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Estimating Impact of Conventional and System of Rice Intensification (SRI) Methods of Rice Production Management on Sustainable Livelihood Generation in the Context of Climate Change in Maharashtra, India: A Factor Analysis

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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 global agricultural community has been preparing to face the imminent threat posed by climate change as projections by scientific communities complement the fact that food production will be affected adversely in the near future. The Indian subcontinent has not been explicit about the effects of natural disasters like floods and cyclones caused due to climatic changes. The aberrant weather patterns along with the inconsistent output of monsoon create unprecedented challenges for the rice-dominated farming system to thrive. It directly impacts the livelihood of the farmers making them economically vulnerable. Thus, it has become necessary for the research community to explore different causal dimensions related to rice production and suggest remedies for the constantly changing agroecosystem. This study aimed to investigate different indicators of impact on sustainable livelihood generation through rice production management in light of climate change in both conventional as well as SRI methods of rice production. An ex post facto research design was adopted for conducting the study. Purposive sampling was used to select the state, district, and talukas keeping in view the backwardness and agricultural status of the area of the study. Using a simple random sampling method, two hundred (200) respondents were selected from two talukas of the Bhandara district of Maharashtra. In case of results found in conventional method of rice production, the variables, Water management, Farm size, Education, Irrigation index%, Selling% and Risk orientation have contributed 9.996 per cent of variance and clubbed into Factor 1. On the other hand, in the case of SRI method, Factor 1 has the following variables i.e., Farm size, Family income primary, Education, Primary occupation, Mass media exposure, Family education status and Sowing time which has contributed 9.54 per cent of variance and has been renamed as ‘Family capability’.

Keywords: Climate Change; conventional method; factor analysis; rice production; SRI Method.

1. INTRODUCTION

A dynamic, complex system of changes in climatic circumstances, the phenomenon of climate change impacts both biotic and abiotic elements of the global ecosystem. Changes in temperature, precipitation intensity, heat waves, CO_2 concentration, and other climatic factors cause new pests, weeds, and diseases to proliferate [1-3].

As global warming continues, it is anticipated that non-climatic risk factors including wars, pandemics, and competition for land between urban growth and food production will interact with climate-driven food poverty and supply instability [4]. By 2050, it is predicted that 15%–40% of rainfed rice areas will no longer be climate suitable [5]. In the context of rice production in Maharashtra, the study revealed that how sensitive rice crop yield is to variations in nighttime temperature. According to projections, rice output in the districts of Kokan, except for Ratnagiri, will decline by 15–25% and 10–40%, respectively, with a rise in the maximum temperature during the 2040s and 2080s. In eastern Vidarbha, rice production is expected to decrease by 5–10% during the 2040s and increase by 10% during the 2080s. The rise in the minimum temperature indicates a 5–10% increase in Kokan and East Vidarbha generally in the 2040s. It is predicted that rice production will have increased by 5–10% overall by the end of the century [6]. A study conducted in Tamil Nadu found that a 4°C increase in temperature causes a 41% decrease in rice crop output [7].

The study of a climate change scenario is expected to shorten the rice maturation period by 8% and enhance output by 12% on average throughout the state. The crop simulations indicate a 6% drop in yield and an 8% reduction in crop maturity period when temperature elevations alone are taken into account. This demonstrates that the positive effects of rising temperatures on rice output are almost offset by the increase in yield brought about by the fertilization effect of higher CO_2 and more rainfall over the state as predicted by the climate change scenario.

The results of the temperature sensitivity trials indicate that the yield continuously decreases with increasing temperature up to 5ºC.

A one-degree increase causes a yield decline of roughly 6% [8]. Thus, further studies have to be conducted to study the impact of climate change on rice production as protecting the staple crop of a larger global population ensures food security and eradication of hunger [9].

With this background, the study aimed to estimate the indicators of impact on sustainable livelihood generation through rice production management in light of climate change by using factor analysis.

2. MATERIALS AND METHODS

2.1 Research Design

To conduct the impact study of rice production management on sustainable livelihood generation in the context of climate change in the state of Maharashtra, an ex post facto research design was used. As the events have already happened, this research design was found suitable for the study**.**

2.2 Sampling Design

Purposive sampling techniques were used for the selection of States, Districts, Blocks, and Villages because the areas were ideal for the problem, convenient for the researcher, and had the necessary infrastructure. Purposive sampling was done in Sakoli and Bhandara, two of the talukas of the Bhandara district in Maharashtra. Eight villages altogether were purposefully chosen from these two talukas, four from each of the talukas.

