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Geospatial Analysis of Land Fragmentation and Its Impacts on Land Use of District Peshawar, Pakistan

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The study analyzes how land fragmentation affects the use of the land in sample villages of Peshawar district. Globally, land is a primary source of productivity, yet the population is expanding at an alarming rate. This population growth has an effect on how land is acquired and used, which frequently results in the problem of land fragmentation. To meet the study's goals, data were gathered from both primary and secondary sources including an intensive field survey using a questionnaire as well as land revenue department and population census organization. Out of a total of 279 villages two sample villages, namely village Ghalji Kander Khel and village Mathra were selected by random means for detailed and intensive study. During 1990-91 to 2020-21, fragmented land in sample villages increased. In village Ghalji Kander Khel fragmented land increased from 5.6% in 1990-91 to 23.9% in 2020-21 while in village Mathra fragmented land increased from 6.9% in 1990-91 to 27.1% in 2020-21 indicating an overall four-time increase during past two decades. The main cause of land fragmentation in sample villages is the Law of Inheritance, followed by population growth, market prices, financial difficulties, social issues, and government infrastructure. In sample villages, both area under cultivation and cultivable waste decreased out of which in village Ghalji Kander Khel cultivated land shrunk from 3478 kanal (1 kanal =506 m^2) to 2194.1kanals and cultivable waste reduced from 31.1 to 25.4 kanal from 1990-91 to 2020-21. In village Mathra, cultivated land contracted from 5473.2 kanal in 1990-91 to 3443.94 kanal in 2020-21, and cultivable waste diminished from 117.81 kanal to 32.4 kanal. The built-up area enlarged from 802.4 kanal to 1298.1 kanal in Ghalji Kander Khel and from 1392.3 kanal to 1991.6 kanal in Mathra. Finally, it was revealed that most of the area under cultivation is transformed into other land uses. The conversion of cultivable waste to cultivable land took place on a very small scale.

Keywords: Land Fragmentation, Land Use, Land Revenue, Cultivated Land

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Introduction:

Land fragmentation is a global problem that is commonly seen as an obstacle to agricultural production and advancement [1]. Land fragmentation has significant impacts on a country's economic growth, and leads to subsistence agriculture. Mechanization, which is connected to economic development and expansion, suffers greatly from land fragmentation. Land fragmentation is a problem in many nations, as one farm utilizes different pieces of land [2][3]. A situation known as "land fragmentation" occurs when a farming household owns several non-contiguous land portions that are frequently scattered across a wide area or when many geographically separate plots of land exist and are farmed separately, this is known as land fragmentation [4]. The concept of "land fragmentation" describes the existence of several parcels, each of which might be treated as separate entities and are all organized by the same landowner, in different regions [5].

Globally, the widespread fragmentation of agricultural land is typically attributed to a variety of factors, such as inheritance laws, historical examples, political systems, and consolidation processes, urban development policies, transaction costs in land markets, and individual assessments of land ownership [6]. Some researchers suggest land fragmentation is one of the main problems with rural land management, especially in rising nations [7].

Agriculture's productivity has a big impact on Pakistan's economy. Land is the essential element of agricultural productivity and is highly valuable in rural areas as it primarily serves as an indicator of the social, political, and economic situation there [8]. Land is an environmentally sustainable, long-lasting resource that is used as a source of earnings. Land also offers protection from dangers and shocks [9]. Although it is the largest resource in a growing nation like Pakistan, land is distributed in a severely uneven way [10]. Agriculture is a significant component of Pakistan's economy. However recently, its expansion has slowed down as a result of land fragmentation. Agriculture's output is limited therefore an attempt has been made to solve this, it examines how land fragmentation affects agriculture yield and profitability. Land use, which typically refers to the usage of land or the intent of a certain piece of land, signifies that these things are happening. Land use involves controlling and converting unbuilt spaces like settlements and semi-natural ecosystems into built spaces [11]. Land use refers to the purpose or aim behind a piece of real estate's usage. The land is an essential resource for growing the available space and accommodating different activities [12]. As a result, there is an increase in the chance of changing land uses. In almost every nation in the world, government organizations as well as people are directly responsible for controlling land usage and its transformation into any kind [13]. The majority of nations utilize scientists to study land use conversion and land use planning. As a result, the alterations are understood to be the results of relations among actors and variables. These changes and their effects are clear, and the situation is becoming worse. Land use changes and its related resources have grown steadily to be a serious issue that is currently attracting attention on a global scale and now sits at the core of environmental preservation and sustainability [14].

It is a finite natural resource that cannot be replaced and is essential to the maintenance and growth of people as well as the preservation of all the planet's primary ecosystems [15]. As a result, it is a form of prosperity that may be transferred from one age group to the following. People hold on tight to land because it is a limited, non-reproducible resource that may be passed down as wealth to future generations as a source of income and financial security [16]. A significant number of people, especially in South Asia, depend on land as their principal cause of earnings. The people and the land are deeply connected. Land has a significant role in setting up one's lifestyle, wealth, social position, and ambitions. However, there is a rapid decline in land ownership [17].

This paper intends to examine the dynamics of land fragmentation and its impact on land use analysis in Mouza Ghalji Kander Khel and Mouza Mathra. Land fragmentation is the result of the processes of land distribution in the sample mouza, which will be discussed in more detail hereafter. The paper is organized as follows. An analytical framework that will serve as the foundation for the analyses is developed in the Method and Material Section. The Results and Analysis Section presents and discusses the analysis's findings. Conclusions are given at the end of the paper.

Objectives:

The study will focus on the following objectives:

i. To find out the spatio-temporal dynamics of land fragmentation in the study area.
ii. To explore the causes and driving factors of land fragmentation.
iii. To analyze the impact of land fragmentation on land use of the selected villages.

Novelty Statement:

The title of the current study is a novel idea where land fragmentation is linked to land use. The paradigm shift of land use toward fragmented land is itself an innovative advancement in such research. The main purpose of this research is to find out the dynamics of land fragmentation and the factors causing land fragmentation. To find out the impact of land fragmentation on land use in the region, this research is uniquely designed.

Materials and Methods:

Investigation Site:

The District of Peshawar covers an area of approximately 1267 km^2 between latitudes 71°22' and 71°45' East and 33°44' and 34°15' North. In the Peshawar district, there are 7 Tehsil: Peshawar City Tehsil, Mathra Tehsil, Shah Alam Tehsil, Badbher Tehsil, Peshtakhara Tehsil, Chamkani Tehsil, and Hassan Khel Tehsil (FR-Peshawar). In winter, the mean minimum temperatures are 1.28 °C and the mean maximum temperatures recorded are 30.25 °C, whereas in summer, the mean maximum temperatures recorded are 47.45 °C and the mean minimum temperatures are 15.60 °C.

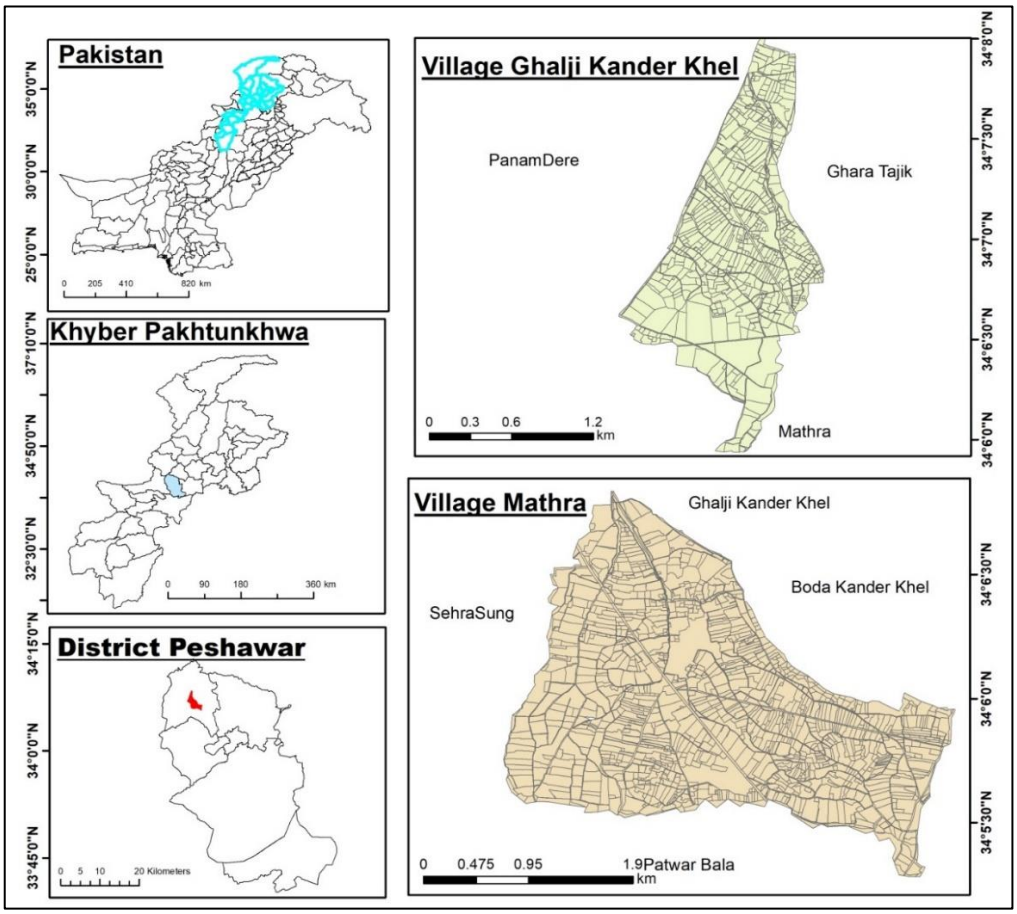

Figure 1. Map of Investigation site

The average yearly precipitation over the past 30 years was 400 mm, with winter months receiving more rain than summer months.

