Innovation-Driven Sustainability Modelling for Poverty Alleviation Initiatives in Rural India: A Mathematical Approach

Chhaya Yadav[#1], S.P.Lal[*2]

[#1]*Research Scholar,*

[*2] *Professor, Department of Production Engineering*

[#*]*B.I.T. Mesra, Patna Campus, India*

***Abstract*—** *Today's world is facing many severe challenges even though it had made encouraging progresses in economic and other respects. Agriculture is one of the important sources of economic and social growth of our country. In this paper we have taken four states of India and done the modelling of innovation driven sustainability and obtained time cost ratio for innovation by different states and evaluate the average sustainability index. Finally we calculated the relative sustainability scores and given the ranking to different states. This will help to find out which state is the most sustainable.*

Keywords— ***Sustainability, Sustainability Index, ICT, indicators, Sustainability scores***

I. INTRODUCTION

"Growth with Social Justice" has been the basic objective of the development planning in India since independence. Despite rapid economic growth in several countries, achieving global poverty reduction remains a major challenge. At the beginning of the first Five-Year Plan, almost half of the Indian population was living below the poverty line, 80% of which lived in the rural areas. The incidence of poverty in villages was widespread. This problem was further aggravated by disparities that existed among the States, between men and women and among different social groups. The magnitude of poverty and disparities that existed between various social groups necessitated planned State intervention to provide succour and relief to millions reeling under poverty, particularly the disadvantaged and marginalised social groups, such as Scheduled Castes, Scheduled Tribes, other backward castes, women, children, the physically handicapped and the disabled.

There has been sustained effort through Government intervention to deal with the problem of poverty in India. During the six decades since Independence, the country has made a significant stride in many areas. It is now a net exporter of food-grains. There has been significant improvement on a range of human development indicators. There has been noticeable achievements in the area of poverty alleviation as well. With the sustained efforts of Government interventions the proportion of population Below the Poverty Line (BPL) has been brought down from 54.8% in 1973-74 to 35.9% in 1993-94 and further to 26% in 1999-2000. The rural poverty [1] during this period has also been brought down from 56.4% in 1973-74 to 37.27% in 1993-94 and 27.09% in 1999-2000. Various national surveys conducted between 1960s and 1990s have indicated that between 37% and 48% of the Indian population live in poverty, slightly more in rural areas (46%) than in the cities (39%) (Krishnaswamy, 1990). The World Bank (2000) estimates that there are 320,000,000 poor in India, approximately one out of every three individuals. ''India has reduced the percentage of the population living in poverty... but progress has been uneven and the total number of poor families continues to increase, albeit at a slower rate'' (World Bank, 2000, p. 11). Since 1965 there has been a slow but steady drop in the poverty rate, with a slight increase in the mid-1990s and a levelling off since then (Datt & Ravallion, 1997; World Bank, 2000)**.[4]**

The point of concern, however, is that, over a quarter of the world's poor are still concentrated in India. The latest estimate by the Planning Commission shows that more than 260 million people continue to live Below the Poverty Line (BPL) which is about **26%** of the country's population. There is still high concentration of the poor in the rural areas. Out of the total, 193 million poor live in the rural areas which is about 75% of the total poor in the country. The poor are also concentrated mostly in backward regions like dryland, rainfed, drought prone, tribal, hill and desert areas. The concentration of the poor continues to be more among the weaker sections of society particularly among SCs, STs, backward classes.

Vast size of the rural population below the poverty line does have its telling effects on the country and its economy. It amounts to great wastage and underutilization of the human resources. There is also a great burden on the economy in terms of recurring relief investment at the time of drought, floods, cyclone etc. since the poor are the most vulnerable**[5]** to natural calamities. It also affects greatly the potential for saving of the economy for productive investment.

Poverty**[2]** also breeds many socio-cultural problems, which are to be tackled separately. It also affects the image of the nation globally, an attempt is being made to briefly analyze the major initiatives taken so far in the country since independence to tackle the problem of poverty[**3]** in rural areas.

