervised maximum-likelihood classification and visual interpretation of remotely sensed data (b) to evaluate the land cover/use changes between 1992 and 2012 using post-classification comparison to track changes from multi-temporal satellite images (c) to provide policy recommendations concerning appropriate improvements towards better management of land cover and land use.

Materials and methods

Study area

The study area is situated in Potwar Plateau. According to (Hagler Bailly, 2007; Ghumman, 2010).

Rawal watershed begins at a lake which is located in Islamabad across Korang River and is about 10 km distance from Rawalpindi with surface area equal to 8.8 km² (at latitude 33°42´ N, longitude 73°07´ E, and altitude of 1,800 m). The lake receives runoff water from four to five major and fourty three small streams. The major streams or tributaries that comprise Rawal Watershed are Shahdara, Chattar, Bari imam, Korang nullah and Quaid-e-Azam University stream. Over the past few years, natural and human factors like construction activities from Banigala up to Murree Hills in the watershed area have contributed to sedimentation and has reduced the dam's storage capacity to 31,000 acre-feet. The area surrounding the Lake has esthetic value as it has been planted with flowering trees and many gardens, picnic spots, and secluded paths have also been developed in the area (IUCN, 2005; Iqbal and Shah, 2011).The map of the study area is shown in Fig. 1.

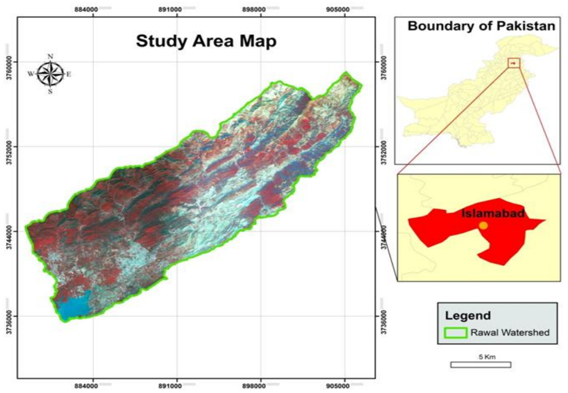

Fig. 1. Study area map showing Rawal watershed.

Data acquisition

The data in this study included two multispectral satellite images to evaluate LULC changes, which comprised of Landsat 5 (TM) for years 1992 and 2012. The Landsat images were acquired for the month of September and are freely available from the Landsat archive from the United States Geological Survey (USGS) (http://glovis.usgs.gov) (http://edcsns17.cr.usgs.gov). In addition to using high-resolution imagery, ancillary data was collected which included ground truth data, aerial photographs and topographic maps. The ground truth data was in the form of reference data points collected using Geographical Positioning System (GPS) from March-June 2012 for 2012 image analysis, used for image classification and accuracy assessment of the results.

Image pre-processing and classification

Satellite image pre-processing prior to the detection of change is needed and has a primary objective of establishing a more direct affiliation between the acquired data and biophysical phenomena (Coppin *et al.*, 2004). Data was pre-processed in ERDAS Imagine 12 for geo-referencing, mosaicking and subsetting of the image on the basis of Area of Interest (AOI). All satellite data were studied by assigning per-pixel signatures and differentiating the watershed into five classes on the basis of the specific Digital Number (DN) value of different landscape elements. The delineated classes were Agriculture, Bare soil/rocks, Settlements, Vegetation and Water class (Table 1). For each of the predetermined land cover/use type, training samples were selected by delimiting polygons around representative sites. Spectral signatures for the respective land cover types derived from the satellite imagery were recorded by using the pixels enclosed by these polygons. A satisfactory spectral signature is the one ensuring that there is 'minimal confusion' among the land covers to be mapped (Gao and Liu, 2010). After that maximum likelihood algorithm was used for supervised classification of the images. It is the type of image classification which is mainly controlled by the analyst as the analyst selects the pixels that are representative of the desired classes.

Table 1. Classes delineated on the basis of supervised classification.

