

Measuring Land Degradation & Major Causes in Panipat District: A Geographical Perspectives

Naveen Kumar¹, Dr. Attar Singh²

¹PhD Research Scholar, Dept. of Geography, BMU, Asthal Bohar, Rohtak-124021

²Professor of Geography, Baba Mastnath University, Rohtak, Haryana -124021

ABSTRACT

Land degradation had emerged as a serious environmental and agricultural concern in intensively cultivated regions of India. Panipat District, located in the fertile Indo-Gangetic plains of Haryana, had experienced increasing pressure on land resources due to intensive agriculture, irrigation practices, industrial growth, and population expansion. Understanding the extent and causes of land degradation was essential for sustainable land management and environmental planning. The main objectives of the study were to measure the extent and types of land degradation, identify spatial variations across blocks and villages, and examine the major causes contributing to land deterioration. The study also aimed to assess the severity of degradation and understand its geographical pattern. The study was based on primary field survey data collected from selected villages across major blocks of Panipat District in 2025. Household surveys and farmer responses were used to identify degradation types and causes. Secondary data sources, including government reports and previous studies, supported the analysis. Data were tabulated and analysed using percentage analysis and spatial comparison methods to identify patterns of degradation. The findings revealed that declining soil fertility was the most widespread form of land degradation across the district, affecting nearly four-fifths of respondents. Soil salinity, waterlogging due to canal irrigation, and industrial pollution were present but less dominant. Most farmers reported that degradation affected less than 25 percent of their land, though moderate impact (25–50%) was common in several villages. The overuse of fertilizers and pesticides emerged as the leading cause of degradation, followed by excess irrigation and canal seepage. Industrial waste discharge, crop residue burning, and climate variability contributed in smaller proportions. The study concluded that land degradation in Panipat District was primarily driven by intensive agricultural practices and irrigation mismanagement rather than severe physical erosion.

Keywords: Land Degradation, Soil Fertility Decline, Salinity & Waterlogging

INTRODUCTION

Land degradation had emerged as a major environmental challenge affecting agricultural productivity, ecological balance, and rural livelihoods across many parts of India. It referred to the decline in land quality caused by natural processes and human activities, resulting in reduced soil fertility, loss of vegetation cover, and deterioration of ecosystem functions. Earlier studies emphasized that land degradation posed serious threats to food security, sustainable development, and environmental stability, particularly in intensively cultivated regions (Lal, 2001; UNEP, 2016). The multiple forms of land degradation, including soil erosion, salinization, waterlogging, nutrient depletion, and vegetation loss. In the Indo-Gangetic plains, unsustainable agricultural practices, excessive irrigation, groundwater depletion, and rapid urban expansion had accelerated land degradation processes (Bhattacharyya et al., 2015). Human-induced pressures such as population growth, industrialization, and infrastructure development had further intensified land deterioration (Oldeman et al., 1991). Geographers and environmental scientists had widely used geospatial technologies to measure and monitor land degradation. Remote sensing and GIS techniques enabled the assessment of vegetation loss, soil moisture conditions, land surface changes, and erosion-prone areas over large spatial scales (Vrieling, 2006). These tools allowed researchers to identify degradation hotspots and assess temporal changes in land conditions. Excessive canal irrigation and poor drainage had contributed to waterlogging and soil salinity in several districts of the state (Sharma & Chaudhary, 2011). Continuous monocropping and heavy use of chemical fertilizers had led to nutrient imbalance and soil fertility decline (Singh & Benbi, 2016). Rapid urban growth and industrial development had also converted fertile agricultural land into built-up areas, increasing environmental stress (Kumar et al., 2018). Panipat District, located in the fertile Indo-Gangetic plains, had experienced rapid agricultural intensification along with industrial and urban expansion. The district's economy depended heavily on irrigated agriculture, particularly wheat–rice cropping systems, which required intensive water use. The over-extraction of groundwater, declining water tables, and soil salinity posed serious challenges to long-term land productivity in the district (Central

Ground Water Board, 2017). Industrial activities, brick kilns, and expanding transport infrastructure had further contributed to land degradation and soil deterioration. From a geographical perspective, understanding land degradation required examining both natural and human factors. Climatic variability, soil characteristics, and drainage conditions interacted with human practices such as irrigation methods, cropping intensity, and land conversion. Spatial analysis helped reveal patterns of degradation and identify vulnerable zones requiring intervention.

