Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2019.24412

163 (2019) 17–25
September

Multicriteria decision making model of wastewater reuse: a stakeholders' perspective in the context of India

Sukanya Das*, Karthick Radhakrishnan

Department of Policy Studies, TERI School of Advanced Studies, Plot No. 10 Institutional area, Vasant Kunj, New Delhi 110070, India, Tel. +91 11 71800222, emails: dasghosh.sukanya@gmail.com (S. Das), karthickratha@gmail.com (K. Radhakrishnan)

Received 13 September 2018; Accepted 14 May 2019

ABSTRACT

Wastewater recycling is gradually becoming an important water management practice in the context of developing nations suffering from water scarcity. Stakeholders perception and involvement plays a significant role in achieving sustainable development goal targets which emphasized on increasing the use of safe and recycled water with innovative technologies. To address this issue there is a need to identify the alternatives and criteria to enhance efficiency of the whole process. The current study applies analytical hierarchical process (AHP) over a range of stakeholders to assess multifunctional benefits of wastewater. Face-to-face interviews as well as web-based interviews were conducted across different stakeholders in Coimbatore, India. The result shows that a higher preference for reuse for agricultural irrigation, followed by ground water recharge and construction of artificial wetland.

Keywords: Wastewater; Reuse; AHP; India

1. Introduction

In recent decades, India is facing an exponential increase in population and variation in climate leads; Indian water sector confronts several environmental challenges like severe scarcity, deterioration in water quality, and adverse health impacts. Current usage of groundwater is also unsustainable, which presents an urgent need for integrated water resource management combining efficient use of water and options for reusing wastewater. Many dry regions are reusing wastewater to drought- proof their existing facilities but still reuse options grapple with several barriers like infrastructural constraints, inefficient treatment techniques and lack of citizen awareness. While addressing these issues, this study proposes to address the knowledge gap in stakeholder's awareness and acceptance level on wastewater reuse. The most common use for reclaimed wastewater is for non-potable like agricultural and urban irrigation uses for arid and semi-arid zones [1] where the water resources are becoming both quantitatively and qualitatively scarce [2,3].

In addition to the potential increase in the supply of irrigation water, wastewater treatment systems produce a significant number of environmental benefits that are also difficult to quantify. Wastewater reuse also faces several constraints in Indian context. Devi and Samad [4] put forward the institutional analysis of wastewater treatment and reuse option for Hyderabad, India. The analysis shows that there is a wide gap between the declared rules and rules-in-use due to: insufficient organizational capacity to implement and monitor the rules, lack of awareness among people, poor water and sewerage pricing system, insufficient attention and budget towards environmental issues of water pollution and the fact that the rules have not kept pace with the changing socio-economic realities of the society. This gap has been used as an indicator to suggest that a change in the existing institutional framework of wastewater treatment and reuse option is essential. In India, the estimated area under wastewater irrigation is over 73,000 ha [5] and the options for wastewater irrigation mostly have been spreading across rivers flowing through such rapidly growing cities as Delhi,

* Corresponding author.

Kolkata, Coimbatore, Hyderabad, Indore, Kanpur, Patna, Vadodara, Varanasi and Dharwad. Along the rivers' water is diverted via anicuts (weirs) to canals and often to tanks and then channelled to the fields for irrigation.

Tamil Nadu is one of the water starved states of India where the surface water resource potential has been fully tapped resulting in an increasing pressure on groundwater exploitation [6]. Subsidized electricity, liberal supply of institutional finance for investment in wells, development of sophisticated water pumping technologies coupled with enterprising nature of farmers have accelerated the extraction of groundwater in an unprecedented manner [7]. Before initiating wastewater reuse it calls for capturing environmental, institutional, technical and social aspects on the community involving various stakeholders.

Multi-criteria analysis (MCA) provides a framework for decision making: consisting of steps and procedures for a piecewise conceptualization of the problem involving multiple objectives and criteria, and a set of techniques aiming at elicitation, introspection, and aggregation of decision preferences [8]. As stated by Greco et al [9], a large number of MCA methods and tools exist to rank, compare and/or select the most suitable alternatives according to the chosen criteria among those techniques analytical hierarchical process (AHP) is the most promising technique to capture perception of different people. The application of AHP within the lens of wastewater management is very scant in literature [10,11]. It is one of the widely used methods for MCA in real life environmental issues.

Most of the MCA has been built taking into the objective of the technological feasibility of the wastewater treatment plants (e.g. [12]) rather than addressing the socio-economical and institutional challenges. Hadipour et al. [11] used AHP to find the best alternative for using wastewater in Iran and results show that groundwater recharge option is the best alternative for wastewater reuse, followed by environmental use. Delgado-Galvan et al. [13] used AHP to explore the groundwater over-exploitation scenario of the Silaoe, Romita aquifer in Guanajuato, Mexico. The study analyzed the scenario in the area characterized by a lack of legislative enforcement, dispersion of competences, and scarcity of economic resources, in order to establish a new prioritization of action plans, and chose from them three specific management options.

The context of wastewater reuse in irrigation at Hyderabad, India investigates the interests and perceptions of government stakeholders and farmers [14]. Most stakeholders associated with the government prioritized health and environment by assigning higher weights far outweighing the cost concerns.

