MEASUREMENT OF SUSTAINABILITY OF AGRICULTURE IN WATERSHED ENVIRONMENT#

K. Atchuta Raju, J. Dilip Babu** and M. Sudarshan Reddy****

The improvement of productivity of agricultural crops is now a days viewed from their sustainability in the fields. In a global conference on "Environment and Development" organized by United Nations under the chairmanship of Brundtland on 1987, the term 'Sustainable Development" was defined as "a development which can last and is different from economic development in *sensuo stricto*. Development is a comprehensive economic, social, cultural and political process aiming at the constant improvement and the well being of the population and of all individuals on the basis of their active, free and meaningful participation in development. Thus sustainable development is that development which can protect the environment by satisfying the needs of the present generation keeping in view the needs for development for future generations". The concept of sustainable development started sometimes in the late 1970's. This has received wider attention among the planners, policy makers, scientists and researchers across the globe. The reason is increase in population growth and its increase in use and misuse of resources which lead to rapid deterioration of natural resource base through the process like, soil erosion, deforestation, air pollution, ozone depletion and water pollution.

Part of Ph.D. Thesis.

* *Research Associate, Krishi Vigyan Kendra, Agril. Research Station, Darsi – 523 247, Prakasam Dt.(A.P.).*

** *Senior Scientist (Hort.), AICRP on PHT of Horticultural Crops, A.R.I., ANGRAU, Rajendranagar, Hyderabad – 500 030.*

*** *Principal & Univ. Head, Extension Education Institute, ANGRAU, Rajendranagar, Hyderabad – 500 030*

Agriculture production in India is vitally linked with farming in dry land areas that account for nearly 70.00 per cent of the total cultivated area and contribute about 45.00 per cent of total food grain production in the country. The fluctuations in agriculture production of dry land areas are caused by erratic monsoons. Apart from this, dry lands are impoverished and deficient in essential plant nutrients. Soil erosion, deforestation and ecosystem imbalances have become serious limitations for sustainability of agriculture production in these areas. Besides, the dry land farmer has extremely poor and fragile resource base and does not have a dependable infrastructure to support the crop production, livestock and marketing activities.

Despite the drawbacks of fragile economic system and poor resource base of the farmers in dry land areas, the prospects of boosting food grain production as well as fodder, fuel, timber and fruits are attractive. There is a lot of untapped potential in these areas through on farm rainwater management, though they are difficult and costly. Runoff collection and recycling, inter-terrace land management, farm ponds, percolation tanks, check dams and agro-forestry were found to be efficacious in increasing production and productivity on these lands. This could further be made attractive to dry land farmers by integrating animal husbandry with crop production and providing subsidiary income-generating activities. To integrate all these activities there is a greater need to develop dry land areas on watershed basis. With these considerations, the present study was carried out with the following specific objectives:

1. To develop an index for measurement of sustainability of agriculture in watershed environment.
2. To find out the level of sustainability of agriculture of watershed area farmers.

Methodology:

Based on the experience from the literature on this aspect, the sustainable agriculture could be operationalised as to protect the natural resources as use of locally available resources which aim at protecting the environment, provides basic food and fibre needs, economically viable and enhances the quality of life of farmers. To identify the indicators which measure the sustainability of agriculture in watershed environment, the relevancy co-efficient was worked out to each of the indicators on the basis of the judges opinion. The extent of influence of each indicator in measuring the sustainability of agriculture is determined from calculated scale values. The mathematical equation has been used to calculate the sustainability index to each of the farmers.

The study was conducted in Mahaboobnagar district of Andhra Pradesh. Ex-post-facto research design was followed for this study. Two watersheds were selected randomly. Two hundred watershed area farmers were selected by proportionate random sampling technique from 12 villages. The data were collected with the help of structured interview schedule and the results were tabulated.

Findings and Discussion

Construction of Sustainability Index:

Based on the review of literature as well as discussion with the experts in the field, 16 indicators were enlisted in accordance with the situation existed in watershed environment. These items were mainly concerned with consequences by using the soil and water conservation practices covering widely from environmental effects to the social aspects. The indicators selected were discussed with the resource persons who had knowledge and experience in watershed and then scrutinised for this amenability for operationalisation of measurement and possibility of eliciting data from farmers. Later on 10 indicators were retained as essential for sustainable agriculture in watershed environment (as provided in Table-1). The final list of indicators was subjected to relevancy rating of 75 judges. The judges were of the cadre of Assistant Professors and above in the area of Agricultural Extension, Agricultural Economics, Agronomy, Entomology, Plant Pathology and Soil Science in the Acharya N.G. Ranga Agricultural University, Hyderabad, ICAR institutes located at Hyderabad, and also the officers in watershed projects. The experts were requested to indicate whether each of the indicator sent to them were relevant and suitable for inclusion in the scale to measure the sustainability index of farmers on a four point relevancy continuum viz., 'Most Relevant', 'Relevant', 'Somewhat Relevant', and 'Not Relevant'. They were also requested to add new indicators which tend to measure the sustainability. In all, 58 judges responded to the call. The responses had from the judges were scrutinised and the relevancy coefficient of 'i'th indicator (Rci) was worked out by using the following formula.

$$R_{ci} = \frac{\text{Total score of all the judges on 'i'}^{th} \text{ indicator}}{\text{Maximum score on the continuum x total number of judges}}$$

All those components with the relevancy coefficient of 0.7 and above were selected for the development of sustainable index. Ten components passed the above criterion and are listed below with the relevancy coefficient.