STUDY AREA

The Panipat district is located between the latitudes of 29° 09' 50" N and 29° 31' 38" N and the longitudes of 76° 37' 51" E and 77° 09' 51" E. Its 1268.00 km² geographical area is made up of 79.35 km² of urban area and 1188.65 km² of rural land. Situated south of Karnal district, Panipat district is a portion of the eastern Haryana Plain. The Yamuna River forms its eastern border, while Uttar Pradesh State is to the west. The Sonipat district forms the southern limit. Jind district is to the west of it (Panipat District Handbook, 2011).

Objectives

- To measure the extent and types of land degradation in Panipat District.
- To analyse spatial variations in land degradation across selected villages and blocks.
- To identify the major causes responsible for land degradation.
- To assess the severity of land affected by degradation.

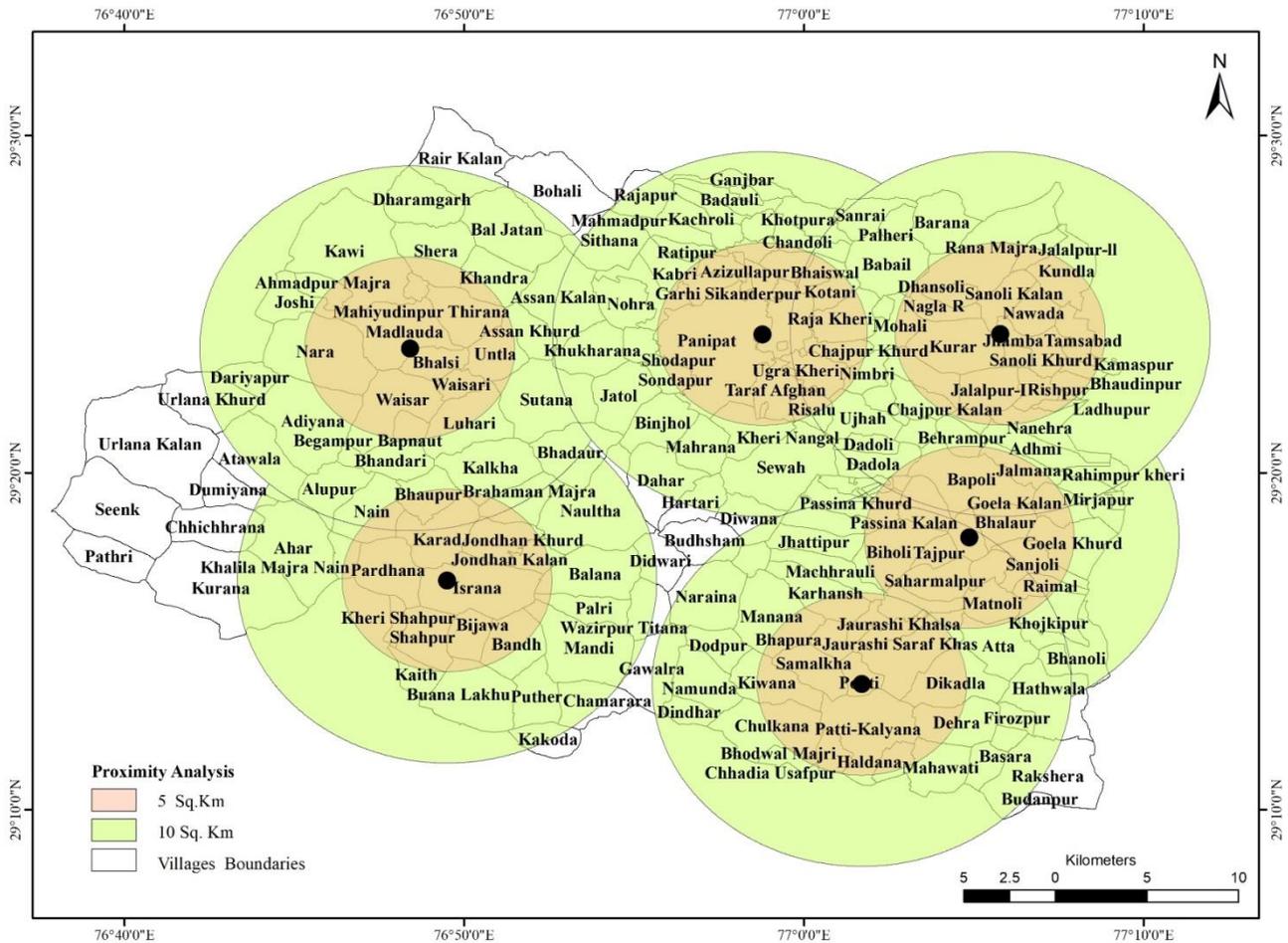
Database & Research Methodology

The primary data have been collected with the help of a well-defined household schedule. The schedule has been designed to understand the land degradation & major causes observed. It has included all significant aspects such as land use patterns, agricultural practices, soil conditions, and water availability to land degradation.

Table 1: Selection Criteria of Villages for Primary Survey in Panipat district, Haryana

Blocks (5)	Total Village (2011)	Sampled Villages	Villages to be Selected	Total Households (2011)	Sampled Households (5 %)
Sanoli Khurd	25	02	Sanoli Kalan	437	22
			Adhmi	573	29
Madlauda	35	02	Bhalsi	431	22
			Dariyapur	363	18
Panipat	34	02	Risalu	333	17
			Binjhol	730	37
Israna	32	02	Bijawah	461	23
			Kaith	357	18
Bapoli	27	02	Pasina Kalan	519	26
			Dhadola	557	28
Samalkha	33	02	Basahra	342	17
			Dehra	847	43
Total	186	12		5,950	300

Source: Primary Census Abstract, Panipat District, Census of India, 2011



Source: Prepared by Researchers

