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RESEARCH ARTICLE

The Relationship between the Development of Population Growth and Density and Land Use in Irbid Governorate using Remote Sensing and Geographic Information System

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ABSTRACT

Overpopulation and increasing population growth put pressure on various resources in general, and on land resources and their use patterns in particular. Jordan is one of the developing countries most exposed to waves of asylum and forced migration, including Irbid Governorate. The governorate also suffers from the problem of overuse of land, which poses challenges to various development projects. According to data from the Department of Statistics, the estimated population growth rate in Jordan for 2004 was (2.3%) and (1.9%) for 2023. The results of images analysis of the study area also showed a positive change in the area of urban and agricultural lands. While we notice a negative change in the area of barren lands, and the relationship between population density and the change in the areas of agricultural and urban lands was a direct relationship, however the relationship with barren areas was characterized by an inverse relationship. The results indicated that the forest area in Irbid Governorate increased during the study period despite the population increase; This can be attributed to a amount of reasons, such as increased awareness among local residents of the importance of forests and wooded areas, and government laws and procedures to protect these areas. The average population density in Irbid Governorate is (590.59) persons per km2 in 2004, rising to (2135.400) persons per km2 in 2004, , which indicates the amount of pressure that will be increased onvariouse land use in addition to creating social, environmental, ecological and health problems hinder development plans.

INTRODUCTION

This study aims to explore the effect of population growth on land use change and to analyse the mutual effects between these two vital factors on sustainable development. Studying this relationship is important to understand how population growth factors affects land use trends and how these changes can affect population growth rates. , as this topic is this analysis is important for understanding the challenges facing urban and economic planning in the future. In the past few years, urban centers in the cities around the world have grown significantly, due to the rapid increase in population and migration movements from villages to cities, especially in developing countries. The developing countries including Jordan have witnessed the highest population growth than other countries, and the population growth in them has been characterized by instability and random planning (Garg,2022). These phenomena have generated overpopulation of resources, which is the ratio of population to the natural resources available in a certain area, which depends on how land and water resources are managed, distributed among all residents in any country (Shiva, 1991). Population growth and the accompanying concentration and overpopulation of the population is the result of the growth of the imbalance between the birth rate and the death rate, and the decline in

death rates, due to the availability of advanced medical services, and the increase in internal migration that creates problems such as unsustainable areas and slums, and pressure on natural resources, land and water, Soil degradation, deforestation, decline size of land holdings, and depletion of groundwater levels, of all these natural resources, land is still the most important element. All agricultural, livestock and forestry products depend on the avail productivity of land. Unmanaged land use is the main cause of destruction of our environment. For the sustainable development of an area, regular monitoring and follow-up of changes in land cover and land use is essential. Rapid population growth, overpopulation, consumption, overuse, waste and misuse of resources have strained the carrying capacity of the land (Garg, 2022). Irbid Governorate is an important region for studying the effects of changes in population growth, population density on land use pattern. Due to the diversity of landscape characteristics in terms of terrain and climatic properties, and the human influences represented by rapid population growth that witnessed in the Irbid governorate. These factors are as a result of natural population growth represented by the increase resulting from the difference between births and deaths, and the increase resulting from internal population migrations (Al-Btoush, 2012), and external population migration from Syria (Doraï, K. 2018.). Therefore, analyzing these factors on land use pattern is necessary to understand the societal and environmental transformations occurring at the governorate level. The methodology is based mainly on using the remote sensing environment and geographic information systems, which enable accurate and effective data analysis to provide scientific conclusions that support decision-that help in strategic planning and sustainable development on the governorate level. Given the importance of the relationship between population characteristics and changes in land use patterns in Irbid Governorate, this study came to shed light on these phenomena and analyze the relationship between population change and the subsequent change in land use patterns and display it in a cartographic style, using geospatial techniques. (Bani Khaled, 2023). The problem of the study and its importance

The problem of the study is represented by the lack of regulation of land use, the spread of most agricultural activities and urban agglomerations with varying population densities over the agricultural lands of Irbid Governorate, which represents the most fertile area of the Kingdom. In addition to the governorate being exposed to waves of different migrations, the latest of which was the Syrian refugee, which is the largest in the history of the Kingdom, which has an obvious impact on the pattern and direction of population development in the governorate, and the consequences on land use patterns.

The study area also represents a diverse region in terms of natural characteristics and multiple human activities, despite of this diversity, this region has not received a comprehensive study on the impact of population size and density changes on land use patterns. Therefore, the importance of the study lies in the importance of changes in population size and density, and predicting the future population development until the year (2034). Expectations and future simulation of land use reality and finding the form and size of the relationship between them, is essential for the success of development planning processes, which is a starting point for eliminating a number of economic and social problems such as poverty and unemployment (Benomar et al, 2006). In addition to the scarcity of specialized studies and research that addressed the region in terms of finding the relationship between changes in population size and density, and the associated changes in land use patterns.

Study objectives

The study seeks to achieve the following objectives:

1. Study the development in population size, and analyze the population density of the study area.
2. Track the change in land use in the study area using satellite images, during the study period (2004-2023) using the remote sensing and geographic information systems environment.
3. Find the shape and size of the correlation between the change in population density, and the changes occurring in land use types.

LITERATURE REVIEW

There are various studies that have addressed the study of population and demographic changes and their impact on land use. A group of them have been reviewed, and they can be presented as follows:

Muhammad's study (2022) entitled "Land use change in the city of Sabha (2006-2019) using remote sensing and geographic information systems" addressed the impact of geographical factors affecting land use, by highlighting the role of natural and human factors in this change, relying on the descriptive approach to clarify the role of these factors, and the historical evolutionary approach to show the changes that occur in land use over time. The study concluded that human factors, most notably population growth and increase, are the main reason for the change in land use in the city of Sabha, Libya.

