Land Use Dynamics and Environmental Consequences in the Vicinity of Ramsar Wetland: A Case Study of Kanjli Wetland Over Three Decades

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Abstract
The Ramsar Convention on Wetlands envisages the significance of various wetland types, including playas, attributing magnitude to their ecological value, biodiversity, and role in ecosystem services. However, both natural influences such as shifts in seasonal rainfall cycles, and anthropogenic factors like urbanization are determinantal in the sustenance of the wetlands. This study focuses on Kanjli wetland, a Ramsar site influenced by a mélange of natural and human-driven forces affecting its hydrological dynamics. Situated in the agricultural plains of Punjab, India, this research endeavors to gauge the impacts of changing land use in the surroundings of Kanjli wetland. A mixed-method approach is employed, Landsat satellite images from 1990 and 2022 are initially classified to assess landscape transformations. Subsequently, primary data is collected and analyzed through fieldwork conducted in villages neighboring the wetland area. The statistically processed results indicate that approximately 85 percent of encroachment in the study area stems from infrastructural developments, exhibiting both positive and negative implications for the wetland ecosystem. The ensuing discussion underscores the imperative of conserving and sustainably managing the unique ecosystems of Ramsar wetlands in alignment with the core objectives of the Ramsar Convention.

Keywords: Developmental Activities, Encroachment, Kanjli Wetland, Land Use Change, Spatial Assessment

1. Introduction

Wetlands in the Plains region can be divided into several types, including prairie potholes, riparian wetlands, and playa wetlands. Wetlands in the form of lakes, rivers, marshes, swamps, peatlands, mangroves, and coral reefs provide an essential ecosystem service to the livelihood of people and play a remarkable role in the ecological sustainability of a region [1] and [2]. Wetlands are believed to have shrunk in recent decades [3]. As per the recent estimates, the global extent of the wetlands has declined between 64 and 71% during the twentieth century, and wetland degradation is still continuing throughout the world [4] and [5]. Prairie potholes are small, shallow depressions in the landscape that fill with water during wet periods and are important breeding habitats for waterfowl and other wetland-dependent species. Riparian wetlands are found along streams and rivers and provide important habitat and water filtration services. Playa wetlands are shallow, circular depressions in the landscape that fill with water during wet periods and are important for groundwater recharge and habitat for migratory birds [6][7] and [8]. The Wetlands and Water Synthesis report from the Millennium Ecosystem Assessment [9] provides an in-depth examination of the function of wetlands in sustaining human well-being and emphasizes that the ecosystem services provided by wetlands, such as water purification, flood regulation, and support for fisheries and agriculture, as well as the drivers of wetland degradation, such as land use change and climate change, and the consequences for human health and livelihoods. Unfortunately, wetlands in the Plains region have been heavily impacted by human activities, such as conversion to agriculture, urban development, and oil and gas development. Wetland degradation had a harmful influence on agriculture, fisheries, and other activities in the region, leading to poverty and food insecurity [10]. As a result, many wetland-dependent species are threatened or endangered, and efforts are underway to conserve and restore wetlands in the region.

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Human activities have had a significant impact on wetlands in the Plains region and around the world. The deterioration of wetlands can have severe consequences for local people, particularly those who rely on wetland resources for a living [11]. Wetlands have been drained, filled, or otherwise, altered for agriculture, urbanization, and resource extraction. These activities have disrupted the natural hydrology of wetlands and caused a decline in the quantity and quality of wetland habitat, resulting in the loss of biodiversity and important ecosystem services. Wetland degradation significantly negatively impacted the local population's livelihoods, particularly those dependent on agriculture and fisheries [12] and [13].

Conservation efforts have focused on several strategies to address such impacts and restore wetlands. Wetland degradation has a detrimental impact on residents, including decreased access to water, food, and income-generating possibilities, so there is a need for long-term wetland management practices that prioritize conservation and livelihoods [14]. One approach is to protect the remaining wetlands from further damage by implementing regulations and policies that limit development and other land use changes. Long-term management practices that balance the demands of wetlands and local populations should be incorporated [15]. Another approach is to restore degraded wetlands by planting native vegetation, restoring hydrology, and removing invasive species. Restoration efforts may also include the creation of new wetlands in areas where they have been lost. Wetland degradation has a substantial negative influence on the economy, society, and environment, and they suggested conservation approaches such as using ecosystem services and sustainable livelihood practices [16]. These efforts may involve the construction of artificial wetlands or the re-establishment of natural hydrology in areas that were previously wetlands.

Wetland restoration projects can provide multiple benefits beyond the restoration of natural habitats. Another study [17] investigated the effects of wetland degradation on rural livelihoods, revealing that wetland degradation has resulted in a drop in ecosystem services, severely impacting local livelihoods, particularly for people who rely on wetland resources like agriculture and fishing. They can provide educational opportunities for communities, promote ecotourism, and enhance recreational opportunities such as fishing, hunting, and bird watching. Overall, wetland restoration efforts in the Plains region around the world are critical for preserving biodiversity and ecosystem services, as well as mitigating the impacts of climate change through carbon sequestration and flood control.

Enlisted as a Ramsar wetland two decades ago, the Kanjli wetlands in Punjab confront a pressing issue of neglect from local stakeholders, leading to a steady decline in health despite implemented improvement measures. The scarcity of comprehensive strategies for wetland revival is evident, and existing reports and news articles have consistently highlighted its degradation [18][19][20] and [21]. This study seeks to validate and assess the current state of the Kanjli wetland, examining both positive and negative aspects.

