Shikshan Sanshodhan : Journal of Arts, Humanities and Social Sciences ISSN(o): 2581-6241
Monthly, Peer-Reviewed, Refereed, Indexed Journal Impact Factor: 7.384
Volume - 7, Issue - 8, August - 2024

DOIs:10.2018/SS/202408012 --:-- Research Paper / Article / Review

Towards Sustainability and Future Policy: An Economic and Political Review of Punjab Agriculture and Policy Perspectives

Angad B S Kalsi, Armaan Rawat
Email: angadbsk03@gmail.com , armaan.rawat4567@gmail.com

Abstract: *The paper aims at providing a holistic view of the current state of agriculture in Punjab, which is at a crucial point in terms of sustainability and surmounted with great challenges towards an irrefutable pivot in current structures. It discusses the detrimental problems in key areas such as cropping patterns, irrigation and water resources, as well as power and subsidies for agriculture followed by an econometric analysis of the crucial determinants of agricultural product with respect to the state agricultural Gross Domestic Product, concluded by vital policy suggestions for making agriculture sustainable for future generations.*

Keywords: *Agriculture, Sustainability, Policy Making, Power and Subsidies, Irrigation, Soil Fertility, Farm Incomes.*

1. INTRODUCTION

Contemporary perceptions of Punjab are synonymous with vast farms spanning the majority of the land. Agriculture is a fundamental part of the history, culture, and identity of Punjab. It played a pivotal role in the growth of state economy after the Green Revolution.

Agriculture remained the prime driver of economic prosperity throughout the 1980s and 90s; Currently, this sector seems to be facing major issues- environmental and economic sustainability. This can be observed in the decreasing contribution of agriculture to the state GDP and an overall decline of the agrarian sector.

Environmental problems- such as declining water table due to farming of water-intensive crops such as paddy and groundwater pollution caused by overuse of chemical fertilizers threatens the future of agriculture in the state.

There is a growing urgency to execute major policy changes to counter these problems. This paper provides a brief outline of Punjab and its agriculture sector, followed by an econometric analysis to assess the impact of various factors on the state's agricultural GDP. It concludes with a few policy recommendations to resolve issues of economic and environmental sustainability.

Geography of Punjab

Punjab is in the north of India, bordered by the states of Haryana and Rajasthan in the south, Himachal Pradesh in the northeast, the UT of Jammu and Kashmir in the north, and the UT of Chandigarh in the East. It also shares an international border with the Punjab province of Pakistan in the West. It has an area of 50,362 km^2 with a population of 27,743,338 people (Census India), making it the 19^{th} largest state by area (around 1.5% of the total land area of India) and 16^{th} largest state by population.

It is bordered by the Himalayas in the north and the Thar desert in the south, which affects its climatic conditions as well. Punjab received an average of 57.8cm of rainfall in the year 2019, with 70% of rainfall coming in the monsoon months. Punjab is a semi-arid region; however, water intensive crops are grown in the state through well-developed irrigation facilities (Tewari, Ram, Roy, & Dagar, 2013).

Contribution of Agricultural Sector to State GDP

The agricultural sector used to dominate the state economy, with it being 45-50% of the state economy in the 1980's, averaging a growth rate of around 5.5% (Gulati, Roy, & Hussain, 2021). The sector was the main driver of Punjab's economic growth and made it the richest state by per capita income. However, agricultural growth has slowed down considerably since the 1990's, and there has been a change in the role of agriculture in the economy of Punjab. In the 2000's the sector grew at under 2% signaling that changes need to be made. There has been a consistent decline in the sector's share in the GDP of the state, and in its growth rate.

In 2023-24, Punjab had an estimated nominal GSDP growth rate of 6.8%. The agricultural sector made up 27% of the GSDP, while the manufacturing and tertiary (service) sectors made up 27% and 46% of the GSDP (PRS, 2023). In terms of growth rate, the agricultural sector had an estimated growth rate of 2.3%, as compared to 7.9% for the manufacturing sector, and 7.2% for the tertiary sector (PRS, 2024).

This shows that agriculture is no longer the predominant sector in the economy, declining in both share of GSDP, and growth rate. There is a structural shift taking place, with the tertiary sector growing in importance. However, in comparison to the rest of India, agriculture still has a much larger share in the GSVA (27%), as compared to the rest of India (18%).

