Measurement of Social Capital in Water Users Association through Analytical Hierarchy Process

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MR and KM designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors KM and KP managed the analyses of the study. Author MR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study aims to construct by using the social capital index through the identified major components and subcomponents in the watershed context by using the analytic hierarchy process (AHP). It was introduced by Satty, for decision making by considering the complex elements involved in the process. This was done through pairwise comparison of the judgments of experts. The empirical findings indicate that among the six major components the level of derived benefits was assigned with high weightage as a contributing component in the social capital index followed by the level of involvement, level of collective management, level of trust.

Keywords: Analytic hierarchy process; derived benefits; involvement; social capital.

1. INTRODUCTION

In India ever since independence, the government has implemented various development programs in different sectors through state governed departments and non-governmental organizations for community welfare. Though there was some success at the

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implementation phase in those programs, it was not long-lasting at the post-implementation phase. To ensure the sustainability of the benefits of those programs, the concentration of group dynamics and participation of the local people at program governance was pointed out. In this way, the role played by the social capital was recognised by the social scientists and programme planner and had been considering as another important capital along with physical and financial capital will generate a stream of benefits in the future. Moreover, social capital has attracted the attention of policymakers who are "looking for less costly, non-economic solutions to social problems" [1].

The explanation for economic activities through social elements was offered by the statement of economists and sociologists such as Adam Smith, John Stuart Mill and Max Weber [2]. Social capital was understood as "the characteristics of a social organisation, such as trust, the norms and the networks that may make society more efficient by facilitating a coordinated form of action" [3].

Social capital was studied in macro (Community and Nations), meso (Institution and Organizations) and micro levels (individual and small groups). The components contributing to the social capital also varying according to the level of analysis. Though there were studies on community and nations, institutions and organizations, very few studies have been carried out related to individual and group level. Hence, in this study, the attempt has been made to study the social capital existing at the group level by concentrating on the water users association with the objectives of constructing the social capital index to measure the functioning of water users association.

1.1 Social Capital Measurement

''The distinction between structural, cognitive, and relational social capital was created, and it is the most widely used and accepted framework for understanding social capital. These dimensions are conceptual distinctions that are useful for analytic convenience, but in practice, social capital involves complex actions of the three dimensions'' [4]. Depends on the social context, the integration of these dimensions leads to different interactions that were grouped and categorized as components. Here too, six major components were identified based on the review of the literature and practical exposure in group dynamics of water users' associations. The identified major components are level of trust, level of involvement, level of affinity, level of derived benefits, level of collective focus and level of collective management. The details of various interactions in their grouping and categorization of subcomponents are furnished below.

1.2 Level of Trust

Based on the theoretical framework, by considering the nature of water users' association, the individual and collective aspects of trust were pooled together by keeping the account of belief system, structure and norms to be followed in group interaction. The structural element should be possessed with the belief component which ultimately leads to the building up of the trust. As for the water users' associations are concerned it was supported by the aspects of credits resource mobilization, with technical guidance by following the norms of mutual obligations and reciprocity. Trust is a basis of social capital that endures economic measures, both in governmental and non-governmental performance' [5]. Hence, the trust components were derived from the belief of members through the subcomponents such as competence, compatibility, accessibility and transparency.

1.3 Level of Involvement

Pursuing through the literature related to community mobilization, people participation and social action, one more component of social capital level of involvement was derived. Since, water users' association is embedded within the social structure of the local community and supporting organizations, the level of involvement was measured through a collective decision and collective participation. Being a part of a village-level organization, the president and members of the water users' association are all from the same villages used to have a formal and informal interaction with the members and leaders of the other village-level organizations such as panchayat raj, self-help groups and community leaders. Involvement and commitment towards a process in which individuals even compromise their own instantaneous needs for attaining the future common goals and interests [6]. The collective involvement of the village level organizations was studied through the subcomponents of decision

making and participation in development activities.

1.4 Level of Affinity

Affinity is another dimension of social capital that intervened with the level of trust and level of involvement. Unless the water users' association has an affinity towards the community members and their development, societal up-gradation will not happen. The community sensitiveness imbibed within the members of the society, give the sense of we feeling. The overwhelming aspects of affinity not only make the members of society to be attached for development but also make them adjust with the defaulters and deviants too. Affinity is considered to 'seek trustable and sustaining human relationships and groups, which results in a positive impact on the individual's life and improves their economic activity by producing and exchanging more products and information which they require [7].