Simple random sampling was used for the selection of farmers or respondents. For the purpose of engagement and data collection, 200 respondents in total were chosen. Out of the 200 farmers (conventional method/SRI method), 100 were chosen at random from the Sakoli block's selected villages, where the SRI method is primarily used, and another 100 were chosen at random from the Bhandara block's selected villages, where the conventional method is the only one used.

2.3 Pilot Study

A pilot study helps in collecting preliminary ideas about the respondents and the intended research idea. With assistance from the supervisor, a comprehensive list of responses was prepared. It was followed by an informal interview involving farmers, local officials, and extension workers.

2.4 Selection of Variables and Statistical Tools

Two sets of variables were decided upon for the measurement of different parameters shortlisted for the study which are as follows:

I) Independent variables

Table 1 elaborates the list of independent variables and their measurement for a better visualization of the study:

Table 1. List of independent variables

Sl No.	Variables	Measurement
1	Age (X_1)	Chronological age of respondent in years.
2	Education (X_2)	Measured with the help of scale developed by Pareek and Trivedi (1964) scale is socio-economic status (rural) and the weightages had been given as Illiterate-(0), Primary-(1), Secondary-(2), Higher secondary- (3), Graduate and above - (4).
3	Family education status (X_3)	Family education status denotes the overall education status of the family members. Measured in five columns to know the extent of literacy or number of years of formal education of every farmer representing "Illiterate", "Primary school", "Secondary school", "Higher secondary" and "Graduate and above" with score of 1,2,3,4 and 5 respectively. Family education status= Total educational score/ Effective Family size
4	Primary occupation (X_{41})	By given rank to the respondent and add it according to their source of income primarily. The scale has been ascribed according to the judge's ratings as follows: Labour (1) / Caste Occupation (2) / Business (3) / Independent profession (4) /Cultivation (5) / Service (6).
5	Secondary occupation(X_{42})	By given rank to the respondent and add it according to their source of income secondarily. The scale has been ascribed according to the judge's ratings. The schedule developed for the study as follows: Labour (1) / Caste Occupation (2) / Business (3) / Independent profession (4) /Cultivation (5) / Service (6).
6	Caste (X_5)	The following scores were given to the castes categories mentioned below, after discussion with experts: General-(4), Other backward classes-(3), Scheduled caste-(2), Scheduled tribe-(1).
7	Family type (X_6)	It had been measured with the help of development of Pareek and Trivedi (1964)

Sl No.	Variables	Measurement
		scale is socio-economic status (rural) and the weightages had been given as Single family-(1) and Joint family-(2).
8	Family size (X_7)	It denotes the total no. of persons living in the respondents' house under a single household.
9	Family income primary (X_{81})	Income from primary sources of occupation in rupees per year divided by number of family member was taken in to account.
10	Family income secondary (X_{82})	Income from secondary sources of occupation in rupees per year divided by number of family member was taken in to account.
11	Farm size (X_9)	The actual area under cultivation in hectare was taken as a measure of farm size.
12	Social participation (X_{10})	Measured by the weightages had been given as No any participation (0), Member of one organization-(1), Member of more than one organization-(2), Office holder-(3) and Wider public leader-(4).
13	Risk orientation (X_{11})	It was measured with the help of risk preference scale developed by Supe (1969). The scale consisted of 5 Items were rated in five-point response categories ranging from 'strongly agree' to strongly disagree' there were three positive items and two negative items in the scale. The scoring for the positive items was Strongly agree-7, Agree-5, Undecided-4, Disagree-3, and Strongly disagree-1. For the negative items the reverse way of scoring was followed.
14	Index of farm mechanization (X_{12})	Farm mechanization index was calculated by the formula developed by Samanta (1977). The index had 12 items which were given weights varying from 3 to 1, according to their degree of contribution towards farm mechanization.
15	Cropping intensity (X_{13})	Total annual cropped area in hectare × 100/ Size of holding in hectare
16	Selling% (X_{14})	The attribute selling % had been operationalized as the selling of produce out of from the total production of rice.
17	Debt (X_{15})	Debt of selected respondents refers to money/loan have been taken from bank or from any other finical institution for rice cultivation whichever was pending during the major part in the year. The scale has been ascribed according to the judge's ratings. The schedule developed for the study. Yes-(1), No-(0).
18	Migration (X_{16})	Migration of selected respondents refers to move from one place to another place for their survival due to heavy loss in rice production. The scale has been ascribed according to the judge's ratings. The schedule developed for the study. Yes-(1), No-(0).
19	Mass media exposure (X_{17})	Mass media exposure was therefore measured by ascertaining from the respondents about the frequency of watching television, listening to radio programmes, reading newspaper as well as other types of exposures.
20	Utilization of personal cosmopolite sources of information (X_{18})	The scoring procedure for the responses was Always-(2), Sometimes-(1) and Never-(0). The score for an individual respondent was obtained by adding the score over different sources.
21	Utilization of personal localite sources of information (X_{19})	The scoring procedure for the responses was Very often-(3), Often-(2), Sometimes-(1) and Never-(0). The score for an individual respondent was obtained by adding the score over different sources.
22	Contact with extension personal (X_{20})	The scoring procedure for the responses was Most often-(4), Often-(3), Sometimes-(2) Rarely-(1) and Never-(0). The score for an individual respondent was obtained by adding the score over different sources.
23	Seed rate% (X_{21})	$\frac{\text{Adopted seed rate kg/h} \times 100}{\text{Recommended seed rate kg/h}}$
24	Fertilizer% (X_{22})	$\frac{\text{Adopted fertilizer dose kg/h} \times 100}{\text{Recommended fertilizer dose kg/h}}$
25	Pesticide% (X_{23})	$\frac{\text{Adopted pesticide dose kg/h} \times 100}{\text{Recommended pesticide dose kg/h}}$
26	Weed management% (X_{24})	$\frac{\text{Adopted herbicide dose kg/h} \times 100}{\text{Recommended herbicide dose kg/h}}$
27	Water management% (X_{25})	$\frac{\text{Adopted water level in cm} \times 100}{\text{Recommended water level in cm}}$
28	Irrigation index% (X_{26})	Total area under irrigation in hectare ×100/ Size of holding in hectare
29	Sowing time (X_{27})	By given rank on the basis of time duration for sowing, the schedule developed

