International Journal of Environment and Climate Change

Volume 12, Issue 12, Page 1843-1850, 2022; Article no.IJECC.95843
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Evaluating the Efficiency of Kharif Crops by Productivity Indices in Chhattisgarh State, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2022/v12i121632

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/95843

Original Research Article

Received: 28/10/2022
Accepted: 30/12/2022
Published: 31/12/2022

ABSTRACT

The present study is aimed to evaluate all the districts of Chhattisgarh based on their relative yield and productivity. The regions were differentiated at the district level according to their crop production efficiency. There was total 5 major kharif crops selected for the evaluation of efficiency zoning viz., rice, red gram, maize, groundnut and soybean. Area and production data collected from the Directorate of Agriculture for a period of twenty years (2000-01 to 2019-20) period. From the result it can be suggested that no crop was recorded under the criteria of efficient and highly stable productivity. But for crops like red gram, Bastar region recorded a zonation of potentially efficient crops with high unstable productivity whereas districts like Baloda bazar, Dhamtari, Gariaband, Mahasamund and Raipur fell in inefficient zone with low productivity. Another crop like rice result showed that only two districts namely Jashpur and Kabirdham touched the criteria of inefficient and low productivity and districts like Balod, Bijapur, Dhamatari, Kanker, Mungeli, Sukma and Janjgir-Champa fall under potentially efficient districts with high unstable productivity. For maize it has

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been observed that districts like Balrampur, Bastar, Bijapur, Dantewada, Dhamtari, Janjgir Champa, Kondagaon, Narayanpur, Sukma come under the criteria of potentially efficient zone with high unstable productivity Same result was also obtained for groundnut, very few districts like Rajnandgaon, Kondagaon, Kabirdham recorded with potentially efficient with high unstable productivity. In the case of Soybean the result obtained is that districts like Baloda Bazar, Balrampur, Bastar, Bijapur, Dantewada, Gariyaband, Janjgir-Champa, Kanker, Kondagaon, Mungeli, Narayanpur, Raipur, Sukma come under potentially efficient zone with high unstable productivity. From the above analysis it can be concluded that the districts with potentially efficient and high unstable productivity can be recommended with the continuous streamlining of technologies and promotion for that crop. The area recorded with low productivity and inefficiency should be identified with their proper reasoning behind it.

Keywords: Relative yield; productivity; production efficiency; Kharif crops; potential.

1. INTRODUCTION

Kharif crops, also known as monsoon crops or autumn crops are domesticated plants that are cultivated and harvested in India, during the Indian subcontinent's monsoon season, which lasts from June to November depending on the area.

Depending on the crop and area, the Kharif season can begin as early as May and end as late as January. The season is generally accepted to begin in India in June and end in October. Typically, kharif crops are planted at the start of the first rains as the southwest monsoon season approaches, and they are harvested at the end of the monsoon season (October–November).

Chhattisgarh, the 26th state of the Indian Union came into existence on November 1, 2000. The geographical location of Chhattisgarh is 17°46' to 24°5' North Latitude and from 80°15' to 84°20' East Longitude, with an average rainfall of around 1207 mm. The total geographical area of the state is around 138 Lakh ha. With a net sown area of 46.51 lakh ha, which is 34% of its total geographical area. About 57% area has medium to light soil. Chhattisgarh has one of the richest bio-diverse areas in the country with around 63.4 lakh ha. area. The area under forest cover is 46% of its total geographical area (Directorate Agriculture, Chhattisgarh Raipur, Agriculture Development and Farmer Welfare and Bio-Technology Department). Paddy, soybean, urd & arhar are the major Kharif Crops while rabi season is mainly led by chickpea and lathyrus. Some districts of the state have good potential for sugarcane crops with 04 Co-operative sugar factories running successfully in the state. Other crops of the state are maize, millets, moong, wheat, groundnut etc. Central plains of Chhattisgarh are known as Rice Bowl of Central India [1,2].