While the **study "Czekajlo, et al" (2021)** entitled "Mapping dynamic peri-urban land use transitions across Canada using Landsat time series: Spatial and temporal trends and associations with socio-demographic factors." aimed to track urban use transitions, and the effects of urban expansion, by using the evolutionary approach to land use classification in order to assess the spatiotemporal patterns of urban expansion and associated land use changes. The study used an annual time series of satellite images (Landsat) for a period of (33) years (1984-2016), the study found that about (2700) square kilometers of natural and/or agricultural lands were converted to urban uses.

Panama, Rawat, S. D., & Kumar, S. (2019) studied the impact of population density on land and water resources, especially in a country like India, which is one of the most vulnerable developing countries and has the second largest population in the world after China, and suffers from the problem of overuse of land and water resources that reduces crop production. The study showed that the average population density in India is (382) people per square kilometer, while the physiological or nutritional density of India is (613) people per square kilometer. The analysis of population and nutritional density indicates that in a short period of time, (78) people per square kilometer have been increased, which indicates the amount of pressure that will be increased on natural resources to meet the demand for food, in addition to creating social, environmental and health problems; as a result of overcrowding and increased population density.

Li Fei, et al. (2015) studied the impact of demographic change as a major driver of land use change. Western Jilin Province in China was selected as a study area to provide a case study to understand the relationship between the spatial and temporal pattern of land use change and population dynamics from 1975 to 2010. The results showed that the change in the proportion of agricultural land area could be well modeled using a quadratic function, and the lowest proportion of agricultural land area (15.4%) was in areas with population density (0 people/km^2), and the greatest proportion of agricultural land area (94.8%) was when population density was (199.25 people/km^2). The percentage of grassland, water bodies, and wetlands decreased significantly with the increase of population density.

Al-Zayoud's study (2014), entitled "Population change and urban growth in the city of Sahab during the period (1952-2014) and its impact on the change in land use patterns", dealt with population change in the city of Sahab in terms of size, change in population densities, in addition to change in population distribution and structure. On the other hand, the urban growth witnessed by the city and land uses from (1952 to 2004) were studied, based on the analysis of aerial photo covers and satellite images at different scales. The study used several methods to identify population changes, including extracting population growth rates, constructing and analyzing statistical tables, and drawing point population distribution maps and population distribution maps according to the Kernel tool. The study concluded that the population of the city of Sahab doubled during two time periods, namely (1961-1979) and (1985-2004), and that land use patterns changed during the study period (1952-2004).

Hashem conducted a study in (2008) entitled "The Impact of Population Density on Land Use in Al-Sha'la City" in which he traced the impact of population density on different land use patterns, and identified the impact of change in population density on the pattern of land use in terms of quantity and quality. To achieve the above objectives, the researcher used the descriptive analytical method, and the study concluded that high population density negatively affected the area of green spaces and agricultural areas and a clear decline in the level of services such as transportation and housing.

The study conducted by **Lambin et al. (2001)** entitled "The causes of land-use and land-cover change: moving beyond the myths" aimed to understand the causes contributing to land-use and land-cover change and the driving forces of land-cover change. The study used the descriptive and historical approaches to achieve the study objectives. The cases reviewed support the conclusion that neither population nor poverty alone constitute the main and sole cause of land-cover change, but rather human activities and their various interactions are primarily what drive land-cover change.

When reviewing previous studies, we note the absence of a specialized study that has been unique in analyzing and finding the relationship between changes in population density and its association with changes in land use. We note that most studies have tracked the impact of population growth and population density on a specific type of land use, while this study has undertaken to determine the form and pattern of the relationship between changes in population density and changes in land use in a quantitative and mathematical manner through its use of quantitative and mathematical coefficients and equations, and finding the role and impact of population growth on land use patterns, and determining the form of the relationship between them in a mathematical manner.

Study area

The study area is Irbid Governorate, one of the twelve governorates of the Hashemite Kingdom of Jordan, located in the northwestern corner of the Kingdom, and extends astronomically between longitudes (35º 23' - 36º 04') east, and latitudes (32º 12' - 32º 46') north. with an area of about (1571.8) square kilometers, constituting (1.8%) of the total area of the Hashemite Kingdom of Jordan. The governorate administratively consists of nine districts (Fig.1). The natural regions in Irbid Governorate are diverse. The governorate is a miniature version of the regions of the Kingdom. It contains parts of the Jordan Valley region and mountainous highlands, and in other parts, the plains and interior plateaus extend. On the other hand, the governorate is distinguished by its large population and the large number of its settlement centers. It occupies the second rank among the governorates in terms of population and number of settlement centers after the capital governorate of Amman (Al-Tarzi, 2007).

