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Analysis of efficient cropping zones for *Rabi* jowar, wheat and gram crops in different tahsils of southern regions of Western Maharashtra

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Abstract
A study was conducted in the Department of Agricultural Meteorology, College of Agriculture, Pune (Maharashtra) during 2022–24 to identify efficient cropping zones (ECZ) for *rabi* jowar, wheat, and gram in the southern regions of Western Maharashtra. Data on the area, production, and productivity of these crops from 2000–01 to 2020–21 were analyzed. Indices such as the Relative Spread Index (RSI) and Relative Yield Index (RYI) were computed to pinpoint potential cropping tahsils.
In the Southern regions of Western Maharashtra identified efficient cropping zones for *rabi* jowar, wheat and gram are 29, 26 and 25 respectively as these areas exhibited high RYI and low RSI values. Conversely, some tahsils demonstrated low RSI and RYI, indicating unsuitability for the respective crops. However, farmers in these areas often grow unsuitable crops due to factors such as market demand and the economic value of the produce, which contributes to their low RYI and RSI values.

Keywords: Efficient cropping zone, relative spread index, relative yield index

1. Introduction
Agricultural efficiency relies on natural resources such as soil, water, nutrients, and minerals, which are essential for crop growth and productivity (Zolekar and Bhagat, 2015) [6]. It is influenced by factors including temperature changes, precipitation patterns, soil quality, and the distribution of pests, insects, diseases, or weeds. These factors collectively shape the agro-ecological conditions necessary for crop nourishment and efficiency. The success of Indian agriculture is heavily dependent on the monsoon (Prasanna V., 2014) [3].
Rainfall during the summer monsoon season plays a critical role in determining cropping patterns and agricultural productivity by supplying water for the two primary crop-growing seasons: *Kharif* and *Rabi*. Variations in monsoon rainfall result in the formation of efficient and inefficient cropping zones (Prasanna V., 2014; Krishna Kumar K. *et al*., 2004) [3, 1].
The concept of an Efficient Cropping Zone (ECZ) is used to identify areas with high potential for specific crops. This is determined through indices such as the Relative Spread Index (RSI) and Relative Yield Index (RYI), which measure the efficient cropping area for crops (Veeraputhiran and Kathikeyan, 2003) [5]. Crop productivity varies across regions, and identifying ECZs enables optimal utilization of natural resources to achieve maximum yield per unit area over time.
Analyzing ECZs help to determine the most suitable areas for specific crops. If a crop is not well-suited to an area based on ECZ analysis, it can be replaced with a more suitable crop that has higher potential for achieving optimal yields (Thavaprakaash *et al.*, 2008) [4].

2. Materials and Methods
The data related to area, production and productivity and total cultivable area of *rabi* sorghum, wheat and gram in different tahsils and districts were collected for 2000–01 to 2020– 2021 (20 years) from the Department of Agriculture, Government of Maharashtra. From the data, Relative Spread Index (RSI) and Relative Yield Index (RYI) were computed by using the following

formula proposed by Kanwar (1972) [2].

$$RSI = \frac{\text{Area of particular crop expressed as percent of total cultivable area in the } tahsil}{\text{Area of crop expressed as percentage to the total cultivable area in the } district} \times 100$$

Where in RSI: Relative Spread Index

$$RYI = \frac{\text{Mean yield of a particular crop in a } tahsil \text{ (Kg/ha)}}{\text{Mean yield of the crop in the District (Kg/ha)}} \times 100$$

Where in RYI: Relative Yield Index

The criterion suggested by Kanwar (1972) [2] was used to demark efficient cropping zone as per RSI & RYI values obtained from computation in respective crops.

Table 1: Criteria for Efficient Cropping Zone

S. No.	RSI	RYI	Cropping Zone
1	>100 (High)	>100 (High)	Most Efficient Cropping Zone (MECZ). The zone with good spread and more yield of crop. Sustainability options have to identified and imposed.
2	< 100 (Low)	>100 (High)	Efficient Cropping Zone (ECZ). The zone with good spread and low yield. The constraints in area spread have to be identified. The ECZ is renamed as Yield Efficient Cropping Zone (YECZ) in Agro Climate Research Centre's Crop Scientist unpublished Report, 2018.
3	> 100 (High)	<100 (Low)	Less Efficient Cropping Zone (LECZ). The zone with high spread and Low yield. The constraints in yield have to be identified.
4	< 100 (Low)	< 100 (Low)	Not Efficient Cropping Zone (NECZ). The zone with low spread and low yield. Suitability of alternate crops may be assessed.