Another stakeholder's study [15] in the context of Chennai of recharging aquifers was conducted on 25 stakeholder groups. To minimise conflict within groups, majority of the stakeholders support the idea to establish an authority in the state for licensing groundwater extraction and also supervising aquifer recharge. One recent study in the context of two slum areas in India by [16] has applied AHP and willingness to pay (WTP) to assess the economic, social and environmental sustainability to plan for decentralized wastewater systems. The users opted for a higher weightage for health and water pollution. They are willing to adopt a cost sharing arrangement provided an affordable system is provided by the government.

Chen et al. [10] used AHP to investigate the principles on how to reuse the reclaimed wastewater in urban areas. The results of the pairwise comparison of the water targets under different assessment criteria level gave higher weightings to agriculture irrigation.

The current study aims to identify the best alternative application of reusing water with the involvement of multi-sectoral stakeholders in the wastewater sector in Coimbatore district of Tamil Nadu. The steps involved include stakeholder selection, objective setting, identification of criteria, selection of alternatives, and collection of data. Though there are multifunctional benefits of wastewater, given the adverse effects related to its impact on health and environment, it is important to understand the framework within water reuse is to be implemented. It is viable only after having a perception and preference choice of the farmers for irrigation purposes stakeholders.

The paper is organised as follows; Section 2 gives details of the study area. The next section discusses materials and methods. Section 4 states the results and Section 5 discusses policy implications and conclusions.

2. Background information on study location

Coimbatore is located in the western part of Tamil Nadu on the bank of Noyyal river basin and Western Ghats (Fig. 1). The total geographical area of the district is 4,732 km^2 and it falls in the latitude 10.9675°N and 76.9182°E. In the last three decades, it has suffered severe water scarcity on account demographic escalation, economic, social pressure and inefficient utilization of water and water bodies.

Tamil Nadu Water and Drainage Board (TWAD) estimated that the per capita water supply is 110 L/cap/d or 135 lpcd. But, in recent years the gradual shifting from open well practice to bore well and seasonal variability are the major causes for less availability in ground water. Notable studies in the context of Coimbatore is of [7] showing evidence of well failures. Later, Kumar et al. [17] also documented the evidence of groundwater depletion on wells and the costs associated covering over-exploited, critical, semi-critical and safe blocks. Table 1 shows the groundwater status in the blocks covered under the survey.

According to Central Ground Water Board (CGWB) [18] out of 12 blocks the ground water over exploited in six blocks, four blocks in critical and two blocks in safe region. As put forward by Srinivasan et al. [19] and Hoek et al. [20] water quality is a major issue in the Noyyal River as most of the sewage and industrial effluents are being disposed leading to serious threat to the environment.

3. Methodology

3.1. Data collection

The stakeholder's survey was carried out in the month of August–September 2017. The stakeholders comprise of government officials, academicians, research scholars, civil societies, farmers and general public. The government officials were selected from several state departments

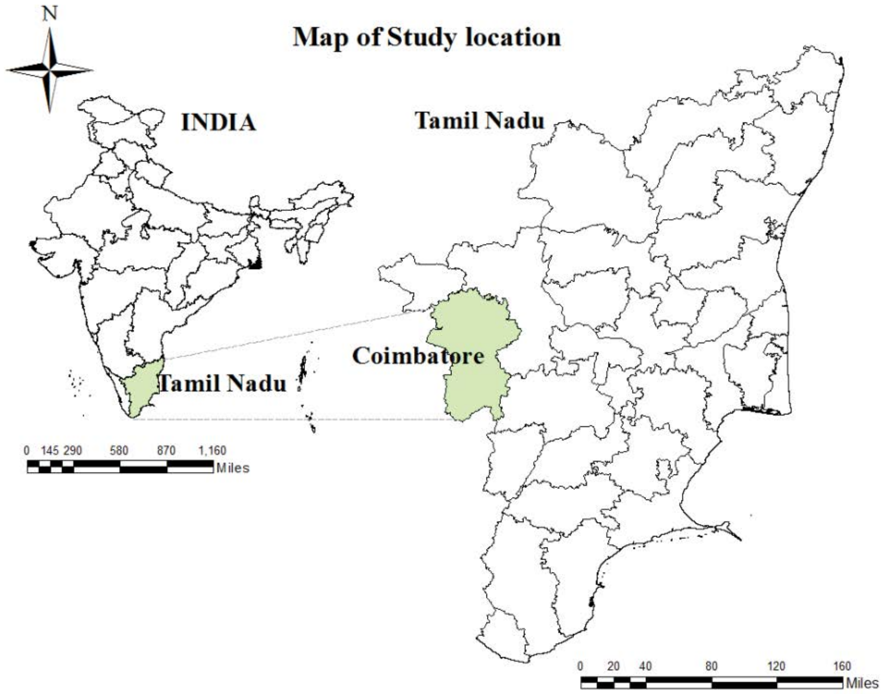

Fig. 1. Map of study location.
Source: Author's own computation using Arc GIS 10.1.

Table 1
Ground water status in the three selected blocks in Coimbatore district (Ha.m)

Blocks	Ground water availability	Existing gross draft for irrigation	Existing gross draft for all users	Net ground water availability for future irrigation development	Stages of ground water development
Annur	3,413.10	5,689.58	5,909.62	–2,505.13	173
Sulur	5,963.77	2,412.00	2,741.98	–291.12	111
Thondamuthur	2,820.59	4,651.92	4,782.98	–1,967.51	170

Source: CGWB, [18].

comprising of Tamil Nadu Public works department (Water resource Organization), Coimbatore City Municipal Corporation, TWAD, Tamil Nadu Economics and Statistics Department, Department of Agriculture, etc. Research scholars are the registered scholars working in technical and social dimensions of water related issues. The academicians and researchers cover a wide range of ecologists, hydrologists, agriculturalists, soil science experts, environmental economists, etc. from local colleges and universities.