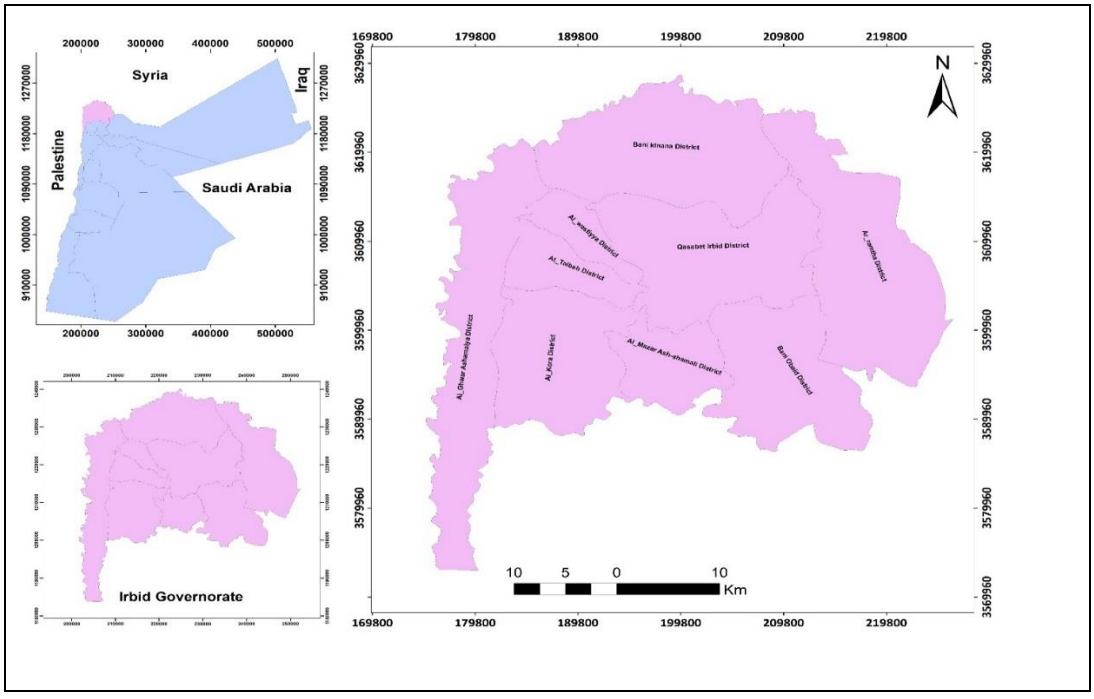


Figure 1: Study area

METHODOLOGY

To achieve the study objectives, the study relied on the following approaches:

The historical evolutionary approach: It is the approach used to track the development of population growth and their spatial distribution, as well as the development of land use patterns during the study period extending from (2004-2021).

Descriptive approach: It is the approach that is concerned with describing phenomena accurately, studying their characteristics, forms, relationships, and the factors affecting them, and extending to the processes of predicting the future of the phenomena studied (Al-Othman, 2021), as this approach was used to identify patterns of land use and land cover in the study area, population numbers in the study area, and population growth rates prevailing during the study period.

The quantitative analytical approach: It depends on studying the geographical phenomenon in its spatial and temporal dimensions from an analytical perspective, and revealing the mutual relationships between phenomena, in order to clarify their implications and show the interconnection between their variables and clarify the strength and direction of the relationship in them. To analyze the population increase with the spatial development of land uses, and to show the change in population growth and different land use patterns.

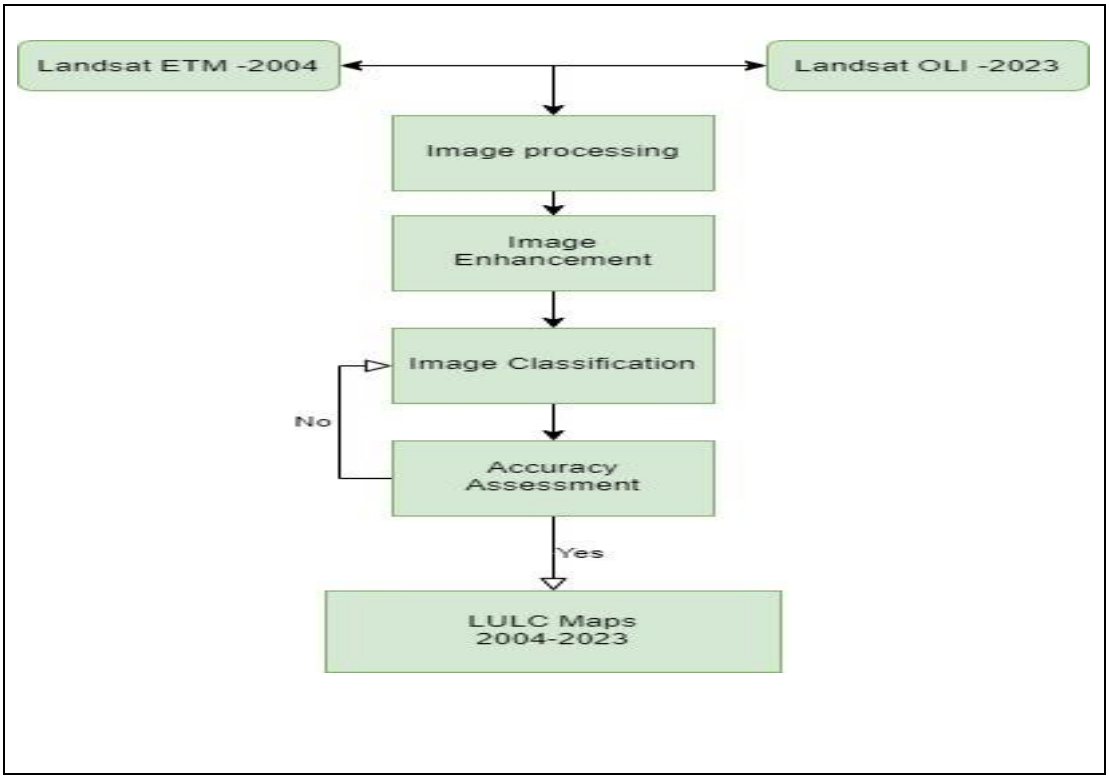


Figure 2: Flowchart of land use and land cover classification procedures

ANALYSIS & DISCUSSION

1. Images classification

Land uses in Irbid Governorate were classified during the two periods (2004-2023) in order to reveal the nature of the change in land use and land cover patterns prevailing in Irbid Governorate during both periods. Thematic maps were produced for the classification process and their results were analyzed, as well as the factors that contributed to the changes and the effects of this change. Supervised classification was conducted for all visuals used in the study, by using spectral bands for visuals and excluding the thermal band for five types of land uses and cover represented by (urban areas, agricultural areas, forests and wooded areas, barren areas, and watershed areas). Figures (3) and (4) and Table No. (1) show the results of the classification of visuals in the study area for the two periods (2023, 2004).

