

An Empirical Analysis of Input Use Dynamics in Punjab Agriculture

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Abstract

This study analyzed the agricultural input use patterns from 1990-91 to 2021-22 in Punjab's agriculture using the secondary data. The findings of the study revealed that there has been significant increase in area sown more than once and gross irrigated area in the state during the study period. The area under total cereals has increased significantly, while, pulses and oilseeds exhibited significantly declining trends. Fertilizer consumption, particularly nitrogenous and potassic types, has risen significantly, underscoring its critical role in productivity enhancements. Irrigation patterns indicated a growing reliance of state's farmers on tube wells. The study also highlighted changes in pesticide usage, reflected evolving agricultural practices. Overall, while there has been improvement in yield of major crops and mechanization in the state. the future policies should focus on resource-efficient practices and mitigating environmental impacts to ensure long-term agricultural growth and resource conservation in Punjab.

Keywords: Cropping pattern, fertilizers, irrigation, mechanization

JEL Classification: Q12, Q16, Q18, Q20

Introduction

Punjab, often referred to as the “Granary of India,” has played a crucial role in the country’s agricultural landscape. The agricultural sector of Punjab has been a significant contributor to both the national and state economies, with agricultural and allied activities accounting for approximately 28.94 per cent of the Gross State Value Added (GSVA) and employing 25.54 per cent of the state’s workforce (Government of India, 2022-23). The state’s agricultural growth has been closely linked to the Green Revolution, which was characterized by the introduction of modern agricultural technology and inputs. The adoption of hybrid seeds, chemical fertilizers, extensive irrigation infrastructure, agro-chemicals for pest management, and mechanization have been pivotal in enhancing agricultural production of the state (Sharma and Gandhi, 1990; Gandhi et al., 2004; Kumar et al., 2012). Over the decades, Punjab agriculture has undergone remarkable transformations, driven by changing input use patterns, technological advancements, policy interventions, and socio-economic dynamics. The Green Revolution marked a shift towards the use of high-yielding variety seeds, chemical fertilizers, and investments in irrigation—particularly tube wells—alongside agro-chemicals for disease, weed, and pest management, and mechanization to ensure efficiency in farm

operations. These advancements were further supported by favorable output pricing policies and subsidies for inputs like fertilizer and electricity, which collectively facilitated rapid agricultural growth and prosperity in the region (Saran et al., 2013 and Gulati et al., 2021).

However, recent years have brought several challenges to Punjab’s agricultural sector, necessitating a re-evaluation of agricultural input use patterns. Issues such as declining soil health, groundwater depletion, environmental degradation, changing climatic conditions, and socio-economic factors have highlighted the need for a more sustainable and resilient approach to Punjab. There has been a noticeable shift in the input use pattern of Punjab’s agriculture, marked by efforts to promote resource-efficient practices, reduce chemical dependency, and enhance ecological sustainability. The constraint of limited land area for production growth has necessitated a significant reliance on yield increase to enhance agricultural production. Gandhi (2021) stated that the increasing demand of rising population in the country has resulted in shortages of fundamental natural resources such as water and land in recent decades. The state has virtually reached the saturation point in the matter of addition to the physical area horizontally. Therefore, sustainability in the growth of production per unit of land area has to come by increasing the input use efficiency or upward shift in the

use of technology as the profitability and competitiveness of Punjab's agriculture are intricately linked to its input use efficiency. Since the mid-1990s, the state has experienced a slowdown in agricultural expansion and decline in profitability (Sidhu et al., 2005). The indiscriminate use of chemical inputs, excessive groundwater extraction, and monoculture practices have raised concerns about long-term environmental degradation and ecosystem resilience. The sustainability of Punjab's agriculture depends upon its ability to adopt resource-efficient practices and mitigating environmental impacts. This situation underscores the importance of understanding the changing input use patterns in the state for promoting sustainable agricultural growth and conservation of natural resources.