The impact of land degradation in each village has been examined from a spatial and socio-economic perspective. The selection of villages has been carried out in three stages. In the first stage, villages in Panipat district have been classified according to administrative blocks. In the second stage, stratified random sampling has been applied by dividing the blocks into two buffer zones based on proximity to degraded land areas, i.e., within 5 km and within 10 km of severely affected zones. In the third stage, one village per forty villages has been selected. Further, from the selected villages, random sampling has been used to identify five percent of households in each village. The total 300 households have been surveyed for the work (Table 1).

RESULT & ANALYSIS

Extent & Type of Land Degradation

Soil fertility was the most widespread form of degradation, resulting from continuous cereal cropping, excessive fertilizer use, and poor organic matter replenishment (Bhattacharyya et al., 2015). Secondary salinization and alkalinity were commonly observed in canal-irrigated regions where inadequate drainage and high evaporation caused salt accumulation in surface soils (Gupta, 2004). Waterlogging in low-lying command areas further reduced soil aeration and productivity, while localized industrial effluents and wastewater irrigation contributed to soil contamination near urban-industrial zones (Singh, 2000). Soil erosion and sand deposition were noted in limited pockets but were not considered dominant threats in intensively cultivated plains. Previous research emphasized that land degradation in such regions often reduced soil quality and crop productivity rather than rendering land permanently uncultivable, and that improper irrigation management, continuous monocropping, and weak soil conservation practices were key drivers influencing its extent and nature (Jat et al., 2012).