A Re-thinking and attempt to attack Poverty directly

There was, therefore, a re-thinking on the need for re-conceptualization of the programmes and policies. The need for direct attack on poverty was finally felt particularly during the Fourth Plan period. The 1970s are a significant decade in this context. Many new programmes including the Rural Works Programmes (RWP), the Drought Prone Areas Programme (DPAP), the Desert Development Programme (DDP), the Food for Work Programme (FWP), Programmes for Small & Marginal Farmers (Small Farmers Development Agency-SFDA, Marginal Farmers & Agricultural Labourers Agency-MFAL) were all tried in rural areas. The programmes basically had objectives to provide three pronged attack on the poverty i.e. (i) in terms of creating an income**[6]** generating asset base for self-employment of the rural poor, (ii) by creating opportunities for wage employment for the poor and (iii)area(land)development activities(programmes) in backward regions like dry-land,rain-fed, drought prone, tribal, hill and desert areas. Subsequently, there were also programmes for providing basic infrastructures for better quality of life in rural areas and also programmes for social security of the poor and destitute. In addition, policy prescriptions were also made and statutory provisions introduced for the empowerment of the people and their participation in the development process.

Innovation

For better and for worse, the effects of the major transformations that have taken place in the world since the 1990s, have now reached even remote rural villages in the poorest countries. The rural poor are citizens of this emerging new world, and no matter how marginalized and excluded they very often are, they cannot rest assured that they can go on -without consequences- with their old ways of life and with their time-tested livelihood strategies, even if they wanted too.

Because of the changes surrounding and affecting them, the rural areas of the developing world nowadays resemble a gigantic laboratory, with new initiatives taking place everywhere and across a range of issues and objectives. While the rural poor are sometimes at the centre of these transformations, very often they are marginalized from the main lines of innovation, or, worse, adversely affected by them.

Also, the innovations**[7]**of the poor are often driven by "push" [**8]**factors, that is, by responses to negative incentives such as depleted soil fertility, difficulty of inability to out-compete agricultural imports (often subsidized), drought, overpopulation in relation to the endowment of natural resources, or lack of political power. In these cases, the objective many times is not so much as to how to grow and expand the capabilities and opportunities of the rural poor, but rather how to suffer the least damage.

In contrast, the rural social strata with greater access to all types of assets, have a greater chance to innovate in response to "pull**"[9]** factors, that is, the new opportunities brought about by the changing local, national and international context, such as, for example, new markets for high value crops, new options for non-farm rural enterprises, stronger links between primary production and industry and services, better roads and modern ICTs, new bio-technologies, and so on.

The opportunities and conditions for innovation are as unequally distributed, and as stacked against the rural poor **[10],** as are many of the assets and resources. This is a serious challenge for an organization like IFAD whose mission is to enable the poor to overcome their poverty, which of course requires enabling the poor to Pro-Poor Innovation Systems participate in those lines of innovation that have the potential to change, for the better, the conditions in which they live.

Sustainability & its Models

We face many urgent sustainability challenges, including climate change, loss of biodiversity, poverty, epidemics, and violent conflicts. These problems range in scale from global to local and are projected to affect future generations. With these features, they are complex beyond our understanding, outside the capacity of our current institutional structures to address, and caused by ingrained behavioural patterns (Seager et al. 2012)**[11]**As we attempt to clarify others' perceptions and misconceptions, it is helpful to have a few definitions and models in our toolkit. The 1987 Report of the Brundtland Commission, *Our Common Future*, defined sustainable development as, "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs**."[12]** To supplement that touchstone definition and others, here are three sustainability models that might help explain what a sustainable society looks like. There are three dimensions of sustainability: economic, environmental and social / cultural. There are three main models ,Three-legged stool model, Three-Overlapping-circles model, Three-Nested-dependencies model which shows the relation among economic, environmental and social sustainability.[13]

II. Problem Definition

A case study of different states of India for modelling and analysis of innovation-driven sustainability using matrix method is considered here with four states and different innovations. The innovations in the area of sustainability and poverty control done by the states considered in the present study are new techniques in the field of agriculture, strategies, ICTs and policies used in sustainability control. Four states are considered whose innovations in the above area are discussed below. There are many types of equipments, tools and different techniques are used as per the soil and climate condition of different states in the agriculture.

Innovative contributions in different states

A. Agriculture in State 'A'

Agriculture is the key to the overall development of the State economy. Agriculture is the backbone of this state. The state has attained self sufficiency in food grains production. Adverse climatic condition like flood, plays a role in decreasing products. But these adverse condition can be overcome to some extent by **strategies, policies and new technologies in flood control enhanced cropping intensity, change in cropping pattern, cultivation practices** and with the availability of better post harvest technology etc.

B. Agriculture in State 'B'

In this state agriculture is the employment and primary income generating activity. The agricultural economy of the this state is characterized by dependence on nature, low investment ,low productivity, mono-cropping with paddy as the dominant crop , in inadequate fertilizers and good seeds.