Table 1: Land cover and land use classification results

Year	2004		2023	
Land use land cover Type	Area km^2	Percentage	Area km^2	Percentage
Water	0.72	0.05	1.55	0.10
Barren	1306.90	83.15	879.90	55.98

Agriculture	80.05	5.09	137.57	8.75
Forest	44.27	2.82	70.09	4.46
Urban	139.86	8.9	482.70	30.71
Total	**1571.8**	**100.0**	**1571.8**	**100.0**

We note from the data in Table No. (1) and Figure No. (3) that there is a clear increase in the area and percentage of urban areas between the two study periods, and this indicates that there is a wide spread of urban movement in the governorate, due to the increase in population growth and population increase, in addition to the migrations that the governorate was exposed to, especially the waves of Syrian refugees after the year (2011), which were concentrated in the cities of Irbid and Ramtha in particular, as the developmental progress and economic growth movement that the governorate witnessed in the last two decades had a clear impact on this increase.

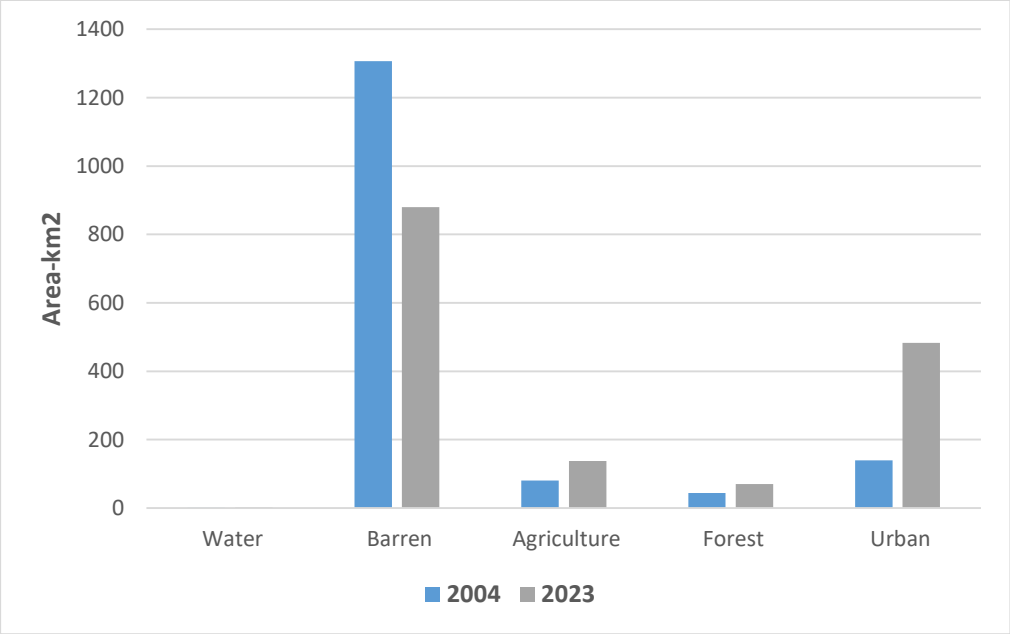
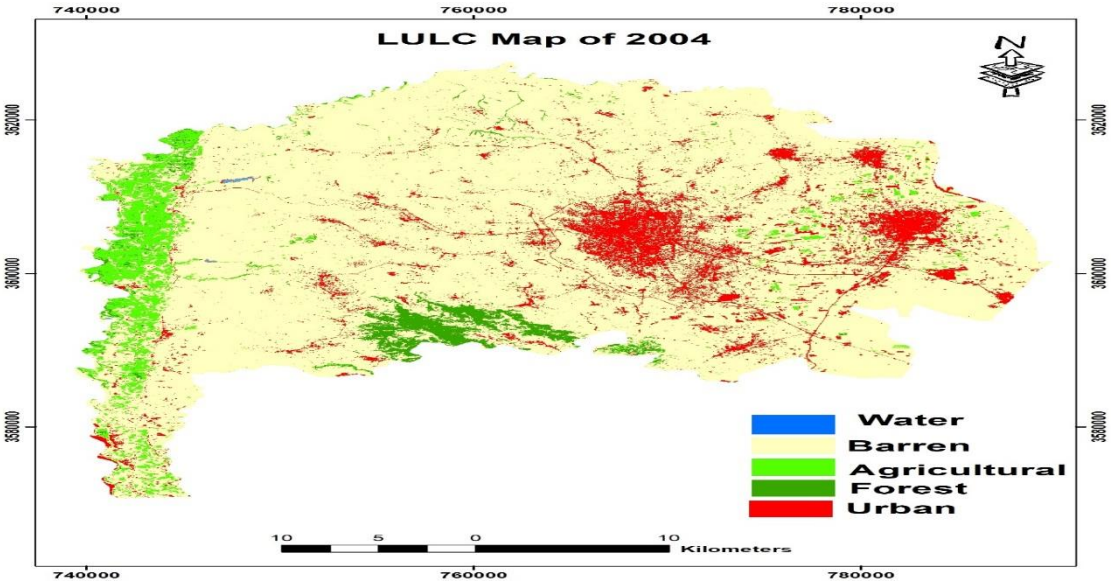


