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Developing a Framework for Sustainable Drinking Water Supply and Irrigation Projects in Shivalik Area of Himachal Pradesh

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ABSTRACT: The increasing demand for water as a result of population growth, urbanization, economic growth and project centric water resources management has resulted huge pressure on water resources. This, if trends continue, may lead to Himachal Pradesh a water stressed region by international standards. Therefore, we need strategies for conservation of water resources and its use in sustainable manner. When we refer "sustainability", as a kind of keyword in the water infrastructure management context, we mean some set of 'Policies and Procedures" called framework to plan, manage and operate the water systems.
In this paper a system approach has been used to develop a framework for sustainable water systems by considering environmental, social, economic, political and institutional components of sustainability. To address the sustainability issues identified from 14 case studies of water supply and irrigation projects, a framework has been proposed. The proposed framework has been evaluated/ validated using Sustainability Index (SI). For validation of the framework, data obtained from 14 case studies of water supply and irrigation projects were used to determine its effectiveness. The results of analysis demonstrated that framework can work as a tool for improvement and appropriate actions for sustainable water systems.

Keywords: Framework, water systems, Sustainability Index (SI), Shivalik area

I. INTRODUCTION

Water is a basic human need. Basic human needs for water were first articulated in 1977 by United Nations declaring; all people have right to access to drinking water in quantities and of a quality of their basic needs (UN, 1977).
Water demand is inordinately increasing due to population growth & socio-economic changes. If current trends remain unchanged, India will be a water stressed region by 2028 and water will be the limiting factor for development and sustainability in all sectors. Safe drinking water and sanitation facilities are preconditions for sustainable development (UNDP, 2005). This realisation has prompted the countries to commit to achieving the Millennium Development Goal (MDG) as set by United Nations (UN, 2006). Himachal Pradesh has made an impressive progress in providing water supply and sanitation facilities to population. Nonetheless, there are many problems with service delivery. A number of studies have highlighted the water shortages and other related problems in the Shivalik region of Himachal Pradesh (Singh *et al*., 2010_a; Singh *et al.,* 2010_b, Singh *et al.,* 2010_c, Singh *et al.,* 2010_d Singh *et al.,* 2012). The water quality is also deteriorating in Shivalik region of Himachal Pradesh (Sharma, 2004) and (Sharma, 2006).
There is a lack of clear cut solution in areas of service delivery in water sector. This has given rise to an appropriate tool to identify the key components those need to be addressed that could help in monitoring the progress achieved by Governments towards sustainable development (UNICEF & WHO, 2004).

II. BACKGROUND TO THE RESEARCH

Sustainable development has been defined as development that meets the needs of present without compromising the ability of future generations to meet their own needs (WCED, 1987). Sustainability explores the relationship between economic development, environmental quality and social equity (Roger *et. al*, 2006). Sustainable water systems are those designed and managed to contribute to the objectives of society, while maintaining the ecological, environmental and hydrological integrity (ASCE, 1998; UNESCO, 1999).

A. Present Scenario

Analysis of the case studies of 14 water systems indicates that water systems in Himachal Pradesh are facing multitude of problems. These include inadequacy of water sources, hydrological regime changes due to rampant mining near the water sources, leaky distribution network due to deferred repair & maintenance, high operating cost coupled with huge subsidy and inefficient management of water infrastructure, institutional aspects stemming from non-involvement of beneficiaries, and top down approach in planning of water systems causing the unsustainability. Institutional and policy frameworks found to be the key for sustainable management of water systems.

A series of institutional arrangements ranging from strong governmental participation to decentralized efforts have been tried and did not yield much largely because of the variability of local situations and the difficulty of transplanting from one context to another.

Within the purview of existing frameworks, acts, regulations, and social practices that affect the governance of water resources, it is a daunting task to develop and manage water supply and irrigation system on sustainable basis in Himachal Pradesh.

It has been observed that statutory framework and the law governing water resources in Himachal Pradesh were fragmented, incoherent and also the organizational framework governing water systems need revisiting. In view of emerging scenarios in hilly State of HP, an appropriate framework based on equitable access of water at design norms and to address the problems & challenges being encountered in planning, development, and operation & maintenance of water systems on sustainable basis need to be developed.

III. PROPOSED FRAMEWORK FOR SUSTAINABLE WATER SYSTEMS

The objective of a sustainable water system is to provide water in sufficient quantities and qualities at acceptable prices and reliabilities and at the same time protect the environment and preserve the biodiversity and health of ecosystems for future generations.