The study area is situated at 71° 27' to 71° 30' East longitude and 34° 7' to 34° 8' North latitude. It is bounded by Boda Kander Khel to the east, Ghara Tajik to the north, Sehra Sang to the west, Patwar Bala to the south, and Ghara Tajik to the west (Figure 1). In 1998, 4,781 people were living in Ghalji Kander Khel, which included 2,483 men and 2,298 women, while 6,528 people were living in Mathra, consisting of 3,389 men and 3,139 women. Ghalji Kander Khel had an overall population of 8,113 people and 993 households in 2017, while Mathra had a population of 12,402 people and 1634 households.

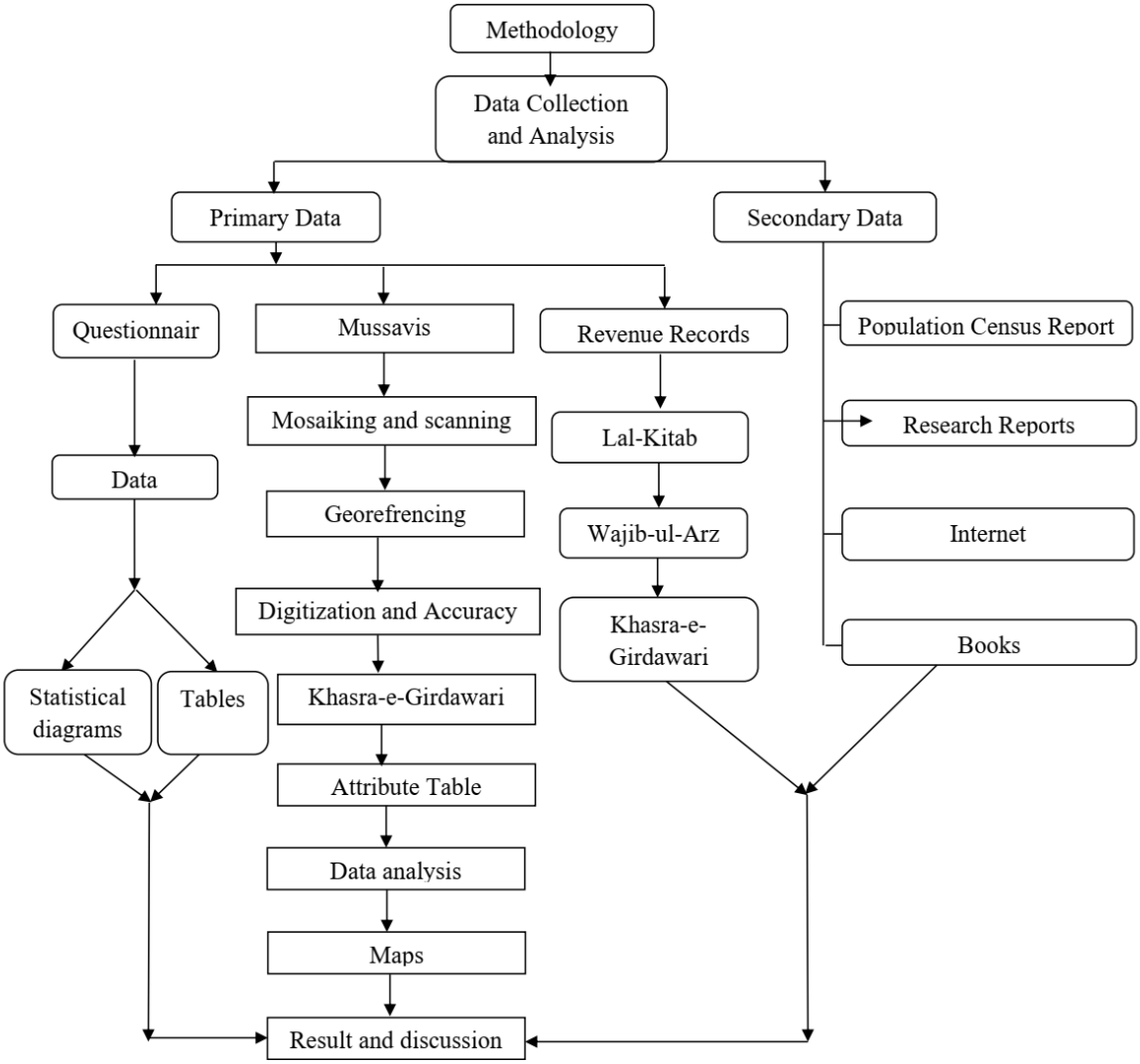

Figure 2. Research Methodology

Data Acquisition and Processing:

Data were obtained from primary and secondary sources to meet the study's objectives. The primary data was gathered through a series of questionnaire surveys. The District Revenue Office and revenue officers (Patwari) of the sample Village (with the lowest revenue estates) provided the data. Questionnaire data are then entered into SPSS software and analyzed so that statistical diagrams and tables are prepared. Mussavis of two Villages are collected from the board of revenue (BOR). A cadastral map is created by mosaicking the Mussavis in Arc GIS. All Khasra (plots) in the cadastral map are scanned, georeferenced, and digitized, and an attribute table is prepared. Topology is used to improve accuracy (Figure 2). Data collected from Lal Kitab (Area, corps, and revenue accounts for each year, Annual land

transfers, sales, mortgages, and assessments), Wajib ul Arz(document of current practices relating to the estate's rights and responsibilities), and Khasra girdaware(Name of owner, name of cultivator, land/khasra number, area, kind of land, cultivated and non-cultivated area, source of irrigation, name of crop and conditions, revenue and rate of income, at least twice a year) are entered in the attribute table and analyzed. To illustrate the dynamics of land fragmentation and the nexus of land use analysis, spatiotemporal maps were created. After that, the tabular information collected from Patwari (revenue officials) was combined with digital cadastral maps. The internet, books, and research papers are consulted for information on literature reviews. Population census reports are used to compile demographic statistics. Finally, the results were interpreted.

Results and Discussion:

In this section, analysis has been performed with a main importance on land fragmentation and land use. The discussion is supported by statistical information that was gathered from both primary and secondary sources. Furthermore, the causes of land fragmentation and its impact on land use have been elaborated.

Figure 3. Land Fragmentations in Village Ghalji Kander Khel (a) 1990-91, (b) 2020-21

Land Fragmentation in Village Ghalji Kander Khel:

Analysis results showed that in Village Ghalji Kander Khel land fragmentation increased from 1990-91 to 2020-21. It was found from the analysis that in 1990-91, out of 819 plots, the number of fragmented plots is 38 spreading 260.5 kanal* (5.6%) represented in the color pink whereas the rest are non-fragmented plots and are represented in blue. In 2020-21 out of 819 plots, 156 plots were fragmented covering an area of 1093.1kanal or 23.9% which shows an increase in land fragmentation (Figure 3).

According to revenue records, in Ghalji kander khel during 1990-91, out of 819 plots, there were 38 fragmented plots which consistently increased to 156 plots in 2020-21. The field survey also confirmed that land fragmentation increased in 2020-21 and this increase is mainly because of the law of inheritance (Table 1; Figure 4).