Chhattisgarh has embarked on a concerted plan to increase double-cropped areas, diversify the cropping pattern and improve income from agro-based small-scale enterprises. To unlock the true potential of agriculture sector in the state, government is paying special attention towards better management of its water resources. To reduce the farmer's dependency on rainfall, the government is working towards increasing the irrigation potential of the state. At present around 14.76 lakh ha is net irrigated area of the state which is about 32% of the net sown area. The inconsistencies in cropping patterns and performance gaps are also highlighted by this type of analysis, which also has the potential to serve as a foundation for the development of resources and technologies as well as an evolving risk management strategy that satisfies national requirements and meets production goals. The area sown under various crops represented as a percentage of gross cropped land in each administrative unit is typically used to demarcate homogeneous crop zones and provide a good description of inter-regional variances [3,4]. "Another approach is to study the relative yield and relative spread of each crop on a district and regional basis to define the crop regions. The best index of the suitability of an area for a particular crop is its relative yield as well as its stability from year to year as judged by the co-efficient of variability (CV) regardless of the area under the crop" [5]. Crop production models and geographic information systems can be used to evaluate such quantitative data on the spatial and temporal variability in crop yield.

2. METHODOLOGY

Area and production data of major crops of Chhattisgarh state were collected from the Directorate of Agriculture for a period of twenty years (2000-01 to 2019-20) period. Crop yield was calculated for each year on a district basis. That was analyzed to work out the relative yield and coefficient of variation in the yield with methods:

$$\text{Relative Yield of Crop X} = \frac{\text{Average yield of crop x in a district}}{\text{Average yield of crop x in the state}} \text{x100}$$

$$\text{Coefficient of Variability of Crop X} = \frac{\text{Standard Deviation of Crop X Yield in a district}}{\text{Average yield of crop x in the district}} \text{x100}$$

The relative yield and CV for each crop in each shire was classified as follows:

Criteria	High	Medium	Low
Relative Yield	Above 120%	80-120%	Below 80%
CV	Threshold varied crop to crop on the basis of the range in values and frequency of their distribution		

Nine combinations of relative yield and CV are arranged in a 3x3 two-way table for each crop indicating the districts in each classification. These were grouped in 5 categories.

S. No.	Category	Productivity level	Efficiency level
01	Districts with low yield and low/medium/high CV	Low productivity	Inefficient
02	Districts with medium yield and medium/ high CV	Medium unstable productivity	Less efficient
03	District with medium yield and low CV	Medium stable productivity	Moderately efficient
04	District with high yield and medium/ high CV	High unstable productivity	Potentially efficient
05	District with high yield and low CV	High stable productivity	Efficient

Based on these criteria, the production efficiency of six major crops grown across Chhattisgarh state is presented in tables. The performance of a crop can be interpreted against the ecological requirements of the crop for climatic, soil conditions and irrigation development. Climate is the major factor that regulates and determines the growth and development of crop plans. Plant productivity is negatively impacted by climatic excesses or deficiencies. This study solely attempts to interpret crop efficiency in terms of climatic factors. Monthly rainfall data for 20 years corresponding to crop data were gathered for the representative stations of each district in order to evaluate productivity in terms of climate. To determine the average rainfall during the crop season and its coefficient of variability, monthly rainfall data from the Directorate of Agriculture in Chhattisgarh were analysed. The IMD gridded data website was used to gather temperature information.

3. RESULTS AND DISCUSSIONS

The analysis was conducted at Department of Agrometeorology, College of Agriculture, Raipur (C.G.). In this study, the objective was to evaluate all the districts of Chhattisgarh based on their relative yield and productivity. The regions were differentiated at district level according to their crop production efficiency of crops. There were total 5 major kharif crops selected for the evaluation of efficiency zoning viz.-Rice, Red gram, Maize, groundnut and soybean.

3.1 Arhar (Red gram)

The long-term data of productivity recorded for arhar is analyzed and the output is described in Table 1 below based on their efficiency. As the result seen only Bastar district was having highly unstable productivity which comes under potentially efficient zone. Districts like Bemetara, Kondagaon, Raigarh, Surajpur were noted to come under the moderately efficient zone and productivity is in medium stable classification. The data recorded for low productivity areas of arhar are Baloda bazar, Dhamtari, Gariaband, Mahasamund, Raipur which were found inefficient zone while 17 districts were found less efficient showing medium unstable productivity zone having less efficiency level.