Failure of any objectives may lead to un-sustainability of system. Sustainability encompasses technology, ecology, social, and political infrastructure of society. It also requires development of key bench marks that provide the basis to evaluate sustainability performance of water systems. The objective of proposed framework is not only to take care of threats/challenges which cause un sustainability but a "pragmatic and principled" approach that incorporates principles of efficiency, equity, reliability and leading to sustainability of water systems. The sustainability framework will function as an effective guiding and monitoring tool. Good water governance framework requires an integrated, holistic service delivery approach that includes not only water supply management, but also demand management, recognizes the importance of community participation and their capacity development, financially self-reliant. It is also important to attract, nurture, and retain talent, so that they will have capable staff to carry out their responsibilities by research & development and trainings. A well-established system of feedback and responsiveness and quality construction & monitoring is also needed to help in setting priorities in water policy interventions and to strengthen the responsiveness of institutions. An appropriate framework to take care of all such determinants of sustainability has been evolved as given in Fig. 1.

The proposed framework is comprised of 10 components.

A. Measurement of Sustainability of Water Systems using the Framework

The measurement of sustainability is most important aspect to identify the parameters and assign a weight value that need to be monitored and evaluated continuously. It may help in timely actions that could reverse the transition of water systems from non-sustainable to sustainable stage. Sustainability of a water system under the proposed framework is a function of 10 diverse parameters.

It is difficult to quantify these subjective parameters hence theses are evaluated by assigning a nominal value based on their relative importance. Normalization is required when parameters have different measurement units. Each of these corresponds to a normalized (weight) value between 1 and 4 depending upon the importance of parameters for achieving sustainability (Nardo, 2008). Parameters of limited importance for achieving the sustainability of water systems are assigned the weight value of 1 and shown in blue colour, parameters which are less critical are shown in green colour assigned the weight of 2, parameters of critical importance to achieve the sustainability are shown in yellow colour assigned the weight 3, parameters of highly critical importance are shown in red colour assigned the weight 4 (Fig. 1).

After assigning the weightage of parameters, each parameter is evaluated individually ignoring the interaction with other parameters at this stage. To standardise the parameters in a comparable frame of reference, scale normalisation approach is used, where all indicators are scored on a 0-1 scale in absolute terms (Bosello, *et al.,* 2011) for Sustainability Index analysis.

Broadly three scenarios of sustainability, I - systems sustainable in long term (LS), II –systems of Acceptable sustainability (AS), and III -Non-sustainable systems (NS), may occur based on the application of theses parameters on a water system. Zero value of sustainability represents Scenario III where most of the prevailing conditions are unfavourable and little scope for sustainability i.e non-sustainable scenario.

If it is 0.5 that represents scenario II where few conditions are not favourable but there is scope of sustainability with some interventions designated as acceptable sustainability. The value of 1 for sustainability represents Scenario I where all requisite conditions for sustainability exists and is designated as Long Term Sustainability.

Thus proposed framework of water system consists of 10 parameters and 3 scenarios of sustainability will make a matrix of 30 elements.