1.5 Level of Derived Benefits

Social capital and social benefits mutually influence and become the product of each other. Most of the watershed activities are focused upon agriculture and its allied sector development which ultimately led to the build-up of physical assets in individual farms and their villages. Apart from the direct benefits in terms of monitory and physical facilities, there were indirect benefits like women empowerment, a decline in migration and establishment of communal religious harmony, *etc*. social capital can benefit enterprise performance by fostering the diffusion of information and knowledge, lowering uncertainty and transaction costs and enhancing economic development depends on the level of trust within networks [8].

1.6 Level of Collective Focus

Studies on the social process, organization behaviour and group dynamics revealed that social capital not only build up through, what they have gained and what they focused to gain. The desire to be excel in one's endeavour is part of human nature as well as collective behaviour [9]. Hence, organizations tend to have a mission and vision, goals and priorities, ambitions and objectives which serve as the cohesive factors that stick the organization together. Water users' associations the future focus to serve as a model

watershed and to be a model village was brought out by its items like serve as a model unit, training unit, resource person, self-governance and social control, *etc*. The Conversation between the members and their collective focus on the work plays a major role in changing the attitude among individuals about the collective actions into more personal [10].

1.7 Level of Collective Management

Any organization will thrive when there is effective management as a guiding force. Without the dynamism of collective management water users' association cannot function. Being a voluntary association by nature, collective management must be evolved within the water users' associations. Such management not only focused upon a goal but also focused upon people's welfare are the essential criteria for thriving. Cooperative and collective management can be maintained only by the active association among the organisations along with their trust and mutual interests and reciprocity [11]. The components of the goal and people focused which was observed among the water users' associations were culled out and framed in such a way to measure the level of collective management.

2. RESEARCH METHODOLOGY

Though all these dimensions were commonly found among water users' associations, the actual contribution of the components in building up of social capital may vary from each other. To identify the actual contribution of these components in building up the social capital, the Analytic Hierarchy Process (AHP), introduced by Satty [12], was known as a multi-criteria decision-analysis method was employed, which is presented in research methodology.

The basic procedure follows for the AHP:

1. Hierarchy construction.
2. Developing a pairwise comparison matrix for each criterion.
3. Normalizing the resulting matrix.
4. Averaging the values in each row to get the corresponding rating.
5. Calculation and checking the consistency ratio.

2.1 Hierarchy Construction

Hierarchy is established by breaking down the overall goal that is building up social capital through basic elements. The review of literature and authors' critical judgments has led to the construction of the hierarchical model consisting of different components. Making such construction helps to identify the components with their exclusive domain. Moreover, it helps to control the duplication of subcomponents.

2.2 Developing a Pairwise Comparison Matrix for Each Criterion

Measure the contribution of one component over another component has to be measure through a psychological scale that builds up through the psychological continuum, by ordering the components through the psychophysical method. In this way, the weight score of pairwise comparison was assigned with a scale of 1-9 as depicted below.

Two items are equally important one item is extremely favoured to another

1 2 3 4 5 6 7 8 9
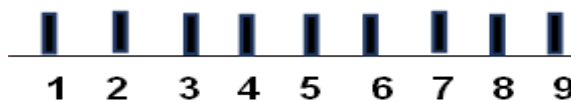
Here, the weightage score assigned by the different experts is pooled together and an average score pairwise was worked out. The pairwise score was depicted in the matrix format

$$\text{Matrix of pairwise element} = \begin{bmatrix} C_{11} C_{12} C_{13} \\ C_{21} C_{22} C_{23} \\ C_{31} C_{32} C_{33} \\ C_{41} C_{42} C_{43} \\ C_{51} C_{52} C_{53} \\ C_{61} C_{62} C_{63} \end{bmatrix}$$

Sum the values in each column of the pairwise matrix $= \sum_{i=1}^{n} C_{ij}$

2.3 Normalizing the Resulting Matrix

To get the overall importance of one element over another element was worked out for the average score of pairwise items in the normalized matrix. To generate a normalised pairwise matrix that each element in the matrix was divided by its column total.

