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Measuring Sustainable Vegetable Farming Index: A Composite Sustainability Index for Vegetable Farming in Hills

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ABSTRACT

Future of agriculture depends upon present agricultural practices. Today good agriculture practices will help to hand over the undisturbed resource base for future generations in a way that future generations can also sustain their lives on available resources. World demographics is changing very fast and agriculture has to be ready to feed additional three billion people by 2050. Assessing agricultural sustainability can help to find ways for future agriculture and keeping in mind the importance of sustainability of farming systems, present study was conducted in Himachal Pradesh to assess the sustainability of vegetable farming. Sustainability vegetable farming index (SVFI) was measured for vegetable farms of self help group members as well as for non-member farmers and study revealed significantly higher sustainability for vegetable farms of self help group members when compared to non-member farmers. In case of SHG members majority of farm (59.33 %) were found moderately sustainable followed by sustainable farm category (34.66 %) where as in case of non-members majority of the farms were moderately sustainable (74.00 %) followed by least sustainable vegetable farms (18.67 %). Only 5.33 per cent members' farms were found highly sustainable where as corresponding figure for non-member was found zero. Independent variable like education, operational land holding, number of trainings, and vegetable production per year and extension contacts found to have significant and positive impact on sustainable vegetable farming index.

Highlights:

- Sustainable vegetable farming index was significantly higher for self help group members' farms.
- Independent variable like education, operational land holding, number of trainings, and vegetable production per year and extension contacts found to have significant and positive impact on sustainable vegetable farming index.
- Organising small and marginal vegetable farmers in groups helps to strengthen vegetable farming sustainability.

Key Words : Future agriculture, Vegetable farming, Sustainability, Sustainable index, Himachal Pradesh

INTRODUCTION

The fate of future agriculture will depend be decided by present actions and inactions as agriculture at present must respond to escalating demands for productivity and efficiency, as well as pressures to improve its stewardship of natural resources. It is already well understood that meeting future requirement from the present resources will impose multitudinous pressure on resource base therefore superintendence of present farming systems is required to improve and hand over the resources for the future generations. Our production systems are at a pivotal stage in terms of meeting consumer demand for affordable food while improving sustainability. Current intensive crop production practices designed to maximize yield have created an unstable, fragile, and non-sustainable production system. In vegetable production systems, the diversity of the enterprise, size and scale of the farm, market and labor demands, and climatic conditions provide unique opportunities or barriers to improving the overall sustainability of the production system (Nair *et al.*, 2014). The changing demographic structure world wide as well

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as in India is matter of great concern and present generation has very big responsibility to pass undisturbed resources to future generation. In its 2019 revision of the World Population Prospects (WPP), the United Nations projected that the world's population would grow from 7.7 billion in 2019 to reach 8.5 billion in 2030, 9.7 billion in 2050 and 10.9 billion in 2100. India is the second most populous country in the world, sustaining 16.7 per cent of the world population on 2.4 per cent of the world's surface area. The population of India is also expected to increase from 121.1 crores to 152.2 crores during the period 2011-2036 - an increase of 25.7 per cent in twenty-five years at the rate of 1.0 per cent annually. As a consequence, the density of population will increase from 368 to 463 persons per square kilometer (GOI, 2020). The population in India is expected to reach its peak by 2046 and approximately 1.46 billion people will be dependent on the available resources. In the case of India, where around 70% of the population lives in rural areas, the development of more sustainable agricultural systems is a major policy concern. As in many other parts of the developing world, farmers are facing a range of challenges associated with cost-price pressures, climate change, knowledge and skill deficits, and difficulties accessing the latest technologies (Siddique, 2011). Agriculture is the lifeline for sustenance of life in the world but when 9.7 billion people will inhibit the world. How can all these people be fed while the per capita land availability is decreasing? A big shortfall is expected between the amounts of food needed to feed huge population by 2050. Present generation need to answer following questions :

– How we are going to feed additional 3 billion more people by 2050?

– Are we having sufficient resource base to fulfil future requirement?

– Are we going in the right direction to explore resources at present?

– Are present practices help to improve resource base?

