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Changing Land Use Pattern and its Implication for the Agricultural Sector in Indian Punjab

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ABSTRACT

Based on secondary data for various land classes between 1966-1967 and 2021-22, this paper examines Punjab's shifting land use patterns and their implications for the agricultural sector. The findings revealed a transition of land use from desirable ecological and agricultural sector to undesirable ecological and non-agricultural sector. The state's net sown area had been rising until the 1990s and then began to decline. The land put to non-agricultural uses, permanent pastures, and other grazing lands, land under miscellaneous tree crops not included in area sown, and the net sown area have shown a significant positive impact on cropping intensity. Conversely, the current fallow land has exhibited a negative and significant impact on the cropping intensity. It is advised that a scientific and institutional framework be built for proper management and conservation of land resources. Additionally, adopting sustainable intensification, precision farming, and advanced conservation agricultural practices can ensure the long-term viability of Punjab agriculture amid changing land use pattern.

Keywords: Land use, Implications, Agricultural sector, Punjab, Cropping intensity

JEL codes: R14, Q13, Q15, R52

I

INTRODUCTION

Land is a fundamental component of agriculture and an important source of income for the vast majority of the population in developing countries. Land use determines their social and economic well-being and the sustained quality of this resource. Economic growth, along with population growth, urbanization, and industrialization, exerts tremendous pressure on a natural resource like land, forcing the change in land use over time (Ashrit, 2014; Bardhan and Tewari, 2010). Land use is a highly dynamic process, and its effective use has always been debated. The land use pattern of a region depends considerably on its socio-economic, agro-climatic, technical, institutional, and ecological factors (Chaturvedi et al., 2011). The changes in land use have important implications for the quality of life. In countries such as India, where most of the population still depends on land, effective land use is essential according to its capacity and type (Pandey and Tewari, 1987; Pandey and Ranganathan, 2018). India occupies only 2.4% of the world's geographical area. Still, it supports more than 16% of the world population, and the Indian agriculture system is a prelude to overall economic development and a prerequisite for alleviating poverty (Ravallion and Dutta, 1996). Therefore, there is a need for serious policy debate on addressing various issues related to land use planning in a country where pressure on the land is four to six times more than the world average (Rai, 2008).

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While some land use shifts might have occurred desirably, others might have been undesirable ones (Sharma and Pandey, 1992).

There are wide variations in the distribution and utilization of land resources across different states based on topographic, geographical, political, and other factors. As a normal process of urbanization, industrialization and economic development occurs, certainly it is obvious nature to change and exerts tremendous pressure on limited land resources (Bardhan and Tiwari, 2010). Punjab, one of the north-western states, has a reported area of 5036 thousand hectares, but according to the village paper of the Director of Land Records, Govt. of Punjab, it is 5033 thousand hectares. Over the period, there has been a gradual shift in land use patterns in Punjab. The socio-economic development plays a significant role in bringing changes in in land use pattern. Population growth, urbanization and governmental policies are the drivers of changes in land use pattern in Punjab, impacting the agricultural sector profoundly (Adhikari and Sekhon, 2014). The need to feed the growing population has intensified the cropping practices, leading to higher cropping intensity across the state. The cropping intensity has increased significantly from 134% in 1966-67 to 190% in 2021-22 (GoP, 1967 & 2022). Moreover, border factors like access to irrigation, availability of agricultural inputs like fertilizer and seeds and market demands has also intensified the cropping intensity in the state.

Paradoxically, despite the increasing need for agricultural production to sustain the growing population, land use is shifting toward non-agricultural purposes, such as infrastructure and urban expansion. While these changes have enhanced the agricultural productivity, they have also led to significant challenges like groundwater depletion, soil degradation, reduced biodiversity and overall unsustainability in agricultural production and the environment. These issues have contributed to an increase current fellow over the last few years (Adhikari and Sekhon, 2014), as farmer struggles declining soil fertility, water scarcity, and raising input costs, which in turn has negatively impacted the cropping intensity. This calls for a careful assessment of land use changes in the state and identify various land use options and suitable policies to balance natural resources and agricultural sustainability, ensuring food and livelihood security. Therefore, the present study examined the intersectoral temporal land-use changes and their implications for the agriculture sector, aiming to provide actionable insights for developing strategies to promote balance land use, long term resource management and agricultural sustainability in Punjab.