Table 1. Productivity and efficiency level of different districts producing Arhar

S. No.	Category	Productivity	Efficiency level	District
1	Districts with low yield and low/medium/High/CV	Low productivity	Inefficient	Baloda bazar, Dhamtari, gariaband, Mahasamund, Raipur
2	Districts with medium yield and medium/High/CV	Medium unstable productivity	less efficient	Balod, Balrampur, Bijapur, bilaspur, Dantewada, Durg, janjgir champa, Jashpur, Kabirdham, Kanker, Korba, Korea, Mungeli, Narayanpur, Surguja, Sukma, Rajnandgaon
3	Districts with medium yield and low/CV	medium stable productivity	Moderately efficient	Bemetara, Kondagaon, Raigarh, Surajpur
4	Districts with high yield and medium/High CV	high unstable productivity	Potentially efficient	Bastar
5	Districts with high yield and low CV	high stable productivity	Efficient	-

S. No.	Category	Productivity	Efficiency level	District
1	Relative yield	Above 120%	80-120%	below 80%
2	CV	above 40%	20-40%	below 20%

Table 2. Productivity and efficiency level of different districts producing Rice

S. No.	Category	Productivity	Efficiency level	District
1	Districts with low yield and low/medium/High/CV	Low productivity	Inefficient	Jashpur, Kabirdham
2	Districts with medium yield and medium/High CV	Medium unstable productivity	less efficient	Balodabazar, Balrampur, Bastar, Bemetara, Bilaspur, Dantewada, Durg, Kondagaon, Korba, Korea, Mahasamund,Narayanpur, Raigarh, Raipur, Rajnanadgaon, Surajpur, Gariaband
3	Districts with medium yield and low CV	Medium stable productivity	Moderately efficient	Surguja
4	Districts with high yield and medium/High CV	High unstable productivity	Potentially efficient	Balod, Bijapur, Dhamtari, Kanker, Mungeli, Sukma, and Janjgir Champa
5	Districts with high yield and low CV	High stable productivity	Efficient	-

S. No.	Criteria	High	Medium	Low
1	Relative yield	Above 120%	80-120%	below 80%
2	CV	above 30%	15-30%	below 15%

3.2 Rice

Rice is the most important food crop in India. Rice is grown under diverse agroecological conditions in a variety of soils, in combination or sequence with a large number of crops. Rice ranks first in the use of land at > 43 million (M) ha, water resources (> 50% irrigation water), and inputs (38 to 40% of fertilizers and 17 to 18% of pesticides) among the crops cultivated in India (Rice Knowledge Management Portal, http://www.rkmp.co.in). Grown in an area of 43 million ha with average productivity of 2.5 t/ha, rice contributes to nearly 41% of the total food-grain production. The demand for rice is projected to increase shortly with the increase in population in India. Future gains in rice yield are expected to be largely driven by knowledge-intensive crop and soil management as compared to the germplasm-driven yield gains since the start of the green revolution.

During the analysis of rice crop, it was observed that districts producing rice are evaluated and according to the data recorded it has been noticed that a few districts come under the criteria of high unstable productivity i.e. Balod, Bijapur, Dhamtari, Kanker, Mungeli, Sukma, Janjgir Champa which is potentially efficient zone. While few districts are recorded with medium unstable productivity which is less efficient zone for example- Balodabazar, Balrampur, Bastar, Bemetara, Bilaspur, Dantewada, Durg, Kondagaon, Korba, Korea, Mahasamund, Narayanpur, Raigarh, Raipur, Rajnanadgaon, Surajpur, Gariaband. After the analysis it can be concluded that only one district comes under medium stable productivity viz., Sarguja which is moderately efficient whereas two districts Jashpur and Kabirdham are reported with low productivity and these districts fall under in efficient zone.