Structure of Landholdings

Table 1: Structure Of Land Holdings Punjab vs India

		India		Punjab	
S.I NO	Size Group	Percentage of number of operational holdings to total	Percentage of area operated to total	Percentage of number of operational holdings to total	Percentage of area operated to total
1	Marginal (Under 1 ha.)	67.1	22.5	15.62	2.55
2	Small (1 - 2 ha.)	17.91	22.08	18.57	6.78
3	Semi-medium (2 - 4 ha.)	10.04	23.63	30.83	21.56
4	Medium (4 - 10 ha.)	4.25	21.2	28.35	43.18
5	Large (Over 10 ha.)	0.7	10.59	6.62	25.93
	Total	**100**	**100**	**100**	**100**
	**Data taken from Statistical Abstract of Punjab*				

Punjab has a completely different landholding pattern from the rest of the country. While the majority (67.10%) of farmers in India have marginal landholdings (below 1 ha.), in Punjab the majority (59.18%) of farmers have semi-medium (2 – 4 ha.) and medium (4 – 10 ha.) size landholdings (Agricultural Census 2010-2011).

Cropping Pattern in Punjab

Punjab has over 84% of its land under agriculture and has a very high cropping intensity of 191%.

Post green revolution, Punjab's cropping pattern saw a drastic change. In the 1960's Punjab had a diverse cropping pattern, with wheat, barley, maize, pulses, oilseeds, sugarcane, cotton, bajra all being grown, while paddy only made up a small percentage of crops planted. At this time, wheat and rice only made up 40% of the total agricultural area. However, after the Green Revolution, they make up 84% of the total agricultural area. So, Punjab went from a diverse cropping pattern to a monoculture of paddy and wheat, which was facilitated by an increase in irrigation infrastructure. There was an increase in the planting, and production of wheat and rice, as seen in the table below. Wheat and rice make up the majority of planted crops, are over 90% of the planted area, while other crops like Maize and cotton have declined significantly. Wheat and Paddy from Punjab is very important at the national level, as it contributes nearly 40% of the rice and 25% of the wheat. However, the production of paddy, comes at a cost, since Punjab does not have the agro-climatic conditions conducive to growing rice and paddy is a heavy water consuming crop. From 1980, the area under rice has risen by almost 3 times, which in turn led to an increase in water consumption. This increase in consumption required an increase in irrigation infrastructure as well. Growing these crops also required heavy use of fertilizers, however reduction in both the water table and soil fertility shows the unsustainability of this design. More

water and fertilizer usage are required just to keep existing levels of productivity up, while there are diminishing returns from agricultural output.

Table 2: Cropping Intensity in Punjab

Year	Cropping intensity
1990-91	178
1995-96	187
2000-01	187
2005-06	188
2010-11	190
2015-16	190
2020-21	190
**Data taken from the Directorate of Economics and Statistics Punjab*	

Table 3: Key Cropping and Irrigation Statistics in Punjab over the years

Year	Gross Sown Area	Gross Irrigated Area	Irrigation Ratio
1990-91	7501	7055	0.941
1995-96	7752	7377	0.952
2000-01	7941	7664	0.965
2005-06	7868	7680	0.976
2010-11	7883	7724	0.980
2015-16	7872	7765	0.986
2020-21	7835	7687	0.981
**Data taken from the Directorate of Economics and Statistics Punjab*			

Table 4: Area under Major Crops (in Thousand Hectare)

Year	Wheat	Rice	Cotton	Maize	Sugarcane
1980-81	2812	1183	649	382	71
1990-91	3273	2015	701	188	101
2000-01	3408	2612	474	165	121
2010-11	3510	2826	483	133	70
2018-19	3519	3102	268	109	95
2019-20	3521	3142	248	115	91
2020-21	3530	3149	252	108	89
2021-22	3526	3143	250	105	87
2022 - 23 (P)	3517	3168	249	93	90.3
**Data taken from Statistical Abstract of Punjab*					

2. Economic Background and Determinants :

Farming serves as the basic pillar of human civilisation without which we cannot prosper ample supply of biological energy via nutrient consumption. Agriculture served as the nucleus of social formation in early human cultures, which further evolved into an agrarian economy as the complexity of human culture increased and labour division started taking place. Agrarianism can be seen as the dawn of nomadic cultures and advent of early human settlements. (Backhaus, 2012)

A fundamental trait of agriculture binds it deeply to economics, that beings its inevitable need for resource transformation and division. It divides natural resource in terms of cultivation and yield. Thereof, economics can be said to begin, the resource-scarcity aspect of economics has been ascertained as a fundamental assumption in formulation of any economic theory, regardless of origin and dimension. It therefore, asserts its direction towards being a part of an economic problem.

