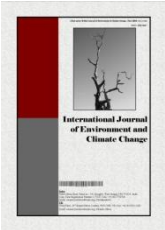

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Delineation of Efficient Paddy Cropping Zones in Andhra Pradesh

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Authors' contributions

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

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ABSTRACT

The research delineated efficient paddy crop zones in Andhra Pradesh. The area, yield and production of paddy were gathered from the Andhra Pradesh Department of Economics and Statistics to compute the Relative Spread Index (RSI) and Relative Yield Index (RYI). The definition of an efficient cultivation zone for paddy shows that in all nine districts of Andhra Pradesh there are numerous possibilities to increase overall paddy production. The primary source of irrigation is groundwater, comprising tubes and wells that cover 49 percent of net irrigation. The grade is of four types: Most Efficient Cropping Zone (MECZ) and Area Efficient Cropping Zone (AECZ) and Yield Efficient Cropping Zone(YECZ) and Not Efficient Cropping Zone (NECZ). It was noted that the West Godavari, East Godavari, Krishna, Guntur and Nellore are five districts inside Paddy's Most efficient cropping zone. Srikakulam and Vizianagaram are two districts within the Area efficient cropping zone. The Kurnool and Prakasam are two districts in which Yields efficient cropping zone. Visakhapatnam, Chittoor, Kadapa and Anantapur are four districts belong to the Not-efficient cropping zone. It is concluded that there was a lot of possibilities of increasing the overall production of paddy in all nine districts of Andhra Pradesh by delineating the efficient cropping

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zone for paddy. In the case of AECZ there is a need for popularisation of high-yielding cultivars, for better management technologies like the Rice Intensification System (RIS) and for integrated nutrient handling to increase yield levels and convert this zone into MECZ. In the case of YECZ, these sites offer promise for rice growing, although a decrease in water availability may be attributed to the less extensive area.

Keywords: Paddy; delineation; cropping zone.

1. INTRODUCTION

Rice is the world's second highest cultivation grain crop after maize. However, rice is seen as the main food crop, because it goes much beyond human consumption of maize. For over two-thirds of the world's population, rice is a major cereal crop and livelihood. Rice is extremely nutritious, and more than 1/5 of the calories humans eat worldwide originate from rice crop. The main business and source of income of more than 100 million families in Asia, Africa and Latin America is rice farming in developing nations. China is the world's leading rice producer (27.3%), followed by India (21.89%). In India, Western Bengal, Uttar Pradesh, Andhra Pradesh, Telangana, Punjab, Bihar and Tamil Nadu are the main rice producers. The Indian rice crop area is 23.3%, while the overall production of food grain is 43%, and 46% of cereals is rice [1]. Over recent decades, the worldwide increase in rice consumption from 437.18Mt to 490.27Mt has been inadequate. There is a increase in Indian paddy cultivation in 43.79 M ha production of 116.42 Mt and at productivity 2659 kg ha-1, respectively. India exhibits a good growth rate in areas (0.24%), production (1.95%) and productivity (1.70%) with 1% of significance [2]. The yield of a particular crop relies on adaptation of the crop. The potential yield for each crop is always higher than the yields achieved. The area is not wide, but the crop yield is considerably higher. Both situations are not appropriate to enable the state to be autonomous to satisfy its growing population and to reduce food security. Although a certain crop is common in an area, the productivity may not be great for several obvious reasons.

The average yield gap owing to agricultural techniques varies from 335 kg/ha (North Coastal Area) to 981 kg/ha (Godavari Area) with a yield gap of 663 kg /ha for the Andhra Pradesh, which shows paddy production in the State may be substantially increased by increase of farmers' management practise [3]. Andhra Pradesh has 5.04% of paddy cultivation in India, which is the fourth largest paddy-grown area. In overall Andhra Pradesh's production, it is the third most important contributor to India's total production, with 3733 kg/ha [4]. In the state, rice is usually cultivated in irrigated circumstances, which is one of the principal reasons for higher productivity. This led, however, to issues of groundwater use and ground level depletion. The irrigation of Krishna canal and Godavari river reserves is a major source of irrigation other than wells and tube wells. Rice is grown in nearly all Andhra Pradesh districts. The Krishna, Godavari delta area, however, is Andhra Pradesh's primary "rice bowl." Consequently, a special focus approach is required to increase rice production in Andhra Pradesh from medium to high productivity states.