Table 1. Land Fragmentation, Village Ghalji Kander Khel

Years	Fragmented Plots	Fragmented Area (kanal*)
1990-91	38	260.5
2020-21	156	1093.2
Change	118	832.2
Total plots	819	4571.5

Source: Revenue Record of Village Ghalji Kander Khel for the agriculture census 1990-91 and 2020-21 *1 kanal =506 m^2

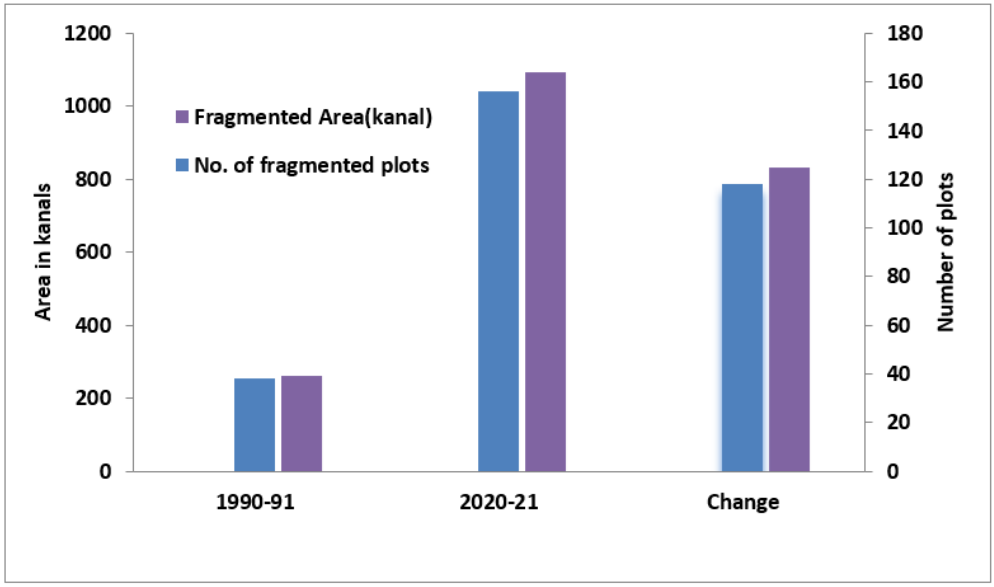

Figure 4. Village Ghalji Kander Khel, Land Fragmentation, 1990-91and 2020-21

Type of Land Fragmentation:

In the study area, there are two types of fragmentation namely cultivated fragmentation and cultivated/uncultivated fragmentation. In cultivated fragmentation, the land is divided into fragments that are used only for cultivation while in cultivated/uncultivated fragmentation the plot is divided into such fragments that one part of this land is used for cultivation while the other part is converted to uncultivated land.

The analysis reveals that in 1990-91 only 5% of land was cultivated fragmented land which increased to 72% in 2020-21. Fragmented cultivated/uncultivated land was 2% in 1990-91 which increased to 22% in 2020-21. From the field survey, it is revealed that 93% of the respondent replied that in 1990-91 their land was not fragmented while 94% replied that in 2020-21 their lands were fragmented (Figure 5).

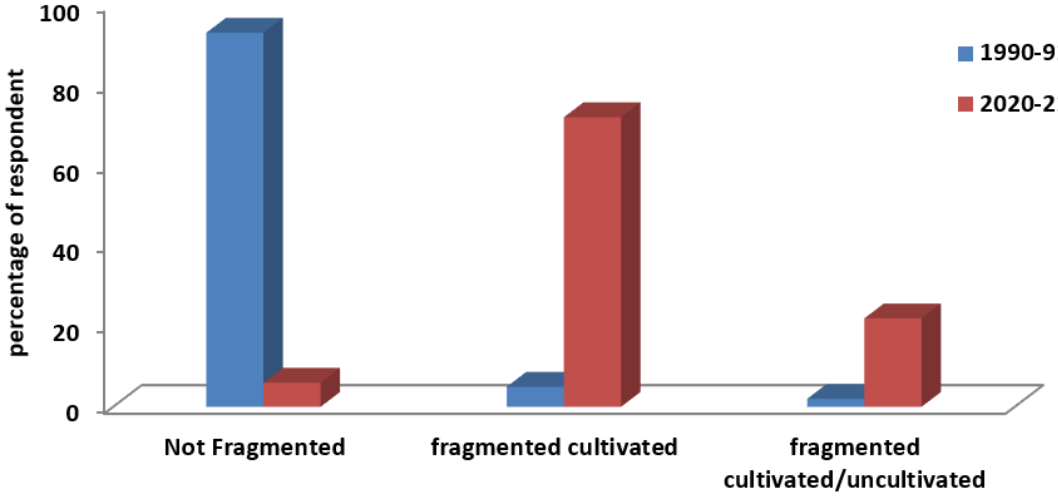

Figure 5. Village Ghalji Kander Khel, the response of owners about the type of land fragmentation

Land Fragmentation in Village Mathra:

The situation in the sample study village between 1990–1991 and 2020–2020 shows that land fragmentation is properly common within the Village Mathra. Out of 1607 total plots, only 105 were fragmented in 1990–1991; these plots covered an area of 518.1 kanal (6.9%). Light pink represents plots with two fragments, dark pink represents plots with three fragments and Blue color represents plots that are not fragmented. Out of 1607 total plots, 394 were fragmented in 2020–2021, making up 2033.3 kanals (27.1% of the total area of the land), a rise of 21 percent in around 30 years (Figure 6).

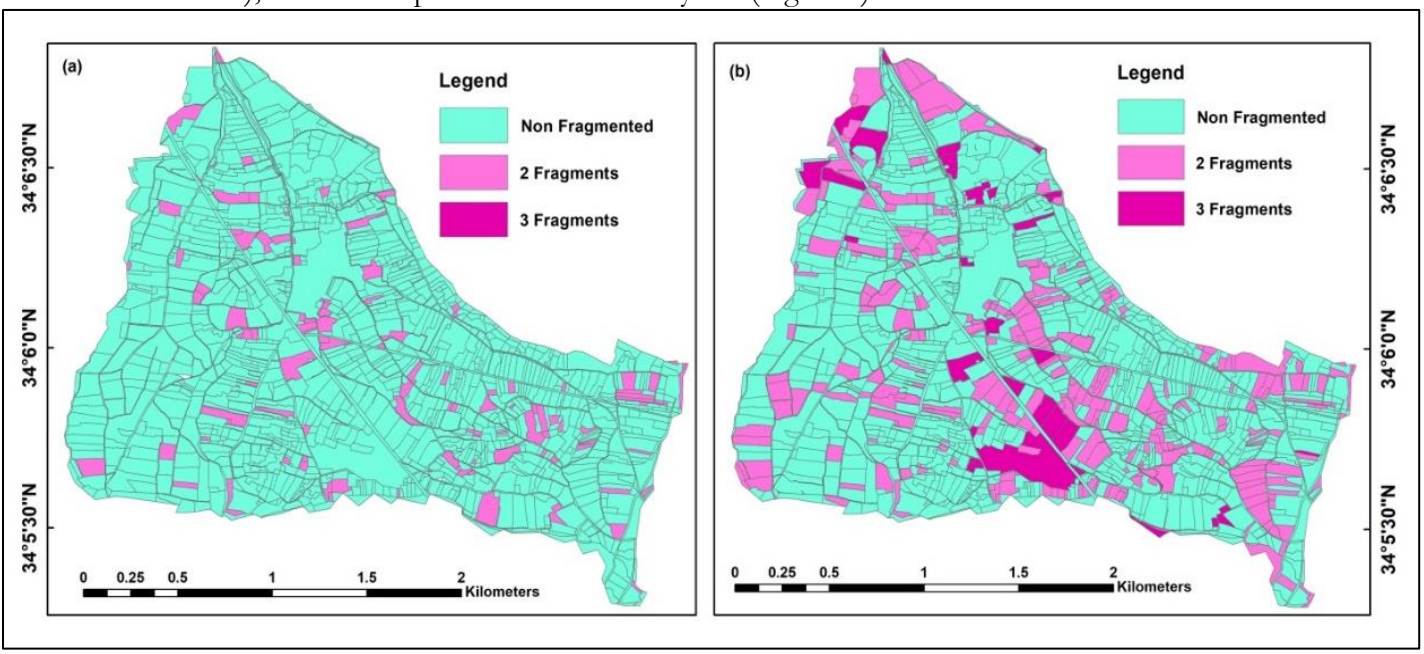

Figure 6. Village Mathra Land Fragmentation (a) 1990-91(b) 2020-21

The findings show the total area and plots from 1990–1991 to 2020–2021. Land fragmentation in 1990–1991 only affected 105 plots, or 5.9% of the total land, covering an area of 518.1 kanal. By 2020–2021, it had grown to 394 plots, or 27.1% of the entire land, covering an area of 2033.37kanal (Figure 7; Table 2).

Table 2. Village Mathra Land Fragmentation, 1990-91 and 2020-21

Years	Fragmented Area (kanal)	fragmented plots	percentage

1990-91	518.1	105	6.9
2020-21	2033.3	394	27.1
Total plots	7501.2	1607	100

Source: Revenue Record of Village Mathra.