This paper does not aim at exploring the organisational organons of agriculture or production in that matter. It however, focuses on the bridge between the two fields, that being policy. Policy is seen quite differently in various

branches of social science, where its relevance can range from being a tool for understanding historical rationality or evoking a spirit of knowing, to accounting for the future based on the current scientific paradigm.

Water Table

Studies conducted by Punjab Agricultural University (Brar, et al., 2017) (Aggarwal, et al., 2020) shows the how the water table in Punjab has steadily declined in the past twenty years at an average rate of 53.6cm per year.

According to the annual Groundwater Resources of Punjab State report prepared by the Ground Water Management Circle Water Resources Department, Punjab and the Central Ground Water Board Northwestern Region in 2022, several blocks in districts like Barnala, Moga, Jalandhar and Sangrur have shown a decline of over 70cm in their water table. In 49% of blocks, the water table depth has gone to 20 meters below, which is sign of concern. Similarly, 76% of blocks in Punjab (114/150) were classified as overexploited, meaning that the stage of groundwater extraction was more than 100% of its recharge. Districts like Sangrur (313%), Malerkotla (303%), Jalandhar (254%) and Moga (234%) all have exceptionally high stages of groundwater extraction. For Punjab as a whole, it is 164%, which is clearly unsustainable and is the highest in the country. Reports from the Central Groundwater Board in 2019, and 2022 have repeatedly raised concern over the rapid fall in water table across Punjab, and its disastrous consequences for agriculture. A committee of the National Green Tribunal also estimated that Punjab may run out of water by 2039, if extraction continues at this rate. This high rate of groundwater extraction also puts Punjab at a high risk of desertification.

Table 5: State of Groundwater Extraction in Punjab

Stage of Ground Water Extraction Category	
≤70%	Safe
> 70% and ≤90% Semi-Critical	Semi-Critical
> 90% and ≤100%	Critical
> 100%	Over Exploited

Table 6: Important Groundwater Statistics in Punjab

Important Groundwater Statistics for Punjab	
Change in Annual extractable groundwater resource	351739 ham (17.08% decrease)
Change in Total annual ground water recharge	385734 ham (16.9% decrease)
Change in net groundwater available for future use	5069 ham (3.1% decrease)
**Data taken from ground water resources of Punjab; report published under Central Ground Water board*	

Irrigation

Irrigation plays a vital role in ensuring that agricultural land fit for any sort of cultivation can bring about yields. Irrigation in Punjab is a multifaceted concern not spreading across a plethora of socio-economic issues immersed in a deeply rooted political stronghold. (Singh & Bhangoo, 2013)

The pricing and usage of irrigation has led to improvident usage of groundwater usage. (Gupta, 2021) The issue stems from the structural shift in pumping technology, this increase in efficiency in water pumping relative to its fuel and power cost is unbalanced, thus leading to an imperceptive cost of irrigation relative to its natural resource depletion. The monetary incentive provided to the farmers through government initiatives such as subsidies on power and other implements allow them to overlook the ongoing exploitation.

Table 7: Distribution of Pumps in Punjab, Electric vs Diesel Operated

Year	Diesel operated	Electric operated	Total (in lakh)
1990-91	2	6 (75%)	8
2000-01	2.85	7.88 (73.84%	10.73
2010-11	2.4	11.42 (82.6%)	13.82
2015-16	1.65	12.54 (88.37%)	14.19
2019-20	1.4	13.36 (90.5%)	14.76
**Data taken from Statistical abstract of Punjab, various editions*			

The above table shows the increasing shift from diesel operated to electric operated pumps in Punjab. This shift can be explained given the beneficial properties of submersible (electric operated) over centrifugal pumps (diesel operated), in reaching a greater depth of water and greater horsepower at less fuel costs (a single time investment that has a high return with increase in time) (Moench, 2007). Table 3 shows that the irrigated area has reached a peak around 98% of the gross sown area being irrigated.

Another area of concern comes from the increasing pollution of groundwater in Punjab, which is expressed as a percentage in Table 8. It shows the high levels of pollution in water resources, which may soon be unfit for cultivation. A major contributor to this problem is the overuse of fertilizers and pesticides.