Figure 3: Area of land use and land cover types



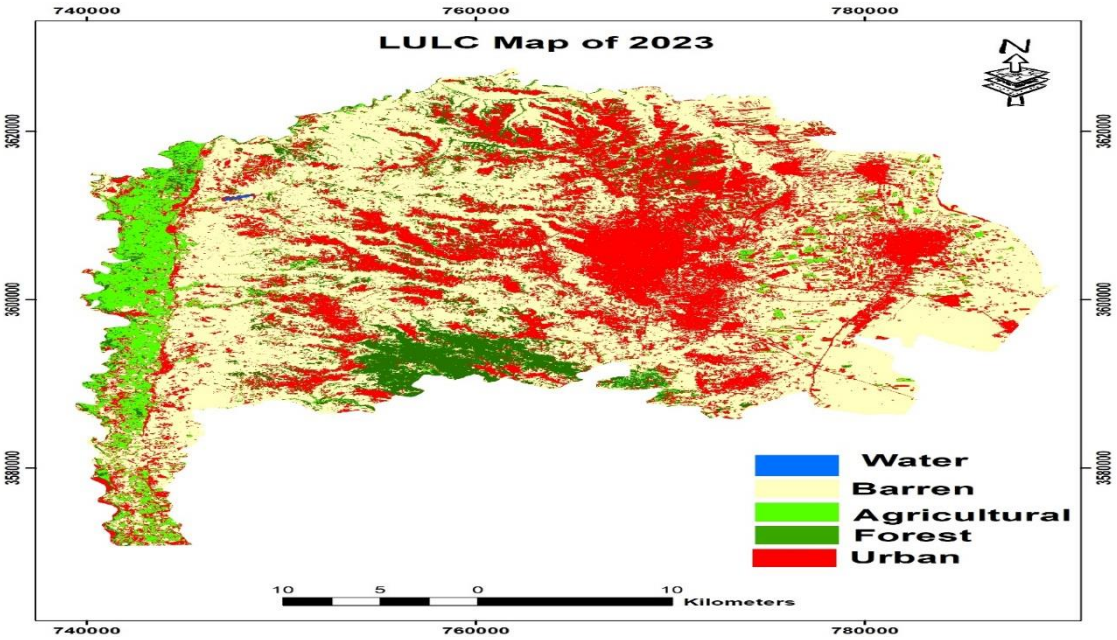


Figure 4: Types of land uses and land cover

The agricultural areas (tree and fruit farms, olive trees, field crops of wheat and barley, in addition to irrigated crops of various vegetables, which are widely grown in the Jordan Valley and the eastern regions of the governorate and which depend mainly on groundwater wells) ranked third in terms of the classified area, as the area of agricultural areas reached (80.05 km^2) and a percentage of (5.9%) of the governorate's area according to the results of the classification in (2004), to rise in (2023) as the area reached (137.57 km^2) and a percentage of (8.75%) of the total area of the governorate. This increase can be attributed to the increase in population numbers and population growth and the accompanying increase in demand for land resources, in addition to the development of agricultural methods and the accompanying greater exploitation of agricultural areas, and the spread of artesian wells, especially in the eastern regions of the governorate and the Hauran Plain areas and the accompanying spread of irrigated agriculture therein.

The results also showed an increase in forest areas and woodlands, as the percentage of forest areas and forests increased by (1.64%) of the total area of the governorate, due to the combination of a number of reasons, most notably stopping repeated attacks on forest areas by cutting and logging, and the combined efforts of various departments from the Ministry of Agriculture and the Royal Administration for Environmental Protection in preventing attacks and afforesting new and additional areas, as well as increasing citizens' awareness of the importance of forests and the need to preserve them. While the open and barren areas ranked first in terms of the classified area of the study area, these areas include open or empty lands, lands left without exploitation, exposed rocks, as well as sandy areas, rock quarries and crushers, and barren lands occupied an area of (1306.9 km^2) and a percentage of (83.15%) of the area of the study area according to the results of the visual classification in (2004), to decline in (2023) to (879.9 km^2) and a percentage of (55.98%) of the total area of the governorate.

The water areas included dams, rainwater collection ponds, and agricultural ponds. The water cover occupied the last place in terms of the classified area, and by a very small percentage, compared to the area of the study area. We note a slight increase in the area of this type between the two classification periods, where this increase can be attributed mainly to the construction of the Al-Wahda Dam on the Yarmouk River and the beginning of storage in the dam lake on (11/22/2006).

The results showed a significant increase in urban areas, as their percentage increased by (21.81%) of the total area of the governorate. This is mainly due to the increase in population growth and the development of population numbers, and the accompanying active movement of development in the governorate in general, and the expansion of road and transportation networks and the wide spread of buildings and houses in all cities, towns and villages of the governorate, especially the urban growth movement witnessed by the city of Irbid and the surrounding towns, as well as the city of Ramtha and its towns. While the open spaces and barren areas ranked first in terms of the classified

area of the study area, these areas include open or empty lands, lands left without exploitation, exposed rocks, as well as sandy areas and areas of rock quarries and crushers. Barren lands occupied an area of (1306.9 km^2) and a percentage of (83.15%) of the area of the study area according to the results of the visual classification in (2004), to decline in (2023) to (879.9 km^2) and a percentage of (55.98%) of the total area of the governorate.

2. Accuracy assessment

The accuracy assessment is known as a comparison process between two sources of data, represented by the results achieved from the supervised classification process. The extent of results conformity to the ground reality and the known identity of the land cover, through comparison between random samples selected from the classified maps, and the classification category under which these samples fell, which leads to what is called the Error Matrix (Lillesand and Kefer, 2004). Relying on various reference information, the most famous of which is field work, as a basic and primary requirement to verify the validity and accuracy of the classification process, and to achieve confidence in the results (Al-Issawi, 2021).

In order to assess the accuracy of the supervised classification applied to all images used in the study, a set of random samples was obtained, which included (155) random samples representing different types of land use and land cover. These samples were obtained by relying on topographic maps of the study area, at a scale of (1: 50,000), images and satellites available through Google Earth and field work through which training points and accuracy display points (Training Area) were obtained using the Global Positioning System (GPS). Then it processed to reach the error matrix, in addition to the points generated randomly and classified manually. The results of the accuracy assessment of the classification conducted for the images of the years (2004, 2023), which showed that the random samples that were correctly classified represent to (126) samples for the year (2004) and (131) samples for the year (2023).