Sr. No.	Class name	Description
1	Agriculture	Crop fields and fallow lands
2	Settlements	Residential, commercial, industrial, transportation, roads, mixed urban
3	Bare Soil/Rock	Land areas of exposed soil and barren area influenced by human impact
4	Vegetation	Mixed forest lands
5	Water	River, open water, lakes, ponds and reservoirs

To improve classification accuracy and reduction of misclassifications, post-classification refinement was therefore used for simplicity and effectiveness of the method (Harris and Ventura, 1995).Moreover, when using a data having medium-spatial resolution such as that of Landsat mixed pixels are a common problem (Lu and Weng, 2005); especially for the urban surfaces that are a heterogeneous mixture of features mainly including buildings, grass, roads, soil, trees, water (Jensen 2007).The problem of mixed pixels was addressed by visual interpretation. For the enhancement of classification accuracy and therefore the quality of the land cover/ use maps produced, visual interpretation was very important. Thus, visual analysis, reference data, as well as local knowledge, considerably improved the results obtained using the supervised algorithm.

Accuracy assessment

If the classification data are to be useful in detection of change analysis, it is essential to perform accuracy assessment for individual classification (Owojori and Xie, 2005). For the accuracy assessment of land cover maps extracted from satellite images, a stratified random method was used to represent different land cover classes of the area. The accuracy assessment was carried out using 100 points, based on ground truth data and visual interpretation. The comparison of reference data and classification results was carried out statistically using error matrices. In addition, a non-parametric Kappa test was also performed to measure the extent of classification accuracy as it not only accounts for diagonal elements but for all the elements in the confusion matrix (Rosenfield and Fitzpatirck-Lins 1986).

Land use/cover change detection

The post-classification change detection technique, performed in ArcGIS 10 was employed for the study. Post classification has been successfully used by various researchers in urban environment due to its efficiency in detecting the location, nature and rate of changes (Hardin *et al.*, 2007). Another technique used to obtain the changes in land cover/use during the specified time period was an overlay procedure. A two-way cross-matrix obtained by the application of this technique was used to describe the main types of change in the study area. In order to determine the quantity of conversions from a particular land cover to other land cover category and their corresponding area over the evaluated period, cross tabulation analysis on a pixel-by-pixel basis was conducted. Thus, a new thematic layer was also produced from the two five-class maps, containing different combinations of "from–to" change classes.

Results and discussion

The classified LULC map of the Rawal watershed of years 1992 and 2002 is given in Fig. 2. Assessment of classification accuracy of 1992 and 2012 images was carried out to determine the quality of information derived from the data. The results showed that the achieved overall classification accuracies were 95.32% and 95.13% and overall kappa statistics were 0.9237 and 0.9070 respectively for the classification of 1992 and 2012 images. Lea and Curtis (2010) stated that accuracy assesment reporting requires the overall classification accuracy above 90% and kappa statistics above 0.9 which were successfully achieved in the present research.

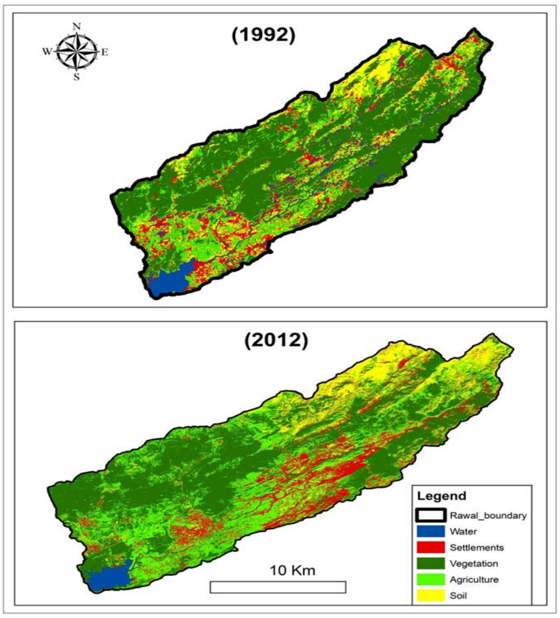

Fig. 2. Classified land use maps of Rawal watershed in 1992 and 2012.

Image classification results revealed that the overall area of land cover/land use classes for Rawal Watershed was 27442 hectares. This area was calculated by first calculating the area of each class in watershed and then adding it up to give total area of watershed. The area covered by each class in both the years is given in

The percentage area of each class in 1992 and 2012 is also shown in Table 2. In 1992 vegetation was the largest class representing 48% (13160 ha) of the total LULC categories assigned. In 2012, the percentage of vegetation class was reduced to 45% (12292 ha). The other classes which faced decline during the study period were water and bare soil/rocks. The area of water represented 6% (1504 ha) of the total area and it was reduced to 2% (462 ha) in 2012, whereas the area of the bare soil was 13% (3574 ha) of the total area in 1992 and it declined to 9% (2504 ha). Only two classes faced an increment in the total share i.e. agriculture and settlements. The share of the agriculture class increased from 21% (5859 ha) in 1992 to 30% (8348 ha) in 2012, while the share of settlements in the total area increased from 12% (3343 ha) to 14% (3838 ha).