Data Sources and Methodology

The present study was based on secondary data spanning the period from 1990-91 to 2021-22. This timeframe was selected to analyze the dynamics of agricultural input usage in Punjab following the economic reforms in India. Based on the availability of the data, the changes in agricultural input use pattern were examined for various important inputs such as land, seed, fertilizers, irrigation, pesticides, farm machinery, and labour. The data were collected from various reliable published sources. These sources included the various issues of Statistical Abstract of Punjab, Economic Survey of Punjab, and Agricultural Statistics at a Glance. Thereafter, the compound annual growth rates (CAGR) were calculated for analyzing the trends and growth of these inputs. The results have been presented in tables and figures to illustrate the trends and facilitate a comprehensive discussion on the implications of these changes for the state's agricultural sustainability.

Results and Discussion

Land use pattern

Land is a fundamental input for agriculture and occupies

an important position among all resources. The analysis of land use patterns in Punjab from 1990-91 to 2021-22 showed that with constant geographical area of 5036 thousand ha, the barren and unculturable land in the state has decreased during the study period, though its CAGR was non-significant (Table 1). Similarly, the area under forest showed fluctuations which may be due to favorable impacts of afforestation and forest related policies of state and central government during the study period (Government of Punjab, 2024). The net sown area has declined slightly at a significant CAGR of -0.10 per cent during the study period, possibly due to urbanization (Singh, 2012 and Arora, 2021). The area sown more than once increased at a significant CAGR of 0.27 per cent demonstrating intensified agricultural practices to maximize productivity. The data also reflected a significantly positive trend in gross irrigated area with CAGR of 0.22 per cent, indicating improved irrigation infrastructure in the state.

Area under different crops

The area under different crops sown in the state has been given in Table 2. Rice and wheat cultivation area showed an overall increasing trend, with higher significant compound annual growth rate (CAGR) of 1.35 per cent for area under rice as compared to wheat (0.23%). The area under total cereals also showed significant increase of 0.62 per cent. The state has extreme specialization of paddy-wheat cropping system which may be attributed to effective implementation of agricultural price policy with minimum support price (MSP) and relative profitability of these crops as compared to other crops (Ali et al., 2012). The area under total pulses experienced a decline, with significantly negative compound annual growth rate of -4.06 per cent, possibly reflecting challenges in pulse cultivation or shifting agricultural priorities. The area under total food grains showed significantly positive growth trend, indicating a continued focus on food grains cultivation. Notably, the area under both total oilseeds and total non-food crops showed

Table 1. Land use pattern in Punjab, 1990-91 to 2021-22

Year	Geographical area	Barren and unculturable land	Area under forests	Net area sown	Area sown more than once	Gross cropped area	Gross irrigated area
1990-91	5036	83	222	4218	3284	7502	7055
2000-01	5036	28	280	4250	3691	7941	7664
2010-11	5036	25	295	4158	3724	7882	7724
2015-16	5036	52	256	4137	3734	7872	7765
2020-21	5036	36	245	4127	3691	7818	7680
2021-22	5036	37	243	4124	3702	7826	7730
CAGR (%)	-	-0.38	0.11	-0.10**	0.27*	0.07	0.22**

Source: Statistical Abstract of Punjab (various issues), Govt. of Punjab

Note: ** and * indicate significance at 1 and 5 per cent level

Table 2. Area under different crops in Punjab, 1990-91 to 2021-22

Year	Rice	Wheat	Total cereals	Total pulses	Total food grains	Total food crops	Total oilseeds	Total non-food crops
1990-91	2015	3273	5525	143	5668	5878	104	1624
2000-01	2612	3408	6223	54	6277	6563	86	1378
2010-11	2826	3510	6484	20	6504	6750	56	1132
2015-16	2970	3506	6615	20	6635	6920	48	952
2020-21	3149	3530	6793	32.8	6826	7062	38	744
2021-22	3145	3526	6782	63	6844	6969	50	737
CAGR (%)	1.35**	0.23**	0.62**	-4.06*	0.57**	0.57**	-3.26**	-2.46**

Source: Statistical Abstract of Punjab (various issues); Economic Survey of Punjab (various issues)

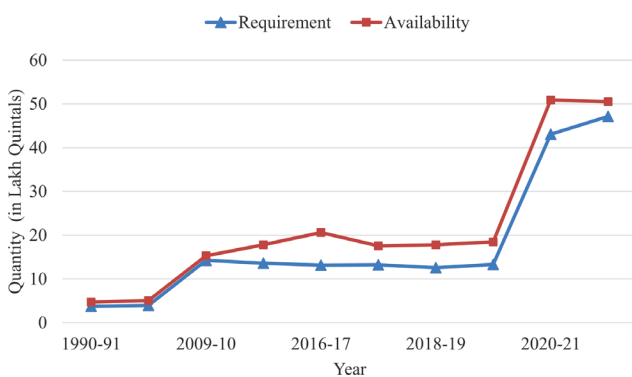
Note: ** and * indicate significance at 1 and 5 per cent level, respectively

significantly negative CAGRs, indicating a decreasing trend in cultivation for these categories over the study period, possibly due to market dynamics or changing agricultural practices. However, in recent years farmers have started growing pulses and oilseeds again due to the increase in its minimum support price.