Types of Land degradation observed in Panipat district:

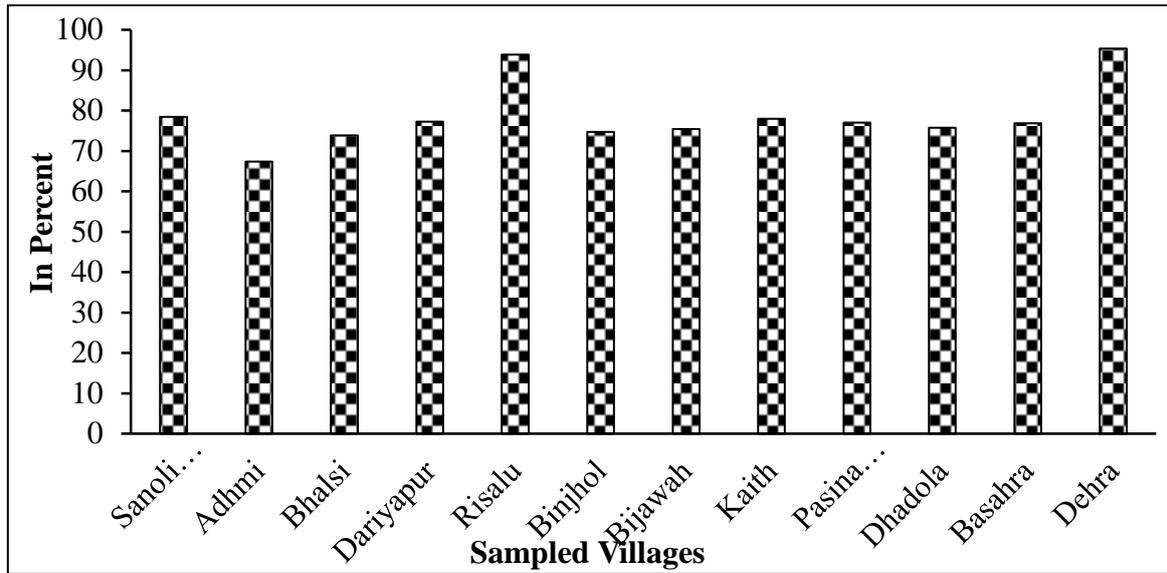
The types of land degradation observed in the sampled villages of Panipat district showed that declining soil fertility was the most serious problem. It appeared across almost all villages in high proportion. The issue looked widespread. In Sanoli Khurd Block, about 72.87 percent respondents reported declining fertility of soil. Other problems such as salinity, waterlogging, and industrial pollution existed but in smaller shares. The land was still productive, but its strength seemed reducing over time. Madlauda Block reflected a similar situation. Around 75.53 percent of land degradation was linked with declining fertility. Villages like Bhalsi and Dariyapur also showed high levels of fertility

decline, indicating continuous cultivation and heavy input use. Farmers appeared dependent on chemical fertilizers. Soil health may be affected. Salinity and waterlogging were present but less dominant (Table 2).

Table 2: Types of Land degradation observed among sampled villages in Panipat District, 2025

S. No.	Name of the Sample Villages & Blocks	Types of Land degradation observed (In %)					
		Soil salinity/ Alkalinity	Waterlogging due to canal irrigation	Soil erosion	Declining soil fertility	Industrial pollution	Sand deposition
1.	Sanoli Kalan	7.37	6.86	1.94	78.40	3.71	1.72
2.	Adhmi	9.05	8.42	2.38	67.34	10.70	2.11
	Sanoli Khurd Block	8.21	7.64	2.16	72.87	7.21	1.92
3.	Bhalsi	6.94	6.46	1.82	73.83	9.33	1.62
4.	Dariyapur	7.29	6.78	1.91	77.22	5.09	1.70
	Madlauda Block	7.12	6.62	1.87	75.53	7.21	1.66
5.	Risalu	1.64	1.53	0.43	93.82	2.20	0.38
6.	Binjhol	6.70	6.24	1.76	74.73	9.01	1.57
	Panipat Block	4.17	3.88	1.10	84.27	5.61	0.97
7.	Bijawah	6.52	6.06	1.71	75.42	8.76	1.52
8.	Kaith	5.85	5.44	1.53	77.97	7.85	1.37
	Israna Block	6.18	5.75	1.62	76.69	8.31	1.44
9.	Pasina Kalan	7.12	6.62	1.87	77.00	5.74	1.66
10.	Dhadola	6.44	5.99	1.69	75.71	8.66	1.51
	Bapoli Block	6.78	6.31	1.78	76.35	7.20	1.58
11.	Basahra	7.05	6.55	1.85	76.85	6.06	1.65
12.	Dehra	1.12	1.05	0.30	95.34	1.93	0.26
	Samalkha Block	4.08	3.80	1.07	86.09	4.00	0.95
Panipat District		6.09	5.67	1.60	78.63	6.59	1.42