Answer to these questions is required to make agriculture better for future generations. This must be ensured by present generation that we hand over the available resource base to future generation without deterioration. Tools need to be developed to assess the past mistakes, present practices to address future requirements. Agriculture sustainability study can be strong tools to assess mistakes and necessary correction. Sustainable agriculture provided proof that agriculture can remain worthwhile to the farmers and consumers while causing no detrimental effect on natural world and its inhabitants, and in the same time even benefitting them. Sustainable agriculture is mending to preserve the environment, improve and expand resources while making agriculture more profitable to the farmers and consumers in consonance with social acceptance. Sustainability of agriculture is a matter of concern for various stakeholders. The challenges encountered by Indian agriculture are due to agro-climatic/environmental, social and economic dimensions. The sustainability strength comes due to vibrancy of these dimensions (Kareemulla *et al.,* 2017). Different stakeholders have different definitions of sustainability, or sustainable development. The definitions reported by some of the most authoritative organizations are as under:

Sustainable Development, as defined in 1987 by the Brundtland Commission (formally known as the World Commission on Environment and Development (WCED) as "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The Food and Agriculture Organization of the United Nations (FAO) defines sustainable development as "the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry, and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable". More specifically, FAO defines sustainable agriculture and rural development as processes that meet the following criteria:

– They ensure that the basic nutritional requirements of present and future generations, qualitatively and quantitatively, are met while providing a number of other agricultural products.

– They provide durable employment, sufficient income and decent living and working conditions for all those engaged in agricultural production.

– They maintain and, where possible, enhance the productive capacity of the natural resource base as a whole, and the regenerative capacity of renewable resources, without disrupting the functioning of basic

ecological cycles and natural balances, destroying the socio-cultural attributes of rural communities, or contaminating the environment.

– They reduce the vulnerability of the agriculture sector to adverse natural and socio-economic factors and other risks, and strengthen self-reliance.

The principle of sustainable development provides for quality environment and balanced economic development for the present and future generations as well as rational use of natural, human and material resources, preservation and development of natural and cultural heritage" (Vidzeme Planning Region, 2014). In India there is preponderance of small and marginal land holdings due to which farmers faces may challenges in practicing agriculture and sustainability of agriculture need to be watched carefully. Multitudinous problems are faced by farmers in hills as farming families try to earn their livelihood from small and marginal fragmented land holdings and sustainability of such farming system is always challenging. Poverty and unemployment are major problems faced by rural community (Singh and Hansra, 2017). Vegetable farming has paved new path of economic development in hilly state like Himachal Pradesh. Now farmers are capable of harvesting more monetary value per unit of land (Singh and Hansra, 2018). It is very much required to assess sustainability of vegetable farming to answer the question of conserving present resources for future generations. Self-help groups engaged in development activities have the potential to empower their members through the provision of knowledge, skills, motivation, and competencies that underpin sustainable agriculture (Kalra *et al.*, 2013) and therefore 'comparative study of vegetable farming sustainability index was carried out in the present study. The study was conducted in the state of Himachal Pradesh with the following objectives:

1. To develop composite Sustainable Vegetable Farming Index (SVFI) for vegetable farming in Himachal Pradesh.

2. To compare sustainable vegetable farming index for vegetable farms of self help group members and non-member farmers.

3. To study the factors influencing sustainability of vegetable farming in Himachal Pradesh.

METHODOLOGY

The study was conducted in the state of Himachal Pradesh covering all three divisions. From each division two districts were randomly selected and from exhausted list of vegetable growing self help groups five self help groups were selected in each district thus covering a total of 30 self help groups from the state. From each selected group, 5 members were selected randomly to collect data on vegetable Production. 150 Non-members from the adjacent villages were selected randomly. So the sample size for the proposed study was 300 (150 group members and 150 non-member farmers). Selected SHG members and non-members were directly interviewed using pre-tested structured schedule. The findings were tabulated, analyzed using appropriate statistical techniques and presented in different groups. Composite Sustainable Vegetable Farming Index (SVFI) was finalized based upon eleven sustainability indicators which were selected based on judges' relevancy rating. The three-dimensional composite sustainability was calculated including economic sustainability, social sustainability and ecological sustainability indices.

