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ИЗМЕНЕНИЯ В ХАРАКТЕРЕ ЗЕМЛЕПОЛЬЗОВАНИЯ НА ТЕРРИТОРИИ ГОРОДА МАНДИ БАХОУДДИН (ПЕНДЖАБ, ПАКИСТАН) С 1990 ПО 2016 ГГ.

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Аннотация.

Цель. Проанализировать изменения характера землепользования в г. Манди Бахоуддин (Пенджаб, Пакистан) в период активной градостроительной трансформации с 1996 по 2016 гг.

Процедура и методы. Изучены пространственно-временные аспекты изменения землепользования в г. Манди Бахоуддин, Пенджаб, Пакистан. Для исследования использованы многозональные спутниковые снимки Landsat TM, ETM+ и OLI/TIRS за 1990, 2000 и 2016 гг. Космоснимки получены с помощью ресурсов Global Land Cover Facility (GLCF) и Earth Explorer. При создании растровых композитов использованы все каналы, дешифрирование проведено с помощью метода контролируемой классификации с использованием ERDAS Imagine 10.2. Выделены три класса объектов: сельскохозяйственные земли, пустоши и застроенная территория.

Результаты. Проведённый анализ показал, что площадь застройки и пустошей увеличились на 30 и 58% соответственно, а сельскохозяйственные земли сократились на 88%.

Теоретическая и практическая значимость. Обобщён материал по исследованной теме. Изменение землепользования (land use/land cover) связано не только с изменением окружающей среды, но и социума, и представляет существенный теоретический и практический интерес. В первую очередь это относится к развивающимся странам, таким, как Пакистан. В качестве объекта исследования выбран г. Манди Бахоуддин, отличающийся стремительным ростом населения. Результаты работы показали изменения в характере землепользования и переход от сельского хозяйства к городской застройке. Показано ведущее значение урбанизации в смене характера землепользования.

Ключевые слова: земля, землепользование, изменение земельного покрова, природная среда, урбанизация

LAND-USE/LAND-COVER CHANGES FROM 1990 TO 2016 ON THE TERRITORY OF MANDI BAHAUDDIN CITY (PUNJAB, PAKISTAN)

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Abstract.

Aim. We analyze land use/land cover in the city of Mandi Bahauddin, Punjab, Pakistan in the period from 1996 to 2016.

Methodology. Spatiotemporal aspects of land-use/land-cover changes in the city of Mandi Bahauddin are analyzed. Landsat satellite imageries of 3 different periods (1990, 2000 and 2016) are obtained from the Global Land Cover Facility site (GLCF) and Earth Explorer site to compute the changes in the land use and land cover (LULC) from 1990 to 2016. To classify different categories, a false-color composite is prepared by combining all bands of downloaded images. The false-color composite is prepared through layer stacking, and supervised classification is used to determine a change in residential land use in Mandi Bahauddin by ERDAS Imagine 10.2. The imageries of the area under study are categorized into three classes: agriculture land, barren land and built-up area.

Results. The results of this study indicate that the size of the built-up area and barren land increased by 30% and 58%, respectively, and the size of the agricultural land decreased by 88%.

Research implications. The land-use/land-cover changes have a great theoretical and practice interest for sustainability of environment and society. It is found that changes are mainly detected in the Mandi Bahauddin city where the population has rapidly increased. The results of investigation have demonstrated the land-use/land-cover changes and shifts from agriculture land to urban settlement. Urbanization is the major cause of land use change in the period from 1996 to 2016 according to the results of the study.

Keywords: land, land use, land cover change, natural environment, urbanization

Introduction

Land use/ land cover (LULC) is the phenomenon that changes the natural environment and social life [1–3]. It is a process of conversion of one type of land into another. The term land use/land cover can be defined as changes in land use due to social actions for different reasons, like farming development, settlement, transportation, etc. [2]. The pattern of land use is not stable and has been changing gradually over the years [1]. Land-use changes cause major environmental problems in the world as well as in Pakistan [2]. In this study, LULC changes are associated with cultivation, industrial and residential development of the Mandi Bahauddin city. The rapid growth in population reduces natural resources for survival over the past few years [3]. Intra-city migration, infrastructure, road networking and provision of basic life necessities in Mandi Bahauddin create barriers for urban planners and administrators. Land-use/cover change exposure is necessary to quantify the landscape changing aspects during a known period for sustainable management [1]. Understanding land-use changes are very significant for decision making and effective land management.

Currently, satellite data are very helpful for the conversion exposure in land use/land cover [6–7]. After the invention of Geographic Information System (GIS) and remote sensing, it becomes easy to classify and calculate the area for agricultural, residential and industrial zones. Application of satellite imagery makes imaginable to detect the change in land use/land cover in different periods, at little expense and correctness [2]. Landsat image thematic mapper (TM) represents constant proceedings of ground superficial. Today, most of the people are moving towards cities for the sake of facilities

and convert barren and agricultural land into residential land [1].

