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ORIGINAL ARTICLES

Analysis of Societal Value Dynamics (SVD) of Groundwater Utilization in South Taluk of Coimbatore District, Tamilnadu, India

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ABSTRACT

Ecosystem services are increasingly recognised as important assets for sustainable development. Groundwater forms an invisible component of the ecosystem. Under the circumstances of uncertainty of surface water storages, at times invisible groundwater resource has attained importance in the overall economic development of the community. The present study focuses on the community involvement process and social analysis for the groundwater resource management in the Coimbatore South Taluk. A detailed survey was conducted to know the values and views of the residents of study area on importance and awareness of groundwater resources. The samples for the survey include residents from rural and urban areas. A target of 500 survey interviews was fixed and the achieved total number of survey interviews was 435. The basic aspects of groundwater values were considered in preparing questionnaire for survey. The respondents in the study area depend on groundwater usage for household use as well as the irrigation use. Moreover, they show keen interest in protecting the groundwater for future generations and they have a strong intrinsic values for both the environment generally and groundwater specifically.

Key words: Groundwater, Social Value, Ecosystem, Sustainable use, Coimbatore South Taluk.

INTRODUCTION

The world faces an extensive rage of ecological and human health crisis related to inadequate access to, or inappropriate management of clean fresh water including groundwater. The recent study of the Millennium Ecosystem Assessment (MEA 2005) conducted by World Resources Institute, Washington, D.C. has concluded that many earth's ecosystem services are seriously affected by indiscriminate use and abstraction of resources by societies. Groundwater is an important natural resource supporting public supply of potable water for domestic consumption and livestock watering. Nearly two billion people depend directly upon aquifers for drinking water and 40% of the world's food is produced by irrigated agriculture that relies heavily on groundwater (Morris *et al* 2003). The most important critical function of groundwater is providing service is its storage and retention for domestic, industrial and agricultural uses. Groundwater is also used for industrial activities such as food product processing, manufacturing processes and cooling water for thermal plants (NRC 1997). The scale and rate of groundwater abstraction for agricultural use has increased substantially over the past five decades due to massive expansion in pumping capacity. In India, the number of diesel and electrical pumps has risen from 87,000 in 1950 to 32.58 million in 2011 as per the Energy Survey of India 2011. Groundwater provides biodiversity and genetic resources, specifically in the form of organisms that are able to breakdown contaminants (NRC 2004). Groundwater serves the important function in the hydrological cycle of storing and subsequently releasing water. It has a very long residence time averaging about 300 years when compared to surface water. Groundwater plays a vital role in the nutrient cycle through the storage, recycling, processing and acquisition of nutrients.

The rapid increase in human population, and urbanization, which presumably causes the regional conflicts over water, ecological degradation and human illness are becoming more frequent and serious issues. Currently various studies depicts the amount of water entering the groundwater system is less than leaving system. Therefore, the mass balance of the groundwater system is disturbed over period of time. As a result, the groundwater level has dropped significantly and this creates concern among the water users especially the farmers and other vulnerable people. Several factors have contributed to decline in water table. The primary factor is the change in monsoon pattern and fall in the average rainfall experienced world wide and especially in the study area. The secondary factor is the over exploitation of groundwater resources for agricultural practices, which results in greater uptake of groundwater as well as preventing rainfall from infiltrating into the aquifer.

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Climatic change is another factor to be considered by the water users group. The rainfall was the most important climatic parameter influencing the groundwater recharge. The change in recharge is also influenced by increase in CO_2 concentration, solar radiation and vapour pressure (McCallum *et al* 2010). Climatic change will result in changes in rainfall (quantity, intensity and duration), temperature, evapotranspiration, and soil moisture retention. Each of these will impact groundwater system.