Furthermore, recognizing the influence of surrounding activities on wetland health, this research delves into an additional dimension. There is hardly any study on the area that took the spatial point of view of land dynamics playing around the wetland and affecting the wetland reservoir. Integrating remote sensing and geographic information system (GIS) in such work is influential. It provides a vantage point for analyzing land use and land cover scenarios, identifying ecological stressors, spatial planning and management perspectives. Consequently, this work pioneers exploring the land dynamics encircling the wetland, offering insights into its reservoir's dynamics with geospatial technology. In an unprecedented approach, the research evaluates the geographical interplay of natural and human-driven factors, addressing a research gap. Additionally, the study considers the role of the local population, which is a crucial factor in shaping the wetland's natural setting. This research aspires to comprehensively understand the complex dynamics influencing the Kanjli wetland's landscape and ecological trajectory by combining environmental and human-centric perspectives.

2. Study Area

Kanjli Wetland is a Ramsar Site located in the Indian state of Punjab. It was designated as a Ramsar site in 2002 and covers an area of 183 hectares. The wetland is located near the city of Kapurthala and is fed by the Kali Bein River, a tributary of the Beas River [22] (Figure 1). Kanjli Wetland is an important bird habitat and supports a rich diversity of aquatic flora and fauna. More than 190 bird species have been recorded at the site, including several migratory species such as the bar-headed goose, common teal, northern pintail, and gadwall. The wetland also supports a number of threatened and endangered species, such as the Indian smooth-coated otter, small Indian civet, and Indian pangolin.

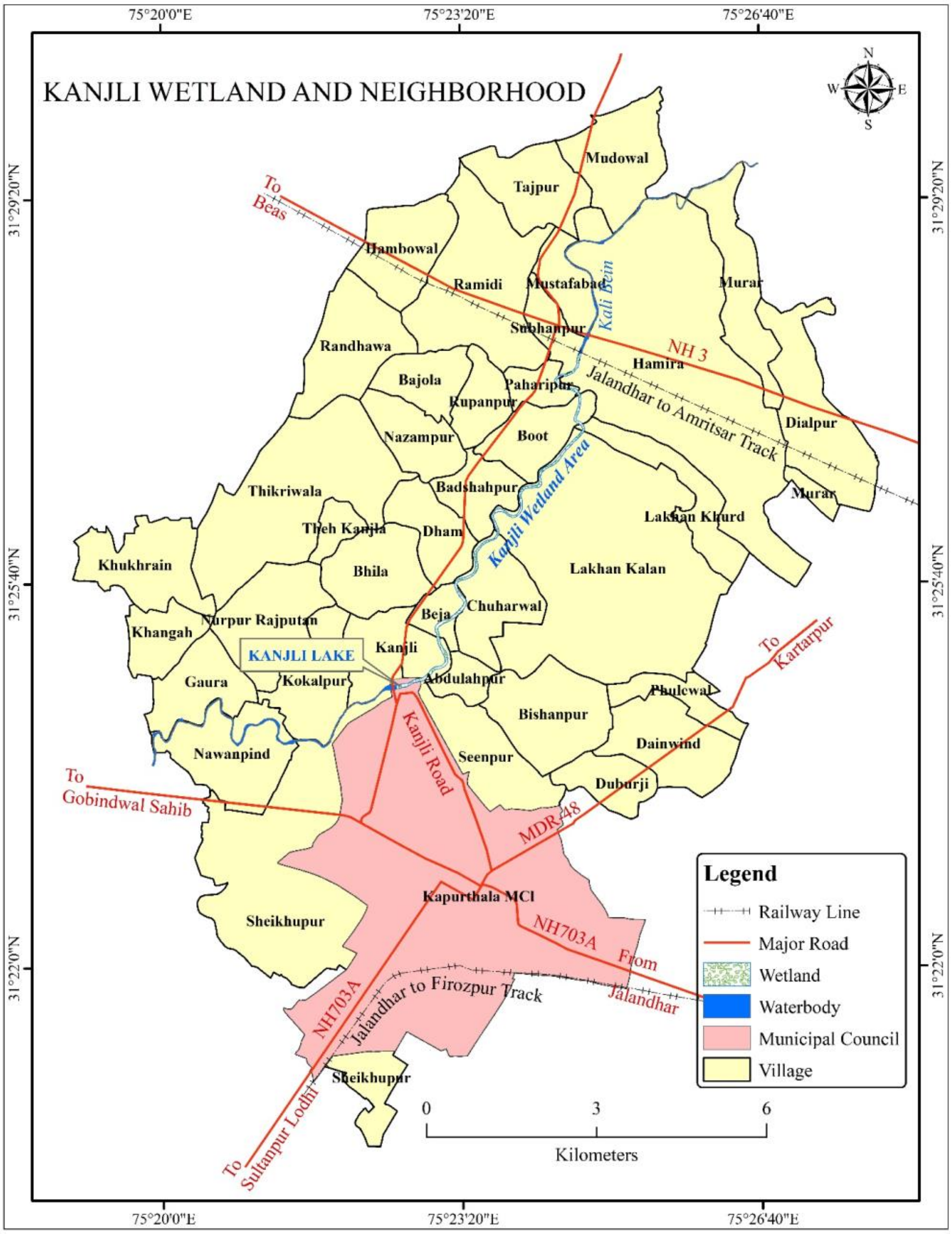

Figure 1: Kanjli, Kapurthala district of Punjab state, India

The wetland is surrounded by agricultural land, and agricultural runoff is a major threat to its ecological health. Other threats to the wetland include hunting, fishing, and the collection of firewood and other natural resources. Invasive plant species such as water hyacinths also pose a threat to the wetland's biodiversity. Several measures have been taken by the government and local communities to address these threats and conserve the wetland's biodiversity. These include the establishment of a wetland management committee, the implementation of a conservation and management plan, and the promotion of ecotourism activities. The wetland management committee regulates human activities in and around the wetland and raises awareness among local communities about the importance of wetland conservation. The ecotourism activities promote the economic benefits of wetland conservation and provide a source of income for local communities [23] and [24].