The cultivable land resources of the state has good potential for higher production of horticulture and forest products. The soil is young and has high capacity of fixation of humus. The forest provides sufficient biomass to feed its soiling. However, lack of training program and good seeds ,Soil erosion and failure to recycle the biomass is depleting the soil fertility. Hence, **land management, good seeds, fertilizers uses, training programmes** for farmers are required only that can improve agriculture productivity.

C. Agriculture in State 'C'

Varied ecological condition enables cultivation of various crops in different parts of the state C. Agriculture is still the backbone of state's C economy. The state has insufficient rainfall, the surface water availability to agriculture is not sufficient due to inadequate storage facilities etc. as far as the status of ground water is concerned, it is also in the poor state due to lacking in irrigation techniques so **different training programmes for conservation of water and irrigation management is required** .This state has been started innovations in new techniques in irrigation.

D. Agriculture in state 'D'

The economy of state D is a balanced mix of agricultural and industrial sectors. In this state economy has been boosted with the presence of modern infrastructural facilities. In the agricultural sector, the presence of fertile soils and favourable climate has aided to emerge as one of the leading agricultural states. The principal problem in this state is that agriculture faces is the shortage **of research and development**. Government and NGOs can help people in this state.

III. MODELING AND EVALUATION OF SUSTAINABILITY

There is now universal acceptance that sustainability has three components: ecological, economic and social [**14]** all three are essential; rather like a three-legged stool; if one leg is missing, the whole thing will fall over.

The world has produced vast and evident technological development during 20th Century, which has tremendously increased the environmental degradation. There is a strong need to confront these problems through systemic perspective analysis and modeling based on social, environmental and innovative capital of firms characterizing sustainability. For this reason, modeling, evaluating and measuring innovation-driven sustainability has become a crucial and important deed in the process of building more environmental-friendly societies. The sustainability modeling in the present chapter includes following general steps:

1. Considering a case-study of innovation-driven sustainability control used in different states by new techniques of agriculture, strategies and policies.
2. Evaluating sustainability status based on preliminary incidence network approach.
3. Determination of costs associated with adoption of various innovations related to agriculture.
4. Determination of adoption time of various innovations done by different states.
5. Selection and classification of components and their underlying sustainability indicators and parameters.
6. Computation of average sustainability index based on weighted average method of various states for different innovations.
7. Evaluation of relative innovation-driven sustainability scores of various states.
8. Ranking of states based on these innovation-based sustainability scores.

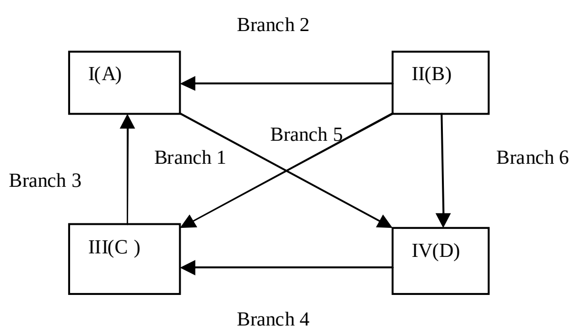
IV.METHODOLOGY

The concept of ‘sustainability as a driver for innovation’ has not been explored in depth. The present section looks at this issue of sustainability from the innovation perspective. The present work starts with undertaking and formalizing a suitable case-study of innovation-driven sustainability control equipments and techniques in agriculture used by different states in India. Then, a preliminary study is carried based to evaluate sustainability status based on incidence network approach. Based on the inference drawn from this initial study, a comprehensive model for measuring and evaluating innovation-driven sustainability has been made. The model involves selection and classification of various indicators of sustainability to arrive at average sustainability indices by various states for different innovations considered under the present study. Also, the costs associated with various innovations, their adoption time and respective occurrence time have been determined based on which the final innovation-driven sustainability scores of different states have been obtained. Finally, these states are ranked according to respective innovation-based sustainability scores obtained by them.

A. Sustainability Evaluation by Incidence Networks

A sustainability incidence diagram as shown in figure 1 as a fitting case study is considered. The diagram pictorially represents the adoption of newer technologies from one state to the other similar to the networks in the electrical circuitry. The nodes denote the leading states in agriculture and the branches depict the technological innovations. The direction shows the concept-run from the innovator to the receiving state. The branches generated from the states are instrumental in bringing sustainability into the recipient state.

Figure I
Sustainability incidence network diagram .