Table-1: Relevancy co-efficient of the indicators to measure sustainability of agriculture in watershed

Sl.No.	Indicators	Relevancy coefficient
1.	Integrated pest management	0.9267
2.	Soil environment level	0.9482
3.	Crop diversity	0.8793
4.	Land productivity	0.8017
5.	Input use index	0.8663
6.	Eco-system management	0.9008
7.	Information self-reliancy	0.8189
8.	Crop yield security	0.7931
9.	Enterprise supporting ability	0.7758
10.	Carrying capacity	0.7327

In order to compute the scale values for each of the selected indicators, their relative importance to the sustainable agriculture were obtained by seeking experts judgement. A list of 58 experts working in relevant specified fields in the Agricultural University, Hyderabad, ICAR Institutes located at Hyderabad and Andhra Pradesh State Department of Agriculture were prepared and considered for seeking response. The judges were requested to give rank order based on the relative importance of the indicator, in the measure of sustainability of agriculture in farmers' farms. After receiving ranks from the judges, they were used in the calculation of scale values.

Calculation of scale values consisted of working out the centile position 'p' based on the formula recommended by Guilford (1954) and working out 'c' scale values, calculating 'Rj' value, and finally determining the scale value 'Rc' by using the formula.

$$Rc = 2.357\ Rj - 7.01$$

The computed scale values for ten indicators were as presented in Table-2.

Table-2: Scale values of indicators

Sl.No.	Indicators	Scale value
1.	Soil environment level	7.60
2.	Integrated pest management	7.36
3.	Eco-system management	7.13
4.	Crop diversity	6.42
5.	Input use index	5.48
6.	Information self-reliancy	5.01
7.	Land productivity	4.53
8.	Crop yield security	3.59
9.	Enterprise supporting ability	2.41
10.	Carrying capacity	1.94

The scale values have been used to arrive at index of sustainability for each farmer.

The ten indicators have been measured and expressed in different units. Hence, all the values were converted into unit values by using simple range and variability as given below.

$$U_{ij} = \frac{Yij - Min.Yj}{Max.Yj - Min.Yj}$$

Where,

Yij = Value of the i^{th} respondent on j^{th} component

Min. Yj = Minimum score on the j^{th} component

Max. Yj = Maximum score on the j^{th} component
Uij = Unit value of the i^{th} respondent on j^{th} component.

These unit values ranged from 0 to 1, when Yij is minimum, unit value is 0 and Yij is maximum, unit value is 1.

Then, these unit values of each respondent were multiplied by respective component scale values, summed up, divided by total scale value and multiplied by 100 to get sustainability index for each respondent.

$$\text{Sustainability Index} = \frac{\text{Uij.Sj}}{\text{Total scale value}} \times 100$$

Where,

Uij = Unit value of the i^{th} respondent on j^{th} component.
Sj = Scale value of j^{th} component.
Total scale value = 51.47

After obtaining scores, the respondents were categorised into three groups based on mean and standard deviation as follows:

Sl.No.	Category	Score range
1.	Low sustainability level	Below (Mean – S.D)
2.	Medium sustainability level	Between (Mean $\pm$ S.D)
3.	High sustainability level	Above (Mean + S.D)

Level of Sustainability of Agriculture in Watershed areas and Its dimensions

The sustainability index of the individual farmer was worked out and the respondents were grouped according to their sustainability level. The level of sustainability in each of the indicators selected in the present study were analysed for respondents. The results in this regard are presented in the subsequent headings.

Sustainability of Agriculture in Watershed areas

The distribution of respondents according to their level of sustainability of agriculture is presented in Table-3.

Table-3: Distribution of respondents according to their sustainability level (n = 200)

Sl.No.	Category	Respondents	
		Frequency	Percentage
1.	Low sustainability level	44	22.00
2.	Medium sustainability level	114	57.00
3.	High sustainability level	42	21.00
	Total	**200**	**100.00**

Mean = 38.15, S.D = 16.23

From Table-3, it could be seen that majority (57.00%) of the respondents belonged to medium level of sustainability, while, 22.00 per cent had low level of sustainability and 21.00 per cent had high level of sustainability.