New approaches to long-term water planning and management that incorporate principles of sustainability and equity are required to protect the groundwater resources. With respect to water resources, as with many other resources, sustainability has not been defined clearly, though several efforts have made progress in defining the issues (Plate 1993, Raskin *et al* 1995, Gleick 1998). Water is not only essential to sustain life, but it also plays an integral role in ecosystem support, resource recycling, protection of biodiversity, economic development, community well-being, cultural values and social values. Humankind has the ability to make development sustainable – *to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.*

According to Gleick et al. (2005) sustainable water use is defined as, the use of water that supports the ability of human society to endure and flourish into the indefinite future without undermining the integrity of the hydrological cycle or the ecological systems that depends on it. Sustainability criteria for water planning are very important to allocate and use water resources. The sustainable use of water will be an integral part of long-term water planning. Presently the world is facing with continued unsustainable water use and threats to both human and ecological survival until the groundwater and ecosystem services are increasingly recognised as important assets for sustainable development (Bergkamp *et al* 2006). Ecosystems services are defined as the goods and benefits provided to people by ecosystems. The interdependencies between ecosystem services and groundwater are recognised and valued in decision making and management of water resources and river basins.

The MEA classifies fresh water including groundwater as a provisioning service, which defined as "Product obtained from ecosystems" (MEA 2005). A large amount of freshwater is not lakes and rivers, but in aquifers. In fact, groundwater is the earth's largest accessible store of fresh water and constitutes about 94% of all fresh water (Ward and Robinson 1990). Groundwater is also an integral component of regulating, supporting and cultural ecosystem services. Groundwater is an essential component of everyday life and is integrated throughout various cultural services including social relations, as spiritual and religious values, within knowledge systems and providing educational value. Sustainable use of ecosystems requires that the stock capital that is available for future generations be equivalent to the capital available at present. The term capital refers to the natural, human, social manufactured and financial forms. Since natural capital has to be interpreted widely, many assets including groundwater services are essential to human life and cannot be replaced by or substituted with manufactured capital (Bergkamp *et al* 2006) . Such ecosystem services are classified as critical natural capital and have an enormous value for livelihoods, economies and societies. The groundwater value of ecosystems provides a useful framework for evaluating ecosystem goods and services and factoring them into useful calculations.

With India's population projected to grow from 1.2 billion in 2008 to 1.6 billion in 2050, a collision between rising human numbers and shrinking water supplies seems inevitable. The risk is that India could face social conflicts that would dwarf those in Rwanda. As James Gasana notes, the relationship between population and natural systems is a national security issue, one that can spawn conflicts along geographic, tribal, ethnic, or religious lines (Lester R. Brown. 2009). The immediate task for the water users group is deciding how to protect the groundwater system from quantity and quality point of view for sustainable groundwater resources management. This study ascertains part of the community involvement process and social value analysis for the groundwater resource management in the Coimbatore South Taluk area. The main objectives is to, identify the social values associated with the groundwater resources of the study area to know their importance and to examine the attitudes people have towards various management options for declining groundwater levels.

Study Area:

Coimbatore is an important district in western part of Tamilnadu and the Coimbatore South Taluk falling in the southwest part of the district. The study area falls between North latitudes $10^{o}50'0''$ to $11^{o}0'0''$ and East longitude $76^{o}40'0''$ to $77^{o}0'0''$ (Fig. 1) and covers an area about 767.64 km^2. It is well connected with adjoining towns and almost all the villages of the area are approachable by roads.

Generally a sub-tropical, climatic condition prevails in this area. The maximum temperature ranges from 36ºC to 41ºC and the minimum temperature varies from 14ºC to 31ºC. The mean daily temperature during summer varies from 33ºC to 40ºC and the mean daily temperature during winter varies from 15ºC to 31ºC. Rain occurs during South-West and North-East monsoons. The north-east monsoon contributes the maximum of 328.2mm during October to December. The average annual rainfall of this district is 647.2mm from four distinct seasons (WRO 2003). The Coimbatore district is bounded on the west and south by steeply rising mountains of Western Ghats. Of these, the Nilgiris on the Northwest and Anaimalai on the south are important ranges, which