Table 2. Land cover/use classes of Rawal watershed and area calculated from classified image.

Land cover/ use Classes	1992		2012		1992-2012
	Area (ha)	%	Area (ha)	%	Changed Area (%)
Agriculture	5859	21	8348	30	42.5
Bare soil/ Rocks	3574	13	2504	9	-30
Settlements	3343	12	3838	14	14.8
Vegetation	13160	48	12292	45	-6.6
Water	1504	6	462	2	-69.3

The comparison of the share of each class in the total area of 1992 and 2012 revealed that the area occupied by agriculture increased by 42.5%, settlements increased by 14.8%, bare soil/rock area decreased by 30%, vegetation decreased by 6.6% and water bodies decreased by 69.3% between 1992 and 2012. As given in Table 2, there has been a marked change in land use/cover during the 20 years of study period.

The reason behind this increase in the agriculture class is the rapidly growing population of twin cities resulting in demand for more food. There are two main approaches being adopted in Pakistan to increase the agricultural food production. Bringing more area undercultivation, which can be done by converting area covered by other classes to agriculture area. The major class subjected to loss of area for this purpose is forest or vegetation class. In addition, formerly used rangelands (small areas surrounded by river water) are also actively transformed to agricultural land in different regions of Pakistan increasing the per hectarecrop yield. Water is a limiting factor in achieving this goal hence it is a common activity to shift the agriculture practices near the main streams or rivers so that more water can be drawn and crop yield can be increased. A blatant conversion from water cover to agricultural land by building of retaining walls against the river water has also been observed over past decades (Ashraf *et al.*, 2007; Qasim *et al.*, 2011).A similar study conducted previously on the Rawal Watershed also reinforces the findings that Agriculture area has increased in past decades in the area and also that over the years, forest, scrub, water and range land cover shifted to Agriculture land cover (Ashraf, 2013).

The second class which showed a significant increase during the study period was Settlements. The reasons behind this rapid increase in area under the settlement class is deforestation, forest transition to urban land, and emigration of rural population towards main city, Islamabad. These findings are comparable to the patterns of land change observed in the Rawal Watershed, around Beijing, Zhejiang and Lake Cuitzeo, Mexico (Han *et al.*, 2007; Mendoza *et al.*, 2011; Arshad, 2013). Over past two decades a number of new housing schemes, farmhouses and recreational pursuits e.g. Lake view point, Chatter, Valley parks, etc. have been developed in the watershed. Along with these developments, there is an incline towards the construction of new pavements, highways, roads and other structures to access these areas. According to IUCN (2005), the reason for the increase in number of houses is partly due to the intensification in local inhabitants and partly due to government and private agencies' investment in developing educational institutions, guesthouses and hotels,military colonies, offices, and residential areas which are often occupied only seasonally. In addition, the improvement of roads and transport facilities has significantly increased the number of tourists in the area (NHA, 2004).Along with these, mushrooming growth of commercial buildings has also been observed in the area all the way down to Banigala near Islamabad. Many independent buildings and housing schemes are also being constructed in the Chattar area namely Utility Housing Scheme, Silver Hills Housing Society, Sanam Garden, Doctors' Housing Scheme and Judicial Town etc., all of these are located in the catchment area of Rawal Lake.

The rest of the three classes showed a significant decline in the area. A major portion of the bare soil/rocks class has been converted to built area owing to many new housing schemes and recreational pursuits in and around main catchment area of the Rawal Watershed. New developments taking place in and across the watershed cause a significant amount of unused land to be converted either into new buildings or has been subjected to construction of roads, pavements and other structures (Ashraf, 2013). However, the upper portion of the watershed has shown an increase in bare soil/rock cover, primarily due to deforestation in that area and also due to the shift of rural population to the urban areas. Other than the construction activities, an increase of extensive agricultural practices in the watershed area have also led to soil degradation and soil loss due to erosion. According to Gliessman (2006) soil erosion has a direct cause-effect relationship with soil agriculture practices. Conventional agricultural practices such as monoculture, short rotations and intensive tillage leave the soil exposed to erosion by wind. Similarly ineffective irrigation practices cause water erosion of agricultural soil and thus every year tons of soil is lost to either air or water.