The above figure shows four nodes naming I, II, III and IV representing the four states. The branches, branch - 1, branch - 2, branch - 3, branch - 4, branch - 5 and branch - 6 represent the transfer of technology and adoption of innovations. The state A represented by node I generates a technological innovation shown in the form of branch - 1 flowing from node I to node IV. This means that the state A is the innovator of technological concept of branch - 1 and it is received by the state D, which is represented by node IV. Similarly state ‘B’ is the innovator of three technological concepts represented by branch - 2, branch - 5, branch - 6 which are adopted by state ‘A, C, and D respectively. The state shown by node III is responsible for generating the technological innovation represented by branch - 3, and state A receives this idea for bringing sustainability into the system. The state ‘D’ is the innovator of the technological innovation of branch - 4 and it is subsequently adopted by state ‘C’. The description of nodes and the branches are summarized in table 1

Table 1: Summary of the incidence network diagram.

States	Node Number	Innovations	Branches Generated	Branches Terminated
A	I	Strategies, policies & New Techniques in flood control	1	2,3
B	II	Training programme for farmers Land management,Good seeds and fertilizers in agriculture	2,5,6	Nil
C	III	Irrigation Management	3	4,5
D	IV	R & D in agriculture:Institutional and Research Management	4	1,6

A nodal incidence matrix is prepared on the basis of the above mentioned network diagram for calculation of the relative scores obtained by the various states. The condition for participation in the incidence diagram is that at least one branch should be generated or terminated for participating node, *i.e.* concerned state must have innovated new concepts, which will be accepted within a time frame for its presence in the diagram or have been the recipient of at least one concept from the other inventor. The determination of comparative scores through nodal incidence matrix is done based on following tensor:

$$\text{Score} = [\lambda_{jk}] \quad \ldots.. \quad \textbf{(1)}$$

where:

$$\lambda_{jk} = \begin{cases} +1, \text{ if branch 'k' leaves the node} \\ -0, \text{ if branching 'k' enters node} \\ -1, \text{ if branch 'k' does not touch node} \end{cases}$$

The receiver of branches will get '0' score and the nodes where branches do not terminate will get '-1' for non participation in the adoption of the relevant and significant innovation, unlike the electrical network incidence diagram. The generator nodes get '+1' for generation as well as the innovation generator will get one '+1' as a credit for innovator of the relevant innovations. Figure 2 shows the relative scores obtained by state.

Innovations (Branches)

States	**1**	**2**	**3**	**4**	**5**	**6**		**Score**
A	**1**	**0**	**0**	**-1**	**-1**	**-1**	=	**-2**
B	**-1**	**1**	**-1**	**-1**	**1**	**1**	=	**0**
C	**-1**	**-1**	**1**	**0**	**0**	**-1**	=	**-2**
D	**0**	**-1**	**-1**	**1**	**-1**	**0**	=	**-2**

Figure 2: Sustainability matrix with relative scores.

B. Innovation-Driven Sustainability Model

The above incidence network matrix approach is a preliminary study, which gives only elementary idea of determining and analysing the sustainability. The above approach can only be applied easily when there is limited number of innovative technology transfers. It is almost difficult to accommodate the transfers of innovations from each inventor state to all the other states during the above study. The study becomes further complicated, if state from dissimilar groups have to be analysed. It is also not possible to consider a large number of states and innovations in the incidence diagram. There are other major inherent drawbacks like adoption time of innovative technologies, occurrence time of different innovations and cost component for developing the technology. A critical need to develop a model to get realistic measures of innovation-driven-sustainability scores by concerned states. The following assumptions have been considered in the present model:

- The model has been restricted to same group of states to avoid complexity in the analysis.
- The states considered in the present analysis must have innovated a new concept or have been the recipient of at least one innovation from the other inventor.
- The adoption time of innovative technologies for innovator and recipient states on a relative scale from '0' to '1' has been assumed. The innovator state gets '1' for innovating and other states get a score in between '0' to '1' depending on the time of adoption.
- The rate of decrement due to delay in adoption of innovation is assumed to be linear from '0' to '1'.
- The cost of adoption of different innovations includes both the initial fixed cost and other maintenance cost in form of normalized matrix. The normalization is done by dividing the individual cost element by sum total of all the cost elements of cost matrix.
- The sustainability index of different state is determined based on the survey of various indicators of sustainability considered in the present analysis.

The adoption time of innovations by various states is important because sustainability depends on the proactive-ness of state to accommodate for the latest innovative technologies. An exemplary data is generated as shown in table 3, where the second column of table is the highest values of columns A,B, C and D. Here it has been assumed that all the relevant states have adopted the considered innovations in an estimated period of time.

Table 2: Adoption time of innovations by different States.