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attain heights of over 2500 m above mean sea level (MSL) and the highest elevation in the plains adjoining the hills is 600 m above MSL. In between the hill ranges, east-west trending mountain ranges are traversing and it is known as Palghat gap. Besides these western ghat ranges, the other hills of the district are Vellingri and Boluvampatti hills which is located in our study area i.e. in Coimbatore South taluk. The Vellingris are the spurs of the Nilgiris mountain lying on the west and north-west of the district. Boluvampatti hills lies on the north-eastern side of the district. The Coimbatore South taluk is bounded with Vellingri and Boluvampatti hills on the north-eastern side. The Noyyil river has its origin in the Boluvampatti valley of the Vellingri hills and called as the Swami Mudiyar. The Noyyil river is ephemeral and remains dry for a major part of the year. Further south, it joins with Periyar and Chinnar. Then it takes east –northeast course and forms the boundary of Coimbatore and Avinashi Taluk. About 5km east of Coimbatore, the river takes north-eastern course in Tiruppur and forms the boundary between Palladam and Erode taluks. The Noyyilriver is ephemeral and remains dry for a major part of the year (WRO 2003). Rocks are composed of minerals and amorphous solids. Since the geological set up controls the occurrence and movement of groundwater, the ability of the parent rock to store and transport groundwater is of great importance for its occurrence. Water quality parameters controlling the occurrence of groundwater to a large extent are porosity, hydraulic conductivity, transitivity etc. The major rock types occurring in the study area are fissile hornblende biotite gneiss, sand and silt, granite, amphibolites, metagabbro, pyroxenite, pyroxene granulite, charnockite, garnet sillimanite – graphite gneiss, calc-granulite and limestone and pink migmatite (WRO 2003). Knowledge of land use and land cover is important for many planning and management activates and is considered an essential element for modeling and understanding the earth as a system. Land cover maps are presently being developed from local to national to global scales. Satellite image have been utilized for land use/land cover mapping (WRO 2003). The spatial distribution of land use/land cover of the study area is given in Table 1.

Methodology:

This study forms part of the community involvement process and social analysis for the groundwater resource management in the Coimbatore South Taluk area. The study follows, and is based on the findings of the qualitative scoping study with the regional community. It aims to (a) Analyse the social values associated with the groundwater resources of the Coimbatore South Taluk area and their importance and (b) Ellict the water user groups (WUG) attitude towards the depletion and pollution of groundwater resources and circumstances.

The study focuses primarily on the values and views of the residents of Coimbatore South Taluk area on importance and awareness of groundwater resources by a detailed survey. The samples for the survey include residents from rural and urban areas in the twenty seven locations in the study area as presented in the Fig.2. The basic aspects of groundwater values such as Direct Values (Provisioning ecological services), Indirect Values (Regulating and supporting ecological services), Option Values (Premium placed on maintaining resources for known and unknown future uses), and Existence Values (Intrinsic value of resources and landscapes, irrespective of its use) were considered in preparing questionnaire for survey.

Preparation of the Questionnaires:

Before water provisions to the environment can be set, identification of environmental, social and economic values need to be considered (Derek Eamus and Ray Froden 2006) to achieve this series of community briefings are necessary (Blair *et al* 2003). Based on this series of discussions were held in the study area as the part of foregoing scoping study. The briefings with water users group, researchers, academicians and publics in the study area were carried out to express their views and opinions related to groundwater values. Information gathered from these briefings, along with discussions between key stakeholders in the study area and the researchers were used as the basis for the development of the survey questionnaire. The following aspects are taken into account for preparing survey questionnaire in the study area.

1. Importance of Groundwater for various purposes – i.e., irrigation, regional household use, industrial use and future use.
2. Environmental values of groundwater and its importance.
3. Trust, confidence and certainty in the ability of the authorities to plan for the future and carry out scientific investigation.
4. Current water use information.
5. Future water use information.
6. Awareness and views on ground water contamination and extraction.
7. Confidence in answering the questionnaire, time lived in the area, age and gender.

The survey questionnaire consists of three parts as presented in Table 2.

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Evaluation Criteria for the Questionnaires:

Respondents were provided with four general categories of groundwater uses (ie., groundwater for irrigation, households, industrial and future use) and three specific uses categories. Respondents were asked to rate the importance of each use within each category by firstly assigning a base value of "10" to the use of least importance. Each of the other uses were then assigned an importance rating in multiples of ten, depending on how important each was in relation to the previous use (e.g. "20" meant the use was twice as important as the least value use). If they were all of equal importance, the same value was assigned to all uses. Finally, respondents were asked to rate the importance of the use categories as a whole in the same way. Value ratings with each category were standardized so that they summed to 100. The category ratings were standardized in the same way. Therefore, in each of the following category tables, the sum of the mean importance shown for each specific use is 100, with the higher the value, the greater the importance. This standardization allows the importance ratings to be compared between respondents by creating a common variance.