Vegetation cover of the watershed generally included mainly scrub forest, conifer forest, dry semi evergreen forest and range land. The forest area has been subjected to deforestation due to an ever increasing population rate which in turn requires increased agriculture production. Hence, it has been oserved that the vegetation class in the watershed area was reduced and replaced by either Settlement or Agriculture class which continued to increase. In addition, extensive wood cutting and animal grazing may also cause a shift from forest land to range land and even barren land. The results are verified by the findings of Arfan (2008) which emphasized that maximum decrease in scrub forest in Rawalpindi area during a thirty year period (i.e. from 1977 to 2006) converted to agriculture and built up area. Although FAO (2005) reported 1.7 % annual rate of deforestation in the country, but due to an increase in agriculture practices and high urban development, the rate of forest decline was higher in the watershed area. Qasim *et al.* (2011) in their study of District Sawat, also concluded that rapid expansion of agriculture area is one of the major causes of forest decline while Tang *et al.* (2005) stated that urban development or increase in urban areas is a major cause of forest areas to decline in a watershed areas. Similar trend of forest decline was observed in previous studies conducted on different watersheds of the world as well (Awasthi *et al.*, 2002; Braimoh and Vlek, 2004).

In line with the vegetation and bare soil/rock classes, the quantity of area covered by the water class has also observed a decrease in percentage area coverage in the Rawal Watershed from 1992 to 2012.This class was prone to the changes occuring in all the other four classes of both the watersheds. As discussed in the above sections that the watershed has witnessed a rapid increase in deforestation, urbanization, agriculture, all of which effect the water class in a variety of ways. Major impact of these land cover and land use changes is on the water quality and availability. It has been observed that most of the tributaries have dried out in the watershed and are replaced by compact surfaces. The rate of surface runoff in the watershed area is also rapidly increasing due to rapid urbanization and agriculture. As the runoff rate exceeds the infiltration rate, it reduces the recharge capacity of ground and infiltration capacity of both the watersheds. This runoff is accelarated mainly due to intensification of deforestation. Thus, water recharge capacity and quality of natural and artificial waterbodies is badly affected by the deforestation in the headwater zones of a watershed and increases the sediment and nutrient transport downstream. This trend is verified by the other research conducted on different watersheds (Ali *et al.*, 2008; Mendoza *et al.*, 2011).

Moreover, the change in the main water-body in the Rawal Watershed was mapped during the study (Fig. 3). The change map of Rawal lake indicates that the lake covered 594 ha in 1992 accounting for 2.2% of the total area of the Rawal watershed, which declined considerably by 2012 and covered only 478 ha area (1.7% of total area of the watershed). This means that Rawal lake has shrank by up to 19.5% in two decades.

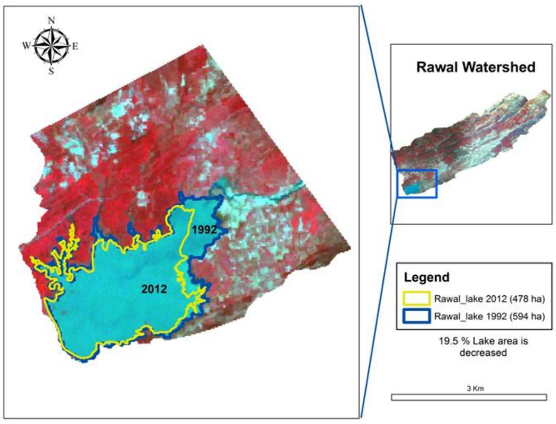

Fig. 3. Map showing decline in Rawal lake area between 1992 and 2012.

This decline in the percentage area coverage of the reservoir is due to the fact that this reservoir is a major source of water supply for an ever increasing population of Rawalpindi and Islamabad and also supply water for irrigation purposes. Other reasons for the loss of water in these reservoirs could be evaporation, seepage and percolation. Studies reveal that the reservoirs in the Potohar region are often subjected to the aforementioned losses (Keller *et al.*, 2000; Ashraf *et al.*, 2007).

GIS was used for the post-classification comparison of the detected change, producing a change map for comprehending the spatial pattern of change between years (Fig. 4).