Table 8: Suitability of Groundwater for Irrigation in Punjab

Ground Water Suitability for irrigation	
% of ground water unsafe	33% (109 out of 330)
% of ground water marginally polluted	11.8% (39 out of 330)
% of groundwater safe or suitable	55.1% (182 out of 330)
**Data taken from Ground Water resources of Punjab State,2022*	

Power and subsidies

Table 9: Power subsidy in Punjab from 1990 to 2020

Year	Power Subsidy (Rs Crore)
1990-91	385
1995-96	693
2000-01	1,659
2005-06	1,362
2010-11	3,487
2015-16	5364.77
2020-21	10150.81
**Data taken from tariff orders of PSPCL, various editions*	

Power subsidies in Punjab, moreover India have remained quite a troublesome issue as the egoistically motivated distribution and politicization of subsidies have caused it to become more than an auxiliary to agricultural production, an electoral bait, perhaps. (Jain, 2006)

Power is maintained by the Punjab State Electricity Board (PSEB) via the Punjab State power corporation limited (PSPCL), and the Punjab State Transmission Corporation Limited (PSTCL), whose tariff structures decide the amount of subsidy claimed from the government. Its actions in subsidies, are mainly centered around cross-subsidies with certain categories of consumers (commercial and large) and agricultural subsidies on water pumps.

However with the existence of some sort of political business cycle in Punjab, since 1997, there has been direct subsidization in the form of free power to subsidized consumers (scheduled castes and non-scheduled Below Poverty castes). (Kaur & Sharma, 2012) Figure _ shows the increase in subsidies in Punjab from 1990 to 2020, which shows approximately an increase of 26 times its original value in 1990, making it a major drain on the state's finances.

The Power sector has seen quite a few drawbacks, given its flat tariff policy for agriculture and subsidy provided to consumers, one being its hand in furthering inequality as the rich farmers which have access to electric pumps benefit. The other being an unreliable system of calculating and meeting energy demands, as free units disrupt the regular energy accounting process, and an additional factor being the high cost of metering tube-wells. (Meenakshi, Banerji, Mukherji, & Gupta, 2013). Additionally, it surmounts the issue of groundwater exploitation using electric operated pumps, which play a major role in facilitating the over extraction of groundwater in the state.

3. Econometric Analysis :

The regression equation has been chosen to estimate the effect of select agricultural variables, the data taken is from 1990 to 2020*. Power subsidy and fertilizer have been taken as the central focus of the model, and irrigation ratio has been taken for model parsimony.

OLS model has been specified as a double log model with critical determinants of agricultural products namely, irrigation ratio (IRGR), fertilizer used per hectare (NPK), power subsidy (PS), and finally the regressand Gross Domestic State Product from Agriculture (GSDPA) in Punjab.

$$\text{GSDPA} = \beta_0 + \beta_1 NPK + \beta_2 PS + \beta_3 IRGR$$

	Regression results and coefficients				
Coefficient	Intercept	NPK	PS	IRGR	
Estimate	9.40***	0.21*	0.04*	5.38***	
Std. Error	0.477	0.09	0.016	1.06	
t-value	19.682	2.275	2.411	5.054	
	Adjusted R^2 =0.94				
Significance:	'***' 0.001	'**'0.01	'*'0.05		

The Ceteris paribus effect of the independent variables fertillizer, power subsidy, and irrigation are found to be significant. Where fertilizer and power subsidy have 95% level of confidence, and 99% for irrigation. The effects as per the model specification, show that a 1% increase in the fertilizer results in 0.21% increase in GSDPA which can be expected given the overuse of fertilizers in Punjab. Similarly, power subsidy has an effect of 0.04% increase in GSDPA for a 1% increase in power subsidy, which can be used to show the ineffectivity of power subsidy in acting as an impetus towards production. The effect of irrigation is much greater than the latter is a 5.38% increase in the GSDPA for 1% increase in the irrigation ratio, which is to be expected as per the theory of agricultural production, it re-emphasises the importance of water in producing productive gains.

The equation explains 94% of the variation in agricultural growth for the given period. Tests for Heteroskedasticity, Autocorrelation, and multicollinearity had been conducted on the model using the respective tests: Breusch-Pagan Test, Durbin- Watson, and variance inflation factor for OLS. Heteroskedasticity and autocorrelation were rejected with p-value favouring the null hypothesis.

4. Policy Recommendations :

Diversification from paddy to other crops is the need of the hour in Punjab, as paddy cultivation is both economically, and environmentally unsustainable and has caused a rapid depletion in the water table in the state. A more diversified cropping pattern can help in solving both of these problems.

Diversification to Maize –

Before the Green Revolution, maize was one of the staple crops of Punjab until the 1970s, but now makes up less than 2% of the total cropped area (ibid). Increasing maize cultivation in Punjab is a way of diversifying the cropping pattern and can be linked to various other industries as well. The primary use of maize is for fodder for livestock and poultry. Growing for this purpose has a lot of potential in Punjab, as it can support the poultry and dairy industry as well. According to ICAR (Indian Council for Agricultural Research) India faces an overall net deficit of 35.6% of green fodder (Mishra, 2019) and the demand for fodder is also high in states like Punjab, Haryana and Uttar Pradesh where the dairy and livestock sector are fairly well developed, and growing fodder for these sectors can provide economic incentive for farmers to switch to maize from paddy.