Assessment to the questions related to Intrinsic Environmental Values were carried out using five continuum scaling factor as presented in Table 3. Use the scale above to record answers, but do not read out the numbers. When the respondents agree (or disagrees), say *"Would that be strongly agree (or strongly disagree)?"* Then note the correct number next to each statement.

RESULTS AND DISCUSSIONS

The study focuses primarily on the values and views of the residents of study area on importance and awareness of groundwater resources by a detailed survey. For the present study a target of 500 respondents were fixed. A final total of 435 interviews were completed. The refusal rate was recorded as 13%, which is considered quite low for this survey methodology, especially given the length of the survey. The reason for the refusal of answering the survey questions is of different reasons such as not interested, too busy, lack of knowledge, etc.,

The mean standardized importance ratings for each irrigation use such as fruits & vegetables, dairy cattle, crops and plant nurseries were evaluated and presented in Table 4. It was observed that irrigating crops and fruits and vegetables were rated most importance and plant nurseries least importance. After the importance rating of each category, respondents were asked if they had any comments to make. A wide range of comments was received, nearly 26.4% of the respondent noted that all uses were equally important. Fifteen percent of the respondents commented that apart from groundwater resources alternate sources should be identified for agricultural uses since the depletion of groundwater is increasing in some locations of study area.

The mean importance rating for industrial use for groundwater in the study area is presented in Table 5. Agriculture and manufacturing industries were seen to be most important, with mining and forestry being rated least importance. The important comments received from the respondent were, utilization of recycled water for manufacturing industries will increase the water table level in the region.

Table 6 represents the mean standardised importance ratings for future use for groundwater in the study area. Future needs of the population growth and environment were rated of greatest importance with new industries and existing industries being least important. Importance of groundwater uses generally are presented in Table 7. The irrigation and household use in the area were rated most important of all the generalized use categories and future use is rated as least importance.

In an attempt to measure these intrinsic values (both generally for the environment and specifically for groundwater), respondents were asked to rate the statements presented in Table 2 Part III. For ease of interpretation, the scale was recorded so that the higher the score, the greater the value. Agreement with intrinsic environmental value statements were presented in Table 8. The results show the extent to which the natural environment that is supported by groundwater is valued by the respondents in the study area. Both environment and groundwater were highly valued for their importance in Coimbatore South Taluk. Nearly 76.07 % and 22.35% of the respondents strongly agree and agree that the protection of natural environment is vital for future generation and 95.94% of them feel honestly that it is their duty to protect the natural environment. The protection of natural groundwater is vital for this question 75.11% and 22.09 % of respondents rated as strongly agree and agree, respectively. It clearly shows that the values for the environment and groundwater have a positive approach towards protecting natural environment and groundwater resources in the study area.

To know the length of residence and age group of the respondent two demographic questions were asked. The details pertaining to length of residence and age group of respondent were presented in Table 9 and Table 10 respectively. The standardized percentage of length of residence of more than 30 years is found to be high and the ager group between 35 to 55 years is found to be high. It is observed that the long length of residence in the study area and middle age group of respondents will provide a better knowledge to answer the questions and results will be of good standard.

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Finally, to know the confidence level of the respondent a question on their confidence in answering was asked and the results were tabulated in Table 11. The confidence level by the respondents was an important key factor in any type of survey, it is observed that 74.39 % of the respondents had answered the questions with confidence and 15.14 % of the respondents with extreme confidence and 10.02 % with somewhat confidence.