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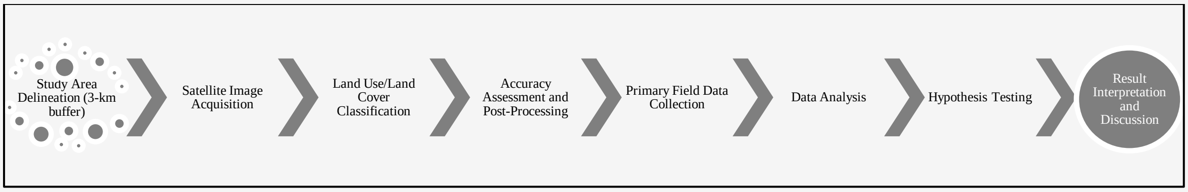

Figure 2: Study Workflow

Table 1: Satellite imagery used in the LULC change analysis

Satellite	Acquisition Date	Spatial Resolution	Providers
Landsat 5 TM	23/3/23	30 meters	https://earthexplorer.usgs.gov/
Landsat 9 OLI-2	23/3/23	30 meters	

Overall, the conservation efforts at Kanjli Wetland demonstrate the importance of Ramsar sites in preserving important wetland ecosystems and the need for continued efforts to protect and manage these sites. The neighboring villages are also considered in the analysis to gauge the impact of human activities on the carved-out wetland.

3. Material & Methods

3.1 Material and Data

The present study includes the procurement of spatial data and the primary data collected from the field surveys of the wetland and its vicinity. The following satellite data, Table 1, has been used for the spatial analysis of the land use in the area. The primary data from 411 households across eleven villages has been collected through extensive fieldwork in the study area. This includes interviews and focused group discussions with the various stakeholders, such as farmers, residents and officials.

3.2 Methodology

The methodological workflow of the study is shown in Figure 2. It starts by delineating the study area, which considers the 3-km buffer around Kanjli wetland. All the villages' administrative boundaries that come under or overlap the selected buffer zone are considered under the study area. It comes from about 38 villages in the study area. Figure 2 shows the carved-out study area. The study area shapefile has then been used to determine the satellite images of 1991 and 2022. The clipped area of the satellite images was subjected to Maximum Likelihood Supervised Classification Method under ArcGIS software. The six-land use and land cover classes have been classified; these are: Built-up, Cropland, Fallow land, Mixed Land use, Vegetation and Waterbody

It is followed by accuracy assessment and post-processing analysis on area calculation. The results have been substantiated with primary data from the field. The sample size was selected at 10 percent (411 households) of the total households. The data was collected based on the prepared questionnaire. The collected data was analyzed in the SPSS. The hypothesis was also designed for the study and tested to validate the results. The result interpretation and subsequent discussion follow the output.

4. Results

The classified image of the year 2022 was also analyzed for accuracy assessment. The overall accuracy of the image came to about 89 percent, and kappa statistics for the same was 0.80. The cropland class, having maximum coverage, has the producer's and user's accuracy above 85 percent, followed by built-up above 90 percent (producer's) and 75 percent as the user's accuracy. The post-processing of classified images includes calculating the proportional area of the land use classes for a comparative view of the changes in the study area. It gives the proportional abundance of each elected class in the Kanjli wetland areas and its surroundings. The changes in the 32 years can be easily visualized in the comparative Figure 3. The southern portion of the map depicted the urban area, whose built-up has grown considerably over time and is encroached towards the wetland area. The other built-up in the maps pertains to the villages in the area, which were minuscule as red dots in the 1990 image but have grown to red spots in the 2022 image, clearly demarcating the built-up area growth. The proportion of vegetation can also be seen increased in the view referring to the two significant aspects played at the area, one the afforestation following the declaration of Kanjli wetland as Ramsar site and the other the growth of plantation within the urban area to support the environment and in the agricultural field to enhance mixed cultivation.