II

DATABASE AND METHODOLOGY

2.1 Data

The study is based on secondary data collected from the Director, Land Records, and other publications of the Economic and Statistical Office, Government of Punjab, and http://data.icrisat.org/dld/ for 56 years (1966-67 to 2021-22), following the reorganization Punjab state in 1966 and based on data availability.

2.2 Method

2.21 Inter-Sectoral Budgeting Analysis

Then, the total land-use classes were grouped into three sectors, viz. (i) ecological sector (E), which includes Fr, P, M, and B, (ii) agricultural sector (A) includes Cw, Cf, Fo, and S, and (iii) non-agricultural (NA) sector. The ecological sector was further divided into two sub-sectors, viz. (i) the desirable ecological sector (E1) includes Fr, P, and M, and (ii) the undesirable ecological sector (E2) includes B. The net changes within each sector were then grouped into the following equations:

$$\Delta E=\Delta E_1+ \Delta E_2 = (\Delta F_r + \Delta P + \Delta M) + (\Delta B) \quad ....(1)$$

$$\Delta A=\Delta C_w+ \Delta C_f+\Delta F_o + \Delta S \quad .... (2)$$

$$\Delta R= \Delta E_1 + \Delta E_2 + \Delta A + \Delta N \quad .... (3)$$

Thus, the annual rates of change in various land classes were calculated and budgeted using the above equations (1), (2), and (3). This budgeting aided in analyzing the direction and dynamics of land-use shifts.

Multiple regression models were used to determine the impact and factors influencing productive land utilization in Punjab. Cropping intensity was specified as an endogenous variable because increasing cropping intensity is desirable for proper land resource utilization, reducing seasonal unemployment in labor-abundant and capital-scarce rural economy, and achieving greater food supply stability (Rao, 1976; Dev, 1986).

2.2.2 Impact of Land Use Pattern on Cropping Intensity

An Ordinary Least Square (OLS) multiple regression function was estimated to determine the impact of land use patterns on cropping intensity. The model was chosen after examining the correlation between explanatory variables to avoid multicollinearity. The variables such as the area under forest, barren and uncultivable lands, culturable wasteland, and fallows other than current fallow land have shown a high correlation with other variables and were excluded from the model. The Cobb-Douglas function is used to specify the model and still widely used to estimate the functional relationship between the dependent and independent variables. The functional form is given below:

$$\ln Y = b_0 \ln X_1^{\,b1} X_2^{\,b2} X_3^{\,b3} \ldots\ldots\ldots\ldots X_n^{bn} \qquad \ldots\ldots (4)$$

Where,

Y = Cropping intensity (%)

X_1 = Land put to non-agricultural uses (‘000 ha)

X_2 = Permanent pastures & other grazing lands (‘000 ha)

X_3 = Land under miscellaneous tree crops not included in area sown (‘000 ha)

X_4 = Current fallows (‘000 ha)

X_5 = Net area sown (‘000 ha)

III

RESULTS

3.1 Changes in Land-Use Pattern

The estimated annual growth rates and percentage change in various land-use classes in Punjab are presented in Table 1. The total reported area rose marginally by 0.2% over the study period. The forest area also saw a significant annual growth of 3.77%, rising from 78 thousand hectares (1966–1967) to 290 thousand hectares (1993-94). However, the same area declined to 243 thousand hectares (2021-22), with an annual decline of 0.75% during Period-II, On the other hand, the total area not available for cultivation showed a significant increase with an annual growth rate of 0.46%, i.e., from 315 thousand hectares (1966-67) to 512 thousand hectares (2021-22). This growth was driven by increasing demand for land for non-agricultural uses, which grew by more than 65% per year from 1966-67 to 2021-22. Conversely, the area under barren and uncultivable land declined significantly by around 89%, with an annual growth rate of -3.59% during the same period. The area under permanent pastures and other grazing lands has decreased by 50% but not significantly. The land under miscellaneous tree crops not included in the area sown also increased significantly with an annual growth rate of 1.34%. However, the culturable wasteland declined significantly by more than 95%, with an annual fall of -4.98 %, i.e., from 158 thousand hectares (1966-67) to 8 thousand hectares (2021-22). The total fallow also decreased by around 70%, from about 263 thousand hectares in 1966-67 to 78 thousand hectares in 2021-22, with an annual decline of -1.75% during the overall study period; however, it increased during the Period-II. On the other hand, the net area sown has increased significantly by 6.6%, from 3870 thousand hectares (1966-67) to 4124 thousand hectares (2021-22), an annual growth rate of 0.04%.