Many constraints apply to the production of rice, which differ between areas. Technical and socio-economic constraints, Pest and diseases, soils, agricultural factors etc., are the technical constraints. Small holding volumes, insufficient supply of inputs and unavailability of inputs are socioeconomic constraints. However, studies on national rice production have shown that production is constrained by various factors such as socio-economic, biotic and abiotic factors.

Late seeding and long transplantation cause of failure and lack of water lowlands mostly in rainfed agriculture.

Low and inadequate use of crop production is mainly observed in highland areas. Severe drought, water supply, temperature, zinc shortage, salt etc. are the abiotic factors which restrict rice output. Biotic constrains includes the insect pests that affect rice brown plant hopper (BPH), gall midge, stem borer, leaf folder, gundhi and hispa. The newly developed pesticides are of significance for rice as panicle mites and thrips.

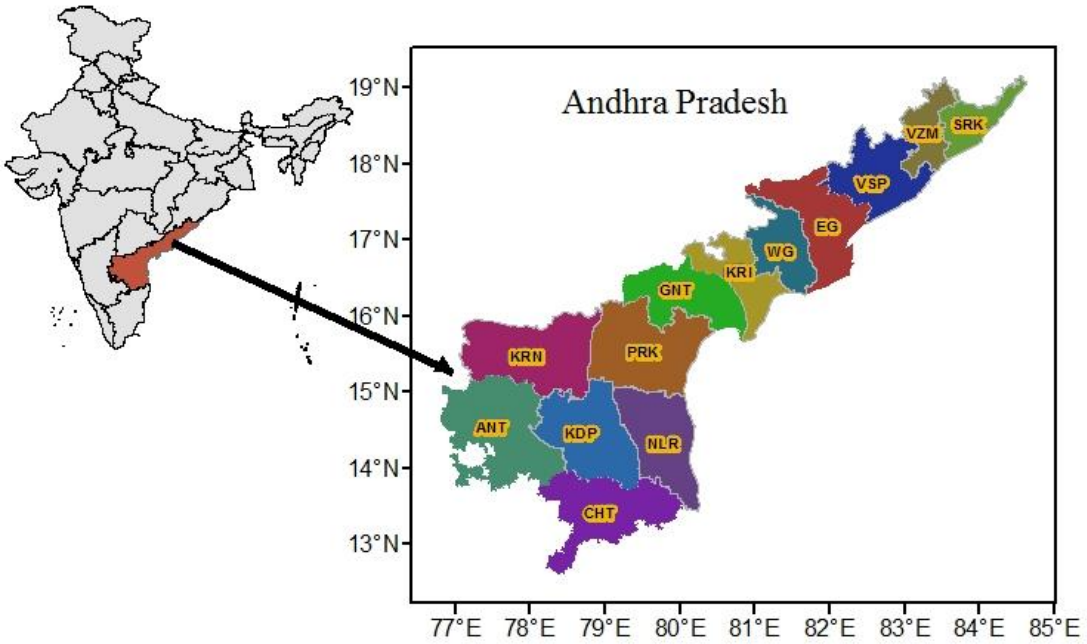

Fig. 1. Domain of study with district of Andhra Pradesh

Moreover, additional fundamental constraints include socio-economic constraints such as analphabetism, less inclusion to know the newest technology, a lack of work, inadequate resource base and investment.

In this context, Fig. 1 show domain map of study area Andhra Pradesh. The main causes for this large yield difference need to be analysed and adaptations identified to increase yield and decrease the yield gap identified. This research focuses on determining Andhra Pradesh's district-based efficient crop zone, the first step towards understanding the reasons for a state yield difference.

1.1 Objectives of the Study

- To understand the concept of delineation of efficient cropping zone for paddy.
- To do the categorization of different cropping zones at the district level over the state of Andhra Pradesh.

2. LITERATURE REVIEW

[5] THIS study analyses the water footprint of rice in the agroclimatic zones (ACZ) of India and finds rice producing areas that are sustainable. In the irrigated northwest and semi-arid tropics, large rice-producing ACZs are unsustainable. In East, Central and (coastal areas of) West India rice may be grown in a sustainable way, since the water footprint is smaller and it can also be reduced further as the crop yield is extremely low. The research recommends that the cropping pattern in the ACZs should be re-aligned, depending on the water availability and footprint.