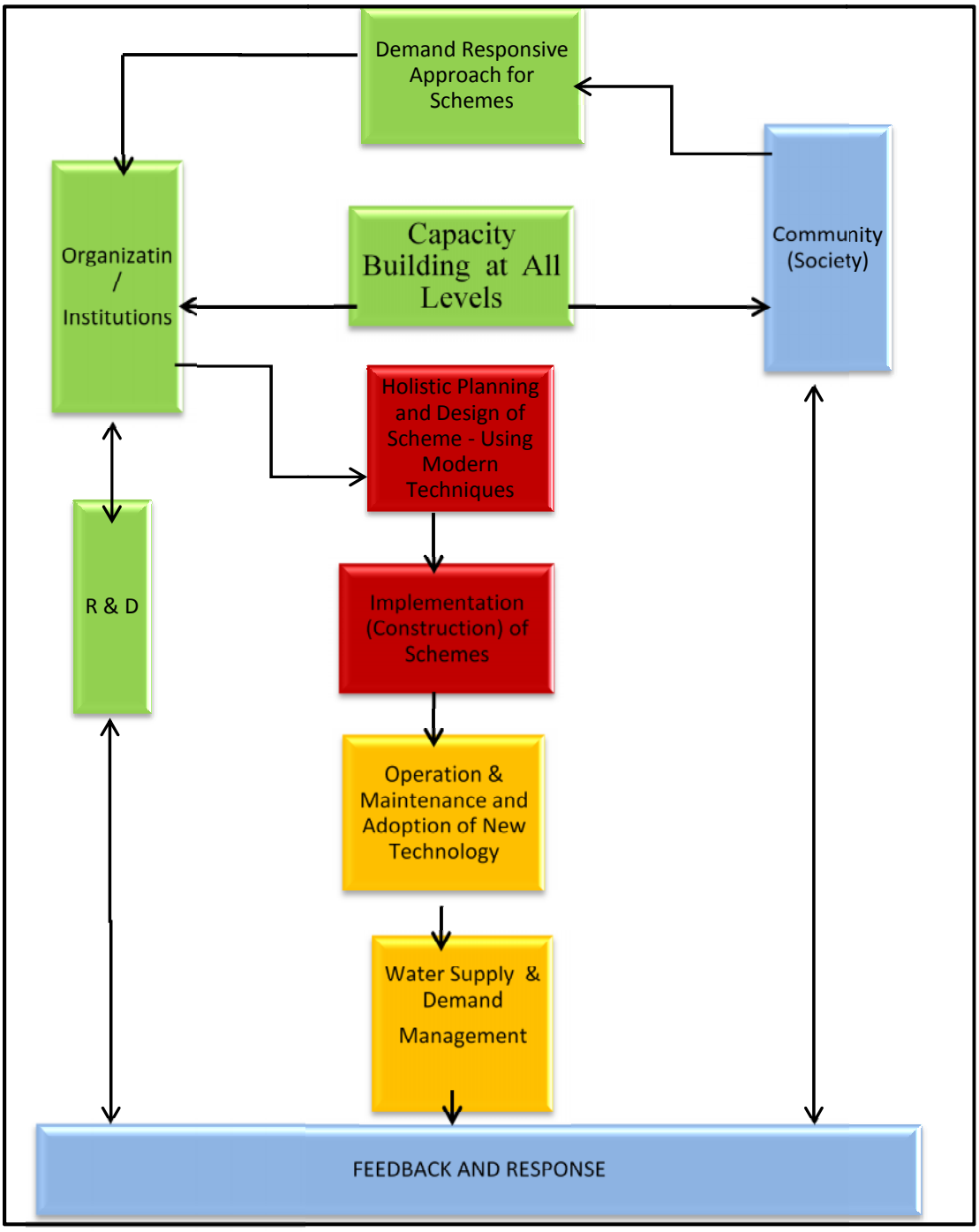

Fig. 1. Proposed Framework for Sustainable Water Supply & Irrigation Scheme.

The matrix is designed to evaluate the validity of the framework that in turn may assess the sustainability of water systems. The matrix containing 10 elements of framework and their rating with respect to its contribution towards sustainability of the water system is presented in Table 1.

The overall score of sustainability of a long term sustainable water system may be as high as 24 which seem very rare in practice. However, the score, for a water system to be sustainable on acceptable basis is 12 i.e. 50% of score of long term sustainable.

Table 1: Matrix of Parameters of Framework and Sustainability Scenarios.

Sr. No.	Parameters		**Scenario I** Non-Sustainable (NS)	**Scenario II** Acceptable Sustainability (AS)	**Scenario III** Long term Sustainable (LS)
		Sustainability Rating Of Scenarios / Weight of the parameter	0	0.50	1.0
1	Community (Society)	1	Less educated and least informed society with high population growth	Moderately educated and informed, society with normal population growth	Well informed, well-educated society with moderate population growth
2	Demand Responsive Approach for Schemes	2	Top down approach	Demand put forth by IPHD (Middle approach)	Demand emerges from users (Bottom up approach)
3	Holistic Planning and Design of Scheme - Using Modern Techniques	4	Planning & designing using adhoc approach and conventional methods	Planning & designing using holistic approach and conventional methods	Planning & designing using holistic approach and modern techniques
4	Implementation (Construction) of Schemes	4	Construction of schemes without proper supervision and quality controls	Construction of schemes with proper supervision and but without quality controls	Construction of schemes with proper supervision and quality controls

5	Operation & Maintenance and Adoption of New Technology	3	O & M without adequate staff & standard operating procedure and preventive maintenance schedule	O & M with adequate staff but without standard operating procedure on adhoc basis maintenance	O & M with adequate staff & standard operating procedure and with preventive maintenance scheduled
6	Organization/ Institutions	2	Multiplicity of roles and responsibilities and inadequate capacities of manpower	Multiplicity of roles and responsibilities of manpower but with adequate capacities	Non -multiplicity of roles and responsibilities of manpower with adequate capacities
7	Research & Development	2	Non-existence of R & D institute	R & D institute exists but with inadequate infrastructure and thrust	R & D institute exists with adequate infrastructure and thrust
8	Capacity Building at All Levels	2	No provision for capacity building of stakeholders	Capacity building of only senior departmental officials but not for users	capacity building of all stakeholders
9	Managing the Demand For Water	3	Supply driven approach	Partial Demand management	Demand management and complemented with RWH
10	Feed Back & Responsiveness Mechanism	1	No feedback mechanism	Feedback mechanism exists but mechanism for incorporating is lacking.	feedback mechanism exists and are duly incorporated for future improvements
	Total	24			