TABLE 1. TRENDS IN DIFFERENT LAND USE CLASSES IN PUNJAB

Particulars	Period -I (1966-67 to 1993-94)				Period-II (1994-95 to 2021-22)				Overall Period (1966-67 to 2021-22)			
	1966	1993	CAGR (%)	Change (%)	1994	2021	CAGR (%)	Change (%)	1966	2021	CAGR (%)	Change (%)
ɔorted area	5025	5033	0.00 (-)	0.2	5032	5033	0.00 (-)	0.00	5025	5033	0.00 (-)	0.2
ıder forests	78	290	3.77* (0.00)	271.8	290	243	-0.75* (0.00)	-16.2	78	243	1.52* (0.00)	211.5
t to non-agricultural uses	315	402	0.50* (0.03)	27.6	458	521	1.30* (0.00)	13.8	315	521	0.46* (0.00)	65.4
ınd unculturable land	326	32	-6.02* (0.00)	-90.2	26	37	-0.51 (0.25)	42.3	326	37	-3.59 (0.00) *	-88.7
ːa not available for on	641	434	-1.26* (0.00)	-32.3	484	558	1.06* (0.00)	15.3	641	558	-0.28* (0.00)	-13.6
ːnt pastures & other grazing	10	7	-0.50 (0.63)	-30.0	3	5	-0.04 (0.67)	66.7	10	5	-0.11 (0.45)	-50.00
der miscellaneous tree crops ıded in area sown	5	2	0.13 (0.45)	-60.0	2	10	2.88 (0.01)	400.0	5	10	1.34* (0.00)	100.00
ɔle wasteland	158	11	-6.21* (0.00)	-93.0	5	8	-1.04 (0.69)	60.0	158	8	-4.98* (0.00)	-95.0
ıer uncultivated lands ıg fallows	173	20	-5.10* (0.00)	-88.4	10	22	0.24 (0.96)	120.0	173	22	-3.16* (0.00)	-87.3
and other than current	1	3	10.37* (0.00)	200.0	2	5	2.61 (0.53)	150.0	1	5	3.52 (0.10)	400.00
fallows	262	72	-4.23* (0.00)	-72.5	36	73	2.92 (0.00)	102.8	262	73	-1.29* (0.00)	-72.1
low land	263	75	-3.67* (0.00)	-71.5	38	78	2.84 (0.00)	105.3	263	78	-1.75* (0.00)	-70.3
sown	3870	4214	0.22* (0.00)	8.9	4210	4124	-0.11* (0.00)	-2.04	3870	4124	0.04* (0.00)	6.6

*Note: * indicates significance at 1 % level*

3.2 Inter-Sectorial Land-Use Shift

Inter-sectorial budgeting analysis was performed to estimate the extent and pattern of dynamics in the land use shift in Punjab (Table 2). The ecological sector experienced an overall declined of around 30% annually, with the desirable ecological sector declining by around 13% annually during the period-II (1966-67 to 1993-94). Conversely, the undesirable ecological sector saw an overall reduction of around 89% annually, but increased significantly during period -II (42%). Agricultural land use also showed a decline of around 1.9 percent annually particularly during period-II (1.01%). In contrast, the non-agricultural land use expanded subsequently across all periods with an overall shift of around 65% annually.

TABLE 2. BUDGETING OF INTER-SECTORAL LAND-USE SHIFTS

Land use sectors	Annual rate of change (%)		
	Period -I (1966-67 to 1993-94)	Period-II (1994-95 to 2021-22)	Overall (1966-67 to 2021-22)
Ecological sector ($\Delta E=\Delta E_1+\Delta E_2$)	-21.00	-8.09	-29.59
Desirable ecological sector (ΔE_1)	221.50	-12.54	186.02
Undesirable ecological sector (ΔE_2)	-90.18	42.30	-88.65
Agricultural sector (ΔA)	0.20	-1.01	-1.88
Non-agricultural sector (ΔN)	27.61	13.75	65.39
Total reported area (ΔR)	0.15	0.01	0.1

3.3 Productive Land Utilization in Punjab

For this study, net sown and irrigated areas were considered productive land use. The area under productive utilization of land in Punjab is shown in Table 3. It was discovered that the area under net sown area increased from 3807 thousand hectares to 4124 thousand hectares from 1966-67 to 2021-22. The percentage of net sown area as a percentage of the total reported area increased marginally from around 76% to 82%. However, the share net sown area was highest during the 1990s and kept declining later. The irrigated area and percentage to the total reported area increased during the study period. Cropping intensity has also increased from 134% in 1966-67 to 189% in 2017-18 but has sown a marginal decline since 2012-13.