3. Results and Discussion

3.1 Efficient cropping zones for *rabi* sorghum

The analysis presented in Tables 2 and 3 reveals that the productivity of *rabi* sorghum, as measured by the Relative Yield Index (RYI), was high in the tahsils of Haveli, Mulshi, Bhor, Velhe, Purandar, North Solapur, South Solapur, Barshi, Akkalkot, Madha, Karmala, Malshiras, Mangalwedha, Satara, Jawali, Karad, Koregaon, Wai, Miraj, Walwa, Palus, Kadegaon, Shirala, Shirol, Hatkanagale, Panhala, Karveer, Gadhingalaj and Chandgad. However, the area under cultivation for this crop in these regions was relatively low, placing them in the Efficient Cropping Zone (ECZ).

In contrast, tahsils such as Mawal, Junnar, Khed, Ambegaon, Shirur, Baramati, Indapur, Daund, Mohol, Pandharpur, Sangola, Patan, Khatav, Dahiwadi, Phaltan, Khandala, Jath, Khanapur, Tasgaon, Atpadi, Kavathemahankal, Shahuwadi, Kagal, Bhudargad and Ajra were characterized by both low RYI and a limited area under *rabi* sorghum cultivation. These tahsils were classified under the Not Efficient Cropping Zone (NECZ).

3.2 Efficient cropping zones for wheat

Wheat is a critical *rabi* crop with significant importance in the agricultural economy. The findings presented in Tables 2 and 3 indicate that the crop demonstrates high yield potential, as reflected by the Relative Yield Index (RYI), despite having a relatively low area under cultivation, as indicated by the Relative Sustainability Index (RSI) in the tahsils of Mawal, Junnar, Khed, Shirur, Indapur, Purandar, South Solapur, Mohol, Madha, Pandharpur, Sangola, Malshiras, Satara, Patan, Karad, Phaltan, Khandala, Wai, Jath, Walwa, Tasgaon, Palus, Shirala, Hatkanagale, Panhala and Kagal. These tahsils are classified under the Efficient Cropping Zone (ECZ) for wheat cultivation.

In contrast, tahsils such as Haveli, Mulshi, Bhor, Velhe, Junnar, Ambegaon, Baramati, Daund, North Solapur, Barshi, Akkalkot, Karmala, Mangalwedha, Jawali, Koregaon, Khatav, Dahiwadi, Miraj, Khanapur, Kadegaon, Atpadi, Kavathemahankal, Shirol, Shahuwadi, Karveer, Gadhingalaj, Bhudargad and Ajra are categorized under the Not Efficient Cropping Zone (NECZ). These regions exhibit both RYI and RSI values below 100%, indicating limitations in both productivity and cultivation area for wheat

3.3 Efficient cropping zones for gram

The findings presented in Tables 2 and 3 indicate that the tahsils Junnar, Shirur, Baramati, Indapur, Daund, Purandar, South Solapur, Barshi, Mohol, Sangola, Satara, Patan, Karad, Khatav, Wai, Miraj, Jath, Khanapur, Walwa, Palus, Shirol, Panhala, Radhanagari, Karveer and Kagal were identified as Efficient Cropping Zones (ECZ) for gram cultivation. These tahsils recorded a Relative Yield Index (RYI) value exceeding 100% and a Relative Sustainability Index (RSI) value below 100%, indicating strong yield potential with sustainable resource use.

On the other hand, tahsils such as Haveli, Mulshi, Bhor, Maval, Velhe, Khed, Ambegaon, North Solapur, Akkalkot, Madha, Karmala, Pandharpur, Malshiras, Mangalwedha, Jawali, Koregaon, Dahiwadi, Phaltan, Khandala, Mahabaleshwar, Tasgaon, Kadegaon, Shirala, Atpadi, Kavathemahankal, Hatkanagale, Bawada, Gadhingalaj, Bhudargad, Ajra and Chandgad exhibited both low RYI and RSI values. As a result, these tahsils were categorized as Not Efficient Cropping Zones (NECZ) for gram cultivation.