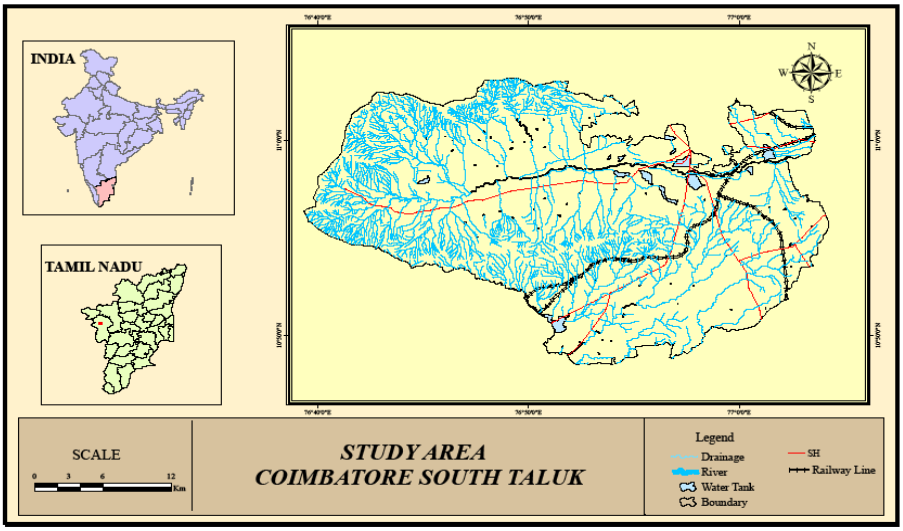

Fig. 1: Location map of the study area

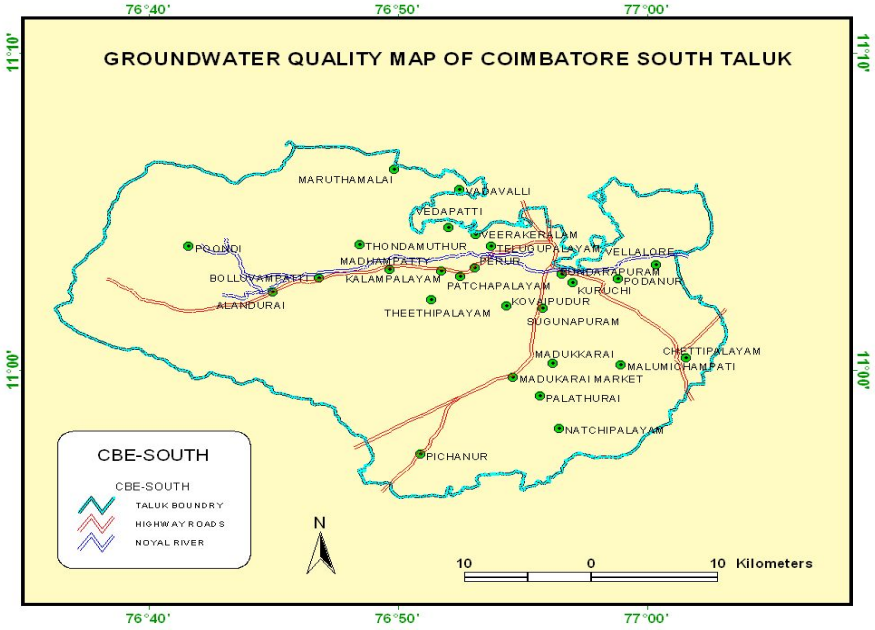

Fig. 2: Sampling locations

Table 1: Detail of Land Use / Land Cover in Study Area

Types of Land Use / Land Cover	Area (km^2)	% of area
Barren Rocky/ Stony Waste	4.86	0.63
Crop land	339.76	44.26
Deciduous forest	80.29	10.46
Dense forest	25.71	3.35
Fallow land	31.54	4.11
Forest Blanks	4.49	0.58
Forest Plantations	22.46	2.93

Gullied/ Ravenous Land	3.27	0.43
Industrial	1.86	0.24
Land with scrub	3.31	0.43
Land without scrub	1.06	0.14
Mining process	0.72	0.09
Open forest	19.92	2.59
Plantations	100.36	13.07
Quarries water	0.22	0.03
Recreational	0.54	0.07
Reservoir	2.04	0.27
Residential	46.74	6.09
River	3.83	0.50
Scrub Forest	56.22	7.32
Tanks	6.97	0.91
Villages	11.47	1.49
Total	767.64	100