Innovations	Expected Adoption time Units of Innovations By all state(months)	Adoption time units of Innovations by different states(months) A	B	C	D
1	18	12	0	7	18
2	10	0	5	10	8
3	12	6	0	10	0
4	14	8	0	14	5
5	11	8	4	6	11
6	12	6	2	4	12

A normalized matrix for the above adoption time has to be obtained, so that proper weight-age to the incorporation time of relevant and innovative technology from the inventor state could be done. This maximum adoption time unit from above table is utilized to determine the corresponding normalized values varying from '0' to '1', which will be obtained from equation (2) as shown in table 3.

$$AT_{jk} = (1 - t_{jk}/t_{max}) \quad (2)$$

where:

AT_{jk} = normalized adoption time to adopt j^{th} innovations by k^{th} State

t_{jk} = time taken to adopt j^{th} innovations by k^{th} State

t_{max} = estimated time till all the States have adopted the relevant technology

Table 3: Normalized adoption time element matrix by different States.

Innovations	Weights depending on Adoption Time of Innovations by different States(scale: 0-1) A	B	C	D
1	0.33	1.00	0.61	1.00
2	1.00	0.50	1.00	0.20
3	0.50	1.00	0.16	1.00
4	0.42	1.00	0.00	0.642
5	0.27	0.63	0.45	0.00
6	0.50	0.83	0.66	0.00

Every state has specific cost associated with the creation and adoption of the innovative technology. The recipient states also have to spent money for the implementation of specific innovations. The two major components of these costs are initial costs and maintenance cost. Table 4 depicts the individual estimated costs values of different technologies. The normalized values of the cost are obtained by taking the ratio of individual cost element to sum total of all the cost elements as shown in table 5.

Table 4: Cost for the implementation of relevant innovations.

	Cost of Incorporation of Relevant innovations by different States(Crores)			
Innovations	A	B	C	D
1	35	60	30	70
2	80	25	60	45
3	110	175	130	160
4	150	100	110	125
5	200	205	210	200
6	125	220	200	250

Table 5: Normalized cost matrix for the implementation of relevant innovations.

	Cost of Incorporation of Relevant Innovations by different States(Units)			
Innovations	A	B	C	D
1	0.01138	0.0195	0.0097	0.02276
2	0.0260	0.0081	0.0195	0.0146
3	0.0357	0.0569	0.0422	0.0520
4	0.0487	0.0325	0.0357	0.0406
5	0.0650	0.0666	0.0682	0.0650
6	0.0406	0.0715	0.0650	0.0813

Table 6: shows the value of 'X_i', where 'X_i' is the ratio of time to cost element for each technological innovation by 'i^{th}' individual state.

Table 6: Time-cost ratio for innovations by various States

	'Xi' Value			
Innovations	State A	State B	State C	State D
1	28.99	51.28	62.88	43.93
2	38.46	61.72	51.28	13.69
3	14.00	17.57	3.93	19.23
4	8.78	30.76	0.00	15.81
5	4.18	9.549	6.65	0.00
6	12.31	11.65	10.24	0.00

Sustainability Index (SI) provides a valuable tool for benchmarking to control the sustainability and natural resource management issues as well as sustainable development, which is demanding attention on a wide scale in the present world scenario. The lack of reliable data to measure sustainable performance based on number of issues hinders attempts to move towards more environmental friendly practices and innovations. While it appears that no state is on a fully sustainable trajectory, at every level of development, some are managing their environmental challenges better than others. Thus, sustainability index offers a mechanism for establishing "peer groups" of states for the purpose of benchmarking environmental performance.

The present analysis is performed considering 4 core components, 15 indicators and 45 variables. which were chosen through concerned literature and consultation with practicing researchers and Agenda 21 as proposed by UNEP (United Nation's Environmental Programme) . The logic for the inclusion of these core components for evaluation of average sustainability index for different innovations by various states are illustrated in table 7.

Table 7: Logic for selection of core components for evaluating sustainability.

Components	Logic
Environmental	The states are more sustainable when their effects on the vital environmental systems are maintained at healthy and improved levels by waste management in agriculture.
Economic and Ecosystem	The states are more sustainable when their effects on the levels of economy and ecosystem stress are low enough to engender no demonstrable harm to ecosystems. We can reduce the stress by waste consumption, land management and financial managements.
Human Vulnerability	The states are more sustainable when their effects on the people and social systems are not vulnerable to environmental disturbances affecting their basic wellbeing by reducing the use of chemicals and pesticides.
Social & Institutional Capacity	The states are more sustainable when it has in place institutions and underlying social patterns of skills, attitudes and networks that foster effective responses to environmental challenges.
Infrastructure Development	The states are more sustainable when it has good infrastructure

The Indicators[**15**] track whether the current agricultural activities of a state threaten the way-of-life for future generations and also reveal, whether things are getting better or worse, or are where we want them. The signals from these indicators influence everything from major investment decisions to consumer and will help tracking the results over time, showing whether states are making progress towards sustainable development or not? Just as sustainability is about finding the balance point between a community's economy, environment and society; selecting a set of indicators for a sustainable enterprise requires balancing of many different needs within the state and community.