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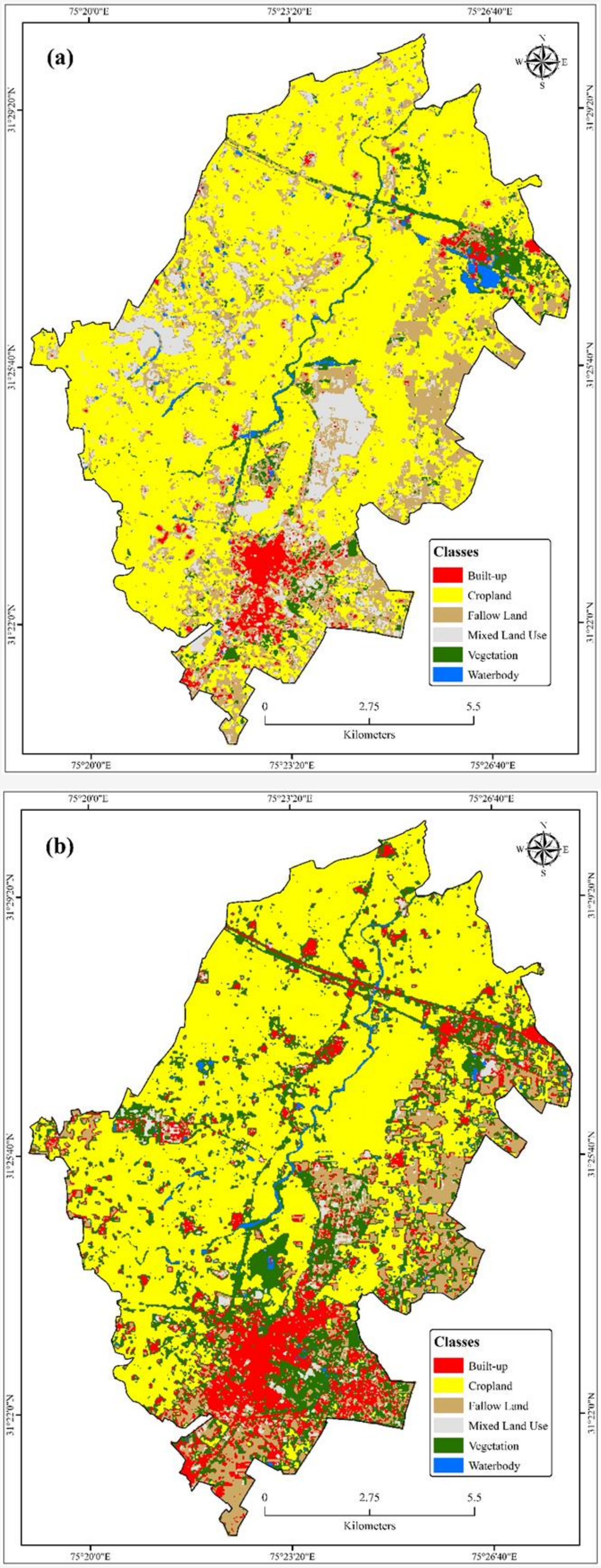

Figure 3: Comparative View of Land Use and Land Cover (a) 1990 and (b) 2022 of Kanjli Wetland and Neighborhood

Table 2: Proportional Area Change of the Land Use classes from 1990 to 2022

Classes	Area in 1990 (km^2)	Area in 2022 (km^2)	Percentage Change
Built-up	4.11	14.06	242
Cropland	87.91	76.72	-13
Fallow Land	24.09	13.92	-42
Mixed Land Use	10.56	2.27	-79
Vegetation	6.20	26.08	321
Waterbody	1.51	1.33	-12

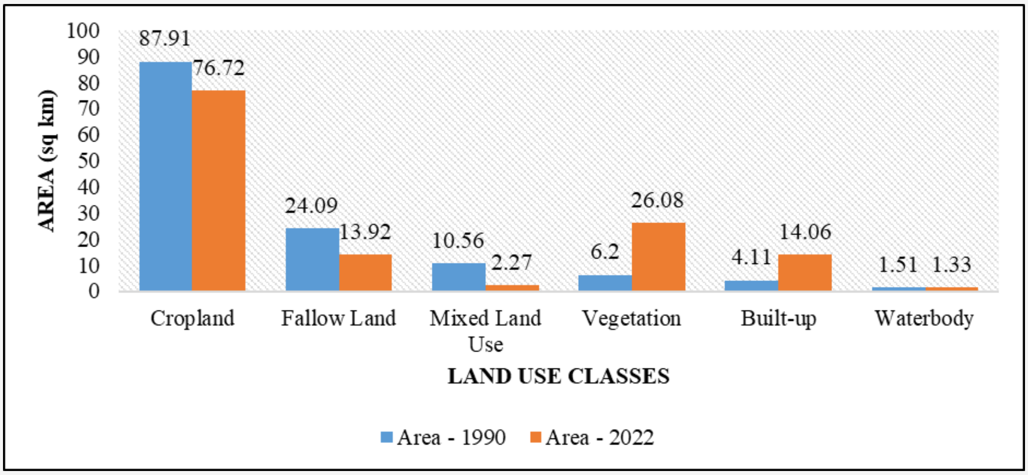

Figure 4: Kanjli Wetland: Land Use Change between 1990 and 2022

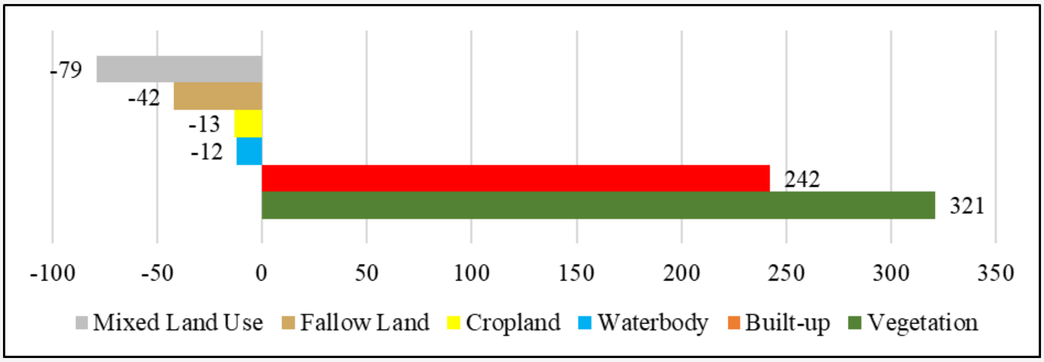

Figure 5: Kanjli Wetland: Percentage Change in Land Use between 1990 and 2022

The picture is clearer by describing the exact statistics of each land use class under Table 2. The statistics of the classified images of two extreme years depict the changing nature of land use classes in the area. Figure 4 demarcates the changes in the land use classes over 32 years. Further, Equation 1 is used to calculate each class's percentage increase and decrease.