The farmers and general public were randomly selected from the selected blocks namely, Annur, Sulur and Thondamathur. Within the three blocks, 8 villages were selected identified as ground water over exploitation areas [18]. The AHP questionnaire has been designed to include the selection of wastewater reuse targets in the given area. It includes both the assessment criteria and targets. Other than the questions related to the AHP background information of the respondent and socio-economic characteristics were also collected. The farmers are selected who at least possess domain knowledge of the irrigation systems to avoid information bias. The responses rate for the survey is presented in Table 2.

3.1.1. Conceptual framework - AHP

AHP as a tool used for multi-dimensional decision making was first proposed by Saaty [21]. It is widely used by the decision makers for complex decision making process and guides the decision makers to set priorities and selecting the best decisions out of the priorities. It also helps the decision makers by reducing the complexity of decision to a series of pair wise comparisons and then synthesizing the results. For the construction of a pairwise comparison matrix, each alternative is rated against every other alternative by assigning relative dominant values between 1 and 9 (1 is equal weight, 3 moderate, 5 strong, 7 very strong, 9 extreme strong, and 2, 4, 6, 8 are intermediate values between adjacent scale values) to the intersecting

Table 2
Sampling distribution and response rate

		Stakeholders response (in Percentage)				
Details	Sample size	Academicians	Government officials	Researchers	Civil society	Farmers
Email sent	44	25.0	50.0	40.9	4.5	0.0
Response from email	11	0.0	0.0	100.0	0.0	0.0
Face-to-face interview	33	9.1	21.2	6.1	6.1	57.6
Total sample	42	7.1	16.7	31.0	0.0	45.2

Source: Author's own computation based on the responses.

cells depending on these density values, an important alternatives was defined for each parameter class and comparison matrices were formed. The alternatives was presented on the vertical axis are more important than the alternatives on the horizontal axis, this value varies between 1 and 9. Conversely, the value varies between reciprocals of the value given by the stakeholders.

$$\left(A - \lambda \tilde{I}\right) \times W = 0 \quad (1)$$

where $\tilde{I}$ refers to Indictor matrix and A pairwise comparison matrix and W is the eigenvector of comparison matrix. Following to pairwise comparison matrix calculations, the computation of eigenvector for the criteria and alternatives had been estimated [Eq. (1)]. The eigenvalue commonly used in the numerical analysis is used to find the eigenvector [22]. The following equation is used to calculate consistency ratio.

$$\text{CR} = \frac{\text{CI}}{\text{RI}} \quad (2)$$

where CR is the consistency ratio, CI is the randomly generated pairwise comparison and RI is the random index

AHP is used to obtain final weights for the alternatives and the CR was calculated taking the ratio between consistency index of matrix and random consistency index (RI) of which range is between 0 and 1. The random consistency index is constant value assigned to the number of contributory alternatives which ranges from 1–9 as 0, 0, 0.58, 0.9, 1.12, 1.24, 1.32, 1.41, 1.45, and 1.49 respectively.

$$\text{CI} = \frac{\lambda_{\max} - n}{n - 1} \quad (3)$$

where $\lambda_{\max} - n$ is maximum eigenvalue and n is the rank of the matrix. Saaty [21] proposed that consistency exists if CR values are <0.1.

3.2. Identification of criteria and alternatives

Taking into account the literature [22] in regard to criteria and alternatives for a successful wastewater reuse project, there is a need to consider regulatory, economic, environmental, engineering, technological and social factors within the wastewater reuse framework (Fig. 2). In the context of our study we categorised them as:

- Economic feasibility (capital cost, operational cost, opportunity cost, income generation and financial cost)
- Environmental feasibility (water preservation, environmental benefits and biodiversity risk)
- Engineering feasibility (technology up-gradation, operation and maintenance, quantity of effluent, institutional arrangements and quality of effluent)
- Technological feasibility (sequential batch reactor, membrane bio reactor and moving bed bio film reactor)
- Social feasibility (public acceptance, technology interface, social benefits, health risk and government support).

3.3. Construction of hierarchy structure

The hierarchy structure was made at four levels. The first level represents the final goal/objective i.e. the best option for wastewater reuse. The second hierarchy level lists the relevant evaluation criteria. The third level is made up of twenty one sub-criteria's and finally, the lowest hierarchy level have five alternatives comprising of -irrigation, groundwater recharge, industrial use, artificial wetland generation, and for domestic purposes. The stages initiated for arriving at the decision through applying the tool of AHP are further depicted in Fig. 3. The weight for each criterion is determined on the basis of pairwise comparisons.

4. Results and discussion

The results and discussion consist of 3 parts, (i) descriptive statistics, (ii) awareness on wastewater reuse among the stakeholders in Coimbatore district and (iii) results of AHP.

4.1. Descriptive statistics

The Descriptive statistics of the stakeholder's survey is represented in Table 3. The primary and survey was conducted over 42 stakeholders from Government departments, academics, researchers and young research scholar from different background who are directly involved and working on the water, wastewater related issues in Coimbatore district of Tamil Nadu. Out of which, 64% of male and 36% of female stakeholders were surveyed.

16% of the stakeholders are government officials, 45% are farmers, farmers, 19% are researchers comprise of research scientists and 12% are Ph.D. scholars working in the water and wastewater related issues. As per as the

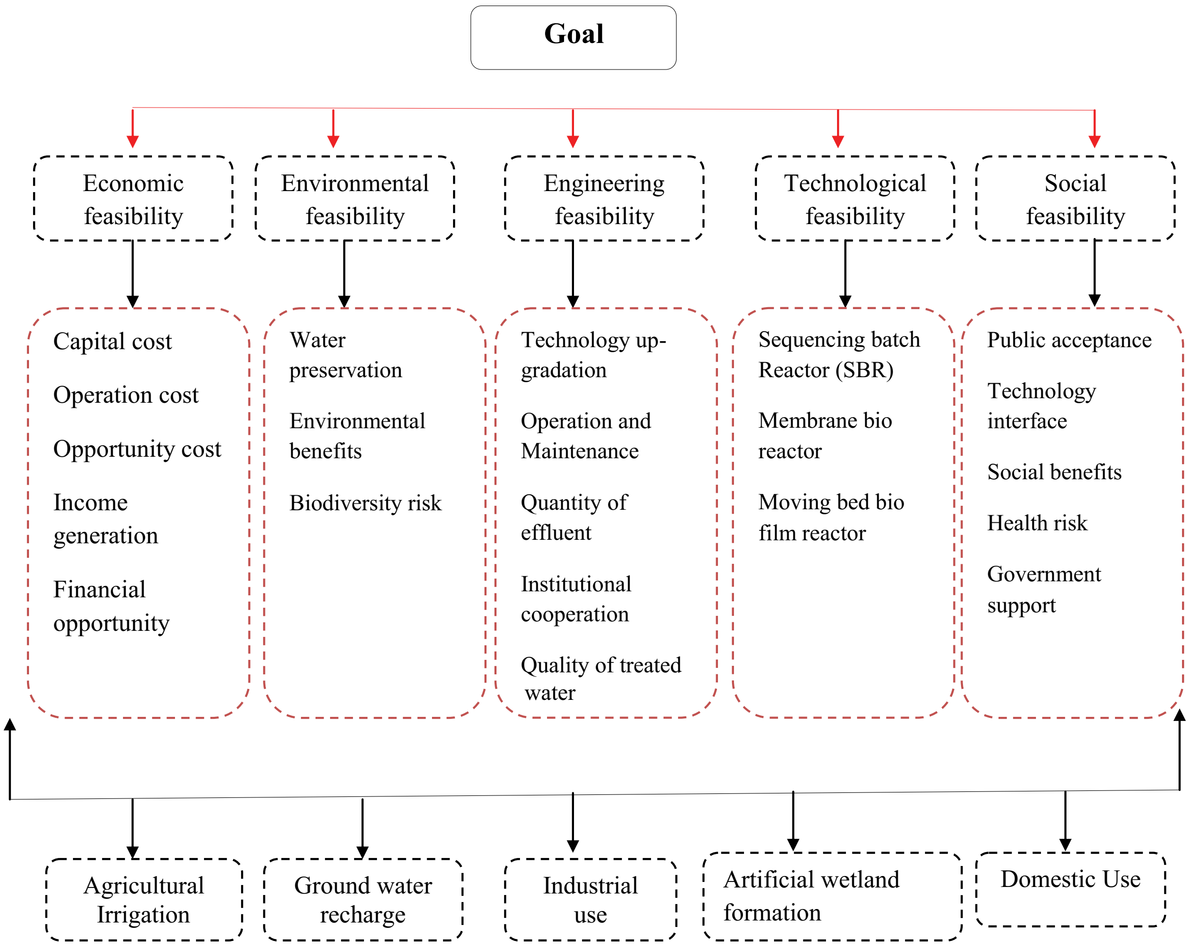

Fig. 2. Hierarchical schematic diagram for wastewater reuse.
Source: Hadipour et. al. [11] and author's own computation.

educational qualification are concerned, 35% are graduate and 79% are above the graduation level. 59% of stakeholders live in owned and storied houses. Average age of the stakeholders is 41 and their average family size 4 per household.

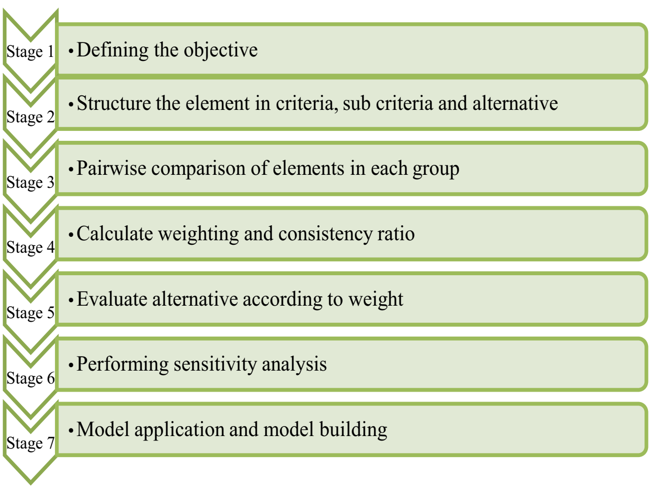

Fig. 3. Stages of building APH in waste water reuse scenario.
Source: Hadipour et. al. [11] and author's own computation.