[6] Tamil Nadu usually cultivates cotton in an area of approximately 0.2 m hectares and produces about 0.6 million cotton ball and the state is excellent for growing long and extra-long staple cottons because of the climate and the soil. In this study, the efficient cropping areas of cotton crop in the state of Tamil Nadu were identified. An analytical research was carried out using a 10 year (2004-2015) data, utilising a Relative yield index and Relative Spread index, to determine the efficient cotton crop zones of Tamil Nadu (RSI). The efficient cotton crop zone has been identified. A research on Tamil Nadu Agricultural University (CEZ) for the cotton crop of Tamil Nadu was performed at the Agro-Climate Research Center in Coimbatore during 2018-19. Salem and Ariyalur were determined to be both under higher effective cotton crop cultivation zones. NECZ and LECZ are the major regions of Tamil Nadu. Four districts in Tamil Nadu have an efficient cultivation area and a larger area compared to yield. These include Tiruchirapalli, Perambalur, Madurai, Virudhanager and other districts.

[7] Sugar cane is a major cash crop, which accounts for 4.6% of overall agricultural production. Although sugar cane is widely available in an area of areas, productivity is much lower. Productivity is extremely high in several other areas, although sugarcane is modest in acreage. This guarantees the definition of efficient sugar cane cultivation zones. Special district data were gathered on the area, production and productivity of sugar cane for the South Indigenous countries to calculate the Relative Spread Index (RSI) and Relative Yield Index (RYI) in the Most Efficient Crop Zone (MECZ) areas, the Area-effective Crop Zone (AECZ). Analysis showed that Tamil Nadu, followed by Karnataka, Andhra Pradesh, and Telangana have the most efficient cane production zone. Due to the existing climatic circumstances, sugarcane is not favoured in Kerala. This study helps to define ways to improve the area and production of sugar cane.

[8] Maize production in India is expected to be 4-5 times the present production in 2050. With little scope to expand the area, the yield has to be improved. This requires the identification of locations where there are enormous untapped yield potential. The current research identifies homogenous agroclimatic areas for maize production in India that take the area as a single unit, utilising factors such as climate, soil, season, and irrigated area under crop conditions. This study aims at addressing this problem. In India, the main crop of maize grows in 146 districts. The cluster analysis has been split into 26 zones. In order to address the gaps in yield, it was possible to investigate the variance of yield across districts in a zone with regards to crop handler methods in those districts. These results may be of immediate importance to maize producers and district managers.

[9] This research identified Andhra Pradesh's prime, moderate and marginal lands on the basis of key soil and climate characteristics such as soil depth, gravel presence and pitch and growth time. The overall primary lands of Andhra Pradesh are 51.52 lakhs ha (31.9 percent), with higher prime lands in the areas of Guntur, Nellore and Krishna, 7.31, 6.82 and 6.67 lakhs ha, respectively. The area of the state's periphery is 43.66 lakhs ha (27.03 percent of TGA). The district of Anantapur has a wide area (14.6 lakhs ha) and followed up by Kadapa (6.68 lakhs ha). State governments should enact laws on strong land use to limit primary land usage for non-farm purposes. Pressures must be minimized on marginal soils by assessing the capacity to currently utilize the land and thus appropriate alternative land use should be proposed.

[10] Methodological research was carried out in 2012 on the prospective districts of rice, maize, and noodles in Tamil Nadu at the Agro-Climate Research Centro, Tamil Nadu Agricultural University in Coimbatore. Data have been gathered on study plant area, production and productivity from 2000-01 to 2009-10, indicators such as the Relative Spacing Index (RSI) and the Relative Yield Index (RYI), and the prospective crop districts were selected for the research plants. Nine districts in Tamil Nadu are identified as potential rice regions, seven maize districts and three groundnut districts because RYI and RSI are high in those locations. RSI is more appropriate for a specific crop in some districts, while the RYI is low, showing that this crop is inappropriate. Due to factors such as market demand and production value, however, farmers are cultivating cultures which are not appropriate for their position, which is associated with low RYI in high RSI.

3. MATERIALS AND METHODS

In order that productivity and efficiency of cropping areas throughout Andhra Pradesh were evaluated, Relative Spread Index (RSI) and Relative Yield Index (RYI) were computed. In the current research, data have been gathered from Andhra Pradesh's Department of Economics and Statistics that consists of the area, productivity and paddy production for all 13 districts of Andhra Pradesh and a cultivable area for the 2005-2019 timeframe. The formula suggests that academics have been using this method for calculating the relative spread index (RSI) and relative yield index (RYI) as suggested by [11,12 and 13].

$$\text{RYI} = \frac{\text{Area under paddy expressed as \% of the total cultivable are in the district}}{\text{Area under paddy expressed as \% of the total cultivable are in the state}} \text{X100}$$

$$\text{RSI} = \frac{\text{Mean yield of paddy in a district(t/ha)}}{\text{Mean yield of paddy in the state}} \text{X100}$$

The combinations of RSI and RYI to identify categories of efficient cropping zones are listed in Table 1.