There are two classes which have seen a tremendous increase in their extent. These are built-up and vegetation, which have experienced a percentage increase of 242 and 321, respectively, as highlighted in Figure 5. All other four classes have declined in proportion in these 32 years.

The maximum decrease occurred under agricultural land, both cropland and fallow land. The waterbody, which primarily includes the Kanjli wetland, has also seen a 12 percent decline over the years. The prime reason behind this is the conversion of some of the perennial river areas into agricultural land. Human activity in the area has increased as a result of developmental initiatives. It has negatively impacted the wetland's natural environment as well as the historical heritage of the adjacent villages that depend on it. Although the wetland is an important destination for visitors and bird watching, growing human activity has disrupted the natural habitats of the native creatures.

The Kanjli Wetland has suffered severely due to development operations, including habitat loss, pollution, and increased construction activities. As a result, an effort has been made in this section to determine how development activities have affected the Kanjli Wetland. This paper relied on both primary and secondary data sources. Primary data was collected through extensive fieldwork in 411 households across eleven villages in the study area, Table 3. The sample size was selected at 10 percent of the total households.

4.1 Development Activities in the Wetland

Wetlands are frequently transformed into agricultural land, industrial zones, or urban areas as a result of development activities. Many native plant and animal species that depend on wetlands for existence may be forced to migrate or become extinct as a result of this habitat loss and fragmentation. Water levels may shift due to this, degrading wetland habitats and affecting species that depend on these ecosystems. Developmental activities can cause agricultural runoff, industrial runoff, or poor waste disposal procedures to enter wetlands. These contaminants have the potential to pollute the water, soil, and sediments of wetlands, damaging their biodiversity and reducing their capacity to carry out vital ecological activities. The development activities in the Kanjli Wetland have been examined in this section with a focus on the perspectives of the surrounding communities. In the Kanjli wetland, different initiatives to develop are undertaken.

Some of these endeavors include infrastructure development, agricultural activities, aquaculture, tourism development, flood control strategies, and restoration initiatives. The data show that the expansion of development activities into other land uses is mainly caused by infrastructure development, including built-up infrastructure and road networks. The results show that 245 respondents reported encroachment connected to built-up infrastructure, whereas 104 reported encroachments relating to road networks. In addition, 62 respondents brought forward other invasion categories, Figure 6. The data in Table 4 depicts each row with surveyed villages and the columns with the fraction of various types of development activities (agricultural, infrastructure (Built-up), infrastructure (Road Network), and others) that led to encroachment in the area of the study. Table 4 depicts the distribution of responsible activities in several villages within the Kanjli wetland area. According to the data, agricultural operations have not encroached on other areas in any villages. In contrast, infrastructure development has encroached on a considerable percentage of the land, with an average of 60% of the area being built-up. It indicates that the region has experienced urbanization and development. The expansion of the road network is readily apparent, with around 25% of the land devoted to this purpose. Furthermore, additional infrastructure operations account for 15% of land use, emphasizing the area's expanding development projects. These findings indicate that the Kanjli wetland area has experienced significant urban growth and infrastructure expansion, which may impact the wetland ecosystem and require rigorous environmental planning and management.

The issue being addressed here is whether there is a substantial relationship between the type of development activities and the encroachments villages in the Kanjli wetland experienced.

Table 3: Village-wise number of sampled households [25]

Sr. No.	Village	Households	Sample size
1	Badshahpur	145	15
2	Beja	25	3
3	Boot	623	62
4	Chuharwal	176	18
5	Dham	110	11
6	Hamira	1652	165
7	Kanjli	235	23
8	Lakhan Kalan	667	67
9	Lakhan Khurd	224	22
10	Paharipur	129	13
11	Subhanpur	123	12
	Total	**4109**	**411**

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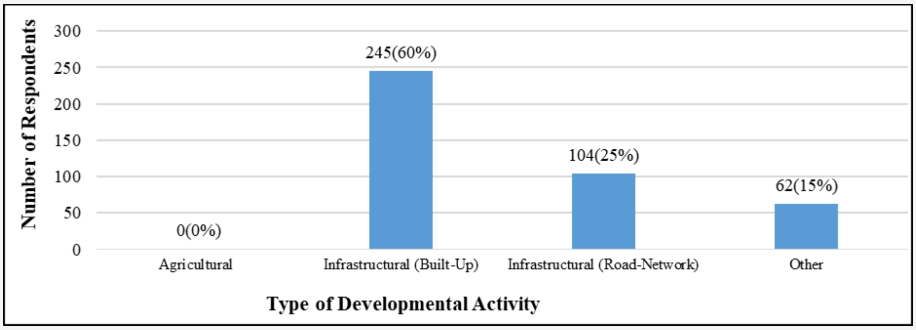

Figure 6: Kanjli Wetland: household perception on encroachment by various development activities

Table 4: Percentage share of various development activities causing encroachment in surveyed villages