Maize is extremely important for producing foodstuffs like cornmeal, which is used for making a variety of food products. Maize has many derivatives such as corn syrup which is a popular alternative to cane sugar.

Maize production also has industrial uses, the most significant of which is ethanol production, made by distilling corn and can be used as a major fuel source for industries and cars. Ethanol production makes up the second largest usage of corn in the US, after livestock/poultry fodder (Ranum, et al., 2014).

Others like the medical and pharmaceutical industry, fertilizers, pesticides, and the production of whiskey all utilize corn and corn-based products, showing potential for maize production in Punjab.

However, maize farmers in Punjab currently face several problems that discourage the large scale growing of maize. While the cost of cultivation of maize is lower than that of paddy, the productivity of HYV of paddy is greater and provides more economic returns. Maize cultivation faces input problems such as lack of High Yield Variety (HYV) seeds and labour shortages during the planting season along with issues of lack of technical knowledge; late sowing of crops, not applying proper seed treatment, and insufficient use of fertilizers leading to lower productivity and profit. It also faces recurring institutional issues- for instance, a lack of proper access to credit, issues with market infrastructure, lack of proper dryers, storage, and processing units in mandis and issues with a lack of market information all of which hinder maize production (Kumar, 2024) (Chahal and Kataria, 2010). These issues must be resolved in order to encourage more farmers to shift from paddy to maize.

Diversification to Horticulture

Horticulture (growing fruits and vegetables) currently only makes up 5.37% of the total cropped area in Punjab, but it provides over 14% of GSVA of agriculture (Department of Horticulture Punjab, 2024). As growth from cereals, grains and rice has been saturated, horticulture can be the way forward for increased economic growth and value addition as fruits and vegetables provide high profitability rates. For India as a whole, horticultural crops are around 13% of the total cropped area but provide over 30% of the gross value added by the sector (Joseph, et al., 2021) (Department of Agricultural Welfare). The aim of the Punjab government should be to take steps in the next 5-10 years to reach the national average of 13% of area under horticultural crops. Horticulture can be the source for bolstering farmer income as it provides high returns per unit, alongside diversification of the cropping pattern.

However, this must be carried out alongside infrastructure development, like setting up of cold storage facilities, and proper supply chains in order to reduce post-harvest losses and spoiling of crops.

Diversification to other miscellaneous crops

The area under pulses has also declined significantly from the 1970s, but pulses like gram, lentils and chickpeas can be viable crops to diversify with, as they have lower water consumption demands than paddy, and can help improve the soil quality through nitrogen fixation, thereby promoting environmental sustainability (Singh and Bansal, 2020).

Similarly, the area under crops likes oilseeds and millets has also declined as compared to the 1970s. However, a return to these crops may be the solution to the diversification problem. Both millets like bajra and oilseeds have lower water consumption than paddy. Oilseeds provide high levels of profitability, and can be used to bridge India's import gap in items like sunflower oil (Sandu, The Tribune, 2022). Millets like bajra and jowar on the other hand, have been a part of Punjab's traditional diet for centuries, and are nutritionally superior to grains like wheat. Millets also consume less than $1/10^{th}$ of the water per acre as compared to paddy and are naturally drought resistant, making them ideal crops to diversify with for Punjab (Sharma, The Tribune, 2023). Millets are also becoming popular worldwide, leading to growing demand in the export market which Punjab's farmers can fill (Press Trust of India & The Business Standard, 2024).

Dairy sector

The dairy sector has quite a promising potential and should be encouraged by the state government. Punjab provides almost 10% of the total milk production of the country and is the 4^{th} largest milk producing state and has the highest per capita milk availability in the country (Gulati, et. Al, 2021) (Bariana, The Tribune, 2020) (Kaur, et al., 2012). Punjab also has a state cooperative of milk producers, called MILKFED (Punjab State Cooperative Milk Producers' Federation Limited) since 1973 which also sells products in neighbouring states as Verka. The problem lies in the untapped potential for milk processing. Wherein only 5% of total milk processing is done by the organized sector(ibid). Rather than selling raw milk, more focus should be on processing, and selling milk products, that provide higher returns. More FPO's (Farmers Producers Organisations) must be encouraged in the state, based on the AMUL model, to set up a competitive dairy sector that is export oriented. Dairy farming has the potential to provide a lucrative source of income for farmers besides paddy farming (Rani and Gagan, 2020). Improvements in infrastructure like cold storage and supply chains are necessary to facilitate this change.