Seed use pattern

Good quality seed of high yielding varieties has played the most important role in increasing agricultural production in Punjab. The government has also made the efforts to increase agricultural production through total replacement of seed of the self-pollinated crops by every three years and that of hybrids by every subsequent year. Due to sincere efforts of concerned state departments, farmers did not face the shortage of seed of principal crops during the recent years (Fig 1).

The data in Table 3 provides insights into the fertilizer consumption in Punjab over a span of three decades, categorized by nitrogenous, phosphatic, and potassic nutrients, along with the total fertilizer usage. In 1990-91, nitrogenous fertilizers constituted the majority, accounting for about 72



Source: indiastat.com

Figure 1. Hybrid seed requirement and availability in Punjab Fertilizer use pattern

per cent of the total consumption, followed by phosphatic at 27 per cent, and potassic at about 1 per cent. By 2021-22, the dominance of nitrogenous fertilizers remained prominent at about 78 per cent, while phosphatic and potassic fertilizers comprised about 18 per cent and 3 per cent, respectively, of the total consumption. Notably, there has been significant growth in the consumption of nitrogenous and potassic fertilizers, indicated by their significant CAGR of 1.95 and 5.29 per cent, respectively. The significant growth of 1.76 per cent in total fertilizers consumption underscores the state's agricultural sector's reliance on fertilizers to enhance productivity, with potassic fertilizers exhibiting the highest growth rate, possibly reflecting increased awareness of soil nutrient management practices. Overall, the gradual rise in fertilizer consumption highlights Punjab's commitment to enhance agricultural productivity and ensure food security.

Source-wise irrigation pattern

Table 4 showed that the primary sources of irrigation in the state of Punjab have predominantly been canals and tube wells. In 1990-91, canals accounted for about 43 per cent of the total irrigated area, whereas tube wells covered 57 per cent, and other sources represented a negligible 0.18 per cent. Over the years, there has been a noticeable shift in the distribution of irrigation sources. By 2021-22, the share of irrigated area by canals has declined to 28 per cent, while tube wells maintained a dominant position at 72 per cent. Notably, the share of other sources is negligible. This trend highlights a gradual but consistent reliance on tube wells for irrigation purposes over the decades, possibly due to factors such as existing cropping pattern, cheap credit and free electricity. This extensive use of groundwater through tube wells have further led to lowering of the groundwater table in most parts of the state (Dhawan and Singh, 2015). Despite fluctuations, the total irrigated area has significantly increased by 0.13 per cent over the study period, reflecting efforts to enhance agricultural productivity and ensuring food security in the state.

Table 3 Consumption of chemical fertilizers in Punjab, 1991-92 to 2021-22

(000' nutrients tonnes)				
Year	Nitrogenous	Phosphatic	Potassic	Total fertilizers
1990-91	877 (71.89)	328 (26.88)	15 (1.23)	1220 (100.00)
2000-01	1008 (76.77)	282 (21.48)	23 (1.75)	1313 (100.00)
2010-11	1403 (73.42)	435 (22.76)	73 (3.82)	1911 (100.00)
2015-16	1447 (74.47)	418 (21.51)	78 (4.02)	1943 (100.00)
2020-21	1496 (77.19)	384 (19.82)	58 (2.99)	1938 (100.00)
2021-22	1574 (78.42)	366 (18.24)	67 (3.34)	2007 (100.00)
CAGR (%)	1.95**	0.80	5.29*	1.76**

Source: Statistical Abstract of Punjab (various issues)

Note: Figures in parenthesis indicates percentage to total; ** and * indicate significance at 1 and 5 per cent level, respectively

Table 4. Source-wise irrigated area in Punjab, 1991-92 to 2021-22

(000' ha)				
Year	Canals	Tube wells	Other sources	Total
1990-91	1669 (42.70)	2233 (57.12)	7 (0.18)	3909 (100.00)
2000-01	962 (23.82)	3074 (76.13)	2 (0.05)	4038 (100.00)
2010-11	1116 (27.42)	2954 (72.58)	-	4070 (100.00)
2015-16	1201 (29.03)	2936 (70.97)	-	4137 (100.00)
2020-21	1144 (28.27)	2902 (71.73)	-	4046 (100.00)
2021-22	1159 (28.30)	2936 (71.70)	-	4095 (100.00)
CAGR (%)	-0.71	0.64	-	0.13*

Source: Statistical Abstract of Punjab (various issues)

Note: Figures in parenthesis indicates percentage to total; and * indicates significance at 5 per cent level

Pesticides use pattern

The use of insecticides and weedicides have played a crucial role in Punjab's agricultural production. The consumption of insecticides/pesticides in the state for recent years has been given in Fig 2. From 2011-12 to 2015-16, there was a relatively stable consumption pattern, with minor fluctuations within a narrow range. Interestingly, a significant drop has been observed in 2020-21 and 2022-23, with consumption plummeting to 5258 and 5130 tonnes (technical grade), respectively, possibly indicating a shift in agricultural practices or external factors influencing pesticide use.

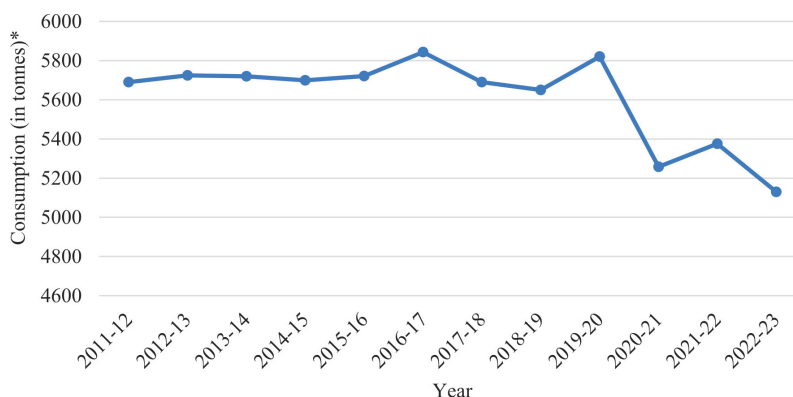
Farm machinery and equipment

The different types of farm machinery utilized and their number has been presented in Table 5. The data shows a significant increase in the number of tractors and combine harvesters, reflecting the widespread mechanization in the state's agriculture. The high mechanization of major farm operations in the state has substantially improved the productivity of crops and the efficiency of farmers by obtaining more output with lesser involvement of labour, increasing cropping intensity and saving their time and

cost (Government of Punjab, 2022-23). The decline in the usage of seed-cum-fertilizer drills and threshers suggests changes in farming practices, possibly due to the adoption of more advanced or alternative technologies, changes in farming practices, economic conditions, and government policies influencing agricultural mechanization. Gulati et al., (2021) revealed that farm mechanization has contributed significantly to the increasing agricultural productivity in Punjab.

Labour use pattern

Punjab experienced a surge in labour demand due to increased crop rotations and higher cropping intensity following the adoption of new agricultural technologies in the mid-1960s. However, the extensive mechanization of agriculture during the 1980s, particularly for harvesting of wheat and paddy and use of labour substituting inputs like weedicides and herbicides, weakened the complementary relationship between agricultural development and labour demand. This resulted in the displacement of a substantial number of agricultural laborers (Dhawan and Singh, 2015). Table 6 presents a comprehensive view of the changing labour use pattern in Punjab. Despite a marginal increase in the absolute number of agricultural labourers, with



Source: Economic Survey of Punjab (various issues); * indicates technical grade

Figure 2. Consumption of pesticides in Punjab agriculture

Table 5. Agricultural Machinery and Implements in Punjab

(in '000')

Particulars	2000-01	2019-20	CAGR (%)
Tractors	395	477	0.95
Disc harrow	255	262	0.14
Seed cum fertilizer Drills	180	145	-1.08
Combine Harvester (Self- propelled)	2.9	8	5.20
Combine harvester (Tractor-driven)	5.1	4.3	-0.85
Threshers	285	88	-5.71
Tube wells	1062	1475	1.66

Source: Economic Survey of Punjab, 2020

compound annual growth rate of 0.61 per cent from 1991 to 2011, their proportion relative to the total main workforce declined significantly from 23.29 per cent in 1991 to 18.79 per cent in 2011. This decline underscored a transition in the composition of Punjab's agricultural labour, with more workers might being absorbed by sectors other than agriculture. Furthermore, Singh and Bhogal (2020) stated that the permanent agricultural labourers in the state had transformed to casual labourers, mainly due to reductions in the demand for labour. Sharma and Sharma (2024) have also revealed a paradigm shift, noting that the share of non-

agriculture employment in the state has increased to 59.3 per cent.

Crop productivity

Table 7 illustrates per hectare annual yield of major crops in Punjab including rice, wheat, maize, sugarcane, and cotton from 1990-91 to 2021-22. Over the decades, different crops have shown distinct patterns of yield growth. Rice and wheat, as staple crops, demonstrated consistent yield improvements, with rice showing significant growth (1.00%) attributed to advancements in irrigation and high-yield varieties. Maize exhibited the highest growth rate among the crops, with a

Table 6. Labour use pattern in Punjab agriculture

Year	Total main workers (lakhs)	Agricultural labour (lakhs)	Percentage of agricultural labour to total main workers
1991	60.36	14.06	23.29
2001	78.35	14.89	19.01
2011	84.50	15.88	18.79
CAGR (%)	1.69	0.61	-

Source: Census of India 1991, 2001 and 2011

Table 7. Yield of major crops in Punjab, 1990-91 to 2021-22

	(kgs/ha)				
Year	Rice	Wheat	Maize	Sugarcane	Cotton
1990-91	3229	3715	1784	55369	463
2000-01	3506	4563	2793	60844	430
2010-11	3828	4693	3707	70059	674
2015-16	3974	4583	3687	73411	376
2020-21	4443	4868	3665	83841	691
2021-22	4340	4216	3930	82153	437
CAGR (%)	1.00**	0.51	2.36**	1.34**	0.45

Source: *Agricultural Statistics at a Glance (various issues)*, Govt. of India

Note: ** and * indicate significance at 1 and 5 per cent level, respectively

CAGR of 2.36 per cent, indicating significant improvements in production efficiency or technological advancements. Sugarcane yields also showed a significantly positive trend with a CAGR of 1.34 per cent, indicating steady growth in sugarcane cultivation and productivity. Cotton, although characterized by variability, recorded a CAGR of 0.45 per cent, aligning with findings by Singh et al. (2023), which noted a significant productivity increase of 1.7 per cent in cotton from 1980-81 to 2019-20 despite declining area and production. These findings provide valuable insights into the agricultural dynamics of Punjab, highlighting the evolving trends and performance of key crops over the years.

Conclusion and Policy Implications

The present study revealed several noteworthy trends in agricultural input use pattern of Punjab. There has been a significant decrease in barren land, indicating efforts towards reclaiming land for agricultural purposes. The shift in cropping patterns, marked by increasing areas under rice and wheat cultivation alongside fluctuating trends in pulses and oilseeds, reflects dynamic agricultural strategies influenced by market dynamics and policy interventions like minimum support prices. Moreover, advancements in seed technology and fertilizer use have contributed to enhanced agricultural productivity, supported by a gradual rise in fertilizer consumption, particularly nitrogenous types. Mechanization has transformed agricultural practices, while altering labour use dynamics. Further, the challenges such as declining groundwater levels due to extensive tube well usage underscore the need for sustainable water management practices in Punjab agriculture. Overall, while the state has made strides in agricultural productivity and mechanization, future policies should focus on balancing productivity gains with environmental sustainability to ensure long-term food security and resource conservation.