Village	Causal Activities				Total (%)
	Agriculture (%)	Built-up (%)	Road Network (%)	Other (%)	
Badshahpur	0	71	21	7	100
Beja	0	100	0	0	100
Boot	0	56	24	19	100
Chuharwal	0	56	33	11	100
Dham	0	100	0	0	100
Hamira	0	66	19	15	100
Kanjli	0	63	25	13	100
Lakhan Kalan	0	37	40	22	100
Lakhan Khurd	0	91	0	9	100
Paharipur	0	46	31	23	100
Subhanpur	0	8	92	0	100
Total	**0**	**60**	**25**	**15**	**100**

4.2 Hypothesis Testing

Hypothesis testing has been done to specify and support the research findings. The null hypothesis (H_0) states that villages are not impacted by the development activity that has encroached on them, meaning there is no relationship between this type of development activity and the encroachments the villages experience. According to the alternative hypothesis (H_1), villages depend on the development activity that has encroached on them, implying that the type of development activity is related to the encroachments that the villages experience.

- H_0: Villages are independent of the development activity encroached
- H_1: Villages are dependent on the development activity encroached

These hypotheses are tested using Chi-Square tests. The Chi-Square tests analyze whether or not the difference between observed and predicted frequencies is significant. Table 5 displays the results of the Chi-Square tests. Both Chi-Square tests (Pearson Chi-Square and Likelihood Ratio) have extremely small p-values (less than 0.001, denoted as .000), indicating that the relationship between the type of development activity and encroachments is statistically significant, Table 5. As a result, the tests reject the null hypothesis (H0) and conclude that villages depend on the development activity infringing on them. In other words, there is a strong link between this type of development activity and village encroachment.

According to the findings, there is a strong link between the type of development activities and the encroachment on villages in the Kanjli wetland. The Chi-Square tests show that the null hypothesis (village independence from development activities) is rejected. It means that the type of development activity is linked to the encroachment that villages experience. The data indicate the impact of agriculture, infrastructure (built-up and road network), and other infrastructure activities on the wetland ecosystem, emphasizing the significance of careful environmental planning and management in dealing with the area's urban growth and infrastructure expansion. Additionally, the following paragraphs have discussed both positive and negative outcomes of developmental activities in Kanjli wetland.

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Table 5: Chi-Square tests

TESTS	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	68.367[a]	20	.000
Likelihood Ratio	74.711	20	.000
N of Valid Cases	411		

df= *degree of freedom,* Asymp. Sig.= *Asymptotic Significance or P-value*

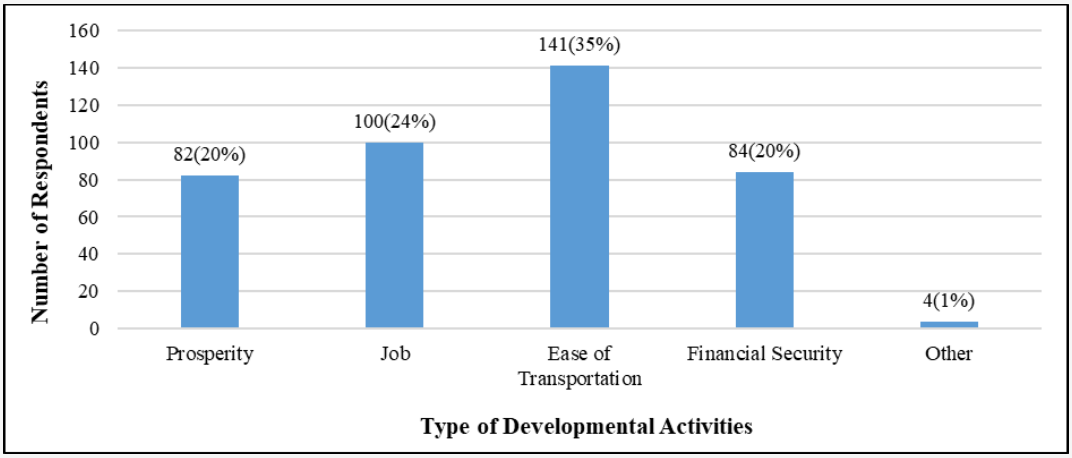

Figure 7: Kanjli Wetland: positive outcomes of developmental activities

5. Discussion

5.1 Positive Outcomes of Developmental Activities in Kanjli Wetland

The developmental activities around wetlands may have beneficial consequences. While wetlands are sensitive ecosystems that require protection, there are some situations where sustainable development can result in good benefits. Figure 7 shows the number and percentage of respondents who observed particular changes, highlighting the positive effects of development efforts in the Kanjli Wetland. Approximately 82 respondents (20%) noted an increase in the economy, demonstrating clear prosperity. As 100 respondents (24%) reported more work prospects, supporting economic growth, job creation is a noteworthy achievement. One notable positive change that has emerged is the ease of mobility, as shown by the 141 respondents (35%), who mentioned that accessibility and enhanced connection are essential for both people and commodities. According to 84 respondents (20%), having financial security indicates a stable and secure financial situation, which has a favourable effect on one's overall quality of life. The 'other' category, which accounts for 1%, suggests a more precise spectrum of improvements and other positive developments not included in the designated categories.

These results show the multifaceted effects of development programmes, including social, infrastructure and economic aspects. All of these factors, like job development, prosperity, improved mobility and financial security, combine to show how positively the Kanjli Wetland has changed, which will ultimately benefit the people who live there by improving their quality of life. Figure 7 also provides a clear summary of the many advantages that result from developmental efforts and shows how successful these programmes are at creating a more affluent and sustainable community in the Kanjli Wetland.