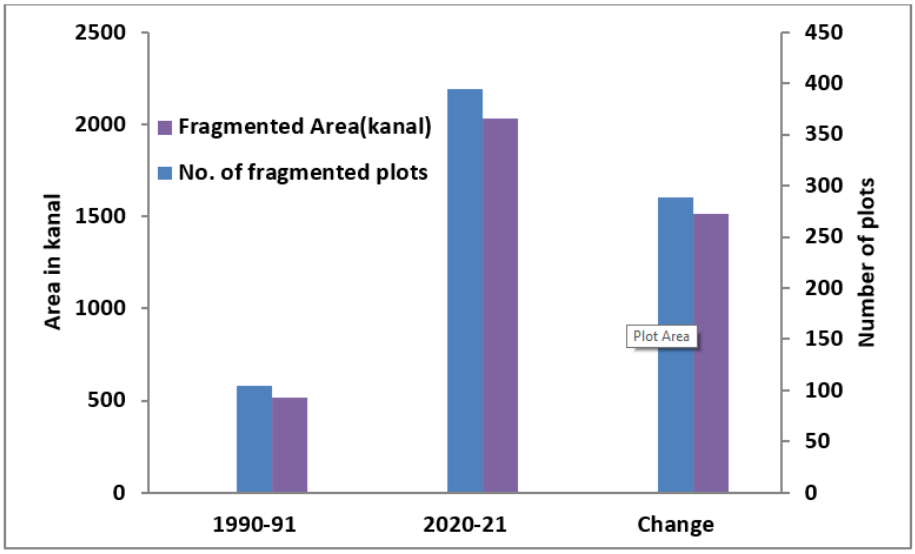

Figure 7. Village Mathra, Land Fragmentation in 1990-91and 2020-21

Type of Land Fragmentation:

The analysis reveals the type of land fragmentation in 1990-91 and 2020-21. In 1990-91 only 5% was cultivated fragmented land which increased to 24% in 2020-21. Fragmented cultivated/uncultivated land was 6% in 1990-91 which increased to 72% in 2020-21. It is analyzed from the field survey that 89% of the respondent replied that in 1990-91 their land was not fragmented while 96% replied that in 2020-21 their lands were fragmented(Figure 8)

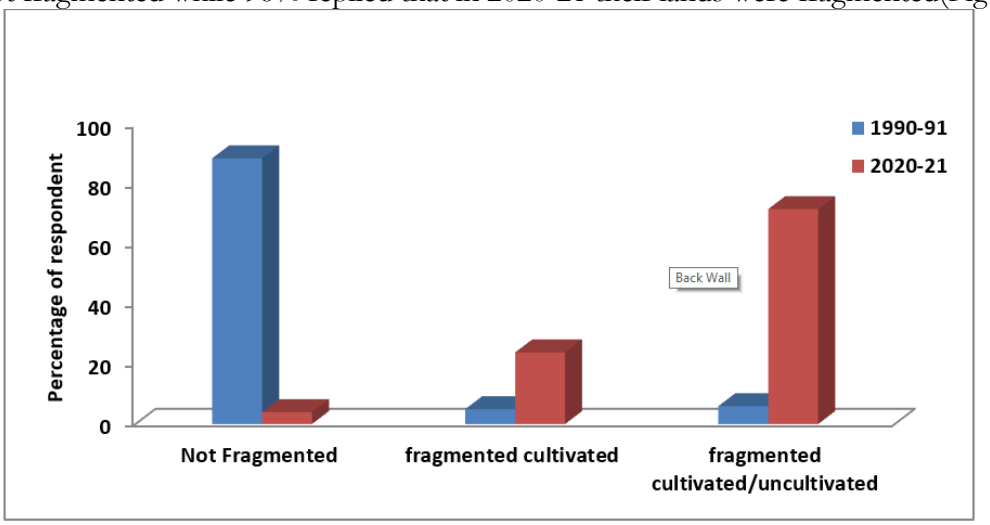

Figure 8. Village Mathra Type of Land Fragmentation, 1990-91and 2020-21

Causes of Land Fragmentation:

There are several reasons for land fragmentation, and they differ among countries [12]. However, the majority of scholars agreed that there are four key causes of agricultural fragmentation. The most well-known of these is known as the law of inheritance. According to inheritance law, the land must be divided among the possible heirs by specified legal proportions. Every sort of land is divided up and distributed among heirs because each piece of land has a different potential. Fragmentation is reduced when the farm's fertility remains

constant. Another element that increases competition for land is population expansion. The land market is yet another factor that is considered to increase land fragmentation.

The field survey's findings indicate that the inheritance law is the primary cause of land fragmentation in the study area, followed by population growth, market values, economic woes, social issues, and government infrastructure (Figure 9).

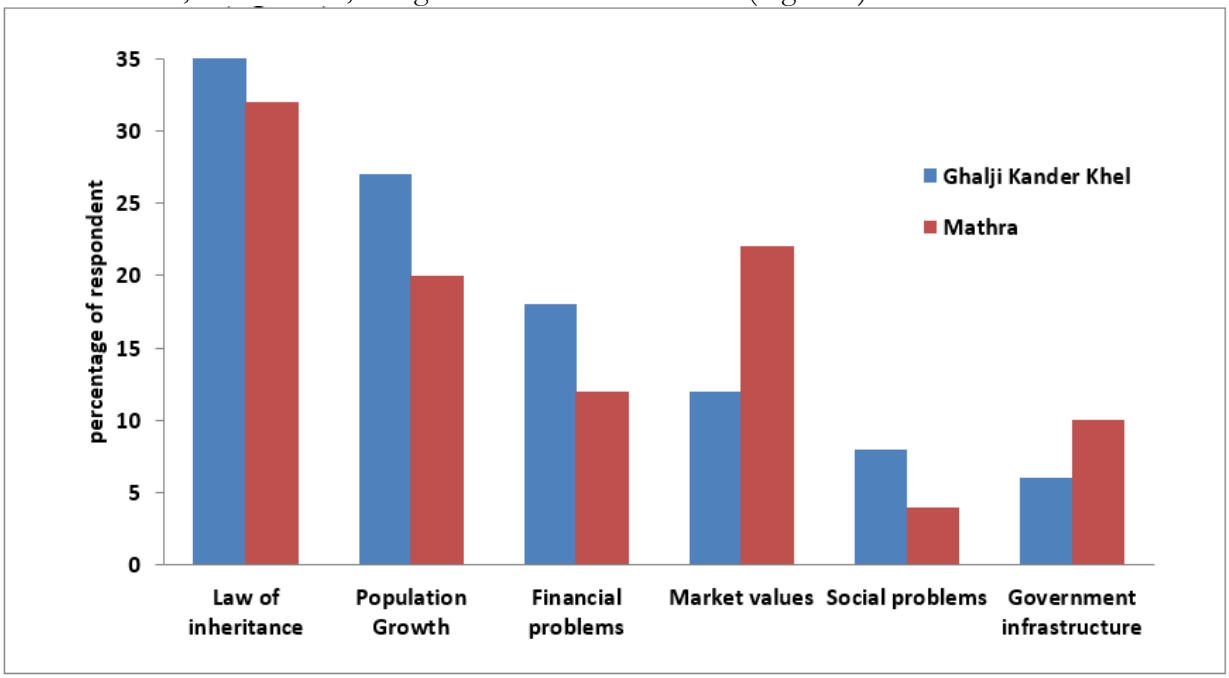

Figure 9. Causes of Land Fragmentation in selected Villages

Land Fragmentation Impact on Land Use:

The impacts of land fragmentation are examined in literature from several scientific disciplines, including agriculture, sociology, anthropology, geography, economics, and agricultural policy [18]. The basic idea is that fragmentation, which is fundamentally split in nature, has an influence on economies of scale and leads to conflicts. It is therefore thought to restrict agricultural development and production effectiveness [19][20]. Critics of land fragmentation, especially economists, authorities in charge of agricultural policy, and geographers, believe that small, asymmetrical plots limit the efficiency of agricultural output. As the distance between plots and farming grows, the cost of transportation, monitoring, and travel time rises.

Additionally, regular and irregular borders, as well as plot patchworks, result in a loss or waste of effective land area. These limits also increase the risk of neighbor disputes and conflicts, obstruct the mechanization of agriculture, and stop the development of drainage and irrigation systems. The cultivation of more significant crops, which typically need larger farms, is further restricted by tiny, dispersed farms, as is banks' willingness to provide farmers loans when they offer small pieces of land as security. This limits investment in agriculture's development, hence limiting economies of scale. Because of the expenses, which reduce farm productivity and farmer income, the economic advantages of increased agricultural productivity and decreased agricultural fragmentation are equal [21][22]. Another risk is that some areas farther from the source may not even farmed [23]. Green space shrinks as a result of land fragmentation. Trees have been cut down as human habitation has expanded. The environment becomes out of balance as a result of weather-related events such as earthquakes, floods, and storms. The effects are thought to be a large reduction in trees and an acceleration of soil erosion as a result of increased settlement and nuclear families [24].