Table 2: Error matrix for image – 2004

		Reference data						
		Water	**Barren**	Agriculture	Forest	Urban	**Total**	**User's Accuracy**
Classified data	Water	**11**	0	1	1	0	13	**84.62**
	Barren	0	**39**	4	0	4	47	**82.98**
	Agriculture	1	2	**31**	3	1	38	**81.58**
	Forest	0	0	3	**16**	0	19	**84.21**
	Urban	0	3	1	0	**29**	33	**87.88**
	Total	12	44	40	20	34	150	
	producer's accuracy	**91.67**	**88.64**	**77.50**	**80.00**	**85.29**		
Overall Accuracy		**%84**						
Kappa Coefficient		**%79.1**						

Table 3: Error matrix for image – 2023

		Reference data						
		Water	Barren	Agriculture	Forest	Urban	**Total**	User's Accuracy
Classified data	Water	**8**	0	0	1	1	10	**80.00**
	Barren	0	**44**	2	1	1	48	**91.67**
	Agriculture	1	3	**35**	2	2	43	**81.40**
	Forest	0	0	2	**19**	0	21	**90.48**
	Urban	0	1	2	0	**25**	28	**89.29**
	Total	9	48	41	23	29	150	
	producer's accuracy	**88.89**	**91.67**	**85.37**	**82.61**	**86.21**		
Overall Accuracy		**%87.33**						
Kappa Coefficient		**%83**						

The results of the error matrix showed that the overall accuracy results for classifying images reached (84%) in (2004) and (87.33%) in (2023). The results of the Kappa Coefficient also showed that the classification of the (2004) image avoided (79.1%) of the classification error, and the (2023) image avoided (83.00%) of the classification error. These results are considered good and acceptable, proving the effectiveness and success of the approach of using images to detect changes in land cover patterns with the time factor.

3. Demographics

The population data and main demographic characteristics in Irbid Governorate provide a basic database for the study, as this data constitutes an information base on the demographic characteristics of the population, upon which development planning and sustainability are based, as its structure is affected by any external changes or influences (Al-Saadi and Khawaldeh, 2016). Studying the development of population size and numbers in any region or geographical area is also an important pillar in directing development plans and programs for these regions and areas. The process of familiarity and knowledge of population numbers and characteristics is considered a supporting basis in various planning and development processes (Abu Ayaneh, 2014).

Table 3: Population of Irbid Governorate by gender 2004-2023

Year	Males	Females	Total
2004	523200	516200	**1039400**
2010	624900	619000	**1243900**
2015	917200	858000	**1775200**
2020	1035500	968300	**2003800**
2023	1103300	1032100	**2135400**

Table 4: Population development of Irbid Governorate during the period 2004-2023

The District	Population – 2004 /people	Population – 2015 /people	Population – 2023 /people	rate of change (%)
Qasabet Irbid	375594	739212	891740	137.42
Ar-Ramtha	109142	238502	287710	163.61
Al Kora	91050	161505	194830	113.98
Bani kinana	76398	131797	158990	108.11
Al-Ghwar Ashamalya	85203	122330	147570	73.20
Bani Obaid	93561	204313	246470	163.43
Al-Mazar A-shamali	44166	78427	94610	114.21
At -Taibeh	29132	51501	62130	113.27
Al - wastiyya	24046	42571	51350	113.55
Total	**928292**	**1770158**	**2135400**	**130.04**

(Source: Researcher's own work , based on data from the Department of Statistics)

The results of Tables No. (2) and (3) show that the governorate witnessed a positive development in population change rates, as the governorate recorded an increase in population from (928,292) people in (2004) to (1,770,158) people in (2015), rising in (2023) to (2,135,400) people, with a total population change rate of about (130.04%). Also, all districts in the governorate recorded a positive change rate in their population during the study period. We also note that the districts of Ar-Ramtha and Bani Obaid had the highest population change rate of (163%), which is mainly attributed, in addition to the high rates of natural increase, to the waves of Syrian refugees that the governorate witnessed in general and the districts of Ar-Ramtha and Bani Obaid in particular.

It was also shown that the central and eastern regions of the governorate, represented by the districts of (Qasabet Irbid, Bani Obaid, Ar-Ramtha), included the largest percentage of the absolute population, and had the largest number of residents and population concentration, as the population percentage in these three districts combined reached (62.3%) and (66.8%) of the total population of the

governorate for the years (2004-2023) respectively, while the districts of (Al Kora, Bani Kinana, Al-Ghwar Ashamalya) formed a lower concentration percentage in the absolute population numbers, as the total population in them constituted (27.22%) and (23.48%) of the total population of the governorate for the years (2004-2023) respectively, then the districts of (Al - wastiyya, At -Taibeh, and Al-Mazar A-shamali) with percentages of (9.74%) and (10.49%) of the total population of the governorate for the years (2004-2023) respectively.