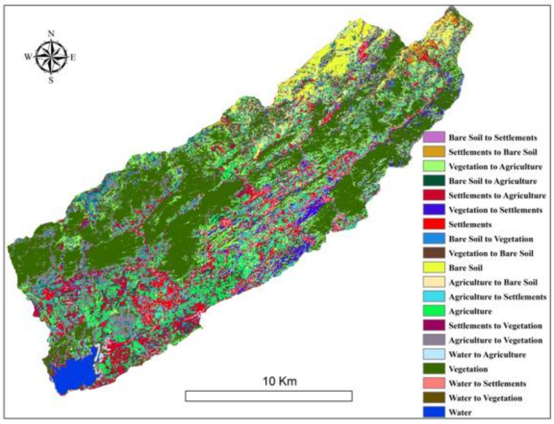

Fig. 4. Major land use conversion in Rawal watershed from 1992 to 2012.

Table 3 summarizes the major LULC conversions, namely 'from–to' information, which occurred during the study period. As specified, the majority of land that was previously vegetation, bare soil/rock or water bodies got converted and acquired by agriculture and settlements, suggesting the existence of increased pressure on natural resources in the Rawal watershed due to active soil erosion, increased agriculture practices in the area and increased developmental activities.

Moreover, the settlement class has increased over past to decades but the overall increase is not so great because it has also lost very small amount of area to agriculture near the waterbody and also because some of its area has also been converted to barren soil or poultry farms that required land clearance.

This increasing trend of land cover/use change in the watershed area reinforces that economic forces are commonly a major stimulus on anthropogenic change of land (Wang *et al.*, 2008) and it is the main reason why the area near the main water-bodies and streams in both the watersheds has shifted from other land covers including Vegetation cover, Settlements cover, Water cover or Bare soil to Agriculture cover. At the start the overall agricultural production and expansion in watershed was only subjected to peripheral lands on steep slopes until biophysical limitations like steep slopes and thin fertile top soils limited further expansion and agriculture land was pushed into formerly wooded areas. Hence, proper management of the watershed resources is required because without proper management, these resources will soon be lost or will no longer be able to play their important role in agriculture production and socio-economic development of the area. What is required here is an adequate knowledge of water availability, requirement, productive and efficient water use.

Table 3. Major land use/cover conversions from 1992-2012.

From Class	To Class	1992-2012 Area (ha)
Agriculture	Bare soil/Rocks	695.82
	Settlements	779.61
	Vegetation	1989.26
Bare soil/Rocks	Settlements	617.98
	Agriculture	1387.55
	Vegetation	565.61
Settlements	Bare soil/Rocks	284.79
	Agriculture	1523.27
	Vegetation	711.73
Vegetation	Agriculture	2602.36
	Settlements	1202.82
	Bare soil/Rocks	473.70
Water	Agriculture	318.18
	Settlements	412.62
	Vegetation	324.96

Conclusion and recommendations

The study concluded that the area of Bare soil, Vegetation and Water classes was shifted somewhat to the other two classes namely settlements and agriculture class which expanded to varied degrees in the total area they covered in watershed by 2012.This haphazard expansion of settlement and agriculture class was mainly due to lack of proper management and land use planning in these areas and the major impact of this expansion was the subjection of vegetation and water class to deforestation and water depletion respectively. One of the most significant land degradation issues faced by a watershed is soil erosion and loss of soil nutrients which could be eradicated by developing strategies to maintain soil fertility and stability, use of appropriate irrigation system to avoid erosion by excess water runoff, cultivation of perennial crops and reduction of intensive tillage and compaction of soil. Proper land use planning should be done for both the watersheds and if any developmental project is to be conducted in these areas, it must be preceded by a proper Environmental Impact Assessment (EIA). Government should take appropriate steps to restore the degraded lands specially degraded soil, water and forest lands and their further degradation must be prevented. This could be achieved by mitigating the effects of urbanization and agriculture land use practices. Hence, there is a need of proper planning and management of available resources. Furthermore, conservation strategies need to be designed to protect the rapidly diminishing forest cover, water resources and degraded soil.

References

Adamo SB, Crews-Meyer KA. 2006. Aridity and desertification: exploring environmental hazards in Jáchal, Argentina. Applied Geography **26(1)**, 61-85.