$$x_{ij} = \frac{C_{ij}}{\sum_{i=1}^{n} C_{ij}}$$

2.4 Averaging the Values in each Row to Get the Corresponding Rating

The sum of the normalized column of the matrix was divided by the number of criteria used to generate the weighted matrix. Moreover, this average score gives the percentage contribution of a particular element towards the goal.

$$w_{ij} = \frac{\sum_{j=1}^{n} x_{ij}}{n} \quad \begin{bmatrix} W_{11} \\ W_{12} \\ W_{13} \end{bmatrix}$$

2.5 Calculation and Checking the Consistency Ratio

Judges may assign the pairwise matrix scale without due consideration of the relative importance of each element. If it is so, the score one got in the early steps may not reflect the reality. To get the validity and reliability of the score, a consistency check has to be carried out. The consistency ratio was calculated to make sure that the original preference ratings were consistent.

There are 3 steps to arrive at the consistency ratio:

I. Calculation of consistency measure.
II. Calculation of consistency index (CI).
III. Calculation of consistency ratio (CR).

I. Calculation of the consistency measure

To calculate the consistency measure, the matrix multiplication function =MMULT() is used for actual rows with the average column.

1. Consistency measure is calculated by multiplying the pairwise matrix by the weights vector.

$$\begin{bmatrix} C_{11} C_{12} C_{13} \\ C_{21} C_{22} C_{23} \\ C_{31} C_{32} C_{33} \\ C_{41} C_{42} C_{43} \\ C_{51} C_{52} C_{53} \\ C_{61} C_{62} C_{63} \end{bmatrix} * \begin{bmatrix} w_{11} \\ w_{21} \\ w_{31} \end{bmatrix} = \begin{bmatrix} C_{M_{11}} \\ C_{M_{21}} \\ C_{M_{31}} \end{bmatrix}$$

2. Consistency vector is calculated by dividing the consistency measure with average criterion Weight.

$$C_{v_{11}} = \frac{1}{w_{11}} [C_{11} w_{11} + C_{12} w_{21} \quad C_{13} w_{31}]$$

$$C_{v_{21}} = \frac{1}{w_{21}}[C_{21}w_{11} + C_{22}w_{21} \quad C_{23}w_{31}]$$

$$C_{v_{31}} = \frac{1}{w_{31}}[C_{31}w_{11} + C_{32}w_{21} \quad C_{33}w_{31}]$$

3. λ was calculated by averaging the value of the consistency vector.

$$\lambda = \frac{\sum_{i=1}^{n} cv_{ij}}{n}$$

II. Calculation of the consistency index (CI)

It was calculated by using the formula given below.

$$Cl = \frac{\lambda Max - N}{N - 1}$$

λMax = averaging the value of the consistency vector
N = Number of criteria

III. Calculation of the consistency ratio (CI/RI where RI is a random index)

It was done by following the formula given below.

$$CR = \frac{Cl}{RI}$$

CI = Consistency index value
RI= Table value

2.6 Random Index (RI)

The RI was obtained from the random inconsistency indices given by satty [12], which is furnished below.

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

3. RESULTS AND DISCUSSION

By following the above-mentioned methodology an index to measure the social capital was done, which is presented below.

3.1 Hierarchy Construction

The review of literature and authors' critical judgments has led to the suggestion of the hierarchical model consisting of six major components as depicted in the flowchart (1). However, here the contribution of major components alone being worked out.

3.2 Developing a Pairwise Comparison Matrix for each Criterion

To get the pairwise matrix 20 judges, who are experts in the field of group dynamics in the watershed association were employed. The pairwise comparison of major elements was obtained in the continuum of 1-9 as proposed by Satty [12]. To build up the pairwise matrix the mean value of the scores assigned by the different judges is used which is depicted in Table 1.

In Table 2, it can be seen that each element in the matrix was divided by column total to get the normalized score.

In Table 3, it can be seen that consistency measure, consistency vector and λ max was calculated from the mean score for the selected criteria based on judges rating that was depicted in Table 1. As per the methodology, consistency measure was obtained by matrix multiplication of row with the average column by using excel MMULT(). Further, the consistency vector was calculated inverse of average multiplied with the consistency measure.