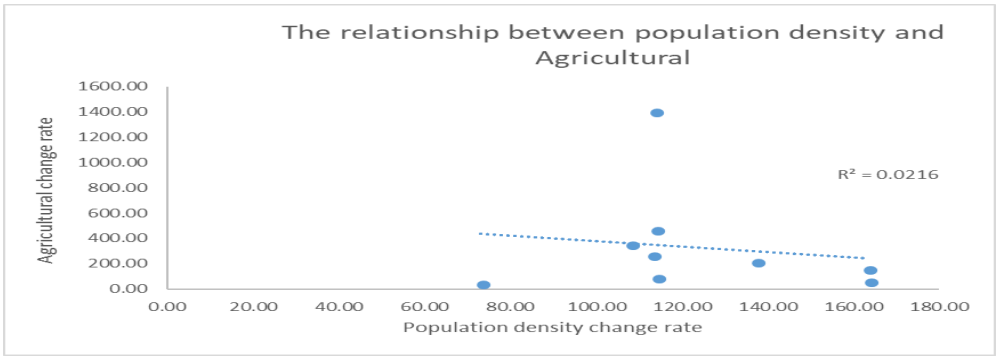
Table 5: Population density of Irbid Governorate during the period 2004-2023

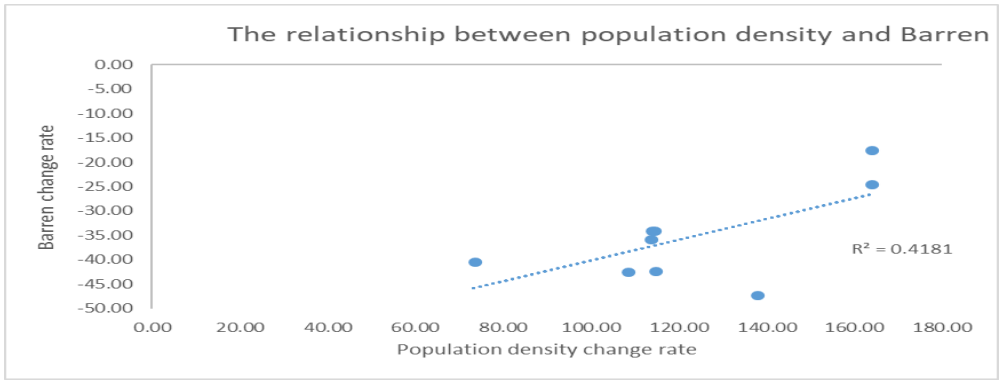
The District	Area-km^2	Population density – 2004	Population density – 2015	Population density – 2023	rate of change (%)
Qasabet Irbid	235.78	1592.98	3135.18	3782.08	137.42
Ar-Ramtha	274.47	397.65	868.95	1048.24	163.61
Al Kora	178.48	510.14	904.89	1091.61	113.98
Bani kinana	252.88	302.11	521.18	628.72	108.11
Al-Ghwar Ashamalya	246.35	345.86	496.57	599.03	73.20
Bani Obaid	188.4	496.61	1084.46	1308.23	163.43
Al-Mazar A-shamali	86.19	512.43	909.93	1097.69	114.21
At -Taibeh	63.47	458.99	811.42	978.89	113.27
Al - wastiyya	45.78	525.25	929.90	1121.67	113.55
Total	**1571.8**	**590.59**	**1126.20**	**2135.400**	**130.04**

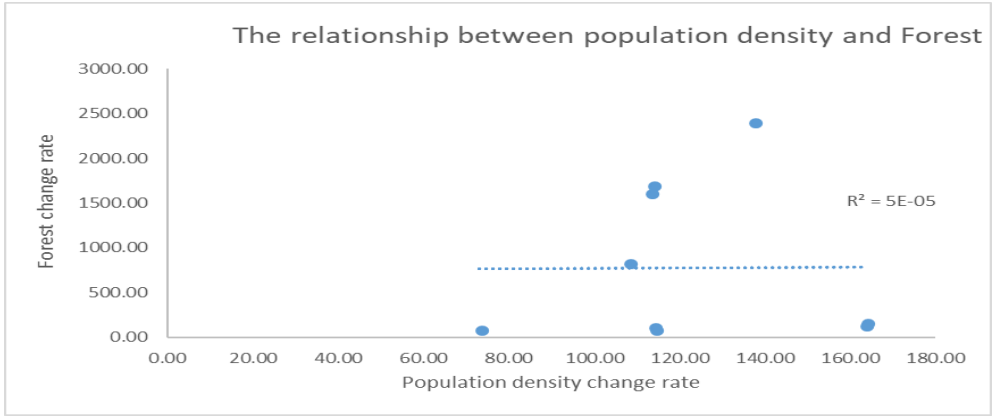
(Source: Researcher's own work , based on data from the Department of Statistics)

4. The relationship between population growth and land use

Population characteristics affect the modification of the type of land use, as there is a group of factors associated with the increase in population that affect the supply and demand for land and its use in a particular area. Therefore, it seems logical to discuss population changes and their impact on changing the pattern of land use. Accordingly, population density is considered the best measure for understanding the variation in population distribution and verifying population pressure, through population density, which is considered a reflection of population growth and the role of humans in pressuring land and its various uses (Kroll & Hasse, 2010). Therefore, population density was taken as a driving force through which the different land change trends are determined, where the variable size of population density was considered an independent variable (x) and the variable size of different land use categories were considered dependent variables (y1,y2……..yn,) by establishing links to reach the regression line and the correlation coefficient (r) for each category, and determining the strength and direction of the relationship between them.