TABLE 3. PRODUCTIVE UTILIZATION OF LAND IN PUNJAB ('000 HA)

Year	Total reported area (TRA)	Net area sown (NAS)	Net area sown as % of TRA	Net irrigated area	Net irrigated area as % of NSA	Cropping intensity
1966-67	5025	3807	75.76	2278	59.83	134
1971-72	5031	4076	81.01	2955	72.49	140
1976-77	5033	4167	82.79	3194	76.64	151
1981-82	5033	4210	83.64	3408	80.95	165
1986-87	5033	4202	83.48	3717	88.45	172
1991-92	5033	4215	83.74	3940	93.47	178
1996-97	5033	4223	83.90	3422	81.03	185
2001-02	5033	4254	84.52	4056	95.34	187
2006-07	5033	4184	83.13	4072	97.32	188
2012-13	5033	4150	82.45	4115	99.15	190
2017-18	5033	4125	81.93	4122	99.95	189
2021-22	5033	4124	81.93	4095	99.29	190

3.4 District-Wise Productive Land Utilization

The district-wise distribution of productive land utilization in Punjab is shown in Table 4. The total reported area is the highest in Ludhiana district, followed by Sangrur, Hoshiarpur, Bathinda, and Patiala districts, and the least in Pathankot district. However, the land under the net sown area is the highest in Sangrur, followed by Ludhiana, Bathinda, and Patiala districts, and the least in Pathankot district. Although all majority of the districts have 100% irrigation facilities, different agro-climatic conditions and other constraints have led to different cropping intensities across the districts with cropping intensity ranges from 135% to 201%.

3.5 Impact of Changes in Land Use Pattern

Table 5 presented the results of the analysis of how the agricultural sector (cropping intensity) responded to the changes in various land use categories for the entire Punjab state. To avoid the problem of multicollinearity, the variables were selected based on the correlation matrix. The variables such as area under forest, barren and uncultivable lands,

culturable wasteland, and fallows other than current fallow land were highly correlated with other variables and so, excluded from the model. A perusal of results revealed that the land put to non-agricultural uses, permanent pastures, and other grazing lands, land under miscellaneous tree crops not included in area sown, and the net sown area are the land use categories that have shown a significant positive impact on cropping intensity.

TABLE 4. DISTRICT-WISE PRODUCTIVE LAND UTILIZATION IN PUNJAB: 2021-22 (AREA IN '000 HA)

District	Total reported area (TRA)	Net area sown (NAS)	Net area sown as % of TRA	Net irrigated area	Net irrigated area as % of NSA	Cropping intensity (%)
Gurdaspur	257	208	81	208	100	196
Pathankot	94	47	51	47	100	200
Amritsar	264	219	83	219	100	188
Tarn Taran	241	217	90	217	100	183
Kapurthala	167	132	80	132	100	201
Jalandhar	266	242	93	242	100	171
S.B.S. Nagar	127	93	76	93	100	194
Hoshiarpur	339	205	60	205	100	165
Rupnagar	139	84	58	75	89.3	164
S.A.S. Nagar	121	86	64	86	100	135
Ludhiana	368	299	81	284	95.0	189
Firozpur	239	218	91	218	100	184
Fazilka	287	257	88	257	100	193
Faridkot	147	128	86	128	100	196
Sri Muktar Sahib	264	230	86	229	99.6	200
Moga	223	194	87	194	100	201
Bathinda	337	283	87	283	100	198
Mansa	214	184	86	184	100	201
Sangrur	361	314	87	310	98.7	199
Barnala	141	125	88	125	100	199
Patiala	322	258	80	257	100	197
Fatehgarh Sahib	115	102	89	102	100	186
Punjab	5033	4124	82	4095	97.7	190

The regression coefficients of land put to non-agricultural uses (0.34), permanent pastures and other grazing lands (0.07), land under miscellaneous tree crops not included in area sown (0.08), and net sown area (2.75) indicate that each percentage increased in the area of this land categories might increase the cropping intensity of the state. On the other hand, the current fallow (-0.05) showed a negative and significant impact on the cropping intensity indicating that the increase in this land category might decrease the total cropping intensity in the state.