Ahmad F. 2013. Land Degradation Pattern Using Geo-Information Technology for Kot Addu, Punjab Province, Pakistan. Global Journal of Human Social Sciences Geography, Geo-Sciences and Environmental **13**, 536-542.

Ahmad F. 2012. Detection of change in vegetation cover using Multi-spectral and Multi-temporal information for District Sargodha, Pakistan. Sociedade and Natureza **24**, 557-572.

Ahmad SS, Erum S. 2012. Remote Sensing and GIS application in Wetland Change Analysis: Case study of Kallar Kahar. Science, Technology and Development **31**, 251-259.

Ali M, Khan SJ, Aslam I, Khan Z. 2008. Simulation of the impacts of land-use change on surface runoff of Lai Nullah Basin in Islamabad, Pakistan. Landscape and Urban Planning **102**, 271-279.

Alphan H. 2003. Land use change and urbanization in Adana, Turkey. Land Degradation and Development **14(6)**, 575–586.

Arfan M. 2008. Spatio-temporal Modeling of Urbanization and its Effects on Periurban Land Use System. M.Sc. Thesis, Department of Plant Sciences, Quaid-e-Azam University, Islamabad.

Ashraf A. 2013. Changing Hydrology of the Himalayan Watershed: Current Perspectives in Contaminant Hydrology and Water Resources Sustainability. Islamabad: Intech.

Ashraf M, Kahlown MA, Ashfaq A. 2007. Impact of small dams on agriculture and groundwater development: A case study from Pakistan. Agricultural Water Management **92**, 90-98.

Awasthi KD, Sitaula BK, Singh BR, Bajacharaya RM. 2002. Land-use change in two Nepalese watersheds: GIS and Geomorphometric analysis. Land Degradation and Development **13**, 495-513.

Baker C, Lawrence RL, Montagne C, Patten D. 2007. Change Detection of Wetland Ecosystems using Landsat imagery and Change Vector Analysis. Wetlands **27**, 610–619.

Batisani N, Yarnal B. 2009. Urban expansion in Centre County, Pennsylvania: spatial dynamics and landscape transformations. Applied Geography **29(2)**, 235-249.

Bazgeera S, Sharma PK, Maheya RK, Hundala SS, Sood, A. 2008. Assessment of land use changes using remote sensing and GIS and their implications on climatic variability for Balachaur watershed in Punjab, India. Desert **12**, 139-147.

Bhandari S. 2010. Urban change monitoring using GIS and remote sensing tools in Kathmandu Valley (Nepal). Available from: http://hdl.handle.net [Accessed 12 February 2013].

Braimoh AK, Vlek PLG. 2004. Land-Cover Change Analyses in the Volta Basin of Ghana. Earth Interactions **8**, 1-15.

Chen X, Vierling L, Deering D. 2005. A simple and effective radiometric correction method to improve landscape change detection across sensors and across time. Remote Sensing of Environment **98(1)**, 63-79.

Chengcheng W, Hongzhi W, Ablat X. 2011. Spatial and temporal changes of lake wetlands in Jianghan Plain after the implementing of 'thirty-six-word policy. Procedia Environmental Sciences **10**, 2574-2580.

Das, T. 2009. Land use/land cover change detection: an object oriented approach. Institute of Geoinformatics, University of Münster.

Dewan AM, Yamaguchi Y. 2009. Land use and land cover change in Greater Dhaka, Bangladesh: using remote sensing to promote sustainable urbanization. Applied Geography **29(3)**, 390-401.

Food and Agriculture Organization (FAO). 2005. State of the world's forests- 2005. Food and Agricultural Organization (FAO), Rome: Italy.

Gao J, Liu Y. 2010. Determination of land degradation causes in Tongyu County, Northeast China via land cover change detection. International Journal of Applied Earth Observation and Geoinformation **12(1)**, 9-16.

Ghumman AR. 2010. Assessment of water quality of Rawal Lake. Environmental Monitoring Assessment **180**, 115-126.

Gliessman SR. 2006. The need for Sustainable Food Production Systems. In: Agroecology: The Ecology of Sustainable Food Systems. Second ed. New York: Lewis Publishers.

Hagler Bailly. 2007. Environmental Baseline study of Margala and Margala North Blocks. Islamabad: MOL Pakistan Oil and Gas Company BV.

Han D, Wang R, Wu J, Zhou B, Shi Z, Ding L. 2007. Quantifying land use change in Zhejiang coastal region, China using multi-temporal Landsat TM/ ETM + images. Pedosphere **17**, 712-720.