3.3 Maize

According to the result obtained in Table 3, it can be seen that the districts growing maize are highly differentiated according to the data recorded. The areas which are found to be potentially efficient are Balrampur, Bastar, Bijapur, Dantewada, Dhamtari, Janjgir -Champa, Kondagaon, Narayanpur, Sukma with highly unstable productivity whereas less efficient zone includes Balod, Baloda Bazar, Surajpur, Bemetara, Bilaspur, Kabirdham, Gariaband, Jashpur, Kanker, Korba, Korea, Mungeli, Raigarh, Sarguja with medium unstable productivity. It has been observed that a few districts for example Durg, Rajnandgaon, Mahasamund and Raipur are found inefficient with low productivity criteria.

3.4 Groundnut

The result saw for groundnut-producing districts all over Chhattisgarh state is interpreted in Table 4. According to the data recorded it can be seen that areas of high unstable productivity with potentially efficient zones are Rajnandgaon, Kondagaon and Kabirdham while areas with medium stable productivity with moderately efficient zones are Balodabazar, Bastar, Bilaspur, Janjgir champa, Jashpur, Durg, Gariaband, Korba, Korea, Raigarh, Mahasamund, Mungeli, Sarguja, Surajpur etc. The districts falling in the less efficient zone with medium unstable productivity are Bemetara, Balrampur, Bijapur, Dantewada, Dhamtari, Raipur, Sukma and Kanker while only two districts of Chhattisgarh are reported to have inefficient zoning with low productivity criteria are Balod and Narayanpur.

3.5 Soybean

The result obtained in Table 5 concluded that production of soybean in different districts of Chhattisgarh is divided into different criteria of efficiency levels. The result observed for the region of high unstable productivity are Baloda Bazar, Balrampur, Bastar, Bijapur, Dantewada, Gariyaband, Janjgir Champa, Kanker, Kondagaon, Mungeli, Narayanpur, Raipur and Sukma are potentially efficient. The districts recorded with less efficient zoning are Bilaspur, Dhamtari, Durg, Jashpur, Korba, Mahasamund, Raigarh, Rajnandgaon, Surajpur, Surguja for medium stable productivity. The districts with less efficient criteria and medium unstable for soybean production are Bilaspur, Dhamtari, Durg, Jashpur, Korba, Mahasamund, Raigarh, Rajnandgaon, Surajpur, Sauguja etc. The districts namely Balod, Bemetara, Kabirdham, Korea are noted for low productivity and their efficiency level is also inefficient.

Table 3. Productivity and efficiency level of different districts producing Maize

S. No.	Category	Productivity	Efficiency level	District
1	Districts with low yield and low/medium/High/CV	Low productivity	Inefficient	Durg, Rajnandgaon, Mahasamund, Raipur
2	Districts with medium yield and medium/High/CV	Medium unstable productivity	less efficient	Balod, Baloda bazar, Surajpur, Bemetara, Bilaspur, Kabirdham, Gariaband, Jashpur, kanker, korba, korea, Mungeli, Raigarh, Sarguja
3	Districts with medium yield and low CV	Medium stable productivity	Moderately efficient	-
4	Districts with high yield and medium/High CV	High unstable productivity	Potentially efficient	Balrampur, Bastar, Bijapur, Dantewada, Dhamtari, Janjgir -Champa, Kondagaon, Narayanpur, Sukma
5	Districts with high yield and low CV	High stable productivity	Efficient	-

S. No.	Criteria	High	Medium	Low
1	relative yield	Above 120%	80-120%	below 80%
2	CV	above 30%	15-30%	below 15%

Table 4. Productivity and efficiency level of different districts producing Groundnut

S. No.	Category	Productivity	Efficiency level	District
1	Districts with low yield and low/medium/High CV	Low productivity	Inefficient	Balod, Narayanpur
2	Districts with medium yield and medium/High CV	Medium unstable productivity	less efficient	Bemetara, Balrampur, Bijapur, Dantewada, Dhamtari, Raipur, sukma, kanker
3	Districts with medium yield and low/CV	Medium stable productivity	Moderately efficient	Baloda Bazar, bastar, Bilaspur, Janjgir champa, Jashpur, Durg, gariaband, korba, korea,Raigarh, Mahasamund, Mungeli, Sarguja, Surajpur
4	Districts with high yield and medium/High CV	High unstable productivity	Potentially efficient	Rajnandgaon, Kondagaon, Kabirdham
5	Districts with high yield and low CV	High stable productivity	Efficient	-