In the world, researchers have done work on land use/land cover, using satellite imagery data [10]. An attempt has been made in this study to quantify the pattern of land use/land cover in one of the developing city and compute the LULC expansion pattern in Mandi Bahauddin city of Punjab (Pakistan), in view to detect the land-use changes using geospatial techniques. Results show such normalized differences in residential land and agricultural land use.

More recent land-use changes caused the conversion of prime natural/agricultural land into residential and industrial areas [1]. Lyle [12] conducted a research on urban sprawl, pattern, and measurement in Lokoja, Nigeria. The study selected ten neighborhoods, used remote sensing techniques, and identified areas of urban residential development. Kearny [13] separated the areas into two major classes (residential and commercial). The study analyzed the relationship between socio-economic and residential land use with biophysical variables. The result showed that residential land use was dominant, followed by commercial uses. The literature shows that the result of such studies could be utilized to generate a spatially explicit explanation to study residential land-use change [1]. McBratney et al. [15] studied trends of urbanization in Shijiazhuang City, Hebei Province of China. This study was conducted through Remote Sensing and GIS. This study revealed that there is a significant change in spatial characteristics of urban areas from 1934 to 2001, and land use from 1987 to 2001 [16]. Urban expansion displays fast and slow growth stages, with most of the districts shifting from the east

or west side from the north or south side of the city [4]. According to researchers, the spatial outlines of urban growth have been observed by special objectives such as oriented type, normal urban growth type, and social-political intervention type [18]. The remotely detected land-use change from 1987 to 2001 shows that the land use was mostly transformed [19]. The land-use conversion relationship suggests that land-use change speeds up due to urbanization [20]. In an environmental framework, urbanization is considered as one of the most significant anthropogenic phenomena which rapidly alter the land [2]. Moreover, the other major factors of land-use change and urban growth are migration of population, industrialization and infrastructure development [3]. Beissinger et al, [1] presented research on South Africa about the challenges of economic growth and related policy, job creation, and provision of adequate infrastructure. It is a basic need of living people having a healthy environment [3]. This research paper focused on the health challenges faced by local people regarding national policy and the excess in the provision of basic services. Many of the insights highlighted are likely parallel to experience in other developing countries [12; 13]. Recently, research has been mainly focused to find out the impact of industrialization and urbanization on the environment. Such studies make use of the regression technique to find out the relation between the variables. The result of the research shows that health is influenced at a large by air pollution and other environmental indicators. The results also describe that carbon dioxide emission has a direct relation with the sanitation facility, whereas fossil fuel energy consumption and industrialization both

have an indirect relation with the infant mortality rate in a country. The result of research also shows that the government's primary responsibility is to provide good outdoor air quality, less environmental pollution and health services. Similarly, Schowengerdt [24] explored the relationship of urban development with the modification of natural resources change and land-use patterns. The study describes that urbanization is a process that increases the modernization system and modifies the socioeconomic activities, which revolutionize the land-use pattern according to period. An unplanned urbanization causes too much problems for developing and developed countries [4]. In developing countries rapid urbanization has led to extensive land-use change [2]. This study revealed the historical urban growth phenomenon and analysis of land-use and land cover change of sub-metropolitan by utilizing remote sensing and GIS. Henderson [27] conducted a research on the land-use changes, explored that land use changes are followed by the urbanization and industrialization pattern. The phenomenon of urbanization and industrialization is highly dynamic and complex [28]. In early stages of urbanization, the natural resources are exploited very rapidly. The industrial sites have also developed near and even within urban areas. A number of studies [10; 27] were conducted to investigate the industrial structure evolution and adjustment in Pakistan. They state that the industrial structure changes and evolves overall trends in economy transforms.

With innovations and modern technology all industries have to be developed according to needs [29]. Researchers have analyzed the structure of industry and economy throughout Pakistan. This paper

provides a history of the development of Pakistan and its impact on the economy of the country. The research suggests that industry can be developed through proper policy innovation. This study also concludes that there is an increase in the land value due to the presence of parks, neighborhood commercial land and even housing schemes.

Methods

Study area

This study was performed for the Mandi Bahaudin district, Pakistan, which is situated in the northeast of the country and covers an area of 2673 km² [30]. The elevation is about 204 m above sea level. Climatically, the area in question has moderate climate. On average, the area receives about 50 cm rainfall. The average maximum and minimum temperatures are 45°C and 12°C, respectively. Cultivation is the main financial activity that is characterized by the canal system. Both agriculture and livestock are equally important for the economy of the area under study; as a growing city, the number of social and economic activities has increased due to which one can observe numerous changes in natural land. The dominant crop types include sugarcane, wheat, rice, citrus, and guava. The total population of the area is 1.41 million. The population growth is about 1.87% [28]. Growing population is engaged in different activities to run the social-economic cycle of the family. The more the population the more the land usage; therefore, this study gives an overview of land-use and land-cover change by RS- and GIS-based techniques.