Components	Indicator No.	Indicators	Variable No.	Variables
Environmental	1	Water management	1	Recycling
			2	Harvesting
			3	Flood control techniques
			4	Drought control
			5	Water treatment plants
			6	Sprinkling methods in irrigation
Economic	2	Waste and consumption pattern	7	Reduction in Hazardous Waste generation
			8	Recycling of Wastes
	3	Land management	9	Land Attributes
			10	Soil conservation
	4	Financial management	11	Market signals and farm financial resources
Human Vulnerability	5	Human Health and welfare	12	Chemical input used
			13	Pesticides spray
			14	Livestock odour
			15	Change in food consumption pattern
			16	Drinking water
			17	Recreation
			18	Sanitation
			19	Medical care
			20	Population
			21	Mortality Rate
Social & Institutional Capacity	6	Governance Policies:	22	Agenda 21 Initiatives
			23	Regulations
			24	Research & Development
			25	Participatory decision making and self rule.
	7	Education	26	Agricultural policies
			27	Skill development/Industrial Training
			28	Adult Literacy/Job oriented training
	8	Private Sector Responsiveness	29	Corporate Sustainability
			30	ISO certified Companies
			31	Private sector environmental innovations
	9	Science & Technology	32	Innovation Capacity
			33	Research scientists
	10	Social security/Insurance	34	Govt. laws & orders
			35	Gender Gap
			36	Women Empowerment
Infrastructure development	11	Energy	37	Solar Energy
			38	Rural electrification
	12	Road	39	Schemes or plan by Government.
			40	Construction of Road
			41	Maintenance of Road
	13	Public Transport	42	Types of vehicle used by public
	14	ICT & Digital Divide	43	Communication
	15	Housing	44	Rural Housing Policy
			45	National Housing Policy

Table 8: Sustainability index building blocks-indicators and variables [16]

A brainstorming session might produce hundreds of indicators and it is difficult to decide the important ones, as keeping more is not better. Keeping less is also not better. For a state, 10 to 25 set of indicators make sense, which should cover all the important issues. There are four common methods for classifying sustainability indicators, namely category or issue lists, goal-indicator matrix, driving force-state-response tables and based on endowments, liabilities, current results, and processes. Here in the present study goal-indicator matrix approach has been used to segregate indicators under five core components as shown in table 8. The sustainability index is mathematically evaluated as an equally weighted average of all the above indicators, which may be measured and analysed by issue-by-issue basis methodology as shown in figure 3.

Figure 3: Evaluating the average sustainability index.

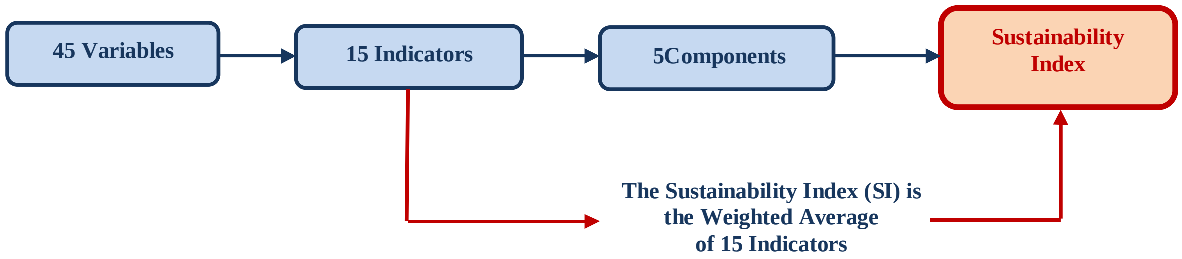


Table :9 shows the average scores and relative importance (weights) obtained by various indicators of sustainability. The scores have been assigned based on the various variables under a particular indicator and their importance with respect to sustainability as per the discussion with the experts in this field and by literature survey. The average sustainability index for each innovation has been obtained by taking the weighted average of all the scores obtained by various indicators for a particular innovation. The weights are the relative importance rating assigned to each indicator in form of 'star' marks.