Table 2: Survey Questions

Part – I	
Category A : Groundwater for Irrigation	
1	Fruits and Vegetables
2	Dairy Cattle
3	Crops
4	Plant Nurseries
Category B : Groundwater for Household Use	
1	Area
2	Household Use
Category C : Groundwater for Industrial Use	
1	Agriculture generally
2	Mining Industry
3	Tourism Industry
4	Manufacturing Industry
5	Dairy based Industry
6	Forestry
Category D : Groundwater for Future Use	
1	Future Population Growth
2	Future Needs of Existing Industries
3	Future Needs of New Industries
4	Future Environmental Needs
Importance of Groundwater use generally	
Category A : Groundwater for Irrigation	
Category B : Groundwater for Household Use	
Category C : Groundwater for Industrial Use	
Category D : Groundwater for Future Use	
Part – II	
Intrinsic Environmental Values	
1	In my opinion, the protection of the natural environment is beyond question
2	I accept as true the protection of the natural environment is vital for future generation
3	I feel honestly that it is my duty to protect the natural environment
4	Eventually, the only value of protecting groundwater is in its use for human welfare
5	To me, the protection of natural groundwater is vital
6	We need to protect ancient groundwater to avoid running out of water in the future
7	I feel a moral obligation to protect natural and ancient groundwater
Part – III	
Demographic and Confidence level	
Length of Residence in the Area	
1	Less than 5 years
2	5 to 10 years
3	10 to 20 years
4	20 to 30 years
5	More that 30 years
Age Group Category	
1	Young <35 years
2	Middle 36-50 yrs
3	old >50 yrs
Confidence Level	
1	Not at all confident
2	Somewhat confident
3	Confident
4	Extremely Confident

Table 3: Rating Scale

1	2	3	4	5
Strongly agree	Agree	Neither	Disagree	Strongly disagree

Table 4: Ratings of Groundwater for Irrigation Use

Irrigation use of groundwater	Frequency	Percentage
Fruits and Vegetables	139	31.94
Dairy cattle	72	16.45
Crops	158	36.33
Plant nurseries	66	15.26

Table 5: Ratings of Groundwater for Industrial Use

Industrial use of groundwater	Frequency	Percentage
Mining	45	10.2
Agriculture	133	30.66
Tourism	58	13.35
Manufacturing Industries	99	22.83
Dairy based	52	12.02
Forestry	48	10.94

Table 6: Ratings of Groundwater for Future Use

Future use of groundwater	Frequency	Percentage
Future Population	151	34.60
Existing Industries	52	11.90
New Industries	105	24.21
Environmental	127	29.29

Table 7: Ratings of Groundwater Use Generally

General use of groundwater	Frequency	Percentage
Irrigation	143	32.8
Household	124	28.53
Industrial use in the area	103	23.61
Future use	65	15.06

Table 8: Tabulation analysis of Intrinsic Environmental Values on Groundwater in the study area

Statement	Rating Scale				
	1	2	3	4	5
In my opinion, the protection of the natural environment is beyond question	2.26	17.16	44.47	25.51	10.61
I accept as true the protection of the natural environment is vital for future generation	76.07	22.35	1.58	0	0
I feel honestly that it is my duty to protect the natural environment	62.08	33.86	4.06	0	0
Eventually, the only value of protecting groundwater is in its use for human welfare	11.29	24.15	16.70	35.21	12.64
To me, the protection of natural groundwater is vital	75.11	22.09	1.82	0	0.98
We need to protect ancient groundwater to avoid running out of water in the future	27.98	63.83	7.2	0.78	0.21
I feel a moral obligation to protect natural and ancient groundwater	75.09	23.34	1.57	0	0

Table 9: Length of Residence in the Region

No. of years	Percentage
Less than 5 years	2.08
5 to 10 years	3.12
10 to 20 years	7
20 to 30 years	23.5
More that 30 years	64.3

Table 10: Age Group

Age in years	Percentage
Young <35 years	34.44
Middle 36-50 yrs	40
old >50 yrs	25.56

Table 11: Respondents Confidence

Confidence Level	Frequency	Percentage
Not at all confident	02	0.45
Somewhat confident	66	15.14
Confident	323	74.39
Extremely Confident	44	10.02

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Conclusion:

An attempt was made in this research to identify the values and views of the residents of study area on importance and awareness of groundwater resources through a survey. A target of 500 residents was fixed and a total of 435 interviews were completed. The results from the survey infer that irrigation and household use in the area were rated most important of all the generalized use categories and future use is rated as least importance. Further, it clearly shows that the values for the environment and groundwater were highly valued for their importance in Coimbatore South Taluk and the residents have a positive approach towards protecting natural environment and groundwater resources.

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