The Landsat satellite series was launched in 1972 and now includes a vast number of time-series images [12]. Landsat images

Рис. 1. / Fig 1. Схема рассматриваемой территории / Map of the area under study

Источник: данные авторов

Таблица 1 / Table 1

Использованные в работе наборы данных Landsat / Landsat datasets used for the study

No	Satellite Image	Spatial Resolution	Acquisition Date	Bands
1	Landsat 4-5 TM	30 m	03-May-1990	7
2	Landsat 7 ETM+	30 m	03-May-2000	8
3	Landsat 8 OLI/TIRS	15 m	03-May-2016	11

Источник: данные авторов

have been broadly used to classify land-use/land-cover changes [15]. The imagery used for this study was downloaded from the USGS website. The data is collected by using three different periods i.e. 3 May 1990, 3 May 2000 and 3 May 2016. The difference in the months of the collected data can affect the results of the classification. Landsat 4-5 TM 1990, Landsat 7 ETM+ 2000 and Landsat 8 OLI/TIRS were obtained by using the Earth Explorer. The imagery was processed by using ERDAS and ArcMap. The table below provides information about data collection sources and the nature of data used in the study for spatial analysis and findings.

After downloading the imagery, classification is performed using the Earth Resources Data Analysis System (ERDAS). The area in question is then clipped from the downloaded imagery and the clipped images are classified. To check out the LULC changes, a supervised classification method is applied, by three categories i.e. built-up area, barren land and agriculture land. After classification, in the next step, the raster image converts into a shapefile for spatial analysis in ArcMap. In this study, the shapefile of the imagery, i.e. 1990, 2000 and 2016, is added in ArcMap and then different classes are classified by different colors to compare the differences

Рис. 2. / Fig. 2. Выделенные классы объектов в М. B.DIN в 1990, 2000 и 2016 гг. /
Land-use categories in M. B.DIN in 1990, 2000 and 2016

Источник: данные авторов

Рис. 3. / Fig. 3. Изменение землепользования в М. B.DIN в 1990, 2000 и 2016 гг. /
LULC change in M. B.DIN in 1990, 2000 and 2016

Источник: данные авторов

of classes, i.e. the change in the barren land in 1990, 2000 and 2016.

Result and Discussion

The results obtained by the analysis of satellite imageries are demonstrated in Fig. 2, which illustrates the LULC changes in different categories, and Fig. 3 depicts the level of change in different land categories.

One can see from Fig. 2 that in 1990 about 90% of the area of Mandi Bahauddin

was under barren land; 5%, under agricultural land; and 5%, under the built-up area. In 2000 about 23% of the area was under barren land; 48%, under agricultural land; and 29%, under the built-up area. Finally, in 2016 the barren land constituted about 2% of the entire territory, while agricultural land and built-up area amounted to 63% and 35%, respectively (Table 2).

Data listed in Table 2 and Fig. 3 depict that both positive and negative changes

Таблица 2 / Table 2

Изменения в землепользовании / Land-use changes

Land use categories	Percentage in 1990 (%)	Area in 1990 (acres)	Percentage in 2000 (%)	Area in 2000 (acres)	Percentage in 2016 (%)	Area in 2016 (acres)
Barren land	90	9907	23	2549	2	183
Agricultural land	5	605	48	5149	63	7168
Built-up area	5	605	29	3110	35	4054

Источник: данные авторов / Source: authors' data.

occurred in the LULC pattern in Mandi Bahauddin. During the last 25 years, the agricultural land in the study area has increased from 5% in 1990 to 48% in 2000 and 63% in 2016. The built-up area has increased from 5% in 1990 to 29% in 2000 and 35% in 2016. The barren land has decreased from 90% in 1990 to 23% in 2000 and 2% in 2016.

Conclusion

One of the developing districts of Punjab in the city of Mandi Bahauddin is examined. The study advocates that multi-temporal satellite imagery plays an important role in the spatial and temporal phenomenon, which is not imaginable through conventional mapping. The study exposes that the main land use in the area in question is for agricultural purposes. Urbanization as a global multiple process rapidly changes the land cover. The results show that human activities influence the natural land, with urbanization being the major cause of LULC change. The

combination of rapid population growth, political change and rapid technological development causes a major change in natural, social and economic growth in the country. Throughout the country, a rapid urban growth of the country is seriously outstripping the capacity of most cities to provide adequate services for their citizens. The results suggested that agriculture and industries should be shifted far away from the center of cities and settlements. Industrial development has expended from the center of the city to outside. This phenomenon causes irregular housing patterns and causes land degradation. New housing schemes should be adopted according to rules and regulations for sustainable urban planning. The formulation of the analysis of the results provides knowledge, policy guideline, and innovation, which will guide for finding solutions for global environmental problems.

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ИНФОРМАЦИЯ ОБ АВТОРАХ

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ПРАВИЛЬНАЯ ССЫЛКА НА СТАТЬЮ

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