Food Processing

The food processing sector in Punjab is fairly well developed, and it makes up 21% of the states manufacturing GSDP as compared to the national average of 8.8%. Punjab also exports over a billion dollars' worth of food products to countries like the US, UK and various middle eastern countries (Invest India, 2024). More growth can be expected from this sector by directly linking food producers to food processing units especially for wheat, which is currently procured from other states due to higher taxes in Punjab (ibid).

Power Subsidy

Strong policy measures can be suggested towards a more transparent and efficient mode of subsidy dispersal, which foregoes the existing inequitable model. As the gap between progressive and backward areas in terms of subsidy is quite high. Measures towards reducing corruption in power officials during dispersal, establishing a more transparent tariff system based on actual demand, and allocation of subsidies accordingly.

Direct Benefit Transfers(DBT) or the practice of paying subsidies right to the account of farmers is a promising method to enhance efficiency. (Laishram & Kumar, 2020) It reduces the delays in subsidies faced by both producers and power companies. (Chauhan, 2023)

Also, solar power is an alternative energy that can be integrated with its power grid to smoothen distribution and provide a backup for domestic supply in the event of power cuts. Solar power may be the optimal renewable resource

for Punjab. The practical potential level in Punjab at 4.00-4.26 kWh/kWp is below the national average in India at 4.32 kWh/kWp (World Bank, 2024), suggesting a need for further development of solar capital. The Punjab energy Development Authority (PEDA) via the PM Kisan Urja Suraksha Utthaan Mahabhiyan (PM-KUSUM) has initiated the establishment of solar pumps as well as rooftop solar panels to supplement faults in the grid, these implements are liable to receive subsidy on them as per the same scheme. (Punjab Energy Development Authority, 2020). However, such efficient methods should be kept in check for overexploitation of groundwater resource, instead should be slowly used to phase off electric and diesel dependence.

Wind resources as an alternative cannot be feasible in Punjab due to only 2% of its area meeting the 150 W/m^2 mean power density for wind power generation (as per the Global Wind Atlas Maintained by the World Bank group). Thus, making solar its only viable natural resource as of now.

Irrigation

Irrigation is an area that requires urgent transformation in Punjab, where the inability to pivot shall prove to be detrimental. With the increasing burden on groundwater resources and decreasing restorative capacity of water, overirrigation playing a major role in the same. Controlling the use of electric pumps and other exploitative methods is the first step towards sustainability.

Innovations such as micro-drip irrigation, co-regulation of water supply and atmospheric water demand, plant centric supply demand dynamics (SDDs) for irrigation, and atmospheric evaporative demand, sensors for vapour pressure deficit and soil moisture (Zhang, et al., 2021). Micro-drips can reduce the amount of soil being salinized. (Zaman, Shahid, & Heng, 2018). MI along with circular waste-water recycling can be pivotal for groundwater conservation and sustainable agriculture. (Suresh & Samuel, 2020)

Additional institutional Support on the part of the government can be undertaken to incentivize micro-drip irrigation and other sustainable alternatives, similar to the incentives carried out by the government in the Malwa region of Punjab, where subsidies were given to help with infrastructure and connect pipelines for irrigation. (Mohan, 2023)

5. Market and Infrastructure :

Marketization played a pivotal role in Punjab, as it helped align the interests of landowners during the Green Revolution towards the state facilitated productive agronomy for fulfilling the country's food requirements (Singh & Singh, 2020). Currently, there is a decline in market procurement of wheat in comparison to its earlier levels, while rice remains at fairly constant slow growth (Agricultural Statistics at a Glance, 2023). MSP should be diversified to facilitate the shift highlighted in the above recommendations to be able reach more farmers and have a greater impact.

6. Conclusion :

Major reforms are needed to facilitate the longevity and prolonged productivity of the agricultural sector of Punjab, as well as deal with structural issues like groundwater depletion, decreasing fertility of soil, toxicity of groundwater, diminishing returns to inputs, and rural distress caused by the disruptions in agricultural incomes. A shift towards a more economically and ecologically sustainable model of agriculture is the need of the hour. The Regression analysis carried out showed that to implement an increase in agricultural product the factors of production, namely irrigation rate must be increased, which in addition to the current state of agriculture highlights the issue that there exists a forthcoming wave of exhaustion in increasing returns to agriculture in its current state.