Source: Field Survey, 2025



Source: Based on table 2

Figure 1: Pattern of Declining soil fertility among sampled villages in Panipat District, 2025

Panipat Block recorded 84.27 percent degradation in the form of declining fertility, showing the seriousness of the issue. Binjhol and Bijawah villages showed notable presence of industrial pollution, possibly due to nearby industrial activities. The problem was visible but not extreme. Waterlogging due to canal irrigation affected some fields, particularly in low-lying areas. Israna Block presented moderate levels of salinity (6.18 percent) and waterlogging (5.75 percent), while fertility decline remained the major concern (76.69 percent). Kaith village showed similar issues (Table 2).

In Bapoli Block, salinity and waterlogging together formed a noticeable share, suggesting drainage-related problems. Pasina Kalan and Dhadola villages also reflected the same pattern. Risalu village stood out with very high reporting of fertility decline (93.82 percent) and minimal other degradation problems. Dehra village showed the highest fertility decline (95.34 percent), while other degradation types were almost negligible. This suggested continuous cropping pressure on soil nutrients. The soil was used again and again. Samalkha Block recorded 86.09 percent fertility decline, reinforcing the district-wide trend. Soil erosion remained very low across all villages, mostly below 2 percent, indicating relatively stable terrain. Sand deposition and alkalinity were present but limited (Fig. 1).

Area affected by Land Degradation:

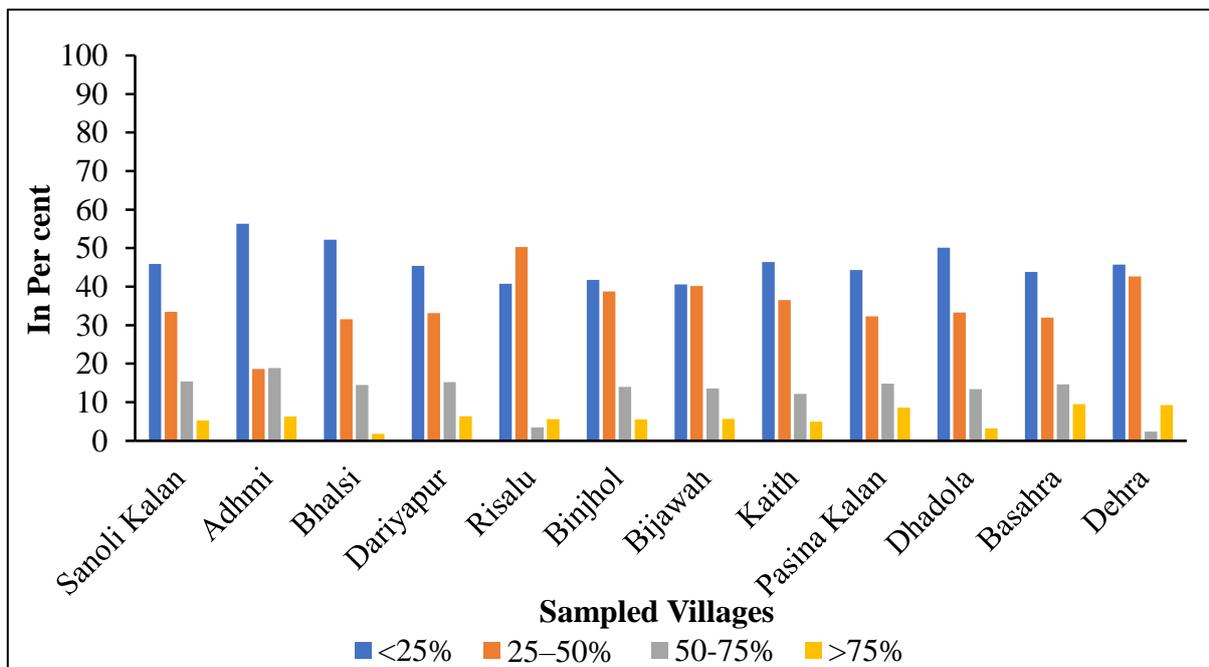
The extent of area affected by land degradation in the sampled villages of Panipat district showed that most farmers experienced the problem on a limited portion of their land. In many villages, the affected area remained below 25 percent. It was noticeable (Table 3). In Sanoli Khurd Block, about 51.10 percent households reported that less than one-fourth of their land was affected. Only a small share faced severe impact. This suggested that degradation existed but was not overwhelming for most farmers. Madlauda Block showed a similar pattern. Nearly 48.77percent households reported damage below 25 percent area, while about one-third reported impact between 25–50%. Villages like Bhalsi and Dariyapur reflected comparable conditions. Moderate impact was present. Severe degradation remained limited. The situation looked manageable but concerning. In Panipat Block, the distribution appeared slightly different. Around 44.55 %households reported degradation affecting 25–50 % of their land, indicating moderate stress on agricultural fields. Risalu village stood out, where over half the households (50.30%) reported degradation affecting 25–50% area (Table 3).