Village Ghalji Kander Khel Land Use Pattern, 1990-91 to 2020-21:

According to authorized revenue data, Ghalji Kander Khel has a total area cover of 4571.5 kanal. From 1990-91 to 2020-21, cultivated land (net sown and current fallow land) decreased from 3477.5 kanal (76%) to 2184.1 kanal (48%) shown in a light green color. Uncultivated land was approximately 802.40 kanal (17.5%) in 1990–1991 (shown in pink), and it climbed to 1298.1 kanal (28.4%) in 2020–2021 (shown in green). Uncultivated land includes the area under roads, graveyards, built environments, water bodies, and other similar uses. Fragmented cultivated/uncultivated covered an area of 86.5 kanal (1.9%) in 1990–1991 (shown in light sea green color), which extends over an area of 603.1kanal (13.2%) in 2020–21. The fragmented cultivated area was 175 kanal (3.9%) in 1990–1991 and expanded to 451.1 kanal (9.9%) in 2022–2021. Cultivable waste (due to factors such as being common land) was around 31.5 kanal (0.7%) in 1990–1991 (shown in yucca yellow), but it was put to other uses and dropped to 25.4 kanal (0.5%) in 2020–2021 (Figure 10).

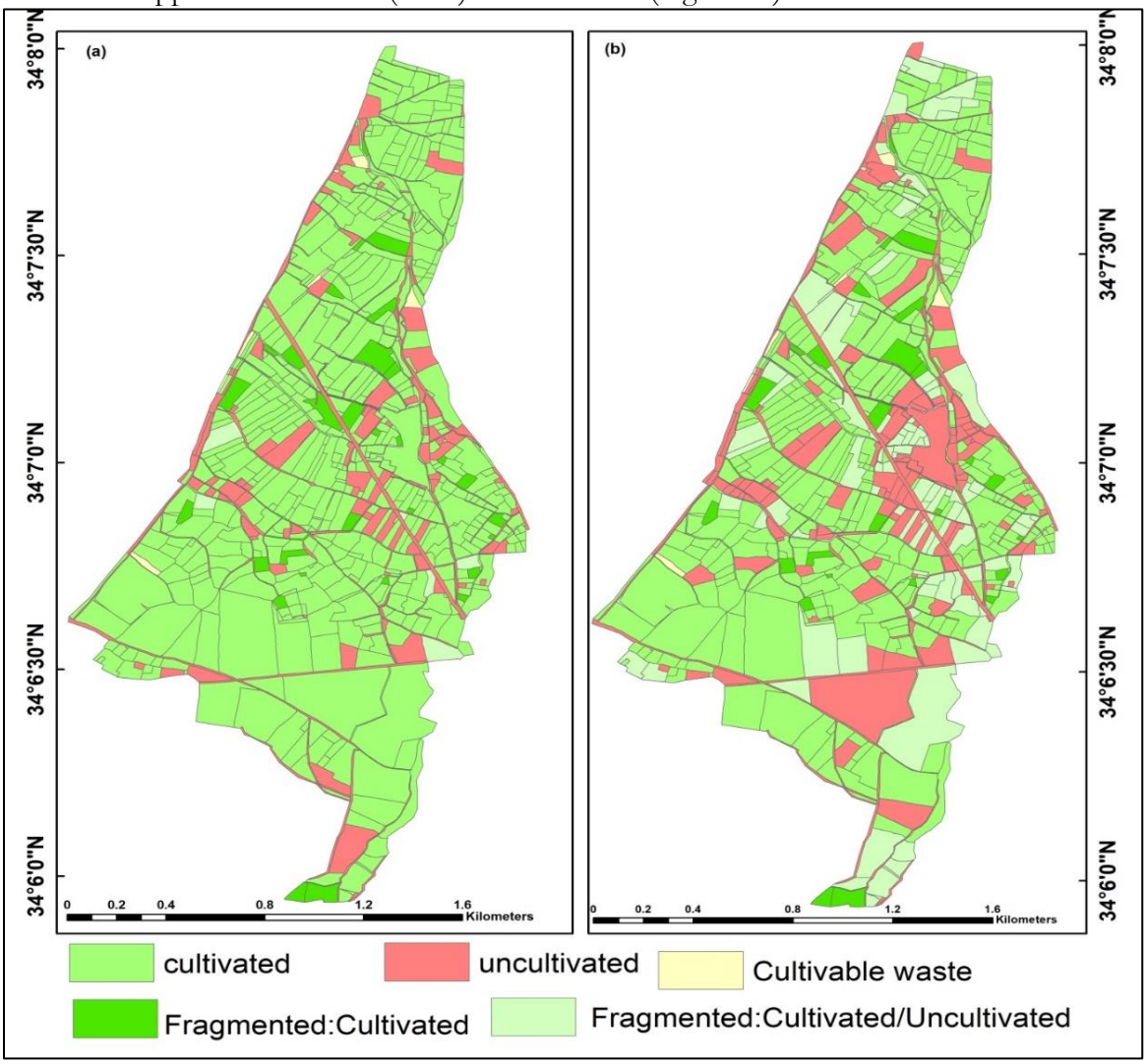

Figure 10. Village Ghalji Kander Khel, Land Use Analysis (a) 1990-91(b) 2020-21

The analysis shows that cultivable wasteland in Village Ghalji Kander Khel in 1990–1991 was around 31.5 kanal (0.7%) of the total land, which fell to 25.4 kanal (0.5%) in 2020-21. A decrease in the amount of cultivated land from 3477.5 kanal (76%) in 1990–1991 to 2194.1 kanal (48%) in 2020-21 will result in increased food security in the next years. On the other hand, uncultivated land expanded, rising from 802.4 kanal (17.5%) in 1990–1991 to 1298 kanal (28%) in 2020–21. The amount of fragmented cultivated land grew from 175.1

kanal (3.9%) in 1990–1991 to 451 kanal (9.9%) in 2020–21. Between 1990–1991 and 2020–2021, the amount of fragmented cultivated and uncultivated land proceeded from 86.5 kanal (1.9%) to 603.1 kanal (13.2%). According to the findings, both cultivated land and cultivable waste declined. From 1990–1991 to 2020–2021, there was an increase in uncultivated land, fragmented cultivated land, and fragmented cultivated/uncultivated land (Figure 11; Table 3).

Table 3. Village Ghalji Kander Khel, Temporal Analysis of Land Use

Years	1990-1991		2020-2021	
	Area (kanal)	Percentage	Area (kanal)	Percentage
Cultivated land	3477.5	76	2194.1	48
Uncultivated area	802.4	17.5	1298	28.4
Cultivable waste	31.5	0.7	25.4	0.5
Fragmented: cultivated/uncultivated	86.5	1.9	603.1	13.2
Fragmented: cultivated land	175.1	3.9	451	9.9
Total	4571.5	100	-	-

Source: Extracted from Revenue Record of Village Ghalji Kander Khel

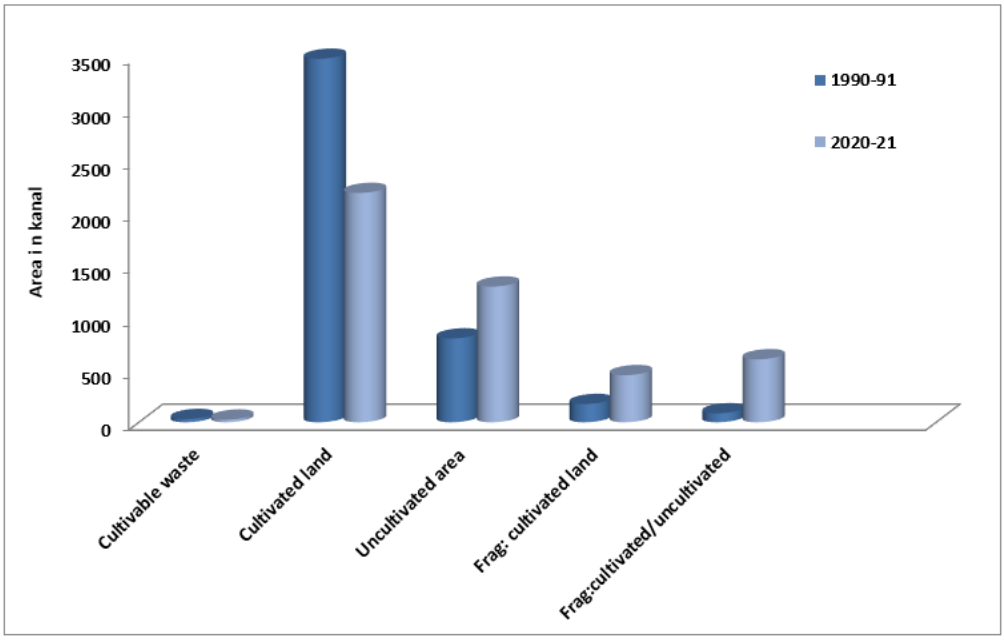

Figure 11. Village Ghalji Kander Khel, Temporal Analysis of Land Use

Village Ghalji Kander Khel Land Use Conversion, 1990-91 to 2020-21:

From the field survey, it is analyzed that 7% of respondents said there had been a change from cultivable waste to cultivated land; 18% said there had been a change from cultivated to uncultivated; 51% said there had been a change from cultivated to fragmented cultivated; and 24% said there had been a change from cultivated to fragmented cultivated/uncultivated. According to the data, most cultivated land is transferred to other land uses. Less cultivable wasteland is turned into cultivation (Table 4; Figure 12).

