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A Decision Support Tool for Stakeholder Involvement in Sustainable Water Resource Development

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Abstract: This paper describes the application of a decision support tool for stakeholder involvement in a proposed water resource development project in the Ma Oya river basin in Sri Lanka. The decision support tool is a five-step framework developed based on 'Educated Trade-offs.' The tool assesses the natural resource uses; identifies the present and future probable issues with regard to resource uses, elicit stakeholder views and then estimate the social and environmental impacts of a proposed development project. The results obtained through the application of the framework are direct inputs for stakeholder education for informed decision-making by the stakeholders. This paper highlights the stakeholder education achieved in the proposed project area and the down stream areas. The study validated the 'Educated Trade-offs' framework which is the decision-support tool and demonstrated its effectiveness.

Keywords: Educated Trade-offs, Stakeholder consultation, stakeholder decision-making, development projects

1. Introduction

The increase in population and the advances in technologies have resulted in ever increasing rates of extraction from water resources especially from rivers. The extraction rates exceeding the natural replenishing capacity of such resources have resulted in significant negative impacts to these environment systems.

Traditionally, management and development of rivers and their resources have been sector specific, hierarchical, state-centred and without the participation of the project beneficiaries or other stakeholders who are negatively impacted. Where attempts have been made to arrive at decisions through stakeholder consultations they were purely on sectoral lines (e.g. water user associations in irrigation sector). The environmental and social impacts of such sectoral activities, especially impacts on other stakeholders were generally not known and were often neglected at the design and planning stages [2], [6]. The negative long-term impacts of such activities/projects are realized only long after the projects have been implemented. Such attitude often leads to creation of an imbalance between the consumption and conservation of the limited natural resources.

Educated decision-making, with the involvement of all stakeholders, is increasingly accepted as a reasonable approach to use natural resources sustainably and preserve them for future generations [7], [16]. The effectiveness and efficiency of such decision-making depends on the degree of relevant knowledge perceived by the stakeholders. The main hindrance for educated decision-making by the stakeholders is the inadequency of methods of educating the stakeholders on the technical, economical and environmental (including social) impacts of the decisions taken by one group of stakeholders on the choices of another group.

Thoradeniya and Ranasinghe [12] and Thoradeniya [13] proposed a framework on 'Educated Trade-offs' as a tool, which facilitates trade-offs between different resource uses by educating the stakeholders on the combined economic values (economic estimates and environmental and social costs) of each resource use. The premise of the framework is that **insufficiently informed** stakeholders tend to make trade-offs between different natural resource uses based on emotional judgment rather than being rational

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The framework consists of five steps. The first step identifies the multiple stakeholders and the uses/issues of the natural resources, through the systematic consultation of stakeholders. The critical bounds of the technical requirements of the resource uses and issues identified in step 1 are then estimated in step two. The economic value and the environmental (including social) cost of the respective critical bound of the technical requirements are estimated in the third and the fourth steps. Combining the economic estimates and the environmental and social costs of critical bounds, form the basis for 'Educated Trade-offs' for stakeholder consultations [12], [13]. The results of this framework are useful information for stakeholders to make rational decisions between different resource uses/issues in a river valley.

The objectives of this paper are to;

1. Present the results from a recent case study of Ma Oya river basin of Sri Lanka, where the 'Educated Trade-offs' framework [13] was applied.
2. Demonstrate the validity and the effectiveness of the 'Educated Trade-offs' framework, as a tool for decision making by stakeholders, by testing the research hypothesis.

A key stakeholder of the Ma Oya river basin, the National Water Supply and Drainage Board (NWSDB) has proposed a multi-purpose, balancing reservoir at Yatimahana as a solution for the temporal water scarcities experienced at present. The economic justification of the project is through improved water supply for water supply schemes, irrigation schemes, industries and hydropower generation [11]. However, the negative social and environmental impacts that could occur basin wide have not been adequately considered in the feasibility report.

This paper discusses the application of the 'Educated Trade-off' framework to the development project of the proposed multi-purpose, balancing reservoir facilitating the stakeholders of Ma Oya river basin to engage in rational discussions leading to less-emotional decision-making between the 'with' and the 'without' project development scenarios.

The next section presents a general description of the river basin and the uses and issues of river resources. Third section describes the application of the 'Educated trade-off' framework to the proposed Ma oya river basin development work. The fourth section presents the validity of the framework as a useful tool in decision making by the application of the framework to the case study to validate the research hypothesis. The conclusions are given in section five.

2. Ma Oya River Basin: Uses and Issues

Ma Oya river commences in the central hilly regions and flows to the Indian Ocean through North Western Sri Lanka. The river drains a catchment area of 1528 km^2 along its total length of 130 km [10]. Annual average rainfall of the Ma Oya basin is 2219 mm [3]. The low rainfall values occur in the months of January, February, June, July and August. The land use of the river basin is mainly characterized with paddy, rubber and coconut cultivations.

The river flows are used for supplying drinking water to 17 major population centers, two major industrial zones and some private water supply schemes. The next major use of the river flow is as a pollutant carrier (absorber) from a number of cities as well as private poor dwellings located on the riverbanks and from a number of industries located in the river valley.

Highly stressed surface water resource situations are experienced during the 6-8 weeks of the dry season [3]. Thus during the low flow periods the two major uses (water supply and pollutant carrier) are conflicting with each other and results in critical water stressed situation both due to inadequate quantity and poor quality [3], [14].

The NