Trends and Determinants of Foodgrains Productivity in Bankura District of West Bengal during the Last Thirty Years

Dr. Samir Show
Assistant Professor in Economics, Kumarganj College, West Bengal, India

Abstract

Foodgrains productivity is an overriding factor for agricultural sustainability and rural livelihoods in the drought-prone areas such as the Bankura district of West Bengal. This study investigates the key factors affecting the foodgrains productivity of the district through an integrated new investigation of agro-climatic conditions, soil characteristics, irrigation infrastructure factors, technology adoption and socio-economic constraints. The study is based on secondary sources of data like district statistical records and relevant literature and uses a descriptive and analytical approach. The yield rates of major crops in Bankura district by 1996 - 97 to 2021 - 22 in kilograms per hectare and their Compound Annual Growth Rate (CAGR) rate changes in over years.The findings show that productivity is badly limited by erratic monsoon rainfall and low soil fertility levels and capacity of water-holding capacity of lateritic soils in Bankura district, As well as poor irrigation coverage and low levels of technological adoption and little institutional support limit agricultural efficiency. The yield trend analysis for a period of 1996-97 to 2021-22 reveals moderate growth in the productivity of foodgrains, however, the growth is even and very sensitive to climatic variability.

The research points out that these are interconnected and are part of the cycle of low investment and low returns in agriculture. To address these challenges, an integrated strategy focusing on irrigation expansion, management of soil health and drought resistant varieties of crops as well as strengthening of extension services is a must, sustainable practices such as watershed management, rainwater harvesting and crop productivity are important to improving resilience to climate risks.

1. Introduction

Agriculture has been the most important component of the rural economy of the Bankura district, the foodgrain productivity of the district is essentially limited by the agroclimatic characteristics and soil constraints (Sawargaonkar et al., 2024). This particularity results in a pedological environment with low fertility and moisture-retention discrepancies (Chandra et al. 2019) due to the dominance of granite gneiss and schist-derived residual soils in the western blocks. Moreover, the undulating topography of the district coupled with the inadequate irrigation facilities worsens the physical limitations (Maity et al., 2025). Apart from the physical difficulties, the area suffers from severe variations in cropping intensity which warrants a thorough investigation of how irrigation access and socio-economic change impact local agricultural performance (Pani et al., 2024). Recent studies indicate that changing rainfall patterns and depletion of groundwater resources in these rainfed tracts must result in a shift towards sustainable agricultural practices to stabilize output (Chakraborty et al., 2025; Pani et al., 2024).This study uses kinked exponential method to analyse growth pattern of leading crops in a district that closely follows the case of growth trend at the state level due to the introduction of technology and institutional changes (Laha & Kuri, 2011). This study places the agricultural production of Bankura within the context of climate change variability through a critical study of technological intervention and environmental limitation (Goswami & Paul, 2023). As such, the study aims to identify the extent to which availability of irrigation, use of chemical fertilizers and diversification of land use help in buffering volatility of Bankura's largely rain-fed farming systems (Mukherjee, 2022; Senapati & Goyari, 2019). It is important to study all these inputs. Moreover, due to the complex relationship between these inputs and other socioeconomic factors, smallholder agricultural investments often fail (Sawargaonkar et al. 2024) Reliance on hard-rock aquifers calls for assessment of groundwater quality, for recent hydrological assessment shows that a large proportion of samples in western lateritic areas may not be suitable for irrigation (Maity et al. 2025). Since assured irrigation access still continues to be a basic requirement for agricultural intensification, the enhancement of groundwater dependence in these geophysically challenging areas is increasingly threatening sustainability (Paria et al., 2021).

2.Literature Review

Agricultural growth in West Bengal is closely tied to several key factors, including reliable irrigation, rural electrification and strong credit systems. When these elements work together, they can greatly improve productivity. For instance, modern irrigation systems have been shown to be a major driver of change in rural areas, helping to stabilize incomes and reduce the risks associated with unpredictable rainfall patterns(Pani et al., 2024).. The involvement of local governing bodies, such as the three-tier Panchayati Raj institutions, has also been crucial in managing and distributing water resources effectively, which in turn helps to address long- standing challenges related to agriculture and the environment (Saha et al., 2025). Soil testing and the promotion of farming practices that don't rely on irrigation are also important for managing the soil's health and increasing overall production(Maity et al., 2025). This is because the soil in the district has its own set of limitations that need to be understood and addressed. Moreover, drought is a complex issue that affects not just the weather, but also water availability and agriculture. To deal with this, it's essential to understand how soil organic matter is depleted in tropical regions, which is critical for sustaining productivity over time. The use of technology, such as shallow tube wells and electric pumps, has made it easier for farmers to access groundwater, leading to more intensive farming practices. However, this also means that there is a greater need for managing these resources in a sustainable way to ensure their availability for future generations. By focusing on these areas, it's possible to create a more resilient and productive agricultural sector in West Bengal. Effective water management, combined with the right farming techniques and technologies, can help mitigate the effects of climate change and ensure that agricultural production remains strong. This not only benefits the farmers but also contributes to the overall food security and economic stability of the region. As such, continued investment in irrigation infrastructure, rural development and sustainable agricultural practices is essential for the long-term growth and prosperity of West Bengal's agricultural sector (Sawargaonkar et al., 2024). In conclusion, the path to enhancing agricultural productivity in West Bengal involves a multifaceted approach that includes improving irrigation systems, promoting efficient farming practices and ensuring the sustainable use of natural resources. By adopting this comprehensive strategy, the region can overcome its agricultural challenges and achieve greater food security and economic growth (Bhutia & Sinha, 2022). The effectiveness of new ways to get water from the ground is often limited by the hard rock beneath the surface in this area. After the rainy season, the top layer of soil dries out quickly and can't hold much water. This makes it hard to get enough water, especially in places like Indpur where the soil is very dense and doesn't absorb water well. As a result, people have to rely on groundwater that is getting worse in quality (Alam et al., 2024). To deal with these problems, the local government has started a program called Matir Srishti to turn unused land into productive farms with a mix of crops and animals. This approach is part of a bigger plan to make farming more sustainable by reusing waste and growing a variety of crops to keep the soil healthy and reduce the impact of climate change. Some new methods, like special water-saving systems and a new way of growing rice, have shown promise in using water more efficiently while still producing a lot of food(Rao & Sharma, 2025). However, to really make farming more resilient, we need to involve the whole community in planning and managing water resources, especially during times of drought. We also need to use farming methods that can withstand the effects of climate change, such as covering the soil with mulch and planting crops that can survive with less water(Kumar et al., 2025). This will help prevent soil degradation and ensure that farms can keep producing food over the long term, even in areas that are very vulnerable to drought and other climate-related problems. By working together and using these new approaches, we can make farming more sustainable and help communities thrive, even in challenging environments(Prasad & Sohoni, 2020). It's not just about introducing new technologies or methods, but about creating a system that works for everyone and helps to conserve our natural resources for the future. This way, we can ensure that our farms are not only productive but also resilient to the impacts of climate change and that we can keep growing the food we need while also protecting the health of our soil and water(Luo et al., 2025; Sahoo et al., 2024).

3. Objectives:-

i) To examine the nature of foodgrains yield and its change over time in Bankura District during the last three decades.
ii) To analysis the Compound Annual Growth Rate (CAGR) of yield in Bankura district last three decades.
iii) To analyze the factors that are responsible for changing Foodgrains productivity in Bankura district over years.

4. Database and Methodology

The primary objective of this study is to analyze the foodgrains productivity and its factors in Bankura district. To achieve this, we conduct a comparative analysis at both levels using secondary data. This study relies entirely on secondary data, which has been collected, examined and analyzed to derive meaningful results and conclusions.The secondary data on foodgrains yield & factors influencing foodgrains productivity has been sourced from various government publications, including the *Statistical Abstract*, *Economic Review*, *District Statistical Handbook*, *National Horticultural Board* and reports from the Ministry of Agriculture, Government of West Bengal.

i)Regression Analysis

Regression analysis will be employed to examine the statistical relationship between foodgrains productivity (independent variables) and various indicators in Bankura district. This analytical technique will allow for the quantification of the impact and direction of these relationships, while also controlling for other confounding factors. The choice of specific regression models will be guided by the nature of the dependent variables. Possible regression models that could be utilized include:

The multiple regression formula models a dependent variable is Y as a linear combination of several independent variables X_1, X_2, X_3 ---- X_k etc.,

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_k X_k + \varepsilon$$

β_0 = Intercept (constant term)
β_1, β_2, ...,β_k = Regression coefficients measuring the partial effect of each X on Y
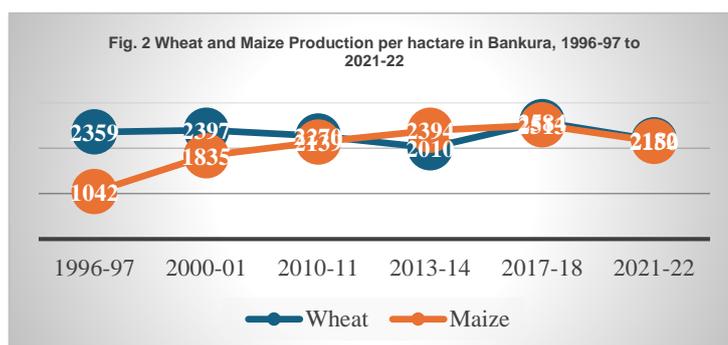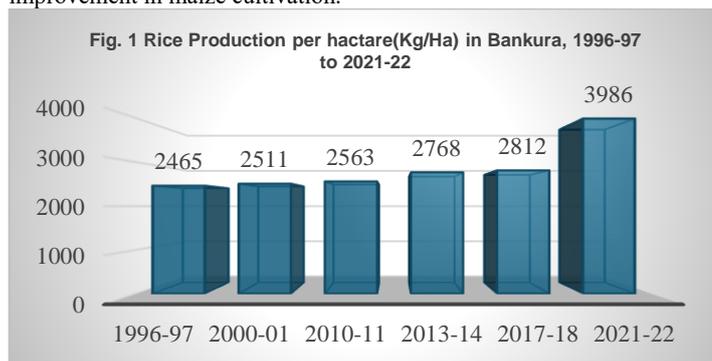ε = Random error term

(ii) Growth Calculation: The study uses Compound Annual Growth Rate (CAGR) along with percentage growth measures to examine temporal changes and growth performance of key variables during the study period.

5.Results and discussion

5.1 Growth and Productivity (Yield) of Principal Crops: Table 1 shows the yield rates of major crops in Bankura district by 1996 - 97 to 2021 - 22 in kilograms per hectare and their Compound Annual Growth Rate (CAGR). The table draws attention to the changes in agricultural productivity over individuals and also mirrors the impact of technological improvements, expansion of irrigation and also changes in cropping practices in the district.

Rice and Other Cereals

Rice productivity in Bankura distt has shown a continuous improvement during the period of study. The yield rose from 2465 kgs per hectare in 1996-97 to 3986 kgs per hectare in 2021-22(Fig.1) with a Compound Annual Growth Rate (CAGR) of 2.02 percent. This growth reflects the improvements in the agricultural practice with the introduction of high-yielding varieties, increase in the area under irrigation and use of modern agricultural inputs.Among the seasonal rice varieties, boro rice had the highest yield levels in all the period. Its productivity rose from 3042 kg per hectare in 1996-97 up to 4611 kgs per hectare in 2021-22, although its CAGR was a relatively modest level of 1.75 percent. The higher productivity of boro rice is mainly attributed to assured irrigation, favourable growing season during dry season and use of improved cultivation technique.Aman rice, the main crop of the monsoon season, also showed a slow increase in productivity. Its yield rose from 2430 kg per hectare in 1996-97 to 3901 kg per hectare during 2021-22 recording a CAGR of 1.99 percent. Similarly, aus rice achieved a yield improvement from 2359 kgs per hectare to 3780 kgs per hectare with CAGR of 1.98 percent.Among other cereals, maize productivity is also a significant increase from 1042 kg per hectare in 1996-97 to 2150 kg per hectare in 2021-22 with a CAGR of 3.06 percent(Fig.2). This suggests improving efficiency of maize production and a gradual transition to diversified cereal production.In comparison, wheat productivity showed a slight decline for the period studied. The yield has reduced from 2359 kg per hectare in the year 1996-97 to 2182 kg per hectare during the year 2021-22 showing a negative CAGR of -0.32 percent(Fig.2). Similarly, other cereals have also recorded a conspicuous decline with a decline in productivity and registered a CAGR of -3.97 percent.Overall, the total yield of cereals has been increased from 2458 kgs per hectare in 1996-97 to 4013 kgs per hectare in 2021-22 suggesting overall improvement of cereal productivity in Bankura district mainly due to increase in yield of rice and improvement in maize cultivation.

Fig. 1 Rice Production per hactare(Kg/Ha) in Bankura, 1996-97 to 2021-22

Fig. 2 Wheat and Maize Production per hactare in Bankura, 1996-97 to 2021-22

Pulses

The productivity of pulses in Bankura district shows mixed trends over the study period. Gram recorded a significant growth in yield from 570 kg per hectare in 1996-97 to 1185 kg per hectare in 2021-22, which is by compound percentage annual growth rate (CAGR) of 3.10 per cent. This improvement represents better cultivation practices and possibly increased attention to the production of grams in some areas of the district. In contrast, other pulses had fluctuations and a general loss of productivity. Their yield fell to 434 kg/ha during 2021-22, giving a negative CAGR of -0.93 percent (Fig.3). This decline may be linked to certain factors including lack of technological support, reduced priority in cropping patterns and competition with crops with higher profitability returns.As a result, total pulse productivity was mainly stagnant over the period of the study. The yield per hectare expanded into a marginal rise from 552 kg per hectare in 1996-97 to 576 kg per hectare in 2021-22, with a very low CAGR of 0.18 percent. This infers that pulse cultivation in the district has not received much technological development and productivity raising and it continues to occupy a fairly minor position in the agricultural system of Bankura.

Oilseeds

The production of the oil seed crops in the study area, Bankura district, was moderate. In the most significant area of oilseeds production, the rapeseed and mustard yield in the district, improved to 1210 kg per hectare in 2021-22 and recorded a Compound Annual Growth Rate (CAGR) of 1.85 percent, compared to 780 kg per hectare in 1996-97(Fig. 3). This development shows a progressive change in production techniques and the growing significance of the crops in the agricultural system of the district.Conversely, the productivity of linseed fell in the course of time. Its harvest reduced to 595 kg per hectare in 2021-22 since it had been 890 kg per hectare in 1996-97, with a negative CAGR of -1.66 percent. The decreasing trend can be linked to the decreased agricultural land or less technological services or farmers moving to plant other more lucrative oilseeds.There were other oilseeds which performed moderately in terms of productivity. Their productivity rose to 560 kg per hectare to 785 kg per hectare at a CAGR of 1.42 percent indicating slow gains of crop management and use of inputs.Generally, there was a rise in the total yield of the oilseed crop, 700 kg per hectare in 1996-97 to 949 kg per hectare in 2021-22 with a CAGR of 1.28 percent. The trend shows that the productivity of oilses is showing a low rate but constant improvement in Bankura district over the course of study.

Fig. 3, Pulses & Oil Seeds Production per hactare in Bankura, 1996-97 to 2021-22
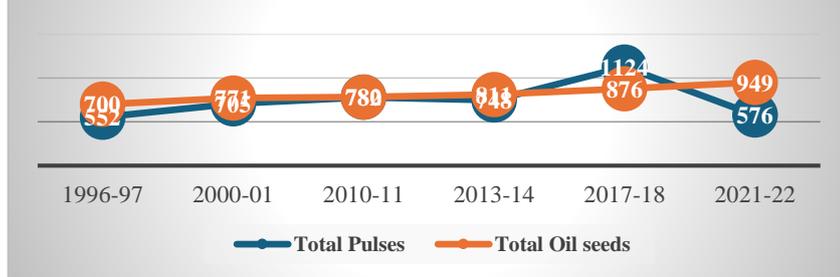
Fibre and Commercial Crops

Of the fibre crops, the productivity of jute reduced tremendously over the period of study. There is a negative Compound Annual Growth rate (CAGR) of -4.18 percent between 1996-97 and 2021-22 that shows the yield dropped to 700 kg per hectare in the years 2021-22 compared to previous record of 1950 kg per hectare in 1996-97. This steep fall portrays the declining value of jute growing in the district, this could be because of the shrinking size of the cultivation region, unstable market prices and less significant seasonal crops that were being produced by farmers.

The productivity of sugarcane also had severe variations between the years and a general decrease recorded with a CAGR as -1.01 percent. Likewise, the productivity of potatoes had been under large variations during the period of research. The trend was not favorable though years, some had relatively high yields but the general tendency was negative with a CAGR of -0.56 percent.

Spices and Other Crops

Of the spice crops, there was a steady increase in the productivity of dry chillies. The yield has grown by 477 kg per hectare in 1996-97 to 1311 kg per hectare in 2021-22 with a CAGR of 4.30 percent. This is based on the improvement of more cultivation practices and more emphasis on spice cultivation in the district.Among crops that were taken into consideration, Ginger demonstrated the greatest improvement in productivity. Its produce was responding sharply to 1140 kg per hectare in 1996-97 and to 9850kg per hectarea in 2021-22, registering tremendously high CAGR of 9.40 percent. Such a high growth demonstrates that there exists a massive increase in the production of ginger, enhanced production methods and an increasing production in the spice crops demand in this district.

Table 1 Yield rates & Growth of Principal Crops in the district of Bankura (Yield:Kg. per hectare)

Crops	1996-97	2000-01	2010-11	2013-14	2017-18	2021-22	CAGR 1996-97 to 2021-22
Rice	2465	2511	2563	2768	2812	3986	2.02
Aus	2359	2209	2296	2552	2615	3780	1.98
Aman	2430	2435	2482	2751	2732	3901	1.99
Boro	3042	3331	2981	3013	3407	4611	1.75
Wheat	2359	2397	2270	2010	2584	2182	-0.32
Maize	1042	1835	2139	2394	2513	2150	3.06
Other Cereals	1400	750	721	1000	572	530	-3.97
Total Cereals	2458	2504	2557	2761	2809	4013	2.06
Gram	570	847	499	769	1321	1185	3.10
Other Pulses	543	857	797	667	1090	434	-0.93
Total Pulses	552	705	780	748	1124	576	0.18
Total Foodgrains	2442	2499	2555	2759	2783	3946	2.02
Rapeseed & Mustard	780	929	817	776	841	1210	1.85
Linseed	890	241	326	297	271	595	-1.66
Other Oil seeds	560	606	767	841	894	785	1.42
Total Oil seeds	700	771	782	811	876	949	1.28
Jute	1950	1880	1950	1950	1370	700	-4.18
Sugarcane	74378	71957	38089	125188	102208	58326	-1.01
Potato	26154	26622	39295	16115	40737	22863	-0.56
Chillies (dry)	477	905	1101	1109	1199	1311	4.30
Ginger	1140	1973	1572	1583	7962	9850	9.40
Total Miscellaneous crops	25857	25083	37150	15231	38492	22588	-0.56

Source: District Statistical Handbook, Bankura

### 5.2 Factors Influencing Foodgrains Productivity in Bankura District

Table 2 indicates the trend of foodgrains productivity and some of the related variables within the bankura district between 1998-99 and 2021-22. Cropping intensity, benefits of storage house, mouza electrification, road density, yield of fertilizers, percentage of irrigated area and yearly rainfall are the variables that are taken into account. All these contribute towards affecting the productivity of food grains like Rice, Wheat and Maize.The main economic basis of the region is agriculture, but its productivity is still limited because of the variability between agroclimatic factors and land management patterns. A complex topography of the district with a naturally low water retention of the soil base complicates all these issues and makes it necessary to thoroughly analyze socioeconomic and environmental factors, which determine the crop yields of the region (Sawargaonkar et al., 2024). Moreover, the structural constraints, including insufficient irrigation facilities and unpredictable rainfall patterns have hindered the shift to the more intensive mode of cultivation in the past (Chakraborty et al., 2025; Maity et al., 2025). It is interesting to mention that a monitored decrease in the cropping intensity within this district provides the basis to critically examine the possible drivers, including the alteration of the occupational structure within any labor, as well as the erosion of the frequency of stable irrigation supplies (Pani et al., 2024). A combination of these physical limitations with the newly manifested effects of the changes in the climate is necessary to comprehend the current stagnation of foodgrain productivity that has been faced over the past twenty years (Goswami and Paul, 2023). This research assesses the interaction of these impediments with the pedological features, especially in the western parts that are of nutrient-poor and weathered soil and the east-alluvial plains (Chandra et al., 2019).It applies a time-series model to estimate the correlation between macroeconomic variables including fertilizer use, gross irrigated land and yearly rainfall and the changes in foodgrain yields, which have occurred annually since 1998 through 2022 (Pattanaik and Mohanty, 2016). Initial evidence indicates that whereas systemic dependence on unpredictable monsoonal precipitation has persistently increased production instability, precipitant efforts to enhance the irrigation area have provided a decisive buffer in response to the periodic lack of yields (Swain, 2014). On the other hand, the lack of change in nutrient-deficient soil behaviors in the western blocks is strongly related to the decreasing marginal returns on application of fertilizers and it is possible to argue that soil health degradation is offsetting the gains made by the expansion of infrastructure. This implies that a shift in policy interventions in future should not focus on total distribution of inputs but limited land areas by adopting localized soil management and precision agricultural methods as a strategy of correcting the loss of long-term land productivity. In addition, it is essential to appraise the socioeconomic dynamics, including the variation in labor supplies and land fragmentation, to eliminate the difference in observed yields between the plateau and plains areas (Mukherjee et al., 2023; Pramanik, 2024). Combining these results with the larger-scale patterns of the region indicates that institutional barriers such as restricted access to formal credit and the abundance of fragmented landholdings contribute to the fact that smallholder farmers will be further vulnerable to the effects of such environmental stressors (Chuilo & Kumar, 2025).In the bankura district, there is a lot of fluctuation in the yield of food grains in the study period. The productivity had reached 2393 kg/ha in 1998-99 which then slowly rose to 2779 kg/ha in 2001-02 and 2850 kg/ha in 2002-03(Table 2). Nonetheless, there are moderate oscillations between the mid 2000s. Since 2011-12, there is a comparatively increased trend in terms of productivity which is 3545 kg/ha in 2018-19 and 3871 kg/ha 2019-20. In 2020-21 it reached the maximum on the scale of 4736 kg/ha and then, the productivity decreased minimally to 3946 kg/ha in 2021-22. This general rising pattern shows that there is a slow coming support to the inputs and infrastructure of agriculture within the district.

Cropping Intensity

There was a remarkable variation in intensity of cropping (CI) within the Bankura District between the 1998-99 and 2021-22. The level of cropping was relatively high in the early years and it stood at 150.63 and 149.68 percent in 1998-99 and 1999-00 respectively meaning that a significant part of cultivated land was under multiple cultivation. The downward trend is however seen to trend in the early 2000s whereby in 2002-03, the Cropping intensity was seen to be declined sharply to 119.69%. This could have been caused by irregular rainfall, shortage of irrigation facilities and the fact that in some areas of the district, mono-cropping is the norm. Following this wet spell, there was a slow recovery in the intensity of cropping. It rose to 136.18% in 2004-05 and further escalated to 159.88 and 164 in 2006-07. Despite the fact that there was moderate variation in the ensuing years, there has been an overall trend of improvement in terms of the usage of better farming practices, current in the form of the expansion of the irrigation facilities and modern well-furnished inputs like fertilizers, varieties of crops such as Rice and Wheat.

The intensity of cropping had been fairly stable in the later years of the study period, topping at 172% in 2019-20, the highest level in the whole period. This growth implies that farmers in the district began using the same farm land more than once in a year to produce more than one crop. This amplification of land use is a significant sign of agricultural growth especially in areas whereby cultivable land is small.In general, the increase in the intensity of cropping is indicative of a slow development of more intensive and diversification in the agricultural mode in the bankura district. Intensified production boosts the efficient exploitation of land resources, augmented aggregate production of agriculture as well as positively affecting foodgrain productivity and rural livelihoods. The increased intensity of cropping however, cannot be maintained without sufficient irrigation, better soil management and good climatic conditions as the agricultural practices in the district are at still maintained partially reliant on monsoon rain.


Fig. 4, Cropping Intensity in Bankura District, 1998-99 to 2021-22
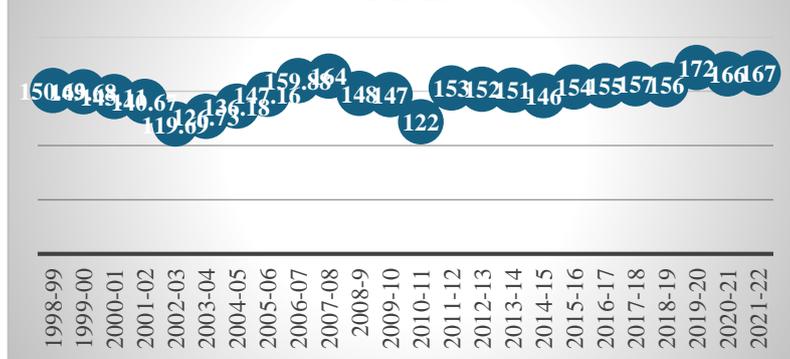
### Storage House Beneficiaries

The beneficiaries of the storage houses of the Bankura District also exhibit an apparent trend of upward increase between 1998-99 and 2021-22. When the figure was 152 thousand in 1998-99, it means that in those years, storage facilities were rather under-covered among farmers. This figure has risen gradually over the years as the rural storage facilities expanded and more farmers were getting involved in the government-sponsored storage programs. The beneficiaries increased dramatically in 2005-06 to 320 thousand and it implies that the availability of storage facilities in the district is considerably improved. The trend was generally positive, steadily increasing to 285,000 beneficiaries in 2021-22(Fig. 5), in spite of slight variations identified within the following years.

This increase of the storage facilities also is significant to reinforce the agricultural economy of the district. Proper storage facilities have helped farmers to store the harvested food grains like Rice, Wheat and other cereals more safely. This assists in minimizing loss of produce in the after-harvest to pests, moisture and rot, which is a frequent issue in rural farms. In addition, better storage enables farmers not to make distress sales right after harvest when the market prices are typically low.Having improved storage facilities, the farmers will be able to store their produce and at a better price to the markets, thus enhancing their income and economic security. Moreover, the proper storage facilities make available the foodgrain supply in the local markets and this also helps stabilize the prices and strengthen the provision of food to the region in general food security.Thus, the constant rise of beneficiaries of the storage house suggests the actual rise in the significance of post-harvest management and urban infrastructure development within the area of bankura district. The storage facilities along with other agricultural inputs like irrigation, fertilizers and improved seeds have aided in improving agricultural productivity and boosting the agricultural economy of the rural area of the district, though indirectly.

Fig. 5, Storage house beneficiaries (000'No.) in Bankura District, 1998-99 to 2021-22
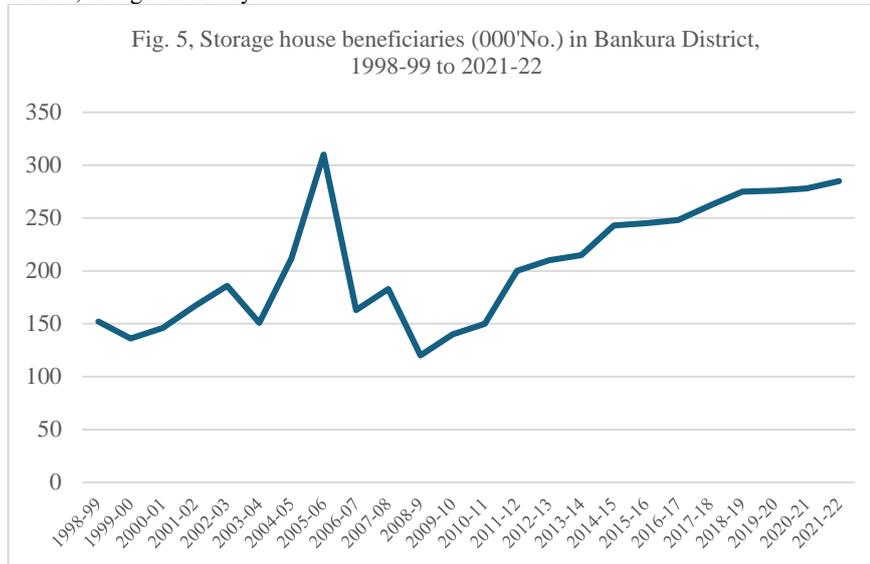
Electrification of Mouzas

The rural electrification in Bankura District has widened tremendously over the study period which indicates rural development efforts and rural infrastructure. Electrified mouzas have risen to 3579 in 2008-09 as compared to the 2374 in 1998-99(Fig.6,). This is a gradual increase, which indicates the quick expansion of electricity networks to the rural settlements in the early and mid 2000s. The level of electrified mouzas continued to be almost the same figure of about 3579 post 2008-09 with an indication that the ratio of the electrified mouzas showed that almost all the mouzas in the district were already connected to the rural electrification network by 2008-09.The spreading electrification has significant consequences to the agricultural growth and food grains output in the district. Availability of electricity also allows the farmers to use the electric irrigation pumps which is one of the ways of ensuring there is a steady water supply to the crops being grown. This is especially significant where agricultural production is usually unstable in relatively drought prone regions such as Bankura due to complete reliance on the monsoon rainfall. Modern agricultural technologies and other small scale agro-processing like processing of crops like Rice and Wheat such as rice milling can also be implemented with the help of electrification.In addition to that electrification of rural areas helps in mechanizing and modernizing agriculture to enable farmers to use better irrigation systems, storage facilities as well as processing facilities. It also improves the operations of rural markets, cold storage facilities and agriculture services centers, hence, contributing to the efficiency of agricultural supply chain.On the whole, the great rise in the number of electrified mouzas indicates the rural development of the infrastructure within Bankura district. This has been a boosting factor in enhancing agricultural production, increasing the output of farms and enhancing the general economy of rural regions.


Fig. 6, Mouzas Electrified in Bankura District, 1998-99 to 2021-22
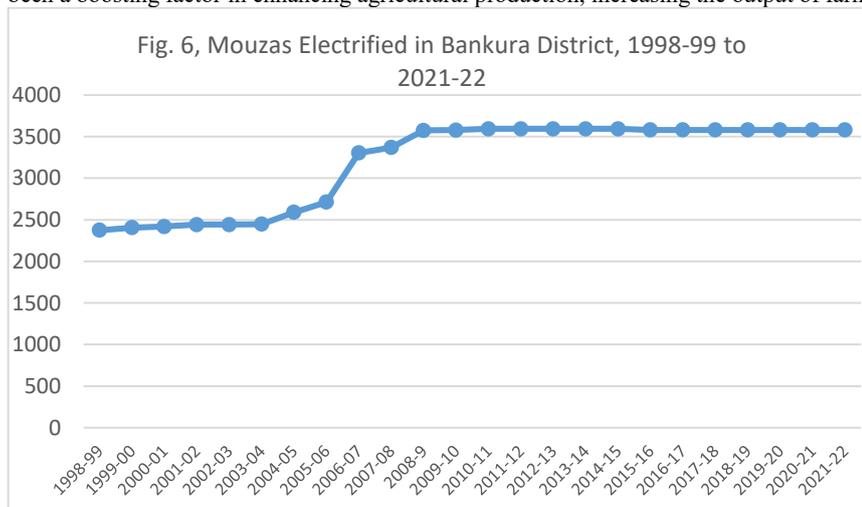
Road Density

It has been observed that the density of road in Bankura District is on an upward and remarkable trend between the year 1998-99 to 2021-22. The road density of the district is relatively low in 1998-99 (0.36), which means transport infrastructure and connection of the rural areas of the district. This has however improved over the years with massive gains being made in the improvement and development of rural road net-works. The value of road density grew steadily to 1.31, 1.74 and 1.95 in 2002-03, 2006-07 and 2010-11 respectively. This trend went on increasing in the next few years and by 2019-20 and 2020-21 the road density had not only stabilized to 2.63 but had also increased slightly to 2.61 by 2021-

22(Fig.7).The gradual increase of road network has had a significant influence in enhancing the agricultural economy of the district. The enhancement of the state of roads has led to orderliness in the transportation of farm inputs including fertilizers, better seeds and farm machines to the rural agricultural regions. Meanwhile, it allows the farmers to transfer their farm produce especially the foodgrains like Rice and Wheat to the local markets and the procurement centers faster and at reduced rate.

Improved road system will also improve accessibility to agricultural extension services, financial institutions and market information by the farmers that promotes the use of better production methods and advanced agricultural technology. Also, an enhanced transport connectivity minimizes post-harvet losses because goods can be transported timely to storage and market centers.

In general, the enhancement of the road density remains steady, which is the indicator of the high level of rural infrastructure development within the Bankura district. This has helped in ensuring that agricultural commercialization, integration and eventually increase foodgrains productivity in the area.

Fig. 7, Road Density in Bankura District, 1998-99 to 2021-22
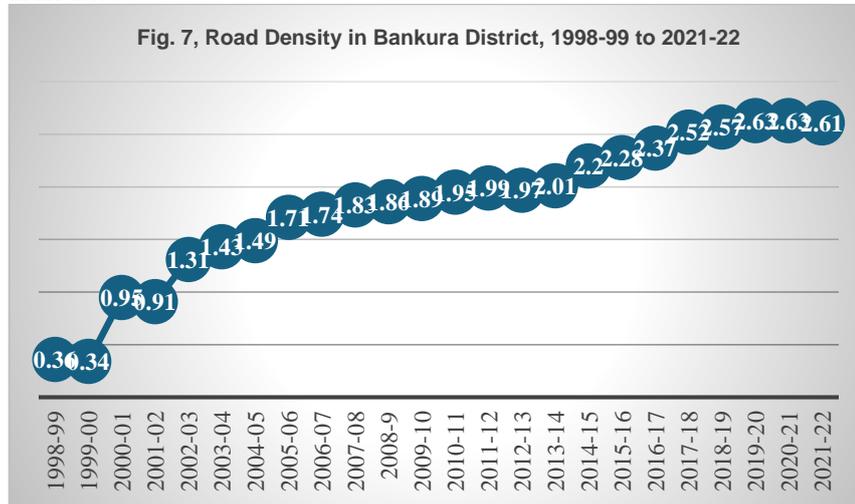
Fertilizer Use

There is the overall tendency of increasing use of chemical fertilizers in the Bankura District across the study period from 1998-99 to 2021-22, which shows adoption of the modern agricultural inputs by farmers. The use of fertilizer in 1998-99 was found to be 97.91 kg/hectare which shows that input input use in agriculture has been relatively moderate. In the subsequent years, there was a steady rise in use of fertilizers as farmers started adopting better means of cultivations and varieties of crops that yielded high yields.In the period of early 2000s, there was an increase in the consumption of fertilizers by farmers to 109.27 kg/ha in 2000-01 and then to 125.70 kg/ha in 2002-03 which proves the increasing awareness of the farmers to the issue of crop management by nutrient management. This growth was further observed in the following years and it reached a higher figure of 137.40 kg/ha and 142.93 kg/ha in 2006-07 and 2007-08 respectively. The fertilizer utilization rose dramatically by the end of the 2000s, which was as high as 162.43 kg/ha in 2009-10 and an average of 150 to 160 kg/ha in the years that followed(Fig.8).

Despite the fluctuations that can be observed in the later period such as the case in 2020-21 in particular, the use of fertilizers in the country increased significantly in the latter period as opposed to the late 1990s. This augmented use of fertilizers has helped in augmenting the nutrient accessibility of the soil and the yield of main foodgrain crops like Rice and Wheat.The increase in fertilizer usage is evidence of the increase and modernization of agricultural activities in the district. The application of proper proportions of fertilizers can lead to a better growth of crops, high yields and the soil can retain its fertility. Nevertheless, the judicial exercise of fertilizers as well as organic manure and integrated nutrient management methods for preventing soil degradation are also needed in sustainable agricultural development.Comprehensively, the increased fertilizer use in Bankura district is a positive development towards introduction of input-intensive agriculture whose contribution has been eminent in the growth of food grain production amidst the study period.

Fig.8, Fertilizer used per hactare in Bankura district, 1998-99 to 2021-22
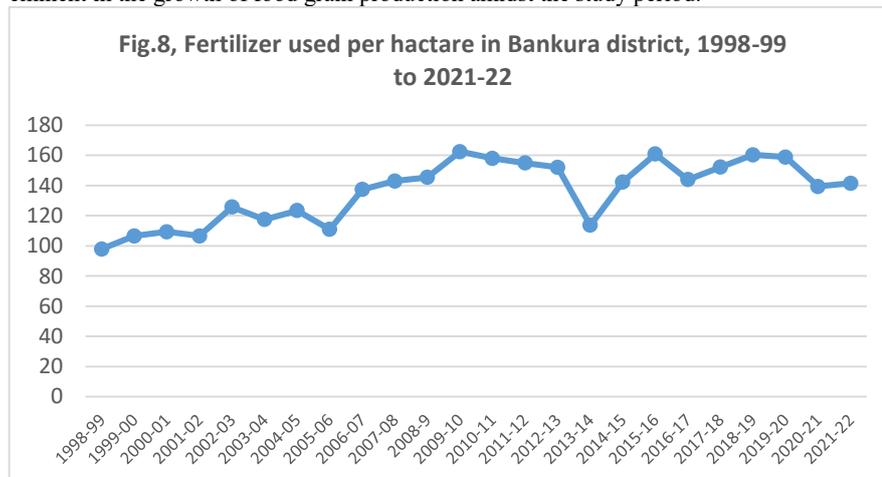
Irrigated Area

The irrigated area is affected by the Bankura District where the percentage of irrigated area is observed to vary significantly across the study period between 199899 and 202122. During the early years the area under irrigation was quite substantial with 73.77 in 199899 and 74.93 in 1999 2000 implying that a huge percentage of land under agricultural works was irrigated throughout those years. But, a steep fall is seen in early twenty first century where the irrigated area has declined to 66.65% of the total area in 2000-01 and even lower down to 34.00% in 2001-02. Such an abrupt decline indicates a large-scale decline in the area of irrigation, that is, probably because of the unusual rain distribution, the lack of water, or the constraints of the irrigation facilities.

The yearly rate of irrigated area percentage is irregular yet there has been moderately good recovery in the following years. To illustrate, it was 45% to 55 % in most of the years and it was in 2023, 2007-08 and 2011-12, 45.82% and 53.18% and 53.00%. A second significant drop was in 2010-11, when the area irrigated decreased to 32.86, indicating that there was a low water supply and less reliance on rainfall.

Later in the period of study, coverage of irrigation reached its maximum level of 45.50 per cent with 47.66 in 2014-15, 49.05 in 2016-17 and 49.67 in 2021-22 (Fig. 9). Though the percentage area under irrigation was not as high as in the late 1990s, the comparatively steady coverage in the later years proves that there was slow progress in the irrigation control and infrastructure.The irrigation is a major factor aimed at maintaining uniform agricultural output especially in the drought prone areas such as the Bankura district. Sufficient irrigation also helps in reducing reliance of farmers on monsoon rain and helps them plant several crops throughout the year thus raising the intensity of cropping and the level of agricultural output. It also facilitates the production of water-demanding crops like Rice that is the prevailing foodgrain crop in the area.The net effect of all this is that the irrigated area has been on the fluctuating pattern due to the continuing influence of climatic variability and the limitation of the water resources within the district. There is consequent need to strengthen irrigation infrastructure and reinforce efficient water management practices in order to maintain the agricultural productivity in Bankura district and provide the long term food security.

Fig. 9, % Irrigated Area in Bankura District, 1998-99 to 2021-22
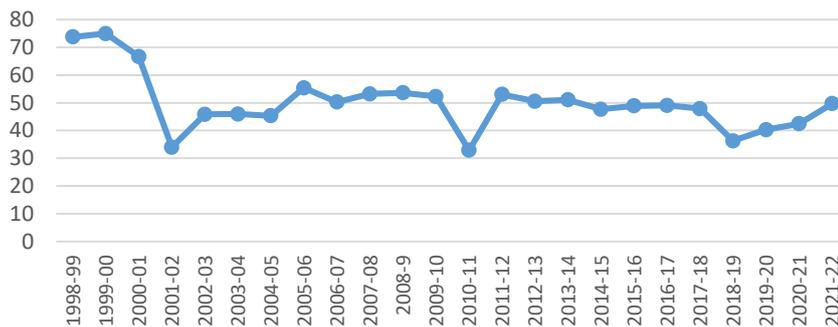
Annual Rainfall

The rainfall on the Bankura District shows significant inter-annual fluctuation within the years of investigations from 1998-99 to 2021-22. The figures indicate that the rainfall amount varies quite extensively indicating the great reliance of the agriculture of the district on the southwest monsoon. As an example, in 1998-99, the district had received 1385 mm of rain which rose to 1525 mm in 1999-00, only to fall at 1235 mm in 2000-01(Fig. 10). Same fluctuations were observed in the years after and it showed inconsistency of rainfall in the area.One of the most pathetic rainy years was 2010-11 in which the district received only 917 mm, which was lowest in all time in the course of the study. This reduction in rainfall can be very negative to agricultural operations and so, this is mostly experienced in places where irrigation facilities are inadequate. Conversely, other years had notably high rain, which included 1803 mm during 2007-08, 1740 mm during 2011-12 and exceptionally high 2382 mm in the year 2020-21, the highest rain actuals have been during the period.As agriculture of the Bankura district is partly rain-fed, the changes in the amount of rain directly affect crop production and foodgrains productivity. Rainfall levels are sufficient and optimum and it promotes growth of crops, availability of soil moisture and yields of various foods like Rice and Maize among others. On the contrary, the years possessing the lack of rainfall or abnormal rainfall may cause moisture stress, decreased intensity of cropping and decreased agricultural yield.

As a whole, rainfall distribution of Bankura district reveals how the farming sector is exposed to climate, meaning that their yield is usually determined by the appearance of the monsoon precipitation and the manner in which it is dispersed. Thus, to decrease risks of variability of rainfall and achieve stable production of agricultural results in the district, the creation of efficient irrigation systems and better practices of water management is necessary.

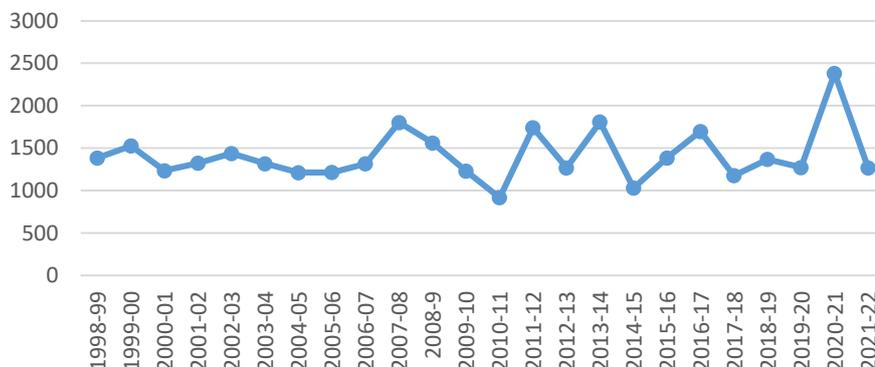Fig. 10, Annual Rainfall(mm) in Bankura District, 1998-99 to 2021-22

Table 2 Factor influencing Foodgrains Productivity in Bankura District,

Year	Foodgrains .Yield (Kg/Ha)	Cropping Intensity (CI)	Storage house beneficiaries (000'No)	Mouzas Electrified (No)	Road Density	Fertilizer Use (Kg/Ha)	% Irrigated Area	Annual Rainfall(mm)
2001-02	2779	140.67	167	2441	0.91	106.57	34.00	1323
2002-03	2850	119.69	186	2442	1.31	125.70	45.82	1437
2003-04	2675	126.73	151	2448	1.43	117.40	45.96	1317
2004-05	2732	136.18	212	2590	1.49	123.40	45.31	1211
2005-06	2599	147.16	320	2712	1.71	110.90	55.39	1213
2006-07	2728	159.88	163	3303	1.74	137.40	50.26	1315
2007-08	2807	164	183	3369	1.83	142.93	53.18	1803
2008-9	2753	148	120	3574	1.86	145.41	53.61	1561
2009-10	2658	147	140	3577	1.89	162.43	52.26	1231
2010-11	2555	122	150	3594	1.95	158.00	32.86	917
2011-12	2963	153	200	3594	1.99	154.96	53.00	1740
2012-13	2743	152	210	3594	1.97	152.07	50.54	1269
2013-14	2759	151	215	3594	2.01	113.67	51.07	1809
2014-15	2760	146	243	3594	2.20	142.29	47.66	1030
2015-16	2734	154	245	3579	2.28	160.84	48.89	1385
2016-17	2799	155	248	3579	2.37	143.87	49.05	1697
2017-18	2783	157	262	3579	2.52	152.16	47.91	1176
2018-19	3545	156	275	3579	2.57	160.27	36.30	1367
2019-20	3871	172	276	3579	2.63	158.80	40.32	1271
2020-21	4736	166	278	3579	2.63	139.37	42.42	2382
2021-22	3946	167	285	3579	2.61	141.46	49.67	1268

Source: District Statistical Handbook, Bankura

5.3 Relationship between Selected Agricultural Factors and Foodgrains Yield

The outcomes of a multiple regression analysis that was conducted to determine the connection between foodgrains yield and some explanatory variables that included cropping intensity, beneficiaries of the storage houses, mouza electrification, road density, the use of fertilizers per hectare of land, proportion of irrigated area and annual rainfall are published in table 3. To conduct the analysis, 21 observations were taken between the year 2001-02 and 2021 22.The strength of the explanatory power of the regression model is rather high. The R^2 (0.78) means that the variation in foodgrains yield in Bankura district could be explained by the independent variables (selected) in the model, which was nearly 78 percent. The value of Adjusted R^2 (0.67) is an indication that despite taking into consideration the number of explanatory variables, a further 67 percentage points are yet to be explained by the model on the variability in foodgrains productivity.Moreover, the fact that the F-statistic of 6.18 is significant at the 1 percent level substantiates the fact that the overall regression model is also significant and the variables selected have joint impact on the yield of the foodgrains.The intercept coefficient is 2288.873 which represents the estimated level of foodgrains yield when all the explanatory variables are maintained at a zero level. Even though there is not much practical interpretation of this value, the value of the value gives a base to the regression equation. The intercept is significant on the 10 percent level (p = 0.088).The coefficients are positive with a value of 14.24, which is significant at the 10 percent level. This implies that, the intensity of cropping positively affects foodgrains yield. That is, as more agricultural land is used by having multiple cropping cycles, then the production will be more. This observation is correlated with the ability of the intensified land use to enhance the productivity of the key foodgrains of the Bankura district like Rice and Wheat.The expression of beneficiants of storage houses is 1.97 suggesting that there exist a positive yet non-significant connection between foodgrains yield and the coefficient of storage houses (p = 0.564). Despite reducing post-harvest losses and enhancing the marketing opportunities of farmers, its effect on crop yield in the regression findings does not seem significant.The coefficient of electrified mouzas is equal to -0.83 and it is not positive but rather negative, it implies that there is negative relationship, which is significant at the 10 percent level with the food-grains yield. This negative relationship can indicate that when the rural electrification became saturated in the district, the addition of electrification to more and more mouzas did not have a direct positive impact on the agricultural productivity. It can also be suggesting that other supportive forces like irrigation systems and effective use of electricity to enhance crop production exist and are of greater significance than irrigation systems.The road density has a positive coefficient of 1137.30 and it is significant at the 10 percent level indicating that the development of transportation infrastructure positively affects the foodgrains productivity. The increased connectivity by the road network helps deliver the agricultural inputs on time, access the market and promote adoption of better farming methods that eventually lead to better agricultural production.The fertilizer use has a coefficient of 0.48 and it shows a positive non significant relationship with foodgrains yield (p = 0.948). The low outcome may be associated with the small differences in the efficiency of the use of the fertilizers, soil properties, or balanced usage of nutrients, even though the usage of fertilizers was also a crucial input in crop production.The coefficient of the percentage of irrigated area is negative and is statistically significant at the 5 percent level. This contraventionary correlation might seem counterintuitive, yet it might be explained by the uneven distribution of irrigation tools or mistakes in the water management. It can also include an indication of some irrigated land being clustered in less productive regions or that changes in rainfall have an extreme effect on agricultural production.The coefficient of positive relation is 0.68 and the coefficient is significant at 5 percent level which means that the role of rainfall as a determinant of foodgrains productivity in the district is important. Given that agriculture in Bankura is in part rain-fed, the availability of sufficient rainfall helps enhance the availability of soil moisture and increase in crop yield.According to the regression analysis, foodgrains yield in the Bankura district is positively affected by the cropping intensity, road density and annual rainfall but the percentage of irrigated area negatively affects as well as electrification of mouzas in the model. Annual rainfall and irrigated land are statistically significant at the 5 percent level, as well as other variables showing the importance of water availability in agricultural production. According to the findings, both natural determinants and rural infrastructural development play significant roles in determining the foodgrains.The regression results suggest that cropping intensity, road density and annual rainfall have a positive influence on foodgrains yield in Bankura district, while the percentage of irrigated area and electrification of mouzas show a negative relationship in the model. Among the variables, annual rainfall and irrigated area are statistically significant at the 5 percent level, highlighting the critical role of water availability in agricultural production. The findings emphasize that both natural factors and rural infrastructure development are important determinants of foodgrains productivity in the district.

Table 3 Percentage of Irrigated Area, Fertilizer Use Per Hectare, Storage house beneficiaries, Road Density and Annual Rainfall in Relation to Foodgrains Yield in Bankura, 2001-02 to 2021-22

Variables	Coefficients	Standard Error	t Stat	P-value	
Intercept	2288.873	1241.538	1.843	0.088*	**R Square(R^2) = 0.78**
Cropping Intensity	14.2442	8.23388	1.729	0.090*	**Adjusted R Square = 0.67**
Storage house beneficiaries	1.96635	3.321798	0.591	0.564	**Observations = 21**
Mouzas Electrified	-0.82996	0.402531	-2.061	0.059*	**Significance F Value= 6.18**
Road Density	1137.302	532.591	2.135	0.052*	**Model Significance 1% Level**
Fertilizer used per hactare	0.476811	7.304983	0.065	0.948	
% Irrigated Area	-33.543	12.42603	-2.69	0.018**	
Annual Rainfall(mm)	0.684593	0.251832	2.718	0.017**	

, *** Indicates coefficient significant at 1 percent level , ** Indicate coefficient significant at 5 percent level, * Indicates coefficient significant at10 percent level.

6. Conclusion

Foodgrain productivity in Bankura district has seen mix of natural and socio-economic challenges. In district crop production depends heavily on monsoon rains. The soils are mostly lateritic, low in fertility and poor in retaining moisture in this region. These conditions make it difficult for farmers to achieve stable and high yields. On top of that, issues like small and fragmented landholdings, limited irrigation facilities, poor access to institutional credit and low use of modern technology further slowdown agricultural progress.

The trend of foodgrains productivity and some of the related variables within the bankura district between 1998-99 and 2021-22. Cropping intensity, benefits of storage house, mouza electrification, road density, yield of fertilizers, percentage of irrigated area and yearly rainfall are the variables that are taken into account. All these contribute towards affecting the productivity of food grains like Rice, Wheat and Maize.

The main economic basis of the region is agriculture, but its productivity is still limited because of the variability between agroclimatic factors and land management patterns. A complex topography of the district with a naturally low water retention of the soil base complicates all these issues and makes it necessary to thoroughly analyze socioeconomic and environmental factors, which determine the crop yields in Bankura district. Moreover, the structural constraints, including insufficient irrigation facilities and unpredictable rainfall patterns have hindered the shift to the more intensive mode of cultivation in the past. It is interesting to mention that a monitored decrease in the cropping intensity within this district provides the basis to critically examine the possible drivers, including the alteration of the occupational structure within any labor, as well as the erosion of the frequency of stable irrigation supplies

Looking at the study period, foodgrain production in the district especially crops like rice, Pulses, Maize and wheat shows fluctuations. Productivity has steady upward trend, instead, it has risen and fallen over the study period. These changes are influenced not only by crop choices but also by factors such as the availability of irrigation, adoption of new farming techniques, rainfall, Storage house beneficiaries, road density and technological improvements. The Compound Annual Growth Rate (CAGR) helps capture these trends and gives a clearer picture of how productivity has changed over time. Bankura's rainfall pattern clearly shows how vulnerable agriculture is to climate variability, as crop yields depend heavily on the timing and distribution of monsoon rains. However, improving water management system and irrigation efficiency is key to reducing risks and ensuring more stable agricultural production in the district.

7. References

[1] M. F. Alam, M. E. McClain, A. Sikka and S. Pande, "Subsidies alone are not enough to increase adoption of agricultural water management interventions," Frontiers in Water, vol. 6, 2024, doi: 10.3389/frwa.2024.1444423.

[2] K. H. Anantha et al., "Landscape resource management for sustainable crop intensification," Environmental Research Letters, vol. 17, no. 1, p. 014006, 2021, doi: 10.1088/1748-9326/ac413a.

[3] M. K. Bhatt et al., "Effects of varied nutrient regimes on soil health and long-term productivity in a rice–wheat system: Insights from a 29-year study in the mollisols of the Himalayan Tarai region," Frontiers in Sustainable Food Systems, vol. 7, 2023, doi: 10.3389/fsufs.2023.1206878.

[4] U. Bhattacharya et al., "Synergistic influence of minimum tillage and integrated nutrient schedules on crop performance, nutrient uptake, profitability and soil microbial diversity in a rice–lentil cropping system," BMC Plant Biology, vol. 25, no. 1, p. 1324, 2025, doi: 10.1186/s12870-025-07231-0.

[5] N. T. Bhutia and M. Sinha, "Water mining and landscape: A study on three blocks (Gangajalghati, Mejhia and Saltora) of Bankura, West Bengal, India," Landscape & Environment, vol. 16, no. 1, p. 48, 2022, doi: 10.21120/le/16/1/4.

[6] S. Chakraborty et al., "Evaluating the impact of rainfall patterns on sustainable agricultural crop production," Discover Sustainability, vol. 6, no. 1, 2025, doi: 10.1007/s43621-025-01392-6.

[7] A. Chandra, P. Mitra, S. K. Dubey and S. Ray, "Machine learning approach for Kharif rice yield prediction integrating multi-temporal vegetation indices and weather and non-weather variables," International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, p. 187, 2019, doi: 10.5194/isprs-archives-xlii-3-w6-187-2019.

[8] A. Goswami and A. K. Paul, Climate Variability and Agricultural Modifications in Purulia and Bankura Districts of West Bengal, p. 189, 2023, doi: 10.1007/978-3-031-42231-7_14.

[9] N. L. Kartini et al., "Impact of long-term continuous cropping on soil nutrient depletion," Ecological Engineering & Environmental Technology, vol. 25, no. 11, p. 18, 2024, doi: 10.12912/27197050/191953.

[10] M. Kumar et al., "Impact assessment of different water management technologies on regional groundwater ecosystem service," Frontiers in Water, vol. 7, 2025, doi: 10.3389/frwa.2025.1654541.

[11] A. Laha and P. K. Kuri, "Measurement of allocative efficiency in agriculture and its determinants: Evidence from rural West Bengal, India," International Journal of Agricultural Research, vol. 6, no. 5, p. 377, 2011, doi: 10.3923/ijar.2011.377.388.

[12] P. Luo et al., "Enhancing soil structure and water dynamics through long-term mulched drip irrigation in arid reclaimed saline soils," International Soil and Water Conservation Research, 2025, doi: 10.1016/j.iswcr.2025.08.007.

[13] S. Maity, S. Sahoo and A. Govind, "A field-based data-driven modeling approach for livelihood vulnerability examination of rice farmers considering climate risk in parts of West Bengal, Eastern India," Discover Sustainability, vol. 6, no. 1, 2025, doi: 10.1007/s43621-025-01711-x.

[14] S. K. Malo and S. Saha, "Assessment of the soil fertility index (SFI) for sustainable nutrient management in rice-based cropping systems of Barind tract of West Bengal, India," Discover Soil, vol. 2, no. 1, 2025, doi: 10.1007/s44378-025-00130-8.

[15] S. Mukherjee, "Agricultural diversification of West Bengal: Nature and policy implications," Indian Journal of Agricultural Economics, vol. 76, no. 4, p. 581, 2022, doi: 10.63040/25827510.2021.04.001.

[16] M. Palmajumder et al., "An appraisal of geohydrological status and assessment of groundwater quality of Indpur Block, Bankura District, West Bengal, India," Applied Water Science, vol. 11, no. 3, 2021, doi: 10.1007/s13201-021-01389-2.

[17] A. Pani, P. Mishra and M. K. Dutta, "Ecological implication of changing irrigation sources and farming practices: Experiences from West Bengal, India," Discover Agriculture, vol. 2, no. 1, 2024, doi: 10.1007/s44279-024-00142-y.

[18] A. Pani, P. Mishra and M. K. Dutta, "Ecological implication of changing irrigation sources and farming practices: Experiences from West Bengal, India," Research Square, 2024, doi: 10.21203/rs.3.rs-4819555/v1.

[19] B. Paria et al., "Irrigation-based agricultural intensification and future groundwater potentiality: Experience of Indian states," SN Applied Sciences, vol. 3, no. 4, 2021, doi: 10.1007/s42452-021-04417-7.

[20] P. Prasad and M. Sohoni, "Agricultural intensification and risk in water-constrained hard-rock regions: A social-ecological systems study," Ecology and Society, vol. 25, no. 4, 2020, doi: 10.5751/es-11825-250402.

[21] G. D. N. Rao and B. Sharma, "Grassroots climate resilience and sustainable agriculture in the Ranbir Singh Pura region of Jammu & Kashmir," Discover Global Society, vol. 3, no. 1, 2025, doi: 10.1007/s44282-025-00260-y.

[22] S. Saha et al., "Effect of irrigation on rural transformation and income at the district level in Bangladesh," PLoS ONE, vol. 20, no. 6, 2025, doi: 10.1371/journal.pone.0326504.

[23] S. Sahoo et al., "Review of climate-resilient agriculture for ensuring food security: Sustainability opportunities and challenges of India," Environmental and Sustainability Indicators, vol. 25, p. 100544, 2024, doi: 10.1016/j.indic.2024.100544.

[24] S. R. Salakinkop et al., "Sustainable intensification of climate-resilient maize–chickpea system in semi-arid tropics through assessing factor productivity," Scientific Reports, vol. 14, no. 1, 2024, doi: 10.1038/s41598-024-53573-4.

[25] G. Sawargaonkar et al., "Envirotyping helps in better understanding the root cause of success and limitations of rainfed production systems," Frontiers in Environmental Science, vol. 12, 2024, doi: 10.3389/fenvs.2024.1417199.

[26] A. K. Senapati and P. Goyari, "Growth and instability in agricultural productivity in Odisha," Agricultural Economics Research Review, vol. 32, no. 1, p. 55, 2019, doi: 10.5958/0974-0279.2019.00005.3.

[27] G. M. Wekesa, "Crop physiology and nutrient management strategies for yield optimization in degraded soils," International Journal of Agriculture and Nutrition, vol. 6, no. 2, p. 44, 2024, doi: 10.33545/26646064.2024.v6.i2a.245.