Mureverwi, *et al.* (2009) developed Sustainability Index. It was used in the sustainability assessments applied to community water utility projects in Central Tanzania (Kaliba and Norman, 2009) and the results were encouraging. Hence, the same methodology is applied with modifications to suit the requirements in the present study. In a simplified format, this relationship may be expressed by the following equation:

$$S.I = 100 \times \frac{w_{p1}r_1 + w_{p2}r_2 + w_{p3}r_3 + \ldots\ldots\ldots\ldots + w_{p10}r_{10}}{w_{p1} + w_{p2} + w_{p3} + \ldots\ldots\ldots\ldots + w_{p10}}$$

Where, $w_{p1}, w_{p2}, w_{p3} \ldots w_{p10}$ = Assigned Weight of different parameters

$r_1, r_2, r_3 \ldots r_{10}$ = Assigned rating of different parameters

B. Validation of the Framework

The SI methodology is used for the validation of framework by applying on the existing 7 Water Supply Systems and 7 Irrigation Systems as shown in Table -2.

Table 2: Application of proposed framework on 14 Water Systems in Himachal Pradesh.

SUSTAINABILITY ANALYSIS OF WATER SUPPLY SCHEMES														
				Parameters of Sustainability										
				Community (Society)	Demand Responsive Approach for Schemes	Planning and Design of Scheme - Using Modern Techniques	Implementation (Construction) of Schemes	Operation & Maintenance and Adoption of New Technology	Organization/Institutions	Research & Development	Capacity Building at All Levels	Managing The Demand For Water	Feed Back & Responsiveness Mechanism	Sustainability Index (in percentage)	Result
	Rating of sustainability			1	2	4	4	3	2	2	2	3	1		
Name of Schemes	**Scenario I: LS (1.0)**	**Scenario II: AS (0.5)**	**Scenario III: NS (0)**												
WWS Shimla				1	2	2	2	1.5	1	0	1	0	0.5	45.83	NS
WSS Nalagarh				0	2	4	2	1.5	1	0	0	0	0	43.75	NS
WSS Sujanpur				1	2	8	2	1.5	1	0	1	0	0	64.58	AS
WSS Daualatpur				1	1	2	2	1.5	1	0	1	0	0	35.42	NS
WSS Ramgarhdhar				1	1	2	4	1.5	1	0	1	0	0	43.75	NS
WSS Bangana and Plata Kokra				1	1	2	2	0	1	0	1	0	0	33.33	NS
WSS Deotsidh				0	0	0	2	1.5	1	0	1	1.5	0	29.17	NS

Irrigation Scheme Parala				**1**	**3**	**4**	**4**	**3**	**2**	**0**	**2**	**3**	**0**	**92.00**	**Nearing LS**
Irrigation Scheme Lower Baijnath				**1**	**0**	**2**	**2**	**1.5**	**1**	**0**	**1**	**0**	**0**	**35.00**	**NS**
Irrigation Scheme Raj Kuhl				**1**	**0**	**2**	**4**	**1.5**	**1**	**0**	**1**	**0**	**0**	**44.00**	**NS**
Irrigation Scheme Sarsa Manjholi				**0**	**4**	**2**	**2**	**0**	**1**	**0**	**1**	**0**	**0**	**41.00**	**NS**
Irrigation Scheme Dhang Plassi				**1**	**4**	**2**	**4**	**3**	**1**	**0**	**2**	**3**	**1**	**88.00**	**Nearing LS**
Irrigation Project Bhabour Sahib				**1**	**3**	**2**	**2**	**0**	**1**	**0**	**1**	**0**	**0**	**38.00**	**NS**

V. CONCLUSIONS

- SI computed for all 14 water systems show that the results obtained using the proposed framework was comparable to the ground realities and findings of case studies of these water systems.
- This shows that if the proposed framework is applied on water supply and irrigation systems, it may work as a guiding tool to evaluate and monitor their sustainability.
- Such framework, if applied properly, may help the managers to plan sustainable water systems.

REFERENCES

[1]. ASCE (American Society of Civil Engineers). 1998. Sustainability Criteria for Water Resource systems. Task Committee on Sustainability Criteria. ASCE, Reston, Virginia, USA.253 pages.