Table 3
Summary statistics of stakeholder's information on wastewater reuse

Variables		Mean (Std. Dev.)
Gender	Male	0.64 (0.49)
	Female	0.36 (0.49)
Experts	Government officials	0.17 (0.38)
	Farmers	0.45 (0.50)
	Academicians	0.07 (0.26)
	Senior researchers	0.19 (0.40)
	Doctoral scholars	0.12 (0.33)
Educational qualification	Illiterate	0.09 (0.30)
	High school	0.12 (0.33)
	Graduation	0.36 (0.49)
	Post-graduation	0.29 (0.46)
	Doctorate	0.14 (0.35)
Basic information's	Number of year of living	27.4 (18.09)
	Family Size	4.62 (4.15)

Source: Coimbatore stakeholders' survey (2017).

4.2. Awareness of wastewater reuse among the stakeholders

Knowledge and awareness for wastewater reuse among the stakeholders were still limited in the context of developing countries. Addressing environmental awareness among the stakeholders is important and it plays a role in the wise use of resources. The environmental awareness related questions are designed in three major classifications namely, water pollution, infrastructure for wastewater treatment and acceptability of wastewater reuse. Farmers are more vulnerable to groundwater degradation and from the survey similar conclusion has been derived (50% of farmers and 16% of government officials strongly agreed that the ground water had degraded over the years in this region).

Due to rapid urbanisation and industrial development over the decades, there is an increase in water pollution and improper waste water management. 50% of farmers, 19% of government officials and more than 13% of researchers and scholars strongly agree to the fact. Around 56.7% of the farmers are ready to accept for wastewater reuse for agriculture (Table 4). Though they accepted that it can be used either for industrial use (47%) as well as feeding the tanks (53%). It justifies that prolonged scarcity of irrigated water. Contrary to their views the researchers and academicians gave a higher weightage for reuse for industrial purposes.

4.3. Results of AHP

4.3.1. Stakeholder preference on wastewater reuse

To analyse the assessment criteria, first stage was to apply to the returned questionnaires and the ranked alternatives, criteria and sub criteria's by the stakeholders were extracted from the data and the weights were transformed into pairwise comparison (Table 5). The maximum eigenvalue (λ_{max}), eigenvector (W) and the standard eigenvector are computed to represent the relative weights for measuring the assessment criteria of the wastewater reuse. The composite weights are derived from the weight given by the stakeholders. In addition the pairwise matrix had been normalized and in which each of the row values are averaged in order to get corresponding value of indicators as Eigen vector (Wi).

The overall performance of the alternatives is then calculated by a linear additive model [23]. Each criterion was then standardized using the index value which is between 0 and 1. While representing graphically the AHP results, (Fig. 4) the weights for alternatives with the criteria's, overall results show the agricultural reuse was ranked first followed groundwater irrigation. The stakeholders are not much interested to use the treated wastewater for domestic purposes and it is ranked low in comparison to other alternatives. Ground water recharge was rated high in economic feasible while comparing with the other alternatives. Interestingly, though 82% of people directly or indirectly involved in industrial activities but has been assigned a composite weight of 0.46.

From economic and social feasibility agriculture irrigation is preferred whereas from environmental, technological and engineering perspective industrial usage is preferred. Similar inference have been derived from a study in the context of Pakistan reported comparison of the financial costs of inputs and value of products for wastewater and canal-water-irrigated farms (with dissimilar cropping patterns) [20] where annual cost of irrigation seems to be significantly low for wastewater farms as compared to canal water farms. Moreover, wastewater farms have a high crop production.

The overall conclusion is that treated wastewater would be used for ground water recharge and wetland generation which are directly associated with the co-benefits of agricultural irrigation for long run sustainable benefits.

Social acceptance is one of the major hindrances for wastewater reuse. The result derived of the acceptance of using wastewater for agricultural purposes is a positive response in resolving the severe drought conditions in the area. Given the weights derived under the alternatives with

Table 4
Stakeholders awareness in Coimbatore district

Environmental awareness	Stakeholders awareness in Coimbatore (in Percentage)				
	Government officials	Farmers	Academician	Researchers	Doctoral scholars
Degradation of water bodies	18.4	44.7	5.3	18.4	13.2
Proper water supply	21.7	56.5	4.3	13.0	4.3
Ground water degradation	16.7	50.0	5.6	16.7	11.1
Ground water contamination	12.5	56.3	6.3	12.5	12.5
Increased water pollution	18.9	51.4	2.7	13.5	13.5
Improper sanitation facilities	20.0	53.3	3.3	20.0	3.3
Insufficient sewage treatment facilities	20.8	58.3	4.2	0.0	16.7
Acceptability reuse water in agriculture	15.6	56.3	6.3	12.5	9.4
Acceptability reuse water in industry	14.7	47.1	5.9	17.6	14.7
Acceptability reuse water in feeding tanks	15.6	53.1	6.3	12.5	12.5

Source: Coimbatore stakeholders' survey (2017).

Table 5
Pair wise comparison matrix of criteria and sub criteria

Economic feasibility	Capital cost	Operational cost	Opportunity cost	Income generation	Financial opportunity
Capital cost	1	1/6	7	1/7	7
Operational cost	6	1	7	7	7
Opportunity cost	1/7	1/7	1	1/6	6
Income generation	7	1/7	6	1	5
Financial opportunity	1/7	1/7	1/6	1/5	1
Environmental feasibility	**Water preservation**	**Environmental benefit**	**Biodiversity risk**		
Water preservation	1	6.00	1/6		
Environmental benefit	1/6	1	7		
Biodiversity risk	6	1/7	1		
Engineering feasibility	**Technology up gradation**	**Operation and maintenance**	**Quantity of effluent**	**Institutional cooperation**	**Quality of treated water**
Technology up gradation	1	7	6	7	7
Operation and maintenance	1/7	1	1/6	1/6	7
Quantity of effluent	1/6	6	1	1/6	1/6
Institutional cooperation	1/7	6	6	1	7
Quality of treated water	1/7	1/7	6	1/7	1
Technology feasibility	**Sequential batch reactor**	**Membrane bio reactor**	**Moving bed bio film reactor**		
Sequential batch reactor	1	7	4		
Membrane bio reactor	1/7	1	1/4		
Moving bed bio film reactor	¼	4	1		
Social feasibility	**Public acceptance**	**Technology interface**	**Social benefits**	**Health risk**	**Government support**
Public acceptance	1	8	7	6	1/6
Technology interface	1/8	1	7	1/7	7
Social benefits	1/7	1/7	1	1/6	7
Health risk	1/6	7	6	1	7
Government support	1/6	1.7	1/7	1/7	1
Criteria used for waste water reuse	**Economic feasibility**	**Environmental feasibility**	**Engineering feasibility**	**Technology feasibility**	**Social feasibility**
Economic feasibility	1	1/6	7	6	7
Environmental feasibility	6	1	6	5	5
Engineering feasibility	1/7	1/6	1	6	6
Technology feasibility	1/6	1/5	1/6	1	6
Social feasibility	1/7	1/5	1/6	1/6	1

Source: Coimbatore stakeholders' survey (2017).

the criteria, we also tried to verify the weightage of the stakeholders of an alternative, given the uncertainty score of 50% (Fig. 5).

The agricultural irrigation is ranked first followed by groundwater recharge, artificial wetland generation, industrial use and domestic use of treated wastewater reuse among the stakeholders in the district. The large sized circles on the graph indicate that the ranking of the alternatives under 50% scoring uncertainty is relatively stable. The final result is a value between 0 and 1, where the weights indicate the trade-offs between the criteria [24]. In x axis the total indicates the ranking of the alternative larger circle indicates the probability of choosing is more and smaller circle indicates the probability of choosing is less.

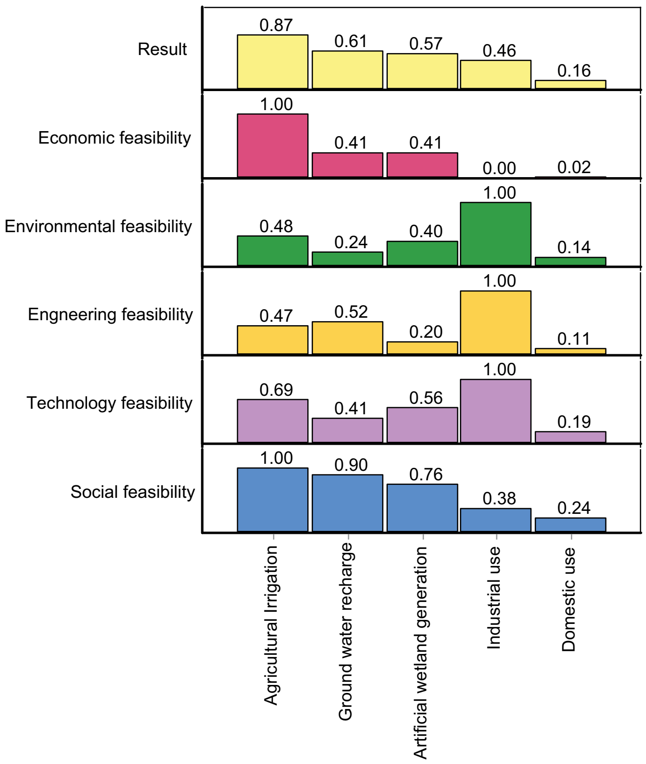

Fig. 4. Weights of alternatives with criteria.
Source: Coimbatore stakeholders' survey (2017).

5. Conclusion

The present study is an attempt to address the multi-functional benefits of wastewater reuse among a range of stakeholders in the context of Tamil Nadu, India. Initiating any reuse project depends on regulatory, economic, environmental, engineering, technological and social factors. The AHP results clearly demonstrated the fact that the best decision can only be achieved by prioritising the decisions of the stakeholders. But as seen from few recent studies that stakeholder's decision is also not enough for wider penetration of wastewater reuse. A recent study (refer [25]) developed a "flexible BAT" (flexible best available technologies), based on the identification of national reference plants assessed with respect to pollutant removal (environmental impact, health impact), costs (economic viability, affordability) and social acceptability conducted over 58 case studies across India. None of the technologies seem to be qualifying alone for FlexiBAT. Another study by Alley et al. [26] identified the key parameters - leadership, water availability, water pricing, regulations, and business savings from four success stories of decentralized wastewater treatment plants across India. As observed, still in the context of India there is a need to develop more cost-effective and innovative technologies which are socially acceptable and economically viable. Wider dissemination of success stories of wastewater reuse can facilitate more investment option.