In addition to the above-mentioned positive outcomes (observed by the local communities), there are some other potential benefits of the development activities in the Kanjli Wetland, as discussed below:

Economic Growth: Wetland development projects have the potential to boost regional economies and generate job opportunities. For instance, constructing tourism infrastructure may draw tourists and bring in money for the local community, promoting economic development and reducing poverty. Even within the wetland compound, some excursion activities generate income for the government (Figure 8(a))

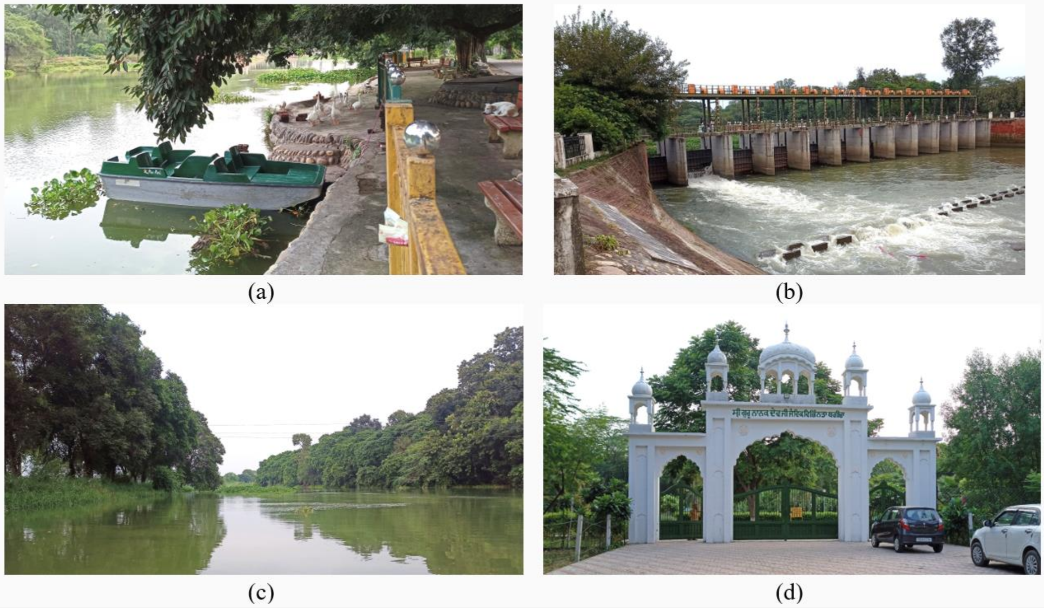

Figure 8: (a): Paid boat services for visitors to generate income from the wetland (b): Installation of water management gates to regulate the water flow (c): Tree Plantation along the wetland margins to mitigate soil erosion (d): A newly opened (2019) Shri Guru Nanak Dev Ji Biodiversity Park in the vicinity of Kanjli wetland to aid research and education. *The author took these field photos in August 2023*

Better Infrastructure: Wetland development may result in the building of necessary infrastructure, including water management systems, bridges, and roadways. These infrastructure upgrades can increase accessibility, connection, and water resource management, which will help the local economy and residents. The government has also installed water management gates at the Kanjli wetland because of the extreme monsoon season in the area, and these gates help to regulate the water flow in the wetland pond efficiently (Figure 8(b)).

Sustainable Resource Use: Sustainable utilization of resources may be encouraged by incorporating sustainable practices into development operations. For instance, aquaculture operations can minimize harmful environmental effects while providing a regulated environment for fish production.

Development in Wetland Ecosystems: can also help with conservation and restoration initiatives. It is feasible to rehabilitate wetlands that have been damaged, to increase biodiversity, and to save endangered species by putting effective management measures into place. The sustainability and long-term health of wetland ecosystems may benefit from this. The government has implemented a tree-planting initiative along the Kanjli wetland margins as a strategic measure to mitigate soil erosion (Figure 8(c)).

Research and Education: Wetland development initiatives may offer chances for research and educational pursuits. Wetland ecosystems can be studied, environmental changes may be tracked, and scientists and students can create creative, sustainable development solutions. The eventual goal is to promote wetland conservation by increasing understanding and awareness about wetlands. A new biodiversity park was inaugurated in 2019, 1 km from the wetland, aiming to catalyze research and education in biodiversity conservation (Figure 8(d)). It is crucial, however, that development in Kanjli wetland is undertaken with careful planning, adherence to environmental regulations, and consideration of the long-term impacts. Balancing development with conservation is essential to ensure the protection of wetland ecosystems and the services they provide for both present and future generations.

5.2 Negative Outcomes of Developmental Activities in Kanjli Wetland

There are also some negative aspects of development in the Kanjli Wetland area. While development activities can bring certain benefits, they can also have detrimental impacts on wetland ecosystems. Here are some potential negative aspects of development in Kanjli Wetland:

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Loss of Biodiversity: Development activities often involve habitat destruction and fragmentation, leading to biodiversity loss. Kanjli Wetland is likely home to diverse plant and animal species, some of which may be rare or endangered. When wetland areas are converted into built-up infrastructure or agricultural land, it disrupts the natural habitats and ecological balance, potentially leading to the decline or extinction of species.