Table 4. Village Ghalji Kander Khel Land Use change

Land use Change,1990-91 to 2020-21	Percentage
Cultivated to Fragmented Cultivated	51
Cultivated to Fragmented Cultivated/Uncultivated	24
Cultivable Waste to Cultivated Land	7
Cultivated to Uncultivated	18
Total	100

Source: Field Survey, October.2022

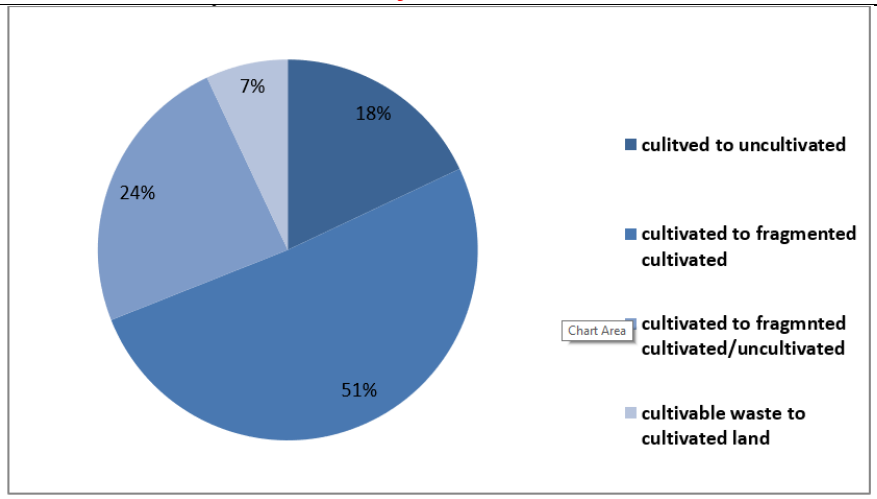

Figure 12. Village Ghalji Kander Khel, Land Use change, 1990-91 to 2020-21

Village Mathra Land Use Pattern, 1990-91 to 2020-21:

According to authorized revenue data, the total area covered is 7501.2 kanal, of which 5473.2 kanal (73%) was cultivated (net sown and current fallow land) in 1990–1991; the proportion dropped to 3444.4 kanal (45.97%) in 2020–21. Due to circumstances such it being common land, the amount of cultivable waste is approximately 118.1 kanal (1.6%) in 1990–1991 (depicted in yucca yellow), which is put to other purposes and decreases to 32.4 kanal (0.43%) in 2020–2021. The uncultivated land, which is shown in pink color, increased from 1392.3 kanal (18.6%) in 1990–1991 to 1992.5 kanal (26.5%) in 2020–2021. Fragmented cultivated area grew to 203.1 kanal (2.7%) in 2020–21 from 140.1 kanal (1.8%) in 1990–91, which can be seen in dark green. Fragmented cultivated/uncultivated area in 1990–1991 was 378.1 kanal (5.1%) indicated in light sea green, but it rose to 1830.4 kanal (24.4%) in 2020–2021 (Figure 13).

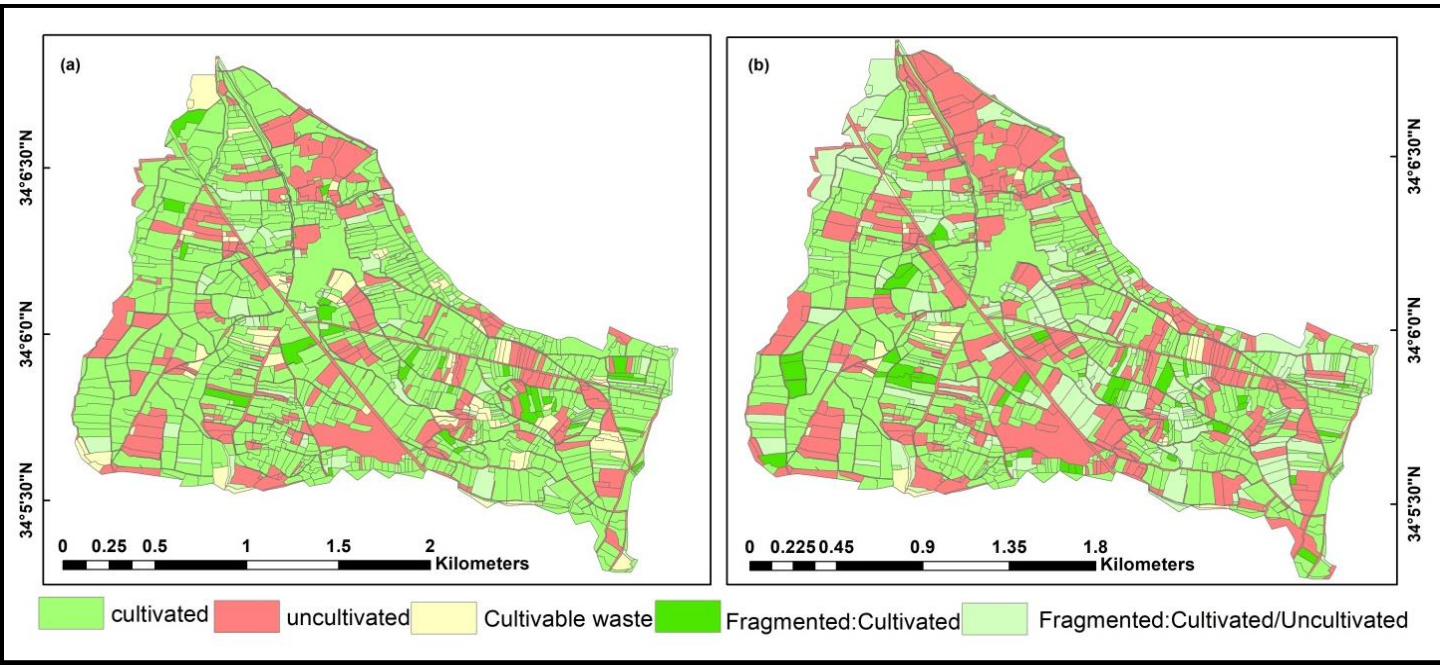

Figure 13. Temporal Analysis of Land Use in Village Mathra (a) 1990-91(b) 2020-21

It is revealed from the analysis that land use in Village Mathra was as; the proportion of fragmented cultivated and uncultivated land grew from 378.1 kanal (5.1%) in 1990–1991

to 1830.4 kanal (24.4%) in 2020–21. Fragmented cultivated land also grew from 140.1 kanal (1.8%) in 1990–1991 to 203.1 kanal (2.7%) in 2020–2021. Uncultivated land increased from 1392.3kanal (18.6%) in 1990-91 to 1992.5 kanal (26.5%) in 2020-21. The proportion of land that was cultivated declined from 5473.1 kanal (73%) in 1990–1991 to 3444.4 kanal (45.97%) in 2020–21. Cultivable waste land reduced from 118.1 kanal (1.6%) of the total area to 32.4 kanal (0.43 According to the study, both cultivated land and cultivable waste declined. From 1990–1991 to 2020–2021, there was an increase in uncultivated land, fragmented cultivated land, and fragmented cultivated/uncultivated land (Figure 14; Table 5).