Hardin PJ, Jackson MW, Otterstrom SM. 2007. Mapping, measuring, and modeling urban growth. In: Jensen RR, Gatrell JD, McLean D, eds. Geo-spatial technologies in urban environments: Policy, practice and pixels, 2nd ed. Heidelberg: Springer-Verlag, 141-176.

Harris PM, Ventura SJ. 1995. The integration of geographic data with remotely sensed imagery to improve classification in an urban area. Photogrammetric Engineering and Remote Sensing **61(8)**, 993-998.

Hartter J, Lucas C, Gaughan, Andrea E, Aranda LL. 2008. Detecting tropical dry forest succession in a shifting cultivation mosaic of the Yucata´n Peninsula, Mexico. Applied Geography **28**, 134-149.

Howarth PJ, Wickware GM. 1981. Procedures for change detection using Landsat digital data. International Journal of Remote Sensing **2(3)**, 277–291.

Hu HB, Liu HY, Hao JF, An J. 2012. Analysis of Land use change characteristics based on Remote sensing and GIS in the Jiuxiang river watershed. International Journal on Smart Sensing and Intelligent Systems **5**, 811 - 823.

IUCN(International Union for Conservation of Nature). 2005. Rapid Environmental Appraisal of Developments in and Around Murree Hills. Available from: http://www.iucn.pk [Accessed June 28, 2013].

Iqbal J, Shah MH. 2011. Distribution, correlation and risk assessment of selected metals in urban soils from Islamabad, Pakistan. Journal of Hazardous Materials **192**, 887-898.

Jensen JR, Im J. 2007. Remote sensing change detection in urban environments. In: Jensen RR, Gatrell JD, McLean D, eds. Geo-spatial technologies in urban environments: Policy, practice and pixels, 2nd ed. Heidelberg: Springer-Verlag, 7-30.

Jensen JR. 1996. Introductory digital image processing. 3rd ed. Upper Saddle River, NJ: Prentice Hall.

Johnson RD, Kasischke ES. 1998. Change vector analysis: a technique for the multi-temporal monitoring of land cover and condition. International Journal of Remote Sensing **19**, 411–426.

Keller A, Sakthivadivel R, Seckler D. 2000. Water scarcity and the role of storage in development. International Water Management Institute **39**, 1-20.

Koneff MD, Royle JA. 2004. Modeling wetland change along the United States Atlantic Coast. Ecological Modelling **177**, 41-59.

Lea C, Curtis AC. 2010. Thematic accuracy assessment procedures: National Park Service Vegetation Inventory, version 2.0. Natural Resource Report NPS/2010/NRR-2010/204, National Park Service, Fort Collins. USA: Colorado.

Li X, Yeh AGO. 1998. Principal component analysis of stacked multi-temporal images for the monitoring of rapid urban expansion in the Pearl River Delta. International Journal of Remote Sensing **19**, 1501–1518.

Lu D, Mausel P, Brondízio E, Moran E. 2004. Change detection techniques. International Journal of Remote Sensing **25**, 2365-2407.

Lu Q, Weng D. 2005. Urban classification using full spectral information of Landsat ETMþ imagery in Marion County, Indiana. Photogrammetric Engineering and Remote Sensing **71(11)**, 1275-1284.

Mendoza ME, Granados EL, Geneletti D, Perez-Salicrup DR, Salinas V. 2011. Analysing land cover and land use change processes at watershed level: A multi temporal study in the Lake Cuitzeo Watershed, Mexico (1975-2003). Applied Geography **31**, 237-250.

Munroe DK, Croissant C, York AM. 2005. Land use policy and landscape fragmentation in an urbanizing region: assessing the impact of zoning. Applied Geography **25(2)**, 121-141.

Nagarajan N, Poongothai S. 2012. Effect of Land Use/ Land Cover Change Detection of Ungauged Watershed. World Applied Sciences Journal **17**, 718-723.

Nagendra H, Pareeth S, Ghate R. 2006. People within parks-forest villages, land-cover change and landscape fragmentation in the Tadoba Andhari Tiger Reserve, India. Applied Geography **26(2)**, 96-112.

National Highway Authority (NHA). 2004. Profile: Islamabad-Muzaffarabad Dual Carriageway N-75. Islamabad: National Highway Authority.