Sl No.	Variables	Measurement
		for the study. For Conventional method-15June-25 June-(1), 26 June- 5 July-(2), 6 July-15 July- (3) and 16 July-25 July- (4). For SRI method-15 July- 23 July - (1), 24 July- 31 July - (2) and 1 August- 8 August- (3).
30	Varietal change (X_{28})	Calculated for both method- varietal change due to climate change - (1) and Other reason- (0).
31	Farm power (X_{29})	The weightages had been given as No drought animal –(0), 1-2 drought animal –(2), 3-4 drought animal or 1 or more prestige animal –(4), 5-6 drought animal –(6).
32	Change in rainfall pattern over last 20 year (X_{30})	By given rank on the basis of change in rainfall pattern over last 20 year. The response of farmer has been taken on the scale value 0-10.
33	Change pattern in temperature(day/night) over Last 20 Year (X_{31})	By given rank on the basis of change pattern in temperature (day/night) over last 20 year. The response of farmer has been taken on the scale value 0-10.
34	Change pattern in weather disaster over last 20 year (X_{32})	By given rank on the basis of change pattern in weather disaster over last 20 year. The response of farmer has been taken on the scale value 0-10.
35	Change in seasonal pattern over last 20 year (X_{33})	By given rank on the basis of change in seasonal pattern over last 20 year. The response of farmer has been taken on the scale value 0-10.
36	Change pattern in insect/ pests & diseases over last 20 year (X_{34})	By given rank on the basis of change pattern in insect/pests and diseases over last 20 year. The response of farmer has been taken on the scale value 0-10.
37	Change pattern in weed problem over last 20 year (X_{35})	By given rank on the basis of change pattern in weed problem over last 20 year. The response of farmer has been taken on the scale value 0-10.

II) Dependent variables

The dependent variable selected for the study was sustainable livelihood generation (y). Livelihood in this study has been focused on the variables, net return from rice and expenditure on health care which has been affected by climate change or by climatic parameters. Net return from the rice was calculated by the gross return from rice production minus the total cost for rice production management whereas expenditure on healthcare was calculated by dividing the yearly expenditure on healthcare in terms of rupee divided by total family members.

To measure the impact of different variables, factor analysis was done by the researcher using IBM SPSS v26.0.

2.5 Pre-testing of Interview Schedule

Pre-testing of the interview schedule guides the researcher to evaluate and remove any irregularities. It also helps in the utility of the questionnaire in getting precise responses from the respondents. The respondents who are questioned after the pre-test are not involved in the final phase of data collection.

2.6 Methods of Data Collection

The Marathi language was used to collect the data during personal interviews of the respondents. For retrieving secondary data, published materials are collected from the State Agricultural Department, Krishi Vigyan Kendras (KVKs), Census reports, and the Directorate of Economics and Statistics of Maharashtra state. Data related to the climate were collected from available on the internet and some important data were collected from literature and books.