For making the indicators scale free following methods was applied

$$SIij = \frac{Xij - Min\ Xij}{Max\ Xij - Min\ Xij} \quad (1)$$

$$Sij = \frac{Min\ Xij - Xij}{Max\ Xij - Min\ Xij} \quad (2)$$

where

i= 1,2,3……n indicators

j= 1,2,3 Dimension of Sustainability

Xij= Value of i^{th} indicator of j^{th} dimension

Equation (1) is applicable for indicators having positive implications on sustainability

Equation (2) is applicable for indicators having negative implication on sustainability

Mean scores of members and non-members farms were compared using Z-statistics for comparison of two means. The Composite 'Sustainable Vegetable Farming Index' will be calculated by taking the weighted mean of three dimensions *i.e*

$$SVFI = \frac{W_1 * ESI + W_2 * SSI + W_3 * EnSI}{3} \quad (3)$$

where

W = Weight assigned to respective dimension

ESI = Economic Sustainability Index

SSI = Social Sustainability Index

EnSI = Environmental Sustainability Index

Based upon the values of sustainability indices, the

vegetable farms of the respondents were categorized as least sustainable, moderately sustainable, sustainable and highly sustainable as per scale developed by Devi *et al.* (2017).

RESULTS AND DISCUSSION

Composite Sustainability Vegetable Farming Index (SVFI) of vegetable farming was examined by considering selected sustainability indicators under three dimensions of sustainability *viz.* economic, environmental and social. Indicator used for assessment of SVFI were production efficiency, net profit , market, community relations, Farmers' knowledge on vegetable farming, access to resources and support services, farmers' knowledge on vegetable farming, soil health, toxicity, water management and preparedness to drought

Dimensions of sustainability:

The three dimensions of sustainability revealed significantly higher values for self help group members' farmers when compared to non-member farmers. Table 1 represent data on distribution of respondent farmers according to various sustainability indices under three dimensions of sustainability.

Composite Sustainable vegetable farming Index:

The composite sustainable vegetable farming Index (SVFI) was worked out by taking all the three dimensional of sustainability *viz.,* economic, social and environmental dimensions. The results are presented in Table 2. In case of SHG members majority of farm (59.33 %) were found moderately sustainable followed by sustainable farm category (34.66 %) where as in case of non-members majority of the farms were moderately sustainable (74.00 %) followed by least sustainable vegetable farms (18.67 %). Only 8 member farms (5.33 %) were found highly sustainable where as corresponding figure for non-member was found zero.

Difference at one per cent level of significance was found between the mean SVFI for the member (0.46) and that of non-member (0.36) vegetable farms. The higher composite SVFI for member was due to higher economic, social and environmental dimensions values for vegetable farms of the member than that of non-

Table 1: Distribution of respondents according to sustainability indices

Category	Percentage								
	Economic sustainability			Social sustainability			Environmental sustainability		
	Member (n=150)	Non member (n=150)	Z-value	Member (n=150)	Non member (n=150)	Z-value	Member (n=150)	Non member (n=150)	Z-value
Least sustainable (0.00-0.25)	11 (7.33)	46 (30.67)	6.06**	7 (4.67)	45 (30.00)	6.63**	4 (2.67)	12 (8.00)	4.67**
Moderately sustainable (0.26-0.50)	74 (49.33)	67 (46.66)		67 (44.00)	67 (44.67)		74 (49.33)	100 (66.67)	
Sustainable (0.51-0.75)	62 (41.34)	36 (24.00)		66 (44.67)	34 (22.67)		67 (44.67)	35 (23.33)	
Highly sustainable (0.76-1.00)	3 (2.00)	1 (0.067)		10 (6.66)	4 (2.66)		5 (3.33)	3 (2.00)	

** Significant at 5% level of probability
(Figure in parenthesis indicates per cent)

Table 2 : Composite Sustainable Vegetable Farming Index of the respondent farm

Respondents	Level of sustainability				Mean value	SD	Members Vs Non-members (Z- stat)
	Least Sustainable (0-0.25)	Moderately Sustainable (0.26-0.50)	Sustainable (0.51-0.75)	Highly sustainable (0.76-1.00)			
Members (n=150)	1 (0.67)	89 (59.33)	52 (34.66)	8 (5.33)	0.46	0.08	9.96**
Non-Members (n=150)	18 (18.67)	111 (74.00)	11 (7.33)	0 (0.00)	0.36	0.09	

** Significant at 5% level of probability
(Figure in parenthesis indicates per cent)

members.

Relationship of independent variables with composite sustainable vegetable farming index:

The relationship of independent variable with composite sustainable vegetable farming index has been presented in Table 3.