The scope of the study is limited as it addresses the issues related to perception and doesn't address the water requirement as it varies across seasons and is complex to perceive accurately across the various categories of stakeholders covered for the survey.

Even if the stakeholders opt and has an affordability to pay for wastewater reuse, the priority lies for creating funding opportunities for developing those infrastructures in the region. As per [27] in rural areas often there lies a choice between decentralized or centralized (multi-village) systems. The priority of funding resort to the option and which is most economic. However the efficacy depends on the voluntary cooperation of the concerned communities. As per Starkl et al. [28] still there lies knowledge gap in regard of sustainability of wastewater systems. Risks are associated with reuse of treated wastewater in agriculture, operational problems and social acceptance.

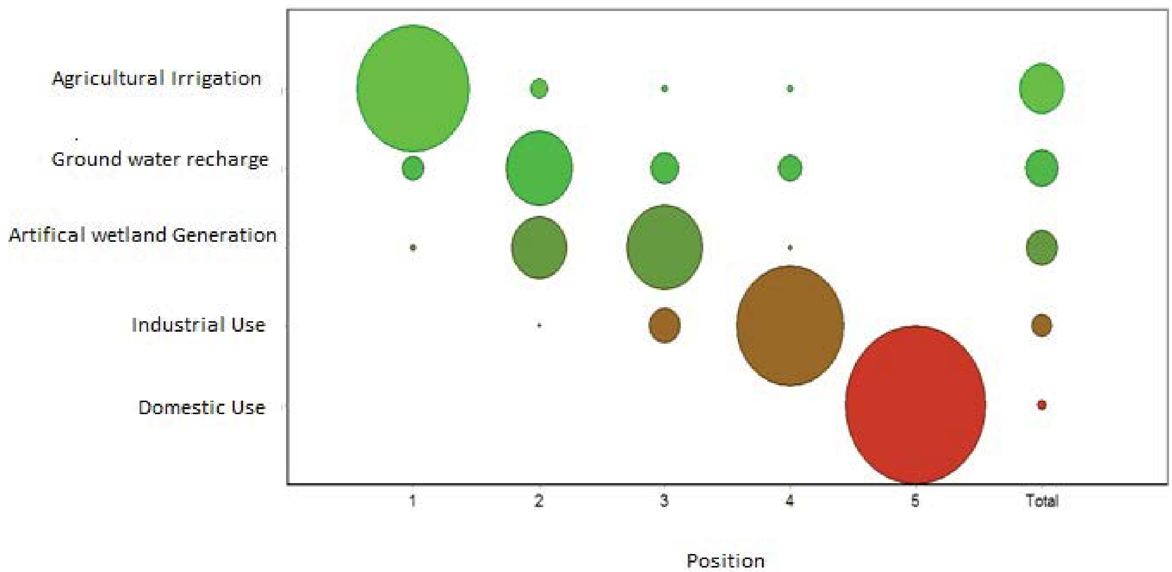

Fig. 5. Probability table of alternative use of treated wastewater.
Source: Coimbatore stakeholders' survey (2017).

In the context of Coimbatore given the limited number of wastewater treatment plants and the state government is initiated to share water with Kerala [23]. The results derived can be explored for constructing new wastewater reuse projects for resolving water stress. Financial models and adequate funding mechanisms need to be facilitated which can have long term solutions. The results of the studies can be explored further by conducting an economic feasibility study for wastewater reuse capturing environmental externalities and further addressing the context specific policy dimensions.

Acknowledgement

The paper is outcome of Project titled "Supporting consolidation, replication and up-scaling of sustainable wastewater treatment and reuse technologies for India (SARASWATI)"funded by Department of Science and Technology, (Government of India).