3. RESULTS AND DISCUSSION

3.1 Factor Analysis Indicating Impact on Sustainable livelihood Generation through Rice Production Management in the Light of Climate Change. (Conventional method of rice)

Table 2 presents the factor analysis indicating the impact on sustainable livelihood generation through rice production management in the light of climate change. (Conventional method of rice). In the present study, thirty-five variables have been reduced to thirteen factors based on the extraction of the receptive factor loading values.

Table 2 also depicted the number of factors; the variable included in the receptive factors, the variables explained the common variables and the factor loadings. Thus, Factor 1 has the following variables i.e., Water management (x_{25}), Farm size (x_9), Education (x_2), Irrigation index% (x_{26}), Selling% (x_{14}) and Risk orientation (x_{11}) which has contributed 9.996 per cent of variance and has been renamed as 'Farm capability'. Factor 2 has the variables i.e., Family income primary (x_{81}), Fertilizer% (x_{22}), Primary occupation (x_{41}), Family education status (x_3) and Pesticide% (x_{23}) which contributed 8.266 per cent of the variance and has been renamed as 'Input support'. Factor 3 has the variables i.e., Age (x_1), Weed management% (x_{24}), Migration (x_{16}), Family size (x_7) and Family type (x_6) which has contributed 7.114 per cent of the variance and has been renamed as 'Family composition'. Factor 4 has the variables i.e., social participation (x_1), Family income secondary (x_{82}) and Secondary occupation (x_{42}) which contributed 5.903 per cent of the variance and has been renamed as 'Social Status'. Factor 5 has the variables i.e., Change pattern in weed problem over last 20 years (x_{35}), and Farm Power (x_{29}) which has contributed 5.32 per cent of the variance and has been renamed as 'Weed management'. Likewise, eight more factors were also obtained and renamed indicating a conglomeration of variables among themselves and their impact while practicing the conventional method of rice production, i.e., Resource support, Weather disaster & seasonal pattern, Extension contact, Rainfall pattern, change pattern in insect/pests and diseases, Exposure, cropping intensity and change in temperature.

Studies have found that a few factors such as land area, labour and pesticides have a significant effect on rice production [10].

3.2 Factor Analysis indicating impact on sustainable livelihood generation through rice production management in the light of climate change. (SRI method of rice)

Table 3 presents the factor analysis indicating the impact on sustainable livelihood generation through rice production management in the light of climate change. (SRI method of rice).

In the present study, 35 variables have been reduced to 15 factors based on the extraction of the receptive factor loading values. Thus, Factor 1 has the following variables i.e., Farm size (x_9), Family income primary (x_{81}), Education (x_2),

Table 2. Factor Analysis: Indicator of impact on sustainable livelihood generation through rice production management in the light of climate change. (Conventional method of rice)

Factor	Variables	Factor loading	% of variance	Cumulative %	Factor renaming
Factor 1	X_2	0.591	9.996	9.996	Farm capability
	X_9	0.672			
	X_{11}	0.198			
	X_{14}	0.332			
	X_{25}	0.673			
	X_{26}	0.546			
Factor 2	X_3	0.32	8.266	18.262	Input support
	X_{41}	0.402			
	X_{81}	0.474			
	X_{22}	0.41			
	X_{23}	0.234			
Factor 3	X_1	0.489	7.114	25.376	Family composition
	X_6	0.279			
	X_7	0.297			
	X_{16}	0.381			
	X_{24}	0.433			
Factor 4	X_{42}	0.374	5.903	31.278	Social status
	X_{82}	0.448			
	X_{10}	0.471			
Factor 5	X_{29}	0.513	5.32	36.598	Weed management
	X_{35}	0.545			
Factor 6	X_{12}	0.506	4.787	41.385	Resource support
	X_{18}	0.347			
	X_{28}	0.4			

Factor 7	X_{19} X_{32} X_{33}	0.42 0.387 0.401	4.095	45.48	Weather disaster & seasonal pattern
Factor 8	X_{20} X_{21}	0.413 0.443	4.075	49.555	Extension contact
Factor 9	X_{30}	0.42	3.541	56.834	Rainfall pattern
Factor 10	X_{27} X_{34}	0.337 0.569	3.446	60.28	Change pattern in insect/pests/diseases
Factor 11	X_{17}	0.338	3.126	63.406	Exposure
Factor 12	X_5 X_{13}	0.353 0.238	2.994	66.4	Cropping intensity
Factor 13	X_{15} X_{31}	0.339 0.381	2.874	69.274	Change in temperature