Table 1. Mean score for the selected criteria based on judges rating

S.No	Major components	LDB	LI	LM	LT	LA	LCF
1.	Level of derived benefits	1.00	1.25	1.50	1.50	1.50	2.00
2.	Level of involvement	0.80	1.00	1.25	1.25	2.00	2.00
3.	Level of management	0.67	0.80	1.00	1.00	1.00	1.50
4.	Level of trust	0.67	0.80	1.00	1.00	1.00	1.25
5.	Level of affinity	0.67	0.50	1.00	1.00	1.00	1.25
6.	Level of collective focus	0.50	0.50	0.67	0.80	0.80	1.00
	Total	4.30	4.85	6.42	6.55	7.30	9.00

Table 2. Normalization matrix for the criteria

S. No	LDB	LI	LM	LT	LA	LCF	Average
1	0.233	0.258	0.234	0.229	0.205	0.222	0.230
2	0.186	0.206	0.195	0.191	0.274	0.222	0.212
3	0.155	0.165	0.156	0.153	0.137	0.167	0.155
4	0.155	0.165	0.156	0.153	0.137	0.139	0.151
5	0.155	0.103	0.156	0.153	0.137	0.139	0.140
6	0.116	0.103	0.104	0.122	0.110	0.111	0.111
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Calculation of consistency vector

Table 3. Matrix multiplication of row multiplied with average, using excel - MMULT()

| S. No	LDB	LI	LM	LT	LA	LCF	Average	Consistency measure	Consistency vector	λ max
1.	1.00	1.25	1.50	1.50	1.50	2.00	0.230	1.387	6.029	6.027
2.	0.80	1.00	1.25	1.25	2.00	2.00	0.212	1.282	6.037	
3.	0.67	0.80	1.00	1.00	1.00	1.50	0.155	0.936	6.027	
4.	0.67	0.80	1.00	1.00	1.00	1.25	0.151	0.909	6.028	
5.	0.67	0.50	1.00	1.00	1.00	1.25	0.140	0.845	6.017	
6.	0.50	0.50	0.67	0.80	0.80	1.00	0.111	0.669	6.024	
Total	4.30	4.85	6.42	6.55	7.30	9.00	1.000	6.028	6.027	

Cij – Row; Wij – Column
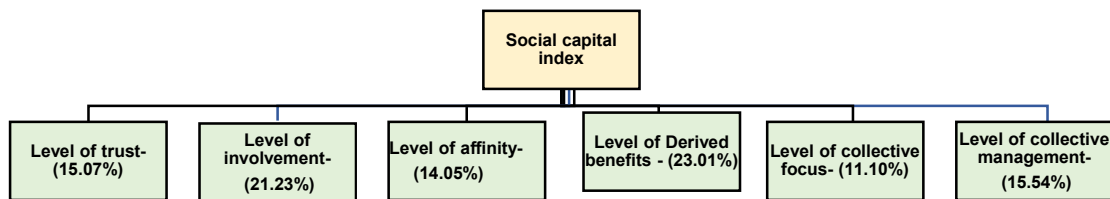
Fig. 1. Weightage score of major components contribution in building social capital as per the judges rating flowchart

1. Calculation of Consistency Index

$$CI = \frac{\lambda Max - N}{N - 1}$$

CI = 6.027-6 / 5 = 0.005.

2. Calculation of Consistency Ratio

$$CR = \frac{CI}{RI}$$

CR = 0.005 / 1.24 = 0.004

Since the calculated consistency ratio value lies below 0.1, it can be ascertained that the weightage score arrived by the judges rating is reliable and the judges agree with each other can be counted. Hence, the selected major factors contributed to building social capital.

4. CONCLUSION

From flowchart 1, it can be concluded that in the first level, the experts opined that the two major components that have contributed towards the building of social capital are level of derived benefits (23.00%) and level of involvement (21.23%) with the average score of (0.230) and (0.212). The contribution of other major components in social capital is a level of collective management (15.54%), level of trust (15.07%), level of affinity (14.05%) and level of collective focus (11.10%) with an average score of (0.155), (0.151), (0.140) and (0.111).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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