Table 3: Area affected among sampled villages in Panipat District, 2025

S. No.	Name of the Sample Villages & Blocks	Area Affected (In %)			
		<25%	25–50%	50-75%	>75%
1.	Sanoli Kalan	45.88	33.49	15.36	5.27
2.	Adhmi	56.31	18.58	18.86	6.25
	Sanoli Khurd Block	51.10	26.04	17.11	5.76
3.	Bhalsi	52.20	31.53	14.46	1.81

4.	Dariyapur	45.35	33.11	15.19	6.35
	Madlauda Block	48.77	32.32	14.82	4.08
5.	Risalu	40.71	50.30	3.42	5.58
6.	Binjhol	41.71	38.79	13.97	5.52
	Panipat Block	41.21	44.55	8.69	5.55
7.	Bijawah	40.57	40.17	13.58	5.67
8.	Kaith	46.37	36.55	12.18	4.90
	Israna Block	43.47	38.36	12.88	5.29
9.	Pasina Kalan	44.28	32.32	14.83	8.57
10.	Dhadola	50.09	33.28	13.42	3.21
	Bapoli Block	47.19	32.80	14.12	5.89
11.	Basahra	43.83	32.00	14.68	9.49
12.	Dehra	45.76	42.67	2.34	9.23
	Samalkha Block	44.80	37.33	8.51	9.36
	Panipat District	46.09	35.23	12.69	5.99

Source: Field Survey, 2025



Source: Based on table 3

This showed more pressure on land resources. Binjhol and Bijawah villages presented a balanced pattern between the first two categories. Israna Block recorded 43.47 percent households with less than 25 percent affected land, while 38.36 percent reported 25–50 percent impact. Kaith village also showed similar distribution. In Bapoli Block, nearly one-third households fell in the 25–50 percent category, suggesting moderate land stress. Pasina Kalan and Dhadola villages reflected comparable trends. Severe degradation affecting more than 75 percent of land remained very low across the district. However, Basahra (9.49 percent) and Dehra (9.23 percent) showed relatively higher shares in this category. Samalkha Block recorded 9.36 percent households reporting severe impact, indicating localized pockets of serious degradation. Though small in proportion, these cases cannot be ignored (Fig. 2).