Disruption of Ecosystem Services: Wetlands provide valuable ecosystem services such as water filtration, flood control, and carbon sequestration. Development activities can disrupt these services, affecting the overall health and functioning of the ecosystem. For example, the conversion of wetlands for agriculture or urbanization can reduce their ability to filter pollutants, resulting in water pollution and a loss of water purification capacity. The wetland is majorly surrounded by cropland, and water from the wetland is being used to irrigate the fields at some places (Figure 9(a)).

Water Management Issues: Wetlands play a crucial role in regulating water flow, especially during heavy rainfall or flooding periods. Altering the natural hydrological processes through development activities can disrupt the water balance in the wetland and surrounding areas. It can increase flood risks downstream and reduce water availability during dry periods. The infectious growth of water hyacinth in the Kanjli wetland waters spreads manifold over time. This results in declining dissolved oxygen concentration in the wetland waters, triggering subsequent concerns (Figure 9(b)).

Soil Degradation: Wetland soils are typically rich in organic matter and have unique characteristics. Development activities, particularly intensive agriculture or improper land use practices, can lead to soil degradation, erosion, and loss of fertile wetland soils. It can reduce soil productivity, impact agricultural yields, and contribute to sedimentation and water pollution.

Impact on Indigenous Communities: The development of wetland areas can have social implications, particularly for indigenous communities with traditional ties to these ecosystems. The loss of wetland resources and disruption of traditional livelihoods can lead to social and cultural upheaval within these communities. But other necessary infrastructural development activities are taking place at the cost of ignoring this wetland site, where the presence of water remains significant, and different facets of the wetland get the brunt of that like a proper library is in ruins at present; no actual improvement drive took place in decades (Figure 9(c), (d)).

Figure 9: (a): An illegal water pump installed on the wetland margin to irrigate the cropland from the wetland pond (b): Infestation of Water hyacinth in the wetland pond leading to low levels of dissolved oxygen concentration (c): An abandoned browser library in the premises of Kanjli wetland compound (d): A cornerstone at the Kanjli wetland compound indicating the last beautification drive occurred as far back as 1995. *The author took these field photos in August 2023*

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6. Conclusion

The present study concludes that land use classes have significantly changed between 1990 and 2022. The built-up area has experienced a substantial increase, rising from 4.11 units in 1990 to 14.06 units in 2022. It represents a significant growth of 242%. The cropland area has decreased over the years, declining from 87.91 units in 1990 to 76.72 units in 2022. It indicates a reduction of 13%. Fallow land has also witnessed a notable decrease, from 24.09 units in 1990 to 13.92 units in 2022. It represents a decline of 42%. The mixed land use area has experienced a significant decline, decreasing from 10.56 units in 1990 to 2.27 units in 2022. It indicates a substantial reduction of 79%. The vegetation area has steadily increased, growing from 6.20 units in 1990 to 26.08 units in 2022. It represents a substantial growth of 321%. The waterbody area has decreased slightly, from 1.51 units in 1990 to 1.33 units in 2022. It indicates a small reduction of 12%.

Therefore, the analysis of proportional area changes in land use classes from 1990 to 2022 reveals several notable outcomes. These include significant growth in built-up areas, declines in cropland, fallow land, mixed land use, a substantial increase in vegetation, and a minor decrease in waterbodies. These findings may have implications for various sectors, such as urban planning, agriculture, and environmental conservation, highlighting the dynamic nature of land use over time.

There is consensus that the Kanjli Wetland is the site of development efforts. Small landholdings are impacted by development (57 respondents), as well as migrant labor requirements (116 respondents) and refusing to engage in agriculture (191 respondents). There were another 47 respondents who pointed out additional, unspecified consequences. Regarding how ecologically friendly the developmental activities are, 79% of respondents said they weren't, while 21% said they were.

All respondents agreed that progress had produced beneficial results. Prosperity (82 respondents), the development of jobs (100 respondents), accessibility to transit (141 respondents), financial stability (84 respondents), and other beneficial consequences (4 respondents) are among these. All (100 percent) of respondents agreed that progress had produced positive outcomes. Prosperity (82 respondents), the development of employment (100 respondents), accessibility for transportation (141 respondents), financial stability (84 respondents), and other beneficial consequences (4 respondents) are among these. On the other hand, all 100 percent of respondents acknowledged the adverse aspects of growth as well, showing that there are issues or drawbacks related to the ongoing developing activities. The collected material did not go into detail on the precise nature of these drawbacks.

The respondents' perspectives are reflected in these comments, which could not fully encompass the whole spectrum of positive and negative effects or the total complexity of the redevelopment operations in Kanjli Wetland. It is crucial to keep this in mind. More data and analysis are needed to fully comprehend the development activities and their effects on the environment, society, and the wetland ecosystem.

Diverse governmental schemes and initiatives have been announced to enhance the ecological condition of the Kanjli wetland. Additionally, notable environmentalist Padmashree, Rajya Sabha Member of Parliament Balbir Singh Seechewal, and local volunteers have consistently spearheaded cleaning and improvement drives within the Kanjli wetland. Despite these commendable efforts, the efficacy of such endeavors appears constrained by a limited duration of impact or, at times, remains confined to bureaucratic processes documented in governmental records. Hence, an urgent imperative exists to perpetuate the positive outcomes derived from prior initiatives aimed at rejuvenating the Kanjli wetland. Such efforts are essential not only for the sustainability of the wetland's ecosystem but also hold the potential to contribute significantly to the replenishment of the diminishing groundwater table in the agricultural state of Punjab, India.

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