Table 3: Relation of independent variables with SVFI

Sr. No.	Variable	Correlation coefficient "r"
1.	Age	-0.14153 NS
2.	Education	0.37951**
3.	Experience	-0.00374 NS
4.	Operational land holding	0.25153**
5.	Number of trainings	0.21228*
6.	Vegetable production (tonnes/year)	0.27119*
7.	Media exposure	0.17892 NS
8.	Extension contacts	0.44782**

NS=Non-significant
** Significant at 1 per cent level of probability
* Significant at 5 per cent level of probability

It is evident from Table 3 that out of eight variables, five were found to have significant and positive association with SVFI. These are education, operational land holding, number of trainings, and vegetable production per year and extension contacts. Age experience and media exposure does not found to have association with SVFI. It is well established that higher education level and extension contacts increase the knowledge gain and adoption level of improved vegetable farming practices, improved skill and social relation. More knowledge, adoption and improved skill might be probable reason for better performance of the farms. With increase in operational land holding, there would have been increased SVFI which might be due to the fact that more income was generated from the other agricultural activities helped farmers in adopting sustainable practices at farms.

Regression analysis of selected independent variables with the composite sustainable vegetable farming index:

The multiple regression analysis was carried out to assess the extent of influence of ten independent variables towards composite sustainable vegetable farming index (SVFI) and results are presented in Table 4. The table reveals that coefficient of multiple regression determination (R^2) was 0.62 which means that 62.00 per cent of the variation in dependent variable is explained by independent variables included in the regression. The value of adjusted R^2 was 0.59 which implies that if the model is estimated from the population rather than the sample it would account for approximately 3.00 per cent less variance in outcome. F-value of 6.863 means that the fitted model is statistically significant at 0.01 per cent level of probability. Table 4 shows that education level (X_2), number of trainings (X_6) and extension contacts (X_{10}) had contributed positively at 0.01 level of probability towards SVFI. Unit increase in education level, number

Table 4 : Regression analysis of selected independent variables with sustainable vegetable farming index

Variable No.	Variable Name	Coefficient	Standard error	"T value"
	Intercept	0.04176	0.01923	0.1430 NS
X_1	Age	-0.00109	0.00054	0.2410 NS
X_2	Education	0.04467	0.01569	3.2913**
X_3	Occupation	0.04362	0.02722	1.2563 NS
X_4	Experience	0.00362	0.00697	0.4392 NS
X_5	Operational land holding	0.03208	0.01239	0.2589 NS
X_6	Number of trainings	0.02226	0.00550	4.0461**
X_7	Loan received	0.01092	0.06406	-2.04283 NS
X_8	Vegetable production	0.00282	0.00007	0.40909 NS
X_9	Media exposure	0.00211	0.00681	0.2951 NS
X_{10}	Extension contacts	0.04671	0.01951	3.7973**
R^2	0.62			
Adjusted R^2	0.59			
F-value	6.863			
Frequency	300			

** Significant at 1 per cent level
* Significant at 1 per cent level
NS = Non-significant

of trainings and extension contacts would result in increasing SVFI to an extent of 0.04467, 0.02226 and 0.04671 units, respectively. Education, number of training and extension contacts had positive and significant contribution towards SVFI. This might be due to the fact that education, number of training and extension contacts facilitated clear understanding of the problem and benefits associated with vegetable farming.

Conclusion:

The development of coherent and adequate agricultural practices requires recognition of critical areas that negatively influence the development of sustainable and efficient agricultural practices. Sustainability is a key concept that has greater concern for future agriculture. Vegetable farming has potential to meet nutritional hunger of increasing population and due to higher economic value, vegetable farming found an indispensible place in agriculture. Due to higher economic returns, vegetable farming has paved new path of economic development for hill farmers. The article presents a holistic approach for assessing sustainable vegetable farming index based on its economic, social and ecological aspects. The study revealed significantly higher sustainability for vegetable farms of self help group members when compared to non-member farmers. In case of SHG members majority of farm (59.33 %) were found moderately sustainable followed by sustainable farm category (34.66 %) where as in case of non-members majority of the farms were moderately sustainable (74.00 %) followed by least sustainable vegetable farms (18.67 %). Only 8 member farms (5.33 %) were found highly sustainable where as corresponding figure for non-member was found zero. Independent variable like education, operational land holding, number of trainings, and vegetable production per year and extension contacts found to have significant and positive impact on sustainable vegetable farming index. It is suggested that there is lot of scope for improvement in overall sustainability of vegetable farming in hill. Organization of small farmers in self help groups can help to make vegetable farming more sustainable in hills and policy intervention is required to cover maximum vegetable growers under self help groups.

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