[2]. Baron, J. S., N. L. Poff, P. L. Angermeier, C. N. Dahm, P. H. Gleick, N. G. Hairston, Jr., R. B. Jackson, C. A. Johnston, B. G. Richter, and A. D. Steinman. 2002. Meeting ecological and societal needs for freshwater. *Ecological Applications* **12**: 1447-1460.

[3]. Bosello, Francesco. Portale, Elisa. Campagnolo, Lorenza. Parrado, Ramiro. 2011; Sustainability index analysis, Seventh Framework Programme, Theme FP7-ENV-2007-1.

[4]. Gleick, P. H. 1998. Water in crisis: paths to sustainable water use. *Ecological Applications* 8: 571-579.

[5]. Kaliba AM, Norman DW. (2004). Assessing Sustainability of Community-Based Water Utility Projects in Central Tanzania with the Help of Canonical Correlation Analysis.

[6]. Mureverwi, C. Carden, K. &Armitage, N. 2007; 'The Evaluation of A Sustainability Index For Integrated Urban Water Management In South Africa', Department of Civil Engineering, University of Cape Town.

[7]. Nardo, M., Saisana, M., Saletelli, A., Tarantola, S., Hoffman, H., & Giovannini, E., 2005., *Handbook on constructing composite indicators: Methodology and user guide.*, Organization for Economic Cooperation and Development (OECD), Statistics Working Paper.

[8]. Rogers, P. P., Jalal, K. F., & Boyd, J. A.; 2008. An Introduction to Sustainable Development. London, ENG: Earthscan.

[9]. Sharma, M.R., 2004 "Water Quality of Beas River in Hamirpur area of outer Himalyas" Pollution Research **23**(1): 41-44.

[10]. Shrama, M.R., (2006), 'Status Report on Traditional Drinking Water Sources in HP', Institute of Integrated Himalayan Studies, Centre of Excellence, HP University, Shimla.

[11]. Singh, H.P, Sharma, M.R., Hassan Quamural, Ahsan Naved, 2010_b "Sustainability of Traditional Drinking Water Sources in Himachal Pradesh", *Journal of Nature, Environment & Pollution Technology*, Karad, Vol. **9**(3).

[12]. Singh, H.P, Sharma, M.R., Hassan Quamural, Ahsan Naved, 2010 "Potential of Rainwater Harvesting in Himachal Pradesh", *Journal of Nature, Environment & Pollution Technology, Karad*, Vol. **9**(4) 2010, pp.837-842.

[13]. Singh, H.P, Sharma, M.R., Hassan Quamural, Ahsan Naved,, 2010_a "Impact of Drought on Drinking water Resources of Himachal Pradesh", *Biological Forum-An International Journal*, Vol. No. **2**(1): 73-77.

[14]. Singh, H.P, Sharma, M.R., Hassan Quamural, Ahsan Naved,, 2010_d "Narrowing the demand & supply gap through Rooftop Rainwater Harvesting – A case study of Kutlehar area", *Biological Forum- An International Journal*, New Delhi, ISSN:0975-1130.

[15]. Singh, Hari Pal., Sharma, M.R., Hassan, Quamrul, 2012_e, *Apex Research Journal of Science & Engg*., Vol. **1**, 46-51.

[16]. M.R., Hassan, Quamurul., Ahsan, Naved., 2010, Impact of drought on drinking water resources of Himachal Pradesh, *Biological Forum – An International Journal*, **2**(1): 73 -77 (2010), ISSN : 0975 – 1130.

[17]. UN (United Nations), 2006; The Millennium Development Goals Report, NEW YORK, 2006

[18]. UNDP United Nations Development Programme**),** 2005: *Human Development Report* 2005. United Nations Development Programme Oxford, University Press Oxford.

[19]. UNESCO (United Nations Educational, Scientific and Cultural Organization), 1999. Working Group M.IV. Sustainability Criteria for Water Resource Systems. Cambridge, UK: Cambridge University Press.

[20]. UNICEF/WHO, 2008; Joint Monitoring Programme for Water Supply and Sanitation estimate for 2008 based on the 2006 Demographic and Health Survey, the 2001 census, other data and the extrapolation of previous trends to 2010.

[21]. United Nations. 1977, Report of the United Nations Water Conference, Mar del Plata. March 14-25, 1997. No. E.77.II.A.12, United Nations Publications, New York.

[22]. WCED (World Commission on Environment and Development), 1987; *Our Common Future.* Oxford University Press, ISBN 019282080X.