The reasons claimed for this trend of results was due to the fact that the farmers were educated through many programmes by the staff of the watershed programme which were included the low-cost technologies to conserve the soil and water in the dryland area. These might have resulted in the adoption of many conservational practices which were responsible for the sustainability. The similar results were also observed by Gowda (1996) and Nagabhushanam (1997).

Level of sustainability in each of the indicators

It could be seen from the Table-4, that the soil environment level was maintained at the medium level by 50.50 per cent. Higher level of soil environment level was observed by 29.50 per cent, whereas, 20.00 per cent of farmers maintained the low level of soil environment level. The medium level of integrated pest management was observed to the extent of 59.50 per cent by the farmers followed by high level of 22.00 per cent, whereas, 18.50 per cent of farmers used low level of integrated pest management practices to control the pest and diseases. Eco-system management was done at the medium level by 64.50 per cent, whereas, 21.00 and 14.50 per cent of farmers did to the extent of high and low level, respectively. Majority (60.50%) of farmers had diversified their crops after the implementation of

Table 4: Distribution of respondents according to their level of sustainability in each of the indicators for sustainable agriculture

(n=200)

Sl. No.	Indicators	Category			Mean	S.D.
		Low	Medium	High		
1.	Soil environment level	40 (20.00)	101 (50.50)	59 (29.50)	3.82	1.62
2.	Integrated pest management	37 (18.50)	119 (59.50)	44 (22.00)	3.63	1.55
3.	Eco-system management	29 (14.50)	129 (64.50)	42 (21.00)	3.43	1.46
4.	Crop diversity	31 (15.50)	121 (60.50)	48 (24.00)	3.09	1.27
5.	Input use index	29 (14.50)	123 (61.50)	48 (24.00)	2.69	1.10
6.	Information self-reliancy	43 (21.50)	121 (60.50)	36 (18.00)	2.22	1.10
7.	Land productivity	33 (16.50)	131 (65.50)	36 (18.00)	2.37	0.93
8.	Crop yield security	43 (21.50)	123 (61.50)	34 (17.00)	1.76	0.76
9.	Enterprise supporting ability	56 (28.00)	101 (50.50)	43 (21.50)	1.07	0.62
10.	Carrying capacity	43 (21.50)	110 (55.00)	47 (23.50)	1.07	0.51

Figures in parentheses indicate percentages.

watershed programme. In addition to that 24.00 per cent of respondents had high crop diversity and only 15.50 per cent had low crop diversity level.

The input use index of farmers expressed that 61.50 per cent of farmers used the inputs to the medium level followed by 24.00 per cent high level of inputs and only 14.50 per cent used low level of inputs for the crops grown by the farmers. Majority of farmers (60.50%) had medium level of information self-reliancy followed by low and high to the extent of 21.50 per cent and 18.00 per cent, respectively. Majority of farmers (65.50%) had medium level of land productivity per unit area which was followed by high and low level of land productivity to the extent of 18.00 and 16.50 per cent of respondents, respectively. As in the case of the other indicators majority of farmers (61.50%) had medium level of crop yield security followed by low and high level i.e., of 21.50 and 17.00 per cent, respectively.

Enterprise supporting ability was observed less in the study area, wherein just above half (50.50%) of the respondents had medium level of subsidiary enterprises which was followed by low level (28.00%) and high level (21.50%). The carrying capacity of farmers observed that little more than half of the farmers (55.00%) had medium level of carrying capacity, whereas, 23.50 per cent had high level of carrying capacity and 21.50 per cent of farmers had low level of carrying capacity.

It could be inferred from the Table 4 that the majority of the farmers belonged to medium to high level of sustainability in case of almost all the indicators. In some of the indicators like soil environment level, enterprise supporting ability and carrying capacity were found low in the watershed area. This might be due to the fact that practices relating to the improvement of soil environment level were not adopted by the farmers due to non-availability of related inputs like vermicompost, compost, bio-fertilizers etc., to the farmers at right time. Similar findings were reported by Gowda (1996) and Nagabhushnam (1997).

Conclusion

The sustainability level of farmers in the watershed environment had achieved only to the medium level. As the majority of the farmers were of small and marginal it is imperative to develop the suitable eco-friendly farming practices which could enable those categories of farmers to adopt. The big farmers who have been found raising the hopes of higher sustainability level must be used as the model sustainable farms to motivate the other farmers.

References

Brundtland Gro Harlem, 1987. "World Commission of Environment and Development", developing the broad political concept of sustainable development, published its report, our common future in April 1987.

Gowda, M. J. C. 1996. Sustainability of rice farming in different ecosystems. Ph.D. Thesis submitted to University of Agricultural Sciences, Bangalore.

Guilford, 1954. Psychometric methods. Tata McGraw Hill Publishing Company Limited, New Delhi.

Nagabhushanam, K. 1997. Sustainability of agriculture in watershed environment – An analysis. Ph.D. Thesis submitted to Tamil Nadu Agricultural University, Coimbatore.