The state and its government need to adopt stern measures to circumvent a halt in its future agricultural functioning. Crucial areas directly correlated to agricultural output such as irrigation must be switched to more sustainable alternatives, power subsides must be implemented in such a way as to ensure efficiency, transparency and promote sustainability. Instead of a conservative shift, novel measures and policies must be adopted to pivot from the situation at hand.

REFERENCES :

1. Aggarwal, R., Kaur, S., & Gill, A. K. (2020). Groundwater Depletion in Punjab. *Punjab Agricultural University*.
2. Backhaus, J. G. (2012). *Handbook of the History of Economic Thought.* Springer.
3. Brar, M. S., Agarwal, R. A., & Kaur, S. (2016). GIS based investigations on ground-water behaviour in Indian Punjab. *Agricultural Research Journal*.
4. Census India. (n.d.). *Punjab Literacy Rate - Census 2011.* Census India.

5. Central Groundwater Board, Department of Water Resources, Ministry of Jal Shakti. (2023). *National Compilation of Dynamic Groundwater Resources.* Central Groundwater Board, Department of Water Resources, Ministry of Jal Shakti.
6. Chaba, A. A. (2020, March 7). *Why Punjab wants to push Pulses Cultivation* . Retrieved from Indian Express: https://indianexpress.com/article/explained/why-punjab-wants-to-push-pulses-cultivation/
7. Chahal, S. S., & Kataria, P. (2010). Constraints in the Production and Marketing of Maize in Punjab. *Agricultural Update* , 228-236.
8. Chauhan, N. (2023). India's Electricity Subsidy Gaps and Challanges. *Soial Policy Research Foundation*, 7-8.
9. Department of Agriculture and Cooperation; Ministry of Agriculture. (2010). *Agricultural Census.* Department of Agriculture and Cooperation; Ministry of Agriculture.
10. Department of Agriculture and Farmers Welfare. (2021). *Horitculutal Statistics at a Glance.* Department of Agriculture and Farmers Welfare.
11. Desk, T. W. (2020, March 10). *Punjab Truly Land of Milk, Tops the Chart* . Retrieved from Tribune India : https://www.tribuneindia.com/news/punjab/punjab-truly-land-of-milk-tops-the-chart-53517
12. Directorate of Statistics, Department of Planning, Government of Punjab. (2022). *Punjab Economic Survey.* Directorate of Statistics, Department of Planning, Government of Punjab.
13. Dubey, S. C. (2021). Retrieved from Department of Animal Husbandry and Dairying: https://dahd.nic.in/sites/default/filess/RS2021.pdf
14. Economic Division, Department of Economic Affairs, Ministry of Finance, Government of India. (2023). *Economic Survey.* Economic Division, Department of Economic Affairs, Ministry of Finance, Government of India.
15. Ground Water Management Circle, Water Resources Department Punjab. (2022). *Ground Water Resoources of Punjab State.* Ground Water Management Circle, Water Resources Department Punjab.
16. Gulati, A., Roy, R., & Hussain, S. (2021). Performance of Agriculture in Punjab. *India Studies in business and Economics*, 77-112.
17. Gupta, D. (2021). Free Power, Irrigation and Groundwater Depletion: Impact of the Farm Electricity Policy of Punjab, India. *Centre for Development Economics*, 5-6.
18. Jagga, R. (2022, February). *Migrants in Punjab and why they matter.* Retrieved from Indian Express: https://indianexpress.com/article/explained/explained-migrants-in-punjab-and-why-do-they-matter-7780706/
19. Jain, V. (2006). Political Economy of the Electrical Subsidy: Evidence from Punjab. *Economic and Political Weekly*.
20. Kaur, I., Singh, V., Kaur, H., & Singh, P. (2012). Cost of Milk Production in Punjab: A Pre-Requisite for Pricing Policy. *Indian Research Journal of Extension Education Special Issue Vol. I* , 313-314.
21. Kaur, R., & Sharma, M. (2012). Agricultural Subsidies in India: Case Study of Electricity: Subsidy in Punjab State: An Analysis. *International Journal of Scientific and Research Publications, Volume 2, Issue 10.*
22. Kumar, N. (2019). Agricultural Situation in Punjab: An Analysis of Transformations from Labour Intensive Farming to Capital Intensive Farming . *Economic Affairs* .
23. Kumar, S., & Grover, D. (2024). Maize (Fodder) in Punjab: An Economic Analysis. *Indian Journal of Agricultural Research* , 307-312.
24. Laishram, R., & Kumar, A. (2020, January 13). The promise and challenges of India's Direct Benefit Transfer agricultural subsidies. *International Food Policy Research Institute*.
25. Meenakshi, J., Banerji, A., Mukherji, A., & Gupta, A. (2013). *Does Marginal Cost Pricing of Electricity affect Groundwater pumping behaviour of farmers?* International Journal of Scientific and Research Publications, Volume 2, Issue 10.
26. Misra, A., & Institute, I. N. (2019). Fodder Production and Utilisation Strategies for Sustainable Livestock Development in India . *Indian Agriculture Research Journals*.
27. Moench, M. (2007). When The Wells Run Dry But Livelihood Continues: Adaptive Responses to Groundwater Depletion and Strategies for Mitigating the Associated Impacts. *The Agricultural Groundwater Revolution: Opportunities and Threats to Development*.
28. Mohan, V. (2023, October). *For Punjab, popularising canal irrigation to be uphill task.* Retrieved from Times of India: https://timesofindia.indiatimes.com/city/chandigarh/for-punjab-popularising-canal-irrigation-to-be-uphill-task/articleshow/104507122.cms
29. Others. (2023, January 14). *Punjab Can Sow Seeds of A Millet Revolution*. Retrieved from Tribune India : https://www.tribuneindia.com/news/comment/punjab-can-sow-seeds-of-a-millet-revolution-470147