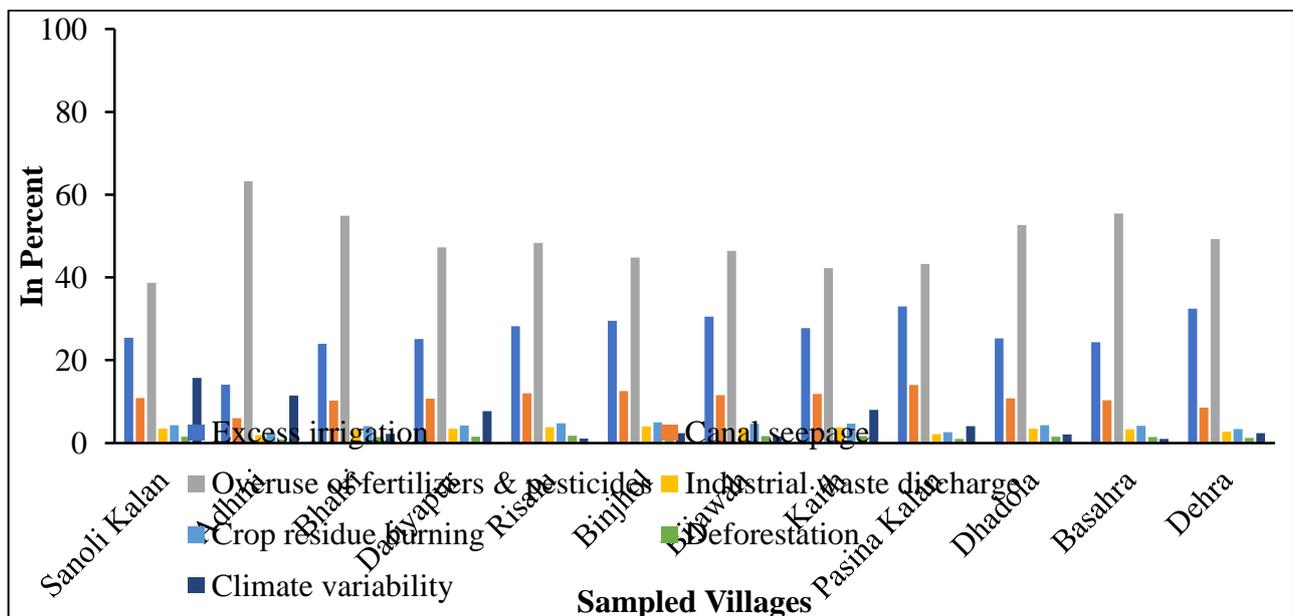
Major Causes observed for Land Degradation:

The major causes of land degradation in the sampled villages of Panipat district showed that excessive use of fertilizers and pesticides was the most important factor. It appeared again and again in almost every village. Farmers relied heavily on chemical inputs to maintain crop yields. Over time, this practice seemed to weaken soil health. In Sanoli Khurd Block, about 50.96 percent respondents identified overuse of fertilizers and pesticides as the main cause. Other factors like excess irrigation and canal seepage were present but less dominant. Madlauda Block reflected a similar situation (Table 4).

Table 4: Major Causes observed for Land Degradation among sampled villages in Panipat District, 2025

S. No	Name of the Sample Villages & Blocks	Major causes for Land Degradation						
		Excess irrigation	Canal seepage	Overuse of fertilizers & pesticides	Industrial waste discharge	Crop residue burning	Deforestation	Climate variability
1.	Sanoli Kalan	25.45	10.83	38.69	3.47	4.30	1.55	15.72
2.	Adhmi	14.12	6.01	63.23	1.92	2.39	0.86	11.47
	Sanoli Khurd Block	19.79	8.42	50.96	2.69	3.34	1.20	13.59
3.	Bhalsi	23.96	10.20	54.87	3.26	4.05	1.46	2.20
4.	Dariyapur	25.16	10.71	47.23	3.43	4.25	1.53	7.69
	Madlauda Block	24.56	10.45	51.05	3.35	4.15	1.49	4.95
5.	Risalu	28.23	12.01	48.34	3.84	4.77	1.72	1.09
6.	Binjhol	29.48	12.55	44.82	4.02	4.98	1.79	2.37
	Panipat Block	28.86	12.28	46.58	3.93	4.87	1.75	1.73
7.	Bijawah	30.53	11.53	46.40	3.69	4.58	1.65	1.63
8.	Kaith	27.78	11.82	42.22	3.78	4.69	1.69	8.02
	Israna Block	29.15	11.68	44.31	3.74	4.63	1.67	4.82
9.	Pasina Kalan	32.98	14.04	43.23	2.11	2.62	0.94	4.09
10.	Dhadola	25.29	10.76	52.65	3.44	4.27	1.54	2.04
	Bapoli Block	29.14	12.40	47.94	2.78	3.44	1.24	3.06
11.	Basahra	24.32	10.35	55.42	3.31	4.11	1.48	1.01
12.	Dehra	32.43	8.56	49.29	2.74	3.40	1.22	2.36
	Samalkha Block	4.05	0.90	3.06	0.29	0.36	0.13	0.67
	Panipat District	26.64	10.78	48.87	3.25	4.03	1.45	4.97