Table 3: *Rabi* Jowar, Wheat, Chickpea crops' computed RSI and RYI value in different tahsils in Southern region of Western Maharashtra (2000-2020)

Sr. No	Tahsil Name	*Rabi* Jowar		Wheat		Gram	
		RSI	RYI	RSI	RYI	RSI	RYI
1	Haveli	0	109	2	99	0	90
2	Mulshi	0	106	1	73	1	82
3	Bhor	8	141	6	72	3	82
4	Maval	1	99	2	105	1	54
5	Velhe	0	140	1	99	1	62
6	Junnar	6	78	16	100	21	110
7	Khed	6	80	3	116	29	79
8	Ambegaon	5	64	5	85	5	92
9	Shirur	25	71	8	119	7	100
10	Baramati	29	99	17	88	20	143
11	Indapur	3	93	12	120	4	127
12	Dhond	4	88	17	97	1	165
13	Purandhar	13	133	11	126	8	114
14	North Solapur	3	107	24	66	6	83
15	South Solapur	2	142	5	101	11	150
16	Barshi	11	114	17	81	14	102
17	Akkalkot	17	102	13	80	38	74
18	Mohol	12	96	12	112	3	118
19	Madha	16	103	3	100	6	79
20	Karmala	16	117	4	87	5	91
21	Pandharpur	1	79	9	131	4	90
22	Sangola	6	65	4	128	5	146
23	Malshiras	5	114	9	152	9	96
24	Mangalwedha	11	61	1	63	1	71
25	Satara	9	125	12	111	8	100
26	Jawali	2	108	6	95	5	42
27	Patan	5	83	8	102	9	113
28	Karad	4	109	16	128	12	182
29	Koregaon	11	106	6	97	19	73
30	Khatav	17	82	9	69	19	124
31	Dahiwadi	25	73	6	72	7	94
32	Phaltan	12	77	19	114	8	92
33	Khandala	9	85	7	117	7	73
34	Wai	7	151	9	129	7	108
35	Mahabaleshwar	-	-	2	65	-	-
36	Miraj	13	106	6	91	12	144
37	Jath	45	86	25	100	21	103
38	Khanapur	3	75	8	83	8	105
39	Walwa	2	155	24	100	21	105
40	Tasgaon	3	71	9	119	9	90
41	Palus	0	108	5	136	8	151
42	Kadegaon	6	101	9	89	6	77
43	Shirala	2	146	3	117	4	86
44	Atpadi	12	70	6	81	3	74
45	Kavathemahankal	15	82	5	82	7	66
46	Shirol	2	124	2	94	5	148
47	Hatkanagale	40	165	34	122	16	90
48	Panhala	2	123	31	119	13	145
49	Shahuwadi	1	86	14	70	6	74
50	Radhanagari	-	-	-	-	3	120
51	Bawada	-	-	-	-	0	75
52	Karveer	15	100	11	82	15	126
53	Kagal	16	69	4	166	20	133
54	Gadhingalaj	23	113	4	72	12	93
55	Bhudargad	1	72	0	75	4	78
56	Ajra	1	44	-	-	2	60
57	Chandgad	1	106	-	-	3	58

Table 3: Classification of Efficient cropping zone for *Rabi* Jowar, Wheat and Chickpea crops across various tahsils of the Southern region of Western Maharashtra (2000-2020)