S. No.	Criteria	High	Medium	Low
1	Relative yield	Above 120%	80-120%	below 80%
2	CV	above 50%	25-50%	below 25%

Table 5. Productivity and efficiency level of different districts producing Maize

S. No.	Category	Productivity	Efficiency level	District
1	Districts with low yield and low/medium/High CV	Low productivity	Inefficient	Balod, Bemetara, Kabirdham, Korea
2	Districts with medium yield and medium/High CV	Medium unstable productivity	less efficient	Bilaspur, Dhamtari, Durg Jashpur, Korba, Mahasamund, Raigarh, Rajnandgaon, Surajpur, Surguja
3	Districts with medium yield and low CV	Medium stable productivity	Moderately efficient	-
4	Districts with high yield and medium/High CV	High unstable productivity	Potentially efficient	Baloda Bazar, Balrampur, Bastar, Bijapur, Dantewada, Gariyaband, Janjgir-Champa, Kanker, Kondagaon, Mungeli, Narayanpur, Raipur, Sukma
5	Districts with high yield and low CV	High stable productivity	Efficient	-

S. No.	Criteria	High	Medium	Low
1	Relative yield	Above 120%	80-120%	below 80%
2	CV	above 50%	25-50%	below 25%

4. SUMMARY AND CONCLUSIONS

The analysis was conducted at Department of Agrometeorology, College of Agriculture, Raipur (C. G.). The analysis results showed that all over Chhattisgarh state includes all the criteria of efficiency of kharif crops at different levels. From the result it can be suggested that no crop was recorded under the criteria of efficient and highly stable productivity. But for crop like arhar, Bastar, district recorded a zonation of potentially efficient crops with high unstable productivity whereas districts like Baloda bazar, Dhamtari, Gariaband, Mahasamund and Raipur were falling under inefficient zone with low productivity. As we know, rice is a staple crop all over India and Chhattisgarh state is known as the bowl of rice. Therefore, according to the result it has been noticed that only two districts namely Jashpur and Kabirdham fell in the criteria of inefficient and low productivity zone and districts like Balod, Bijapur, Dhamatari, Kanker, Mungeli, Sukma and Janjgir Champa achieved potentially efficient with highly unstable productivity zone. Other major kharif crops like maize, soybean and groundnut results also recorded no area or district coming under the efficient zoning. For maize it has been observed that districts like Balrampur, Bastar, Bijapur, Dantewada, Dhamtari, Janjgir Champa, Kondagaon, Narayanpur, Sukma achieved the criteria of potentially efficient zone with high unstable productivity whereas four districts Raipur, Mahasamund, Rajnandgaon and Durg are recorded to be in inefficient zone with low productivity. The same result was also obtained for groundnut, very few districts like Rajnandgaon, Kondagaon, Kabirdham achieved potentially efficient with highly unstable productivity zone while many districts are recorded to be moderately efficient zone like Baloda Bazar, Bastar, Bilaspur, Janjgir Champa, Jashpur, Durg, Gariaband, Korba, Korea, Raigarh, Mahasamund, Mungeli, Sarguja, Surajpur. In the case of Soybean many districts viz., Balodabazar, Balrampur, Bastar, Bijapur, Dantewada, Gariyaband, Janjgir-Champa, Kanker, Kondagaon, Mungeli, Narayanpur, Raipur, Sukma are the districts achieved potentially efficient zone with high unstable productivity whereas four districts are noted with low productivity and inefficient zoning i.e. Balod, Bemetara, Kabirdham, Korea. From the above analysis it can be concluded that the area with potentially efficient with highly unstable productivity can be recommended with the proper and continuous streamlining of technologies. The area recorded with low productivity and inefficiency should be identified with their proper reason behind it and recommended for the proper management system or diversification.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/95843