Source: Field Survey, 2025



Source: Based on table 4

Figure 3: Major Causes observed for Land Degradation among sampled villages in Panipat District, 2025

Around 51.05 percent respondents pointed to chemical overuse as a key cause of degradation. Villages such as Bhalsi and Dariyapur also showed high percentages in this category, indicating intensive farming practices. Excess irrigation contributed to the problem, especially in canal command areas. Water seepage increased moisture imbalance. The land suffered slowly. In Panipat Block, overuse of fertilizers (46.58 percent) remained the leading cause, followed by excess

irrigation (28.86 percent). Binjhol and Biajwah villages reported significant impact from irrigation-related issues, suggesting overwatering and poor drainage. Crop residue burning was present in small proportions but added to soil stress. Industrial waste discharge appeared in limited pockets, especially near industrial zones. Israna Block recorded 44.31 percent responses for fertilizer overuse and about 29 percent for excess irrigation. Kaith village showed some influence of climate variability (8.02 percent), suggesting weather irregularities affecting soil condition. In Bapoli Block, chemical overuse remained dominant (47.94 percent), while canal seepage and irrigation issues also contributed. Pasina Kalan and Dhadola villages reflected similar trends. Basahra village recorded a high share (55.42 percent) for fertilizer overuse, indicating pressure from intensive cultivation. Dehra village also showed notable responses for excess irrigation and chemical inputs. In contrast, Samalkha Block reported very low percentages across all causes, suggesting relatively less perceived degradation pressure or better land management practices (Fig. 3).

CONCLUSION

The study revealed that land degradation in Panipat District had been widespread but varied in intensity and form. Declining soil fertility emerged as the most dominant form of degradation, affecting a large proportion of agricultural land across the district. This indicated continuous cereal cropping, excessive chemical fertilizer use, and insufficient organic matter replenishment. Soil salinity and alkalinity, waterlogging due to canal irrigation, and localized industrial pollution were also observed but remained secondary in comparison. Soil erosion and sand deposition were minimal, reflecting the relatively stable topography of the Indo-Gangetic plains. Spatial analysis showed that most farmers experienced degradation on less than one-fourth of their land, suggesting moderate but manageable stress. However, a considerable number of households reported degradation affecting 25–50 percent of their fields, indicating increasing pressure on land productivity. Localized pockets of severe degradation were observed in villages such as Basahra and Dehra, where soil fertility decline exceeded 90 percent. The findings also indicated that Madlauda Block exhibited a similar pattern, with declining soil fertility accounting for over three-fourths of degradation cases.

The study further found that the overuse of fertilizers and pesticides was the most significant cause of land degradation, reported by nearly half of the respondents across the district. Excess irrigation and canal seepage were the next major factors, contributing to salinity and waterlogging in canal command areas. Industrial waste discharge and crop residue burning had localized impacts, particularly near industrial zones, while climate variability played a minor but emerging role. The land degradation in Panipat District was largely human-induced and closely linked to intensive agricultural practices and irrigation mismanagement. Although the land remained productive, its quality was gradually declining. If current practices continue, soil health deterioration may intensify and threaten long-term agricultural sustainability. Therefore, the adoption of balanced nutrient management, improved irrigation practices, organic soil amendments, and awareness programs for farmers is essential to maintain soil productivity and ensure sustainable land use in the district.

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