Table 5. Village Mathra Temporal Analysis of Land Use

Years	1990-1991		2020-2021	
	Area (kanal)	Percentage	Area (kanal)	Percentage
Fragmented: cultivated/uncultivated	378.1	5.1	1830.4	24.4
Fragmented: cultivated land	140.1	1.8	203.1	2.7
Uncultivated area	1392.3	18. 6	1992.5	26.5
Cultivated land	5473.1	73	3444.4	45.97
Cultivable waste	118.1	1. 6	32.4	0.43
Total	7501.2	100	-	-

Source: Revenue Record of Village Mathra for the agriculture census 1990-91and 2020-21

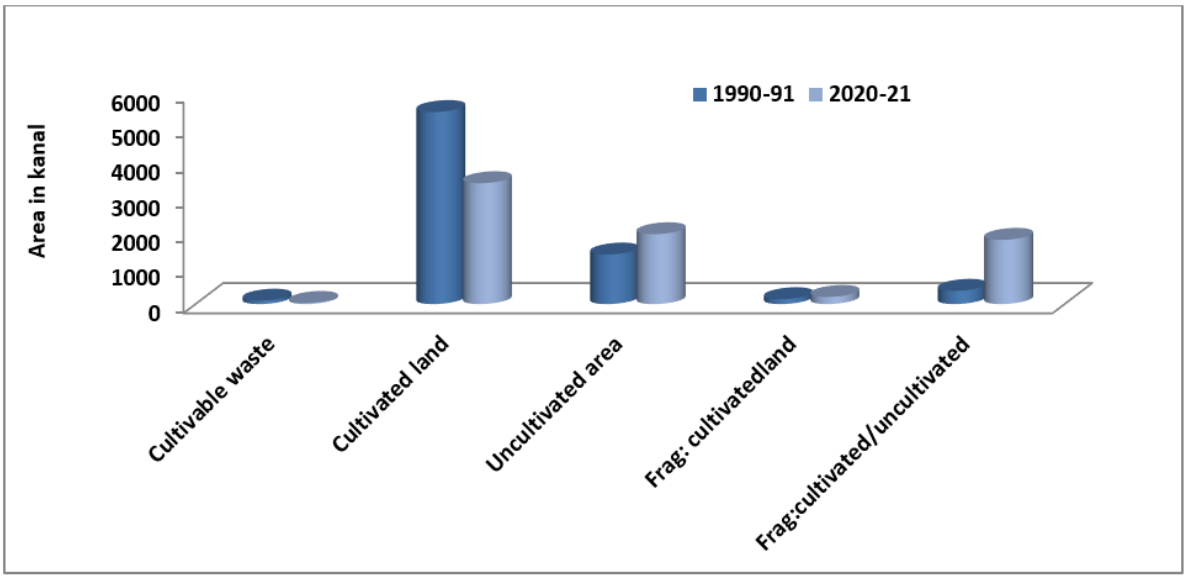

Figure 14. Village Mathra Temporal Analysis of Land Use

Village Mathra Land Use change, 1990-91 to 2020-21:

According to the research, the change in Village Mathra took place between 1990–1991 and 2020–21 and 49% of respondents responded change is from cultivated to fragmented cultivated/uncultivated, 24% of respondents responded change occurred from cultivated to fragmented cultivated, 6% of respondents, change occurred from cultivable waste to cultivated land and 21% of respondents responded change occurred from cultivated to uncultivated. The analysis shows that the majority of cultivated land is converted to other land uses. For example, more land is converted to uncultivated and fragmented cultivated/uncultivated, less land is converted to fragmented cultivated, and only a very small portion of land is converted from cultivable waste to cultivated land (Table 6; Figure 15).

Table 6. Village Mathra Land Use Change, 1990-91 to 2020-21

Land use Change	Percentage
Cultivated to Fragmented Cultivated/Uncultivated	49
Cultivated to Fragmented Cultivated	24

Cultivable Waste to Cultivated Land	6
Cultivated to Uncultivated	21
Total	100

Source: Field Survey, October ,2022

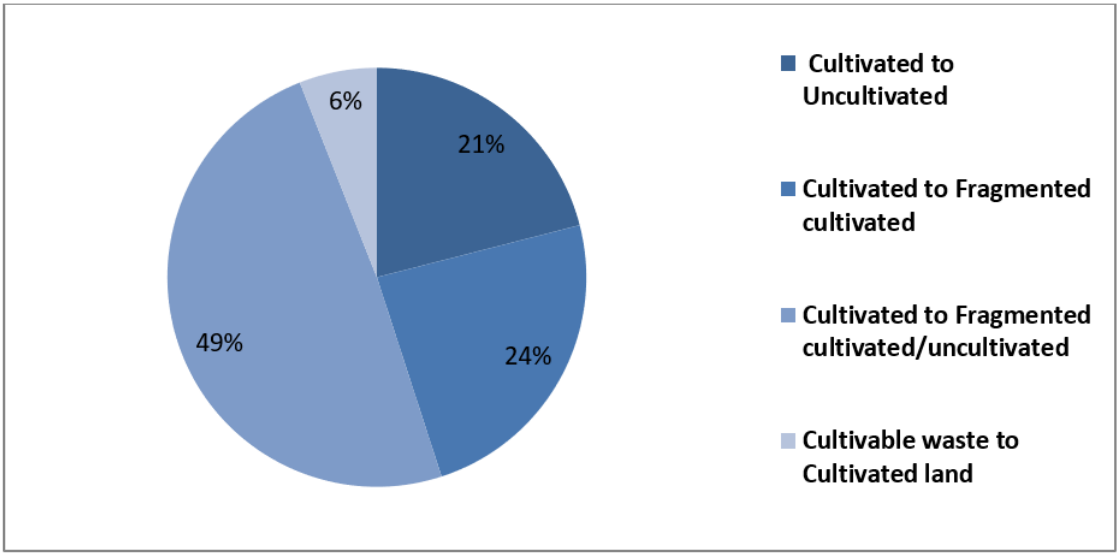

Figure 15. Land use Change 1990-91 to 2020-21 in Village Mathra

Village Ghalji Kander Khel and Village Mathra, Land Use Comparison 1990-91 and 2020-21:

It can be shown through a comparison of the two villages that overall cultivation has decreased in both. In Mathra, the cultivated area declined from 73% to 45.97%, while in Ghalji Kander Khel, it fell from 76% to 48%. The proportion of cultivable waste has dropped from 1.6% to 0.43% in Mathra and from 0.7% to 0.5% in Ghalji Kander Khel. The uncultivated land has grown in both villages from 18.6% to 26.5% in Mathra and from 17.5% to 28.4% in Ghalji Kander Khel. In both villages, the amount of fragmented land has increased; in Ghalji Kander Khel, the amount of fragmented cultivated land is greater (3.9% to 9.9%) than in Mathra (1.8% to 2.7%); meanwhile, the amount of fragmented cultivated/uncultivated land is greater in Mathra (5.1% to 24.2%) than in Ghalji Kander Khel (1.9% to 13.2%) (Figure 16).

According to the analysis, the change in cultivable waste, cultivated land, uncultivated land, fragmented cultivated land, and fragmented cultivated/uncultivated land is -0.2, -28, +10.9, +6, and +11.3 respectively in Ghalji Kander Khel, while in the village of Mathra, the conversion is -1.17, -27.03, +7.9, +0.9, and +19.3. According to the study, fragmented cultivation occurred mostly in the village of Ghalji Kander Khel, but in the village of Mathra, there was a greater proportion of fragmented cultivation/uncultivated land. Village Mathra is represented between 1990-1991 and 2020-21 on a bar graph, together with Village Ghalji Kander Khel (Figure 17, 18; Table 7).

Table 7. Comparative Analysis of Land Use in Sample Villages

Land use	Mathra(% of total area)			Ghalji Kander Khel(% of Total Area)		
	1990-91	2020-21	Change	1990-91	2020-21	Change
Fragmented: cultivated/uncultivated	5.1	24.4	19.3	1.9	13.2	11.3
Fragmented: cultivated	1.8	2.7	0.9	3.9	9.9	6
Uncultivated Area	18.6	26.5	7.9	17.5	28.4	10.9
Cultivable waste	1.6	0.43	-1.17	0.7	0.5	-0.2