30. Press Trust of India and Business Standard . (2024, February 13). *APEDA facilitates Punjab Farmer to Export Millet to Australia, Says Govt.* . Retrieved from Business Standard: https://www.business-standard.com/industry/agriculture/apeda-facilitates-punjab-farmer-to-export-millets-to-australia-says-govt-124021301407_1.html
31. *Punjab Budget Analysis 2024-25*. (2024). Retrieved from PRS India: https://prsindia.org/budgets/states/punjab-budget-analysis-2024-25
32. Punjab Energy Development Authority. (2020). *Punjab Energy Development Authority*. Retrieved from Punjab Energy Development Authority: https://www.peda.gov.in/assets/media/gallery/SWP.pdf
33. Ranum, P., Pena-Rosas, J., & Garcia- Casal, M. N. (2014). Global Maize Production, Utilisation, and Consumption. *Annals of the New York Academy of Sciences*.
34. Sandhu, K. (2022, March 8). *Spotlight Back on Oilseed Cultivation in Punjab as Import Hit Due to Ukraine Crisis*. Retrieved from Tribune India: https://www.tribuneindia.com/news/punjab/spotlight-back-on-oilseed-cultivation-375963#
35. Singh, I., & Bhangoo, K. S. (2013). Irrigation System in Indian Punjab. *Munich Personal RePEc Archive*, 2.
36. Singh, L., & Bansal, S. (2020). Pulses in Punjab: Growth Rate and Decomposition Analysis. *International Journal of Farm Sciences*.
37. Singh, P., & Singh, I. (2020). Political Economy of Capitalist Development in Punjab Agriculture. *Agrarian South: Journal of Political Economy*.
38. Suresh, A., & Samuel, P. M. (2020). Micro-irrigation development in India: challenges and strategies. *CURRENT SCIENCE, VOL. 118, NO. 8*.
39. Tewari, J. C., Ram, M., Roy, M., & Dagar, J. C. (2013). LIvelihood Improvemnets and Climate Change Adaptations Through Agroforestry in Hot Arid Environments. *Advances in Agroforestry*, 155-183.
40. TNN. (2022, June 20). *Initiating the International Year of the Millets 2023 from Punjab* . Retrieved from Times of India : https://timesofindia.indiatimes.com/entertainment/events/chandigarh/initiating-the-international-year-of-the-millets-2023-from-punjab/articleshow/92344720.cms
41. Vasudev, K. (2024, June). Retrieved from Indian ExpressCanal Water reaches several Punjab villages after decades amid fears of desertification: https://indianexpress.com/article/cities/chandigarh/canal-water-punjab-villages-decades-fears-desertification-9404344/
42. Welfare, D. o. (2023). *Agricultural Statistics at a Glance*. Ministry of Agriculture and Frmer Welfare.
43. World Bank. (2024). *GLOBAL PHOTOVOLTAIC POWER POTENTIAL* |.
44. Zaman, M., Shahid, S. A., & Heng, L. (2018). rigation Systems and Zones of Salinity Development. In: Guideline for Salinity Assessment, Mitigation and Adaptation Using Nuclear and Related Techniques . In *Irrigation Systems and Zones of Salinity Development* (pp. 91-111). Springer.
45. Zhang, J., Guan, K., Peng, B., Pen, M., Zhou, W., Jiang, C., . . . Grant, R. (2021). Sustainable irrigation based on co-regulation of soil water supply and atmospheric evaporative demand. *Nature Communiaction*.