References

[1] S. Bakopoulou, C. Emmanouil A. Kungolos, Assessment of wastewater effluent quality in Thessaly region, Greece, for determining its irrigation reuses potential, Ecotoxicol. Environ. Saf., 74 (2011) 188–194.
[2] A. Capra, B. Scicolone, Recycling of poor quality urban wastewater by drip irrigation systems, J. Cleaner Prod., 15 (2007) 1529–1534.
[3] C. Faria, I. Vaz-Moreira, E. Serapicos, O.C. Nunes, C.M. Manaia, Antibiotic resistance in coagulase negative staphylococci isolated from wastewater and drinking water, Sci. Total Environ., 407 (2009) 3876–3882.
[4] M.G. Devi, M. Samad, Wastewater treatment and reuse: an institutional analysis for Hyderabad, India, Water, 1 (2006) 513–523.
[5] M. Strauss, U.J. Blumenthal, Human Waste Use in Agriculture and Aquaculture: Utilization Practices and Health Perspectives: Executive Summary, International Reference Centre for Waste Disposal (IRCWD), Switzerland, 1990.
[6] K. Palanisami, A. Vidhyavathi, C.R. Ranganathan, Wells for welfare or illfare? Cost of groundwater depletion in Coimbatore, Tamil Nadu, India, Water Policy, 10 (2008) 391–407.
[7] K. Palanisami, D. Suresh Kumar, Impact Assessment of Select Watersheds in Coimbatore District of Tamil Nadu: Report Prepared for National Bank for Agriculture and Rural Development, Mumbai, Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore, 2004.
[8] J. Figueira, G. Salvatore, Eds., Multiple Criteria Decision Analysis: State of the Art Surveys, Springer, New York, 2005.
[9] S. Greco, R. Słowiński, J. Stefanowski, M. Żurawski, Incremental Versus Non-Incremental Rule Induction for Multicriteria Classification, J.F. Peters, A. Skowron, D. Dubois, J.W. Grzymała-Busse, M. Inuiguchi, L. Polkowski, Eds., Transactions on Rough Sets II: Rough Sets and Fuzzy Sets, Springer, Berlin Heidelberg, 2005, pp. 33–53.
[10] S.-M. Chen, Y.-M. Wu, L. Yang, Application of the analytic hierarchy process for the selection of wastewater reuse targets, Manage. Decis., 52 (2014) 1222–1235.
[11] A. Hadipour, T. Rajaee, V. Hadipour, S. Seidirad, Multi-criteria decision-making model for wastewater reuse application: a case study from Iran, Desal. Wat. Treat., 57 (2016) 13857–13864.
[12] M. Garrido-Baserba, R. Reif, M. Molinos-Senante, L. Larrea, A. Castillo, M. Verdaguer, M. Poch, Application of a multi-criteria decision model to select of design choices for WWTPs, Clean Technol. Environ. Policy, 18 (2016) 1097–1109.
[13] X. Delgado-Galván, J. Izquierdo, J. Benítez, R. Pérez-García, Joint stakeholder decision-making on the management of the Silao–Romita aquifer using AHP, Environ. Model. Software, 51 (2014) 310–322.
[14] M. Starkl, N. Brunner, P. Amerasinghe, J. Mahesh, D. Kumar, S.R. Asolekar, S. Sonkamble, S. Ahmed, M. Wajihuddin, A. Pratyusha, S. Sarah, Stakeholder views, financing and policy implications for reuse of wastewater for irrigation: a case from Hyderabad, India, Water, 7 (2015) 300–328.
[15] N. Brunner, M. Starkl, P. Sakthivel, L. Elango, S. Amirthalingam, C.E. Pratap, M. Thirunavukkarasu, S. Parimalarenganayaki, Policy preferences about managed aquifer recharge for securing sustainable water supply to Chennai City, India, Water, 6 (2014) 3739–3757.
[16] N. Brunner, M. Starkl, A.A. Kazmi, R. Alvaro, N. Jain, V. Mishra, Affordability of decentralized wastewater systems: a case study in integrated planning from India, Water, 10 (2018) 1644.
[17] D. Suresh Kumar, K. Palanisami, Can drip irrigation technology be socially beneficial? Evidence from Southern India, Water Policy, 13 (2011) 571–587.
[18] Central Ground Water Board (CGWB), District Groundwater Brochure Coimbatore District, Technical Report, Ministry of Water Resources, Government of India, 2008. Available at: http://www.cgwb.gov.in/District_Profile/TamilNadu/Coimbatore.pdf.
[19] V. Srinivasan, K. Suresh, P. Chinnasamy, S. Sulagna, D. Sathivel, P. Paramasivam, S. Lele, Water Management in the Noyyal river Basin A Situation Analysis, Ashoka Trust for Research in Ecology and the Environment, Environment and Development Discussion Paper, Bangalore, 2014.
[20] W. van der Hoek, M.U. Hassan, J.H.J. Ensink, S. Feenstra, L. Raschid-Sally, S. Munir, R. Aslam, N. Ali, R. Hussain, Y. Matsuno, Urban Wastewater: A Valuable Resource for Agriculture: A Case Study from Haroonabad, Pakistan, Research Report 63, International Water Management Institute, Sri Lanka, 2002.
[21] T.L. Saaty, The Analytic Hierarchy Process, McGraw Hill, International, New York, Translated to Russian, Portuguese, Chinese, Revised editions, Paperback (1996, 2000), RWS Publications, Pittsburgh, 1980.
[22] S.-M. Chen, Y.-M. Wu, L. Yang, Application of the Analytic Hierarchy Process for the Selection of Wastewater Reuse Targets, Manage. Decis., 52 (2014) 1222–1747.
[23] T.L. Saaty, M. Ozdemir, the Encyclicon, RWS Publications, Pittsburgh, PA, 2005.
[24] V. Belton, T.J. Stewart, Multiple Criteria Decision Analysis: An integrated Approach, Kluwer Academic Publishers, Boston/Dordrecht/London, 2002.
[25] M. Starkl, J. Anthony, E. Aymerich, N. Brunner, C. Chubilleau, S. Das, M.M. Ghangrekar, A.A. Kazmi, L. Philip, A. Singh, Interpreting best available technologies more flexibly: a policy perspective for municipal wastewater management in India and other developing countries, Environ. Impact Assess. Rev., 71 (2018) 132–141.
[26] K.D. Alley, N. Maurya, S. Das, Parameters of successful wastewater reuse in urban India, Indian Politics Policy, 1 (2018) 91–122.
[27] N. Brunner, M. Starkl, Financial and economic determinants of collective action: the case of wastewater management, Environ. Impact Assess. Rev., 32 (2012) 140–150.
[28] M. Starkl, N. Brunner, E. López, J.L. Martínez-Ruiz, A planning-oriented sustainability assessment framework for peri-urban water management in developing countries, Water Res., 47 (2013) 7175–7183.