Cultivated land	73	45.97	-27.03	76	48	-28
Total	100	-		100	-	

Source: Revenue Record

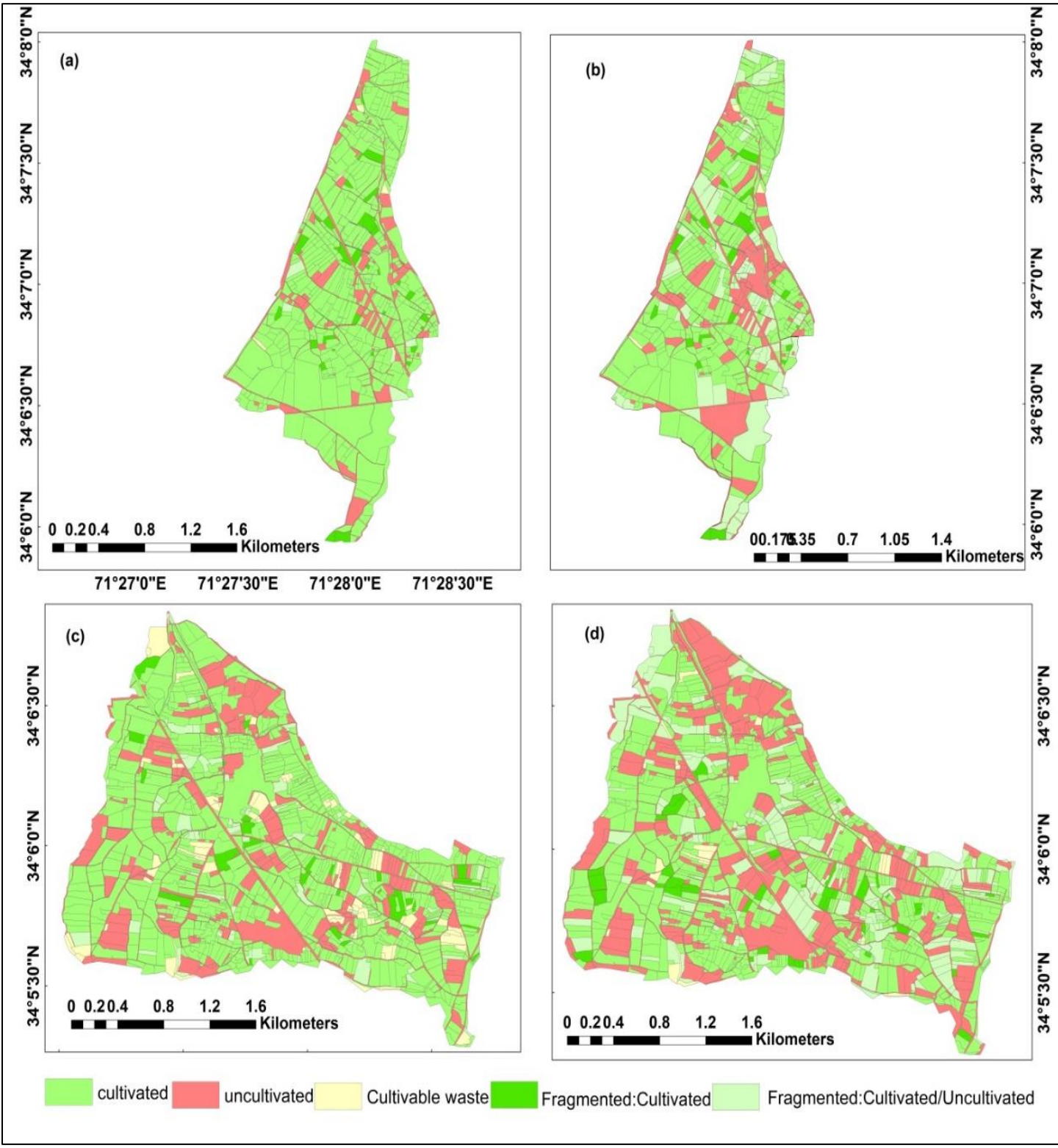

Figure 16. Land Use Analysis In Selected Villages,(a)Village Ghalji Kander Khel, 1990-91(b) Village Ghalji Kander Khel, 2020-21(c)Village Mathra, 1990-91(d)Village Mathra, 2020-21

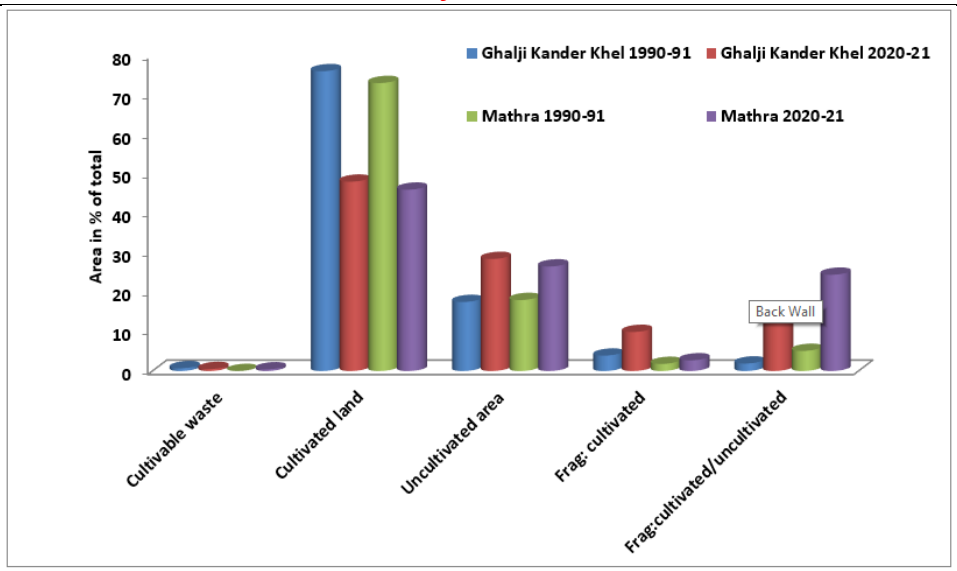

Figure 17. Land Use Analysis in selected Villages

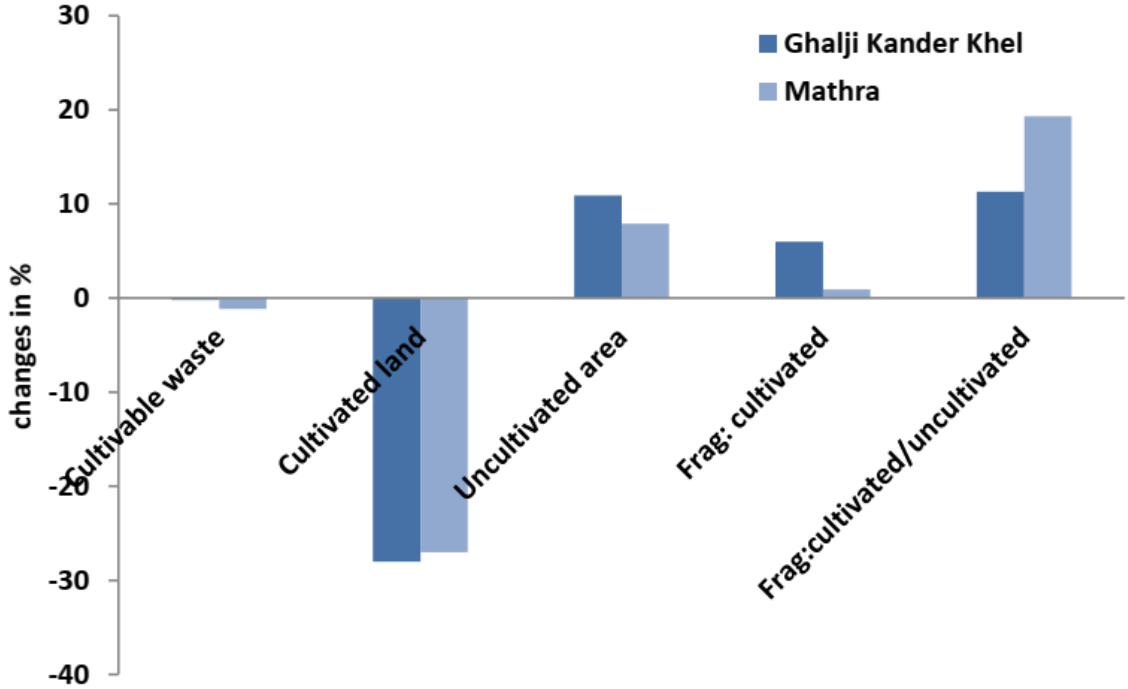

Figure 18. Land Use Analysis in selected Villages, 1990-91 and 2020-21

Conclusion:

The case study of land fragmentation in the village of Mathra and Ghalji Kander Khel indicates that between 1990-1991 and 2020 -21 there was an increase in land fragmentation in both villages. In the research region, there is either fragmented cultivated land or fragmented cultivated/uncultivated land. There is fragmented cultivated land in the village Ghalji Kander Khel and fragmented cultivated/uncultivated land in the village Mathra. This is due to the fast development of Mathra commercial sectors that the land is fragmented into cultivated and uncultivated sections. The fragmentation process has historically been ongoing, and given the present operating environment, it is likely to continue absent appropriate actions to stop it.

The study found that the study area's land is fragmented due to several variables. The two main factors are population growth and inheritance. The number of owners grows along

with the population, and according to the inheritance law, the land is to be divided between the inheritors. Because every sort of land must be shared among the heirs, each one only obtains a very little plot, which is likewise spread. Besides this, market values, financial problems, social problems, and government infrastructure were some other factors for rapid land fragmentation. The government should pay proper attention to land fragmentation reduction measurement.

Analysis also showed that in 1990–1991 agricultural land dominated in the selected villages. The built-up area started to grow with time. As the amount of cultivated land decreased, the built-up area of Ghalji Kander Khel and Mathra grew. The cultivable waste was reduced and used for other purposes. According to the report, the decline in cultivable land represents a serious threat to food security, while the uncultivated area has nearly doubled. According to the results of the field survey, the majority of respondents in Village Ghalji Kander Khel stated that their lands were cultivated in 1990–1991 yet their cultivated lands were decreasing and their uncultivated land was increasing by 2020–21.

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