TABLE 5. IMPACT OF CHANGES IN LAND USE PATTERN ON CROPPING INTENSITY

Explanatory variables	Coefficients	p-value
Land put on non-agricultural uses	0.34 (0.08)	0.00*
Permanent pastures and other grazing lands	0.07 (0.03)	0.03**
Land under miscellaneous tree crops not included in area sown	0.08 (0.02)	0.00*
Current fallows	-0.05 (0.03)	0.05***
Net sown area	2.75 (0.83)	0.00*
Constant	-19.92 (7.16)	0.00
R-squared	0.79	
Adjusted R-squared	0.69	
F-statistic	25.71	

*Note *, ** indicates significance at 1% and 5% level*

Since the 1960s, the state has been adopting a highly intensive agriculture system (particularly rice-wheat), with the availability of HYV seeds, fertilizer, and irrigation infrastructure, as well as a price support system and an effective marketing system (Singh and Kaur, 2012). With the commercialization of the agricultural sector and increasing population, the area under culturable wasteland, current fallow, and barren and unculturable land categories have great pressure on crop production and urbanization and infrastructural development and it has also shown a drastic decline in the area of these land categories. And eventually, the net sown area and land put to non-agricultural use has increased and cropping intensity *per se* to meet the increasing food demand. However, this accomplishment has come at a high cost in terms of environmental degradation in the form of groundwater depletion, and deterioration of soil health such as alkalinization, salinization, barrenness, and desertification (Dhillion *et al*., 2010). and thus, the net sown area has declined since the 2000s and this decline is consistent with the increase in current fallow in the state. The demand for land resources for settlement and non-agricultural activities has also increased along with the food crop as the population has grown. Therefore, a desirable sectoral approach should be made with modern technology to enhance the productivity of food crops sustainably with the changing land use pattern.

IV
DISCUSSION

4.1 Changes in Land-Use Pattern

The land use pattern in Punjab shows a significant shift over the study period, with various implications for ecological and economic sustainability. While the forest area experienced significant growth during the period I, there was a subsequent decline in period II, which could be due to deforestation and poor state planning as the public expenditure on forest and wildlife had declined (Singh et al., 2021). Similar growth results were found in forest areas while studying the dynamics of land use patterns in Tamil Nadu (Ramasamy *et al*., 2005). Therefore, this highlights the needs of sate interventions and sustainable forest management policies to counter this trend. The increasing demand for land for non-agricultural uses reflects the increasing pressure of urbanization and infrastructure development, which is primarily dependent on the growing population, industrial and service sectors. The decline in barren and uncultivable land might be due to proper soil-water conservation and reclamation measures by the government for agricultural and non-agricultural purposes as the public expenditure on soil and water conservation has been increasing in the state (Singh *et al*., 2021) as well as other illegal encroachment by the public. Similar findings have also been observed in Karnataka (Aravind, 2010).

The reduction in permanent pastures and other grazing lands poses significant challenges for livestock sector and efforts should be made for conservation to support rural livelihoods. Similarly, the decline in culturable wasteland and fellow lands reflects increase pressure on this land resources. Yet, the reversal of trends in fellow land during phase II highlights emerging challenges such as climatic variability, irrigation problems and declining agricultural profitability. The net sown area, despite an overall slight increase, shows sign of reduction in recent years. This decrease is consistent with the increasing total fallow land, and these findings are also consistent with those findings from Bihar (Singh *et al*., 2014). Moreover, growing fallow land and decline in the net sown area are related to changing climatic conditions and other issues such as inadequate irrigation infrastructure, falling soil fertility, and uneconomical crop-farming returns (Alonso-Sarria *et al*., 2016). These changes might significantly impact the livelihood of farmers by reducing the income stability increasing dependence on non-farm activities and increasing vulnerability to economic and environmental shocks.

4.2 Inter-Sectorial Land-Use Shift

The inter-sectorial land use shift analysis shows a significant shift in land use across the different sectors in Punjab over the study period. The findings reveled a transition of land use from desirable ecological and agricultural sector to undesirable ecological and non-agricultural sector, highlighting the economic and ecological consequences of such shift and the need for increased attention. The results are also

consistent with the findings of the study conducted in Jammu and Kashmir (Wani et al., 2009). Such shifts of land use may be mitigated by vertically utilizing land for non-agricultural uses instead of expanding horizontally to meet the rising demand for urbanization and industrialization. Moreover, immediate proper management and regulatory measures should be taken to prevent the natural land resources from deteriorating and shifting to other undesirable uses.