References

Ali S Z, Sidhu R S and Vatta K 2012. Effectiveness of minimum support price policy for paddy in India with a case study

of Punjab. *Agricultural Economics Research Review* **25**: 231-242. DOI: 10.22004/ag.econ.137357

Arora M R 2021. Urbanisation and its implications on changing cropping pattern and crop diversification of Bathinda district (Punjab). *International Journal of Multidisciplinary Education Research* **10**: 17-21. <http://ijmer.in/doi/2021/10.06.103>

Census of India (1991, 2001 & 2011). Office of the Registrar General & Census Commissioner, India. <https://censusindia.gov.in/census.website/data/census-tables>

Dhawan V and Singh J M 2015. Role of farm inputs in sustaining Punjab agriculture. *Indian Journal of Economics and Development* **11**: 325-331. DOI: 10.5958/2322-0430.2015.00036.0

Gandhi V P, Zhou Z Y and Mullen J 2004. India's wheat economy: will demand be a constraint or supply? *Economic and Political Weekly* **39**: 23-29. https://www.researchgate.net/publication/262124390_India's_Wheat_Economy_Will_Demand_Be_a_Constraint_or_Supply

Gandhi V P 2021. Indian agriculture at a critical crossroad: change and transformation needed for a bigger future. *Indian Journal of Agricultural Economics* **76**:12-77. <http://isacindia.org/wp-content/uploads/2021/04/02-Presidential-Address-Vasant-Gandhi.pdf>.

Government of India 2022-23. Economic Survey 2022-23. Ministry of Finance, Department of Economic Affairs, Economic Division, New Delhi. <https://www.indiabudget.gov.in/economicsurvey/doc/echapter.pdf>

Government of Punjab 2022-23. Economic Survey of Punjab 2022-23. Directorate of Statistics, Department of Planning, Government of Punjab. <https://punjab.gov.in/wp-content/uploads/2023/10/EconomicSurvey2022-23.pdf>

Government of Punjab 2024. Department of Forests and Wildlife Preservation, Government of Punjab. https://forest.punjab.gov.in/media/documents/forest_literature_IMPORTANTSHEME.pdf

Gulati A, Roy R and Hussain S 2021. Performance of agriculture in Punjab. In: *Revitalizing Indian Agriculture and Boosting*

- Farmer Incomes*, Eds: A Gulati, R Roy and S Saini, Springer, Singapore, 77-112. https://www.researchgate.net/publication/3498388263_Performance_of_Agriculture_in-Punjab
- Kumar A G, Mehta R, Pullabhotla H, Prasad S K, Ganguly K and Gulati, A 2012. *Demand and supply of cereals in India: 2010-2015*. IFPRI Discussion Paper 01158. International Food Policy Research Institute, New Delhi, India. https://www.researchgate.net/publication/254416821_Demand_and_supply_of_cereals_in_India_2010-2025
- Saran S K, Kataria P and Kaur A 2013. An electricity energy usage and energy subsidy in Punjab agriculture. *Indian Journal of Economics and Development*, **9**: 99-206. https://www.researchgate.net/publication/269746096_An_electricity_energy_usage_and_energy_subsidy_in_Punjab_agriculture
- Sharma J S and Gandhi V P 1990. *Production and consumption of food grains in India: Implications of accelerated economic growth and poverty alleviation*. Research Report of International Food Policy Research Institute. <https://core.ac.uk/reader/6289690>
- Sharma M and Sharma P 2024. Changing Employment Patterns: An Analysis of Rural Labour Force in Punjab. *The Indian Economic Journal*, **72**: 526-539. <https://doi.org/10.1177/00194662231199234>
- Sidhu R S, Bhullar A S and Joshi A S 2005. Income, employment and productivity growth in the farming sector of Punjab: Some issues. *Journal of Indian School of Political Economy* **17**: 59-72. <https://i-scholar.in/index.php/JISPE/article/view/172542#tp1>
- Singh A, Kumar R, Gupta M and Singh J 2023. Production performance of cotton in north India: a state level analysis. *Agricultural Research Journal* **60**: 627-633. DOI: 10.5958/2395-146X.2023.00092.3
- Singh J 2012. Punjab Losing land to urbanization. The Tribune Sept 3, 2012. https://www.researchgate.net/publication/277973203_Punjab_losing_land_to_urbanisation
- Singh S and Bhogal S 2020. Punjab's agricultural labourers in transition a longitudinal study of three decades. *Economic and Political Weekly* **55**: 26-27. <https://www.epw.in/journal/2020/26-27/review-rural-affairs/punjabs-agricultural-labourers-transition.html>

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