Table 9: Relative weights and average score of indicators

Sr. No.	Indicators	Relative Weights	Indicator Average Scores					
			Innov-1	Innov-2	Innov-3	Innov-4	Innov-5	Innov-6
1	**Water management** • *Recycling* • *Harvesting* • *Flood control techniques* • *Drought control techniques* • *Water treatment plants* • *Sprinkling methods in irrigation*	****	0.6	0.5	0.65	0.65	0.7	0.85
2	**Waste and Consumption Pattern** • *Reduction in Hazardous Waste generation* • *Recycling of Wastes*	*	0.65	0.6	0.7	0.7	0.75	0.8
3	**Land Management** • *Land Attributes* • *Soil conservation*	**	0.3	0.3	0.65	0.65	0.75	0.85
4	**Financial Management** • *Market signals and farm financial resources*	*	0.3	0.3	0.45	0.45	0.5	0.5
5	**Human Health and Welfare** • ***Chemical input used*** • ***Pesticides Spray*** • ***Livestock odor*** • ***Change in food consumption pattern*** • ***Drinking water*** • ***Recreation*** • ***Sanitation*** • ***Medical care*** • ***Social Security/Insurance***	***	0.5	0.55	0.7	0.7	0.8	0.9
7	**Governance policies: changes in** • ***Agenda 21 Initiatives*** • ***Regulations*** • **Research and development** • **Participatory decision making and self rule.**	**	0.6	0.55	0.75	0.7	0.8	0.85
8	**Education** • ***Agricultural policies*** • ***Training and Information*** • ***Skill development/Industrial Training*** • ***Adult Literacy/Job oriented training***	****	0.8	0.8	0.95	0.75	0.7	0.65
9	**Private Sector Responsiveness** • ***Corporate Sustainability***	**	0.35	0.3	0.65	0.6	0.7	0.8

	• *ISO Certified Companies* • *Private Sector environmental innovations*							
10	**Science & Technology** • *Innovation Capacity* • *Research scientists*	****	**0.6**	**0.55**	**0.95**	**0.8**	**0.85**	**0.7**
11	**Population** • *Gender gap& Digital Divide* • *Women empowerment* • *Mortality rate*	***	**0.6**	**0.4**	**0.5**	**0.7**	**0.8**	**0.7**
Sum =		**26**	**21.05**	**13.85**	**19.05**	**18.05**	**19.55**	**19.90**
Average Sustainability Index (W_i)			**0.809**	**0.532**	**0.732**	**0.694**	**0.751**	**0.765**

The average sustainability index of different state is basically average sustainability improvement index, which is based on the estimated scores of relevant modules for adopting the new innovations by the innovator and recipient states. The indices are obtained on the basis of the survey of various indicators of sustainability considered in the present analysis. Here it is assumed that the adopting the new technology, the innovator state gets the maximum benefit in comparison to other competitive states.
Table 10 shows the procedure for obtaining innovation-driven-sustainability scores by taking sum of the product of 'W_i' and 'X_i' for each individual state, *e.g.* the innovation-driven sustainability score of state 'A' is found to be 20.24 %. Finally, the relative innovation-driven sustainability score on percentage basis have been calculated, which will be utilized to evaluate the sustainability of various states for different innovations.

Table 10: Innovation-driven sustainability scores of different states.

Innovations	**Ave. Sus. Index (W_i)**	**State A**		**State B**		**State C**		**State D**	
		X_A	**$W * X_A$**	**X_B**	**$W * X_B$**	**X_C**	**$W * X_C$**	**X_D**	**$W * X_D$**
1	0.809	28.99	23.4	51.28	41.48	62.88	50.86	43.93	35.53
2	0.532	38.46	20.4	61.72	32.83	51.28	27.28	13.69	7.28
3	0.732	14.00	10.24	17.57	12.86	3.93	2.87	19.23	14.07
4	0.694	8.78	6.09	30.76	21.34	0.00	0.00	15.81	10.97
5	0.751	4.18	3.13	9.54	7.15	6.65	4.99	0.00	0.00
6	0.765	12.31	9.41	11.65	8.91	10.24	7.83	0.00	0.00
Total Score			72.67		124.57		93.83		67.85
% Score			**20.24**		**34.70**		**26.14**		**18.90**

V. CONCLUSION

The innovation-driven sustainability scores obtained by various states basically depend upon average sustainability index and adaption time to cost ratio for different innovations considered under the present analysis and modeling. The time-cost ratio has been obtained the respective ratios of the normalized adaption time and implementation cost data of various states or different innovations. The average sustainability index has been obtained based on various core component and their underlying indicators selected, which are directly and indirectly influencing the sustainable behavior of the state. The various indicators are allotted average scores in the scale of '0' to '1' based on various variables under consideration for different sustainability indicators along with relative weights depending upon their importance. The weighted average method was used to evaluate the sustainability index of various states for different innovations.