4.3 Productive Land Utilization in Punjab

The decreasing net sown area over the recent years might be attributed to several factors including climate change impacts, soil degradation, and overexploitation of ground water resources and poses significant challenges to the sustainable crop farming and productivity. In contrast, the expansion of irrigated area indicates efforts to intensify agricultural activities added by improvements in agricultural infrastructure. The increase in cropping intensity also reflects intensified land used and a shift towards high input and output farming system in the state.

4.4 District-Wise Productive Land Utilization

The high cropping intensities across the districts shows the robust development of agricultural framework, including assured irrigation facilities, modern technologies and favorable climatic conditions. However, the variation in the productive land utilization across districts was driven by geographical factors, agro-climatical conditions and infrastructural development, emphasizing the need of region-specific strategies to optimized productivity and address the challenges effectively.

4.5 Impact of Changes in Land Use Pattern

Since the 1960s, the state has been adopting a highly intensive agriculture system (particularly rice-wheat), with the availability of HYV seeds, fertilizer, and irrigation infrastructure, as well as a price support system and an effective marketing system (Singh and Kaur, 2012). As a result, the states' cropping pattern has altered from traditional wheat-maize to water-intensive wheat-paddy. Furthermore, with the commercialization of the agricultural sector and increasing population, the area under culturable wasteland, current fallow, and barren and unculturable land categories have great pressure on crop production and urbanization and infrastructural development and it has also shown a drastic decline in the area of these land categories. And eventually, the net sown area and land put to non-agricultural use has increased and cropping intensity per se to meet the increasing food demand. However, this accomplishment has come at a high cost in terms of environmental degradation in the form of groundwater depletion (Kaur and Vatta, 2015), and deterioration of soil health such as alkalinization, salinization, barrenness, and desertification (Dhillion et al., 2010). and thus, the net sown area has declined since the 2000s and this decline is consistent with the increase in current fallow in the state.

The demand for land resources for settlement and non-agricultural activities has also increased along with the food crop as the population has grown. Therefore, a desirable sectoral approach should be developed, integrating policies and modern technology and to promote sustainable land use practices without compromising the food crop productivity specially the livelihoods of small and marginal farmers. Moreover, this approach should be tailored to the state's diverse agro-climatic zones and adapt to the changing land use patterns.

V

CONCLUSION AND POLICY IMPLICATIONS

The paper examined the land use dynamics in Punjab and their implications for the agricultural sector. The findings revealed a significant shift of land from a desirable ecological and agricultural sector to an undesirable ecological and non-agricultural sector. The net sown area in the state had increased till the 1990s and then showed a declining growth rate, indicating that crop farming is being impacted by changing adverse climatic conditions as well as soil and water constraints such as depleting groundwater and soil fertility. Even though majority of the districts have 100% irrigation, the different agro-climatic conditions, and other constraints have shown different cropping intensities. The land put to non-agricultural uses, permanent pastures, and other grazing lands, land under miscellaneous tree crops not included in the area sown, and the net sown area is the land use categories that have shown a significant positive impact on cropping intensity.

It is suggested that an appropriate institutional scientific mechanism be established focusing on sustainable land use practices, efficient water management for adequately managing and conserving land resources. Furthermore, land reform laws and policies must be strictly enforced to preserve dwindling agricultural lands from illegal encroachment and undesirable ecological uses. Therefore, the lands could be used to produce the diverse and growing global food demand, which puts pressure on the agricultural sector for more production. Parallel to the depleting natural land and water resources, declining productivity, and increasing production costs, crop diversification, adoption of precision farming techniques should also be encouraged for sustainable growth as it increases not only farm income and production but also productivity by improving soil fertility and preventing the land and water resources from degradation. Moreover, exploring models for sustainable intensification, precision farming, and advanced conservation agricultural practices may also help in achieving sustainable from crop production that ensure the long-term viability of Punjab agriculture amid changing land use pattern. The expansion of land use for non-agricultural use may be mitigated by vertically utilizing of land instead of expanding horizontally to meet the rising demand for urbanization and industrialization. Moreover, immediate proper management and regulatory measures should be taken to prevent the natural land resources from deteriorating and shifting to other undesirable uses. Future research should be developed and focus on district

specific land use dynamics, the socio-economic impacts of this changes and the ineffectiveness of implemented policies.

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