Table 1. Criteria for efficient cropping zone

RYI Value	RYI category	RSI value	RSI Category	Cropping Zone	Reference
>100	High	>100	High	Most Efficient Cropping Zone (MECZ)	
<100	Low	>100	High	Area Efficient Cropping Zone (AECZ)	Arulmathi (2016)
>100	High	<100	Low	Yield Efficient Cropping Zone (YECZ)	
<100	Low	<100	Low	Not Efficient Cropping Zone (NECZ)	

4. RESULTS AND DISCUSSION

Andhra Pradesh state have five agro climate i.e Godavari zone (East Godavari, West Godavari), Krishna zone (Krishna, Guntur, Prakasam), South zone (Nellore, Chittoor, Kadapa), Scarce rainfall (Anantapur, Kurnool) including the North Coastal zone (Vizianagaram and Visakhapatnam).

4.1 Andhra Pradesh Cropping Zones of Paddy

The paddy area of Andhra Pradesh was 23.45 lakhs ha, with a production of 117.47 lakhs tonnes and 5009 kg/ha productivity. West Godavari (4,02,215 hectares) is the highest average area for paddy growth, and East Godavari (3,77,031 hectares) is a contributing area for the Godavari region which accounts for close to 33 percent of total paddy production and Anantapur (38,231 hectares) is the lowest average area to grow paddy in a rainforest zone. Nellore (6015 kg/ha), then West Godavari (5556 kg/ha), are the greatest productivity. The paddy productivity is between 5000 – 6000 kg/ha in Prakasam, Kurnool, Krishna, the districts of Guntur. Productivity ranges from 4000-5000 kg/ha for the districts of Chittoor, Kadapa and Anantapur. Paddy productivity between 2500 and 4000 was recorded in Vizianagaram, Srikakulam and Vishakhapatnam, with the lowest productivity rate recorded in Visakhapatnam (2693 kg/ha).In West Godavari districts paddy cultivation and production is highest among district in Andhra Pradesh 17% and 19% respectively in Fig. 2.

Table 2. Andhra Pradesh efficient cropping zone (2005-2019)

District	Paddy Area(ha)	Total Paddy Production in (Tonnes)	Yield (t/ha)	Cultivable area(ha)	% of paddy area to total cultivable area	RYI	RSI	Zone type
Srikakulam	1,98,511	660818	3342	356705	56%	66	209	AECZ
Vizianagaram	1,19,795	460834	3836	365979	33%	76	122	AECZ
Visakhapatnam	99,785	269638	2693	398839	25%	53	94	NECZ
East Godavari	3,77,031	2056727	5479	514796	73%	108	273	MECZ
West Godavari	4,02,215	2217182	5556	476566	84%	110	314	MECZ
Krishna	3,01,988	1580751	5299	545691	55%	105	204	MECZ
Guntur	2,63,508	1367926	5273	726190	36%	104	133	MECZ
Prakasam	98,690	533827	5458	906159	11%	109	39	YECZ
Nellore	2,32,638	1396333	6015	575481	40%	120	150	MECZ
Chittoor	54,843	272212	4972	687258	8%	99	29	NECZ
Kadapa	52,634	214334	4167	614423	9%	82	32	NECZ
Anantapur	38,231	158529	4162	1379357	3%	83	10	NECZ
Kurnool	1,05,261	558285	5313	1154385	9%	106	34	YECZ

Area cultivated in Andhra Pradesh is 23.45 lakhs ha, Production is 117.47 lakhs tonnes and productivity 5009 kg/ha