Finally the innovation driven sustainability scores by different states have been obtained by taking the mean of the sum of the product of time-cost ratio and average sustainability index respectively. Table 11 shows the innovation-driven sustainability relative percentage scores of the four different states in summarized form along with the ranks in decreasing order. The state 'B' has the highest sustainability score followed by the state 'A' and then others. These ranks are of immense importance because they give preliminary idea about the performances in implementing sustainable agriculture practices based on various innovations carried and adopted by the relevant units. It enables the concerned agriculture units to get realistic glimpses of their performances in comparison to the competitor.

Table 11: States ranking based on innovation-driven sustainability scores.

States	Relative Sustainability Scores (%)	Ranks Obtained
B	34.70	**1**
C	26.14	**2**
A	20.24	**3**
D	18.90	**4**

Figure 4 also shows the chart for innovation-driven sustainability scores by various States and it is clearly evident that the innovation-driven sustainability score of state 'B' is the highest among all the participating states.

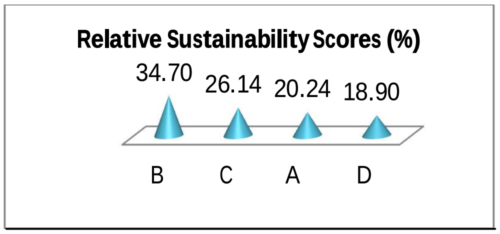


Fig: 4 Comparative result of Sustainability Scores.

REFERENCES

[1] Kate Bird, David Hulme, Karen Moore and Andrew Shepherd"CHRONIC POVERTY AND REMOTE RURAL AREAS" Institute for Development Policy and Management, UK. ISBN 1-904049-12-5.pp1-57.

[2] Khalid Zaman, Muhammad Mushtaq Khan and Mehboob Ahmad, The Study of Pro-poor Growth and Poverty Reduction in Pakistan, (1999–2006), Social Change, 42, 2 (2012): pp249–261.

[3] Lawrence M. Mead, "The Poverty of Poverty Research," Acad. Quest. (2012) 25:(Spring 2012):pp. 539–545

[4] Douglas A. Abbott et al, The Emotional Environment of Families Experiencing Chronic Poverty in India, Journal of Family and Economic Issues, Vol. 25(3), Springer 2004, pp387-409.

[5] Ronald U. Mendoza, Why Do The Poor Pay More?Exploring The Poverty Penalty Concept, Journal Of International Development, 23, (2011) Pp:1–28.

[6] INDRANEEL DASGUPTA and RAVI KANBUR, Community and anti-poverty targeting, Journal of Economic Inequality, Springer 2005, Vol- 3:pp 281–302.

[7] David J. Spielman, Kristin Davis, Martha Negash , Gezahegn Ayele , Rural innovation systems and networks: findings from a study of Ethiopian smallholders, Agric Hum Values,vol- 28 (Springer 2011):pp. 195–212.

[8, 9]NICOLOV, M[irela] & BADULESCU, DIFFERENT TYPES OF INNOVATIONS MODELING, Annals of DAAAM for 2012 & Proceedings of the 23rd International DAAAM Symposium, Volume 23, No.1, pp:1071-1074

[10]Abusaleh Shariff, Rural Income and Employment Diversity in India During 1994 and 2005, SAGE 2009 , Vol 25(2), pp: 165–208.

[11]Sander van der Leeuw et al, How much time do we have? Urgency and rhetoric in sustainability science, Sustain Sci Springer(2012) 7, pp:115–120.

[12]Pim Martens , Sustainability: Science or fiction? Springer 2006(vol-2) ,1, pp:36-41.

[13]Three Sustainability Models, Bob Willard, July 20th, 2010. http://sustainabilityadvantage.com/2010/07/20/3-sustainability-models/

[14,16] John Custance and Hilary Hillier Statistical issues in developing indicators of sustainable development, J. R. Statist. Soc. A(1998)161, Part 3, pp.281-290.

[15] Li-Yin Shen, J. Jorge Ochoa, Mona N. Shah, Xiaoling Zhang, The application of urban sustainability indicators : A comparison between various practices, Habitat International 35 Elsevier(2011),pp: 17-29.