Nelson RF. 1983. Detecting forest canopy changes due to insect activity using Landsat MSS. Photogrammetric Engineering & Remote Sensing **49**, 1303-1314.

Owojori A, Xie H. 2005. Landsat image-based LULC changes of San Antonio, Texascusing Advanced atmospheric correction and Object-oriented image analysis Approaches. In: 5th International Symposium on Remote Sensing of Urban Areas, Tempe, AZ.

Pelorosso R, Leone A, Boccia L. 2009. Land coverand land use change in the Italian central Apennines: a comparison of assessment methods. Applied Geography **29(1)**, 35-48.

Qasim M, Hubacek K, Termansen M, Khan A. 2011. Spatial and temporal dynamics of land use pattern in District Swat, Hindu Kush Himalayan region of Pakistan. Applied Geography **31**, 820-828.

Qazi F, Ahmad SS. 2012. Change Analysis of Wetlands for the Year 1971-2008 of Kallar Kahar. Journal International Environmental Application and Science **7**, 140-150.

Rao PJ, Harikrishna P, Rao BSP. 2006. Studies on silt deposition in Gambhiram Reservoir – A Remote Sensing Approach. Indian Geophysical Union **10**, 285-292.

Ridd MK, Liu JJ. 1998. A comparison of four algorithms for change detection in an urban environment. Remote Sensing of Environment **63**, 95–100.

Rosenfield GH, Fitzpatirck-Lins K. 1986. A coefficient of agreement as a measure of thematic classification accuracy. Photogrammetric Engineering & Remote Sensing **52(2)**, 223–227.

Schulz JJ, Cayuela L, Echeverria C, Salas J, Rey Benayas JM. 2010. Monitoring land cover change of the dryland forest landscape of Central Chile (1975-2008). Applied Geography **30(3)**, 436-447.

Serra P, Pons X, Saurí D. 2008. Land-cover and land-use change in a Mediterranean landscape: a spatial analysis of driving forces integrating biophysical and human factors. Applied Geography **28(3)**, 189-209.

Shalaby A, Tateishi R. 2007. Remote sensing and GIS for mapping and monitoring land cover and land-use changes in the Northwestern coastal zone of Egypt. Applied Geography **27(1)**, 28-41.

Singh A. 1989. Digital change detection techniques using remotely-sensed data. International Journal of Remote Sensing **10(6)**, 989-1003.

Tang Z, Engel BA, Pijanowski BC, Lim KJ. 2005. Forecasting land use change and its environmental impact at a watershed scale. Journal of Environmental Management **76**, 35-45.

Townshend JRG, Justice CO. 1995. Spatial variability of images and the monitoring of changes in the normalized difference vegetation index. International Journal of Remote Sensing **16**, 2187–2195.

Wang S, Kang S, Zhang L, Li F. 2008. Modelling hydrological response to different land-use and climate change scenarios in the Zamu River basin of northwest China. Hydrological Processes **22(14)**, 2502–2510.

Wu Q, Li H, Wang R, Paulussen J, He Y, Wang M, Wang B, Wang Z. 2006. Monitoring and predicting land use change in Beijing using remote sensing and GIS. Landscape and Urban Planning **78**, 322-333.

Wyman MS, Stein TV. 2010. Modeling social and land-use/land-cover change data to assess drivers of smallholder deforestation in Belize. Applied Geography **30(3)**, 329-342.

Xiao J, Shen Y, Ge J, Tateishi R, Tang C, Liang Y, Huang Z. 2006. Evaluating urban expansion and land use change in Shijiazhuang, China, by using GIS and remote sensing. Landscape and Urban Planning **75**, 69-80.

Xie Z, Xu X, Yan L. 2010. Analyzing qualitative and quantitative changes in coastal wetland associated to the effects of natural and anthropogenic factors in a part of Tianjin, China. Estuarine, Coastal and Shelf Science **86**, 379-386.

Yuan F, Sawaya KE, Loeffelholz B, Bauer BE. 2005. Land cover classification and change analysis of the Twin Cities (Minnesota) metropolitan area by multitemporal Landsat remote sensing. Remote Sensing of Environment **98 (2-3)**, 317-328.

Zhang WW, Yao L, Li H, Sun DF, Zhou LD. 2011. Research on Land Use Change in Beijing Hanshiqiao Wetland Nature Reserve using Remote Sensing and GIS. Procedia Environmental Sciences **10**, 583-588.