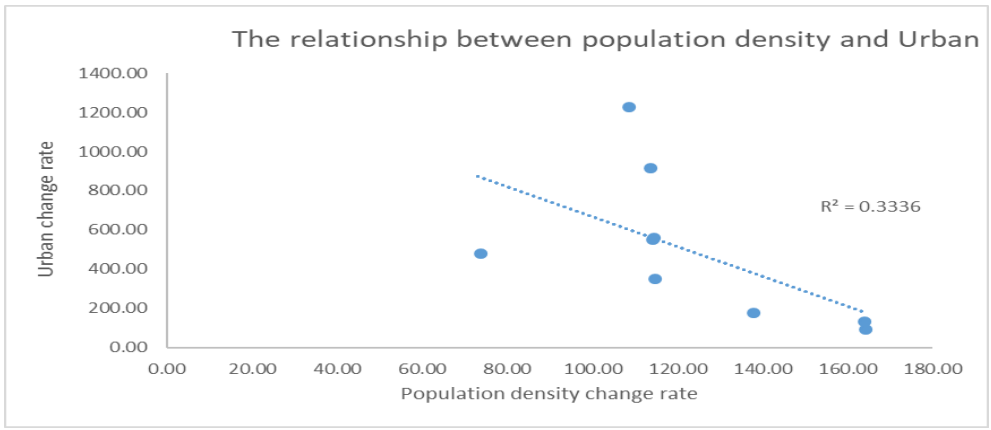


Figure 5: The correlation between the change in population density and the change in land use

We note from the above figures that the size of the change in agricultural areas is positively related to the size of the change in population density, as there is a positive correlation coefficient between the changing size of population density and the change in the size of agricultural lands and areas (r = 0.15). On the other hand, there is a clear decrease in the area of barren lands and open areas, as the size of this decrease was largely linked to the increasing demand for agricultural and urban lands in various parts of the governorate, and the results of the correlation coefficient showed a strong negative correlation coefficient between these two factors, and the correlation coefficient ratio reached (r = - 0.65).

While the percentages of urban areas increased with the increase in population density and in all districts of the governorate, It is noticed that the size of the change in urban areas is positively correlated with the size of the change in population density, and this indicates the existence of a direct relationship between the size of the change in population density and the changes in urban areas in the study area, and the correlation coefficient reached (r = 0.58). The relationship between the change in the area of forested areas and woodlands, and the rates of increase in the size of population density in the governorate's districts, was characterized by a weak direct relationship, as we notice that the size of the change in forested areas and woodlands is also positively correlated with the size of the change in population density, and the correlation coefficient reached (r = 0.01).

The present analysis provides a comparison of population change and land use dynamics in the study area. The results reveal significant changes in land use categories over the study period. The main changes include losses in open land and barren areas in favor of other categories, especially urban and agricultural use, while expansions in the area of agricultural and urban areas are in direct proportion to the increase in population numbers and growth, as we notice an increase in urban and agricultural areas in parallel with the increase in population density in the region, while population density was inversely related to changes in the area of barren land and open areas.

The direct relationship between the increase in growth and population density on one hand and the increase in agricultural and urban areas on the other hand can be justified by the development and increase in population numbers and the accompanying increase in economic activities, especially after the Syrian crisis and the waves of Syrian asylum starting in 2011. In addition to the natural increase witnessed by the region, and the accompanying increase in economic and urban activities, and the expansion of agricultural activity for which the region is famous, especially irrigated crops of vegetables and fruit trees, and the clear spread of artesian wells, especially in the eastern and southeastern regions of the governorate (Ministry of Agriculture, 2022).

Accordingly, it is clear that population growth and its developments were one of the most important driving forces for the increase in agricultural land and the expansion of urban areas, and the accompanying decrease in the areas of barren lands and open areas during the study period extending from (2004-2023). It also became clear that the strict laws enacted to protect forest areas, including the Agriculture Law, the creation of forestry departments in all agricultural directorates, the establishment of the Royal Administration for Environmental Protection in the Public Security Directorate. In addition to the efforts of the Ministry of Agriculture in planting and distributing millions of forest and fruit trees free of charge to be planted throughout the Jordanian geography, the role assigned to the Ministry of Agriculture in afforestation of lands that can be afforestation, and the Ministry's efforts to reduce the risks of fires that annually devour a precious part of the most beautiful area in the Kingdom, which is the forests of Pine, Cypress, Oak, Aleppo Pine and Maple. All these efforts and others have borne fruit in preserving these areas and increasing their area, especially in the southern parts of the governorate.

RESULT

The results of the study showed an increase in the population in all the districts of the study area. The districts of Ar-Ramtha and Bani Obeid had the highest population change rate of (163%). This is mainly attributed, in addition to the high rates of natural increase, to the waves of Syrian refugees that the governorate witnessed in general and the districts of Ar-Ramtha and Bani Obeid in particular. The wastiyya district ranked last in terms of the total population size according to the 2015 census and estimates for the year (2023), at a rate of (2.4%) of the total population of Irbid Governorate. In addition to the doubling of the population size in the study area by almost two and a half times during the period (2004-2023), where the total increase amounted to (1,207,108) people during (19) years.

The results of the study confirmed the decline of barren lands, which was offset by an increase in urban and agricultural areas during the study period, which indicates the role of population growth and population density in the increase in human activities, especially in the field of irrigated agriculture and urban growth. The study concluded that the use of groundwater plays a major role in irrigated agriculture and its development in the study area. Moreover, the results demonstrated the ability and effectiveness of the methodology of using remote sensing programs and geographic information systems applications in detecting changes and highlighting the development of land cover patterns and land uses with the time factor**.**

RECOMMENDATIONS

Preparations a database for the population characteristics and land cover patterns and land uses distribution at the Kingdom level, by employing remote sensing techniques and geographic information systems. It is necessary to take into account the population growth rates in Irbid Governorate and the factors affecting it, and to take them into account by planners and decision-makers when setting population policies. The study also recommended the use of satellite images with high spatial discrimination capabilities, in order to obtain higher accuracy in the classification process. Furthermore, developing a comprehensive development plan to develop and exploit barren lands and open areas, which constitute the largest part of the study area.

The study recommends increasing community awareness and education about the economic and environmental role of forests land, and generalizing the pioneering experience in combining legal, legislative and executive efforts followed in the management and maintenance of forests and woodlands in similar sectors, due to its proven success and effectiveness. The study also recommends establishing special units for geographic information systems and remote sensing in the municipalities of Irbid Governorate Districts to benefit from their applications in organization and planning work.

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