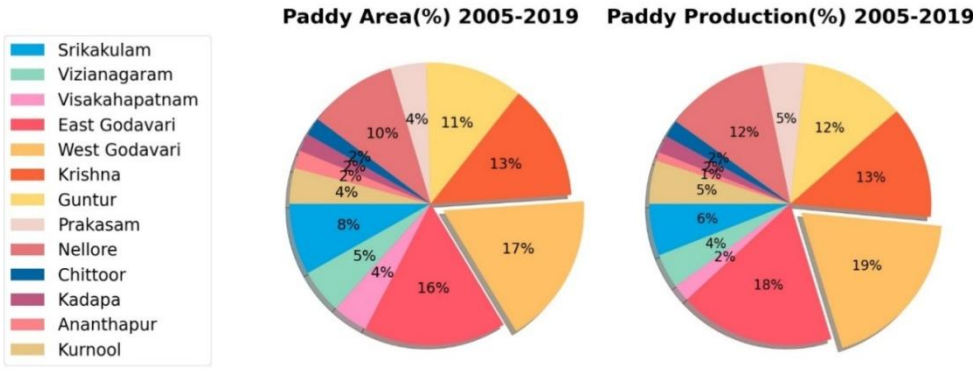

Fig. 2. Andhra Pradesh cropping zones of Paddy

In Nellore, West Godavari, Prakasam, East Godavari, Kurnool, Krishna, and Guntur relative spread index values greater than 100 percent were observed. In the district of West Godavari, East Godavari, Srikakulam, Krishna, Nellore, Guntur and Vizianagaram the relative yield index was observed to be over 100%, indicating outstanding paddy crop performance.

Based on Andhra Pradesh's estimated RSI and RYI, Identification of efficient cropping zones in Table 2 the districts of East Godavari, West Godavari, Krishna, Guntur and Nellore are among the most efficient cropping zones (MECZ). Both RSI and RYI values are greater than 100%. The Srikakulam and Vizianagaram districts with RYI below 100% and RSI over 100% have a range of Area efficient cropping zones (AECZ). Kurnool and Prakasam, on the other hand, which have RSI values below 100% and RYI values over 100%, come within the Yield efficient cropping zone (YECZ). But Visakhapatnam, Chittoor, Kadapa and Anantapur are districts with RSI and RYI values less than 100 percent. They are categorized in non-efficient crop areas (NECZ). The history and current state of rice in various districts of Andhra Pradesh may now be understood in relation with the various infectious growing zones. With this foundation, other adaptation options may now be included to enhance rice production and productivity in Andhra Pradesh.

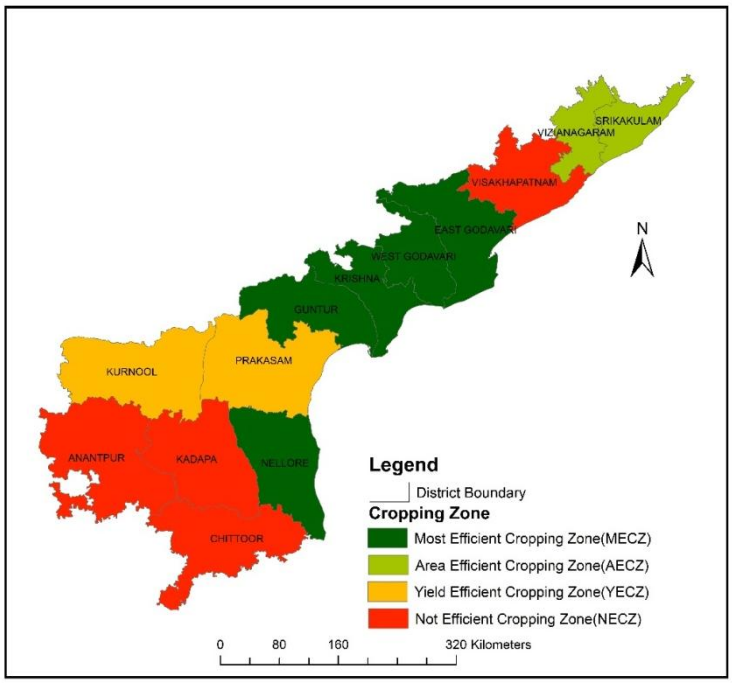

Fig. 3. Cropping Zone

5. CONCLUSION

Delineation of the efficient cropping zone for paddy showed that in the nine districts of Andhra Pradesh there is much room for increasing paddy production. In the case of AECZ there is a need for popularisation of high-yielding cultivars, for better management technologies like the Rice Intensification System (RIS) and for integrated nutrient management to increase yield levels and convert this zone into MECZ. With regard to YECZ, these sites offer rice agriculture potential, however less area spread may be owing to water supply decrease. Micro irrigation, for example fertigation, has to be promoted in these areas with nutrient control. Measured to collect water and improve the efficiency of water usage to increase the area in the paddy. In the event of inefficient areas, alternative crops as well as integrated agricultural syatema may be found to increase agricultural productivity and revenue.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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