Primary occupation (x_{41}), Mass media exposure (x_{17}), Family education status (x_3) and Sowing time (x_{27}) which has contributed 9.54 per cent of variance and has been renamed as 'Family capability'. Factor 2 has the variables i.e., Family size (x_7), Family type (x_6) and Change pattern in weather disaster over last 20 year (x_{32}) which contributed 8.35 per cent of the variance and has been renamed as 'Weather disaster'. Factor 3 has the variables i.e., Secondary occupation (x_{42}), Family income secondary (x_{82}), Index of farm mechanization (x_{12}), Social participation (x_{10}), and Cropping intensity (x_{13}) which contributed 6.332 per cent of the variance and has been renamed as 'Occupation mobility'. Factor 4 has the variables i.e., Debt (x_{15}), Farm Power (x_{29}) and Utilization of personal localite sources of information (x_{19}) which contributed 5.856 per cent of the variance and has been renamed as 'Debt'. Factor 5 has the variable i.e., Contact with extension personnel (x_{20}) which has contributed 5.046 per cent of the variance and has been renamed as 'Extension contact'. Similarly, ten more factors were also obtained

Table 3. Factor Analysis: Indicator of impact on sustainable livelihood generation through rice production management in the light of climate change (SRI methods of rice)

Factor	Variables	Factor loading	% of variance	Cumulative %	Factor renaming
Factor 1	X_2 X_3 X_{41} X_{81} X_9 X_{17} X_{27}	0.519 0.351 0.462 0.665 0.67 0.435 0.284	9.54	9.54	Family capability
Factor 2	X_6 X_7 X_{32}	0.741 0.759 0.305	8.35	17.89	Weather disaster
Factor 3	X_{42} X_{82} X_{10} X_{12} X_{13}	0.413 0.41 0.305 0.363 0.238	6.332	24.222	Occupation mobility
Factor 4	X_{15} X_{19} X_{29}	0.496 0.322 0.351	5.856	30.078	Debt
Factor 5	X_{20}	0.435	5.046	35.124	Extension contact
Factor 6	X_{11} X_{14} X_{28}	0.376 0.327 0.438	4.515	39.638	Varietal change
Factor 7	X_5 X_{18} X_{26}	0.339 0.396 0.497	4.383	44.021	Irrigation facility
Factor 8	X_{31}	0.555	4.134	48.156	Change in temperature
Factor 9	X_{22} X_{23} X_{34}	0.407 0.3 0.446	3.993	52.148	Input support
Factor 10	X_{30}	0.371	3.643	55.792	Rainfall pattern

Factor 11	X_{21}	0.347	3.283	59.075	Seed rate
Factor 12	X_{25}	0.236	3.098	62.173	Water management
Factor 13	X_{35}	0.482	3.037	65.21	Weed management
Factor 14	X_{16}	0.104	2.868	68.078	Migration
	X_{24}	0.355			
Factor 15	X_{1}	0.21	2.614	70.692	Change in seasonal pattern
	X_{33}	0.436			

and renamed indicating different groupings of variables and their impact while practicing SRI method of rice production, i.e., Varietal change, Irrigation facility, change in temperature, Input support, Rainfall pattern, Seed rate, Water management, weed management, Migration and Change in seasonal pattern.

Similar studies have found that state interventions like direct cash to payments, extension services provisions and HYV seeds have contributed extensively to boost rice production [11].

4. CONCLUSION

Climate change poses heavy repercussions on agri-food systems due to adverse effects of physiological stress as well as ecological hazards. Even the rice crops are experiencing its menace and are unable to escape their devastation. The study sheds light on the impact of different management practices on sustainable livelihood practices in light of climate change by comparing both the conventional and SRI methods. The results concluded that different variables such as Water management (x_{25}), Farm size (x_9), Education (x_2), Irrigation index% (x_{26}), Selling% (x_{14}) and Risk orientation (x_{11}) can be clubbed together to form a single umbrella variable like Farm capability. It makes integrated farm management practices easier and more cost-effective in case of conventional method of rice production. In the case of SRI method, factor analysis indicated that variables like Farm size (x_9), Family income primary (x_{81}), Education (x_2), Primary occupation (x_{41}), Mass media exposure (x_{17}), Family education status (x_3) and Sowing time (x_{27}) can be conjoined to make a single variable called Family capability. This paves the way for collective decision making and effective use of family labour to derive maximum benefits from the farmland. As climate change demands more vigilance and alertness from the farmers, proper awareness and scheduling of farm practices will invite positive returns for the farmers and protect the farm from future threats. Similar kinds of studies must be conducted to help policymakers formulate effective plans for different agroecological zones catering to their local needs.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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