Sr. No	Tahsil Name	*Rabi* Jowar			Wheat			Gram		
		RSI	RYI	CZ	RSI	RYI	CZ	RSI	RYI	CZ
1	Haveli	L	H	ECZ	L	L	NECZ	L	L	NECZ
2	Mulshi	L	H	ECZ	L	L	NECZ	L	L	NECZ
`3	Bhor	L	H	ECZ	L	L	NECZ	L	L	NECZ
4	Mawal	L	L	NECZ	L	H	ECZ	L	L	NECZ
5	Velhe	L	H	ECZ	L	L	NECZ	L	L	NECZ
6	Junnar	L	L	NECZ	L	H	ECZ	L	H	ECZ
7	Khed	L	L	NECZ	L	H	ECZ	L	L	NECZ
8	Ambegaon	L	L	NECZ	L	L	NECZ	L	L	NECZ
9	Shirur	L	L	NECZ	L	H	ECZ	L	H	ECZ
10	Baramati	L	L	NECZ	L	L	NECZ	L	H	ECZ
11	Indapur	L	L	NECZ	L	H	ECZ	L	H	ECZ
12	Dhond	L	L	NECZ	L	L	NECZ	L	H	ECZ
13	Purandhar	L	H	ECZ	L	H	ECZ	L	H	ECZ
14	North Solapur	L	H	ECZ	L	L	NECZ	L	L	NECZ
15	South Solapur	L	H	ECZ	L	H	ECZ	L	H	ECZ
16	Barshi	L	H	ECZ	L	L	NECZ	L	H	ECZ
17	Akkalkot	L	H	ECZ	L	L	NECZ	L	L	NECZ
18	Mohol	L	L	NECZ	L	H	ECZ	L	H	ECZ
19	Madha	L	H	ECZ	L	H	ECZ	L	L	NECZ
20	Karmala	L	H	ECZ	L	L	NECZ	L	L	NECZ
21	Pandharpur	L	L	NECZ	L	H	ECZ	L	L	NECZ
22	Sangola	L	L	NECZ	L	H	ECZ	L	H	ECZ
23	Malshiras	L	H	ECZ	L	H	ECZ	L	L	NECZ
24	Mangalwedha	L	H	ECZ	L	L	NECZ	L	L	NECZ
25	Satara	L	H	ECZ	L	H	ECZ	L	H	ECZ
26	Jawali	L	H	ECZ	L	L	NECZ	L	L	NECZ
27	Patan	L	L	NECZ	L	H	ECZ	L	H	ECZ
28	Karad	L	H	ECZ	L	H	ECZ	L	H	ECZ
29	Koregaon	L	H	ECZ	L	L	NECZ	L	L	NECZ
30	Khatav	L	L	NECZ	L	L	NECZ	L	H	ECZ
31	Dahiwadi	L	L	NECZ	L	L	NECZ	L	L	NECZ
32	Phaltan	L	L	NECZ	L	H	ECZ	L	L	NECZ
33	Khandala	L	L	NECZ	L	H	ECZ	L	L	NECZ
34	Wai	L	H	ECZ	L	H	ECZ	L	H	ECZ
35	Mahabaleshwar	-	-	-	L	L	NECZ	-	-	-
36	Miraj	L	H	ECZ	L	L	NECZ	L	H	ECZ
37	Jath	L	L	NECZ	L	H	ECZ	L	H	ECZ
38	Khanapur	L	L	NECZ	L	L	NECZ	L	H	ECZ
39	Walwa	L	H	ECZ	L	H	ECZ	L	H	ECZ
40	Tasgaon	L	L	NECZ	L	H	ECZ	L	L	NECZ
41	Palus	L	H	ECZ	L	H	ECZ	L	H	ECZ
42	Kadegaon	L	H	ECZ	L	L	NECZ	L	L	NECZ
43	Shirala	L	H	ECZ	L	H	ECZ	L	L	NECZ
44	Atpadi	L	L	NECZ	L	L	NECZ	L	L	NECZ
45	Kavathemahankal	L	L	NECZ	L	L	NECZ	L	L	NECZ
46	Shirol	L	H	ECZ	L	L	NECZ	L	H	ECZ
47	Hatkanagale	L	H	ECZ	L	H	ECZ	L	L	NECZ
48	Panhala	L	H	ECZ	L	H	ECZ	L	H	ECZ
49	Shahuwadi	L	L	NECZ	L	L	NECZ	L	L	NECZ
50	Radhanagari	-	-	-	-	-	-	L	H	ECZ
51	Bawada	-	-	-	-	-	-	L	L	NECZ
52	Karveer	L	H	ECZ	L	L	NECZ	L	H	ECZ
53	Kagal	L	L	NECZ	L	H	ECZ	L	H	ECZ
54	Gadhingalaj	L	H	ECZ	L	L	NECZ	L	L	NECZ
55	Bhudargad	L	L	NECZ	L	L	NECZ	L	L	NECZ
56	Ajra	L	L	NECZ	L	L	NECZ	L	L	NECZ
57	Chandgad	L	H	ECZ	-	-	-	L	L	NECZ

4. Conclusion

In the southern regions of Western Maharashtra, 29 tahsils were identified as efficient cropping zones for rabi jowar, 26 for wheat, and 25 for gram. These areas have the potential to adopt practices aimed at enhancing productivity for the respective crops. While these zones show promise for higher yields, crop production in these areas may still face challenges from biotic and abiotic factors that could adversely affect output.

To mitigate such risks, promoting crop insurance within these efficient cropping zones can serve as a safeguard for farmers, protecting them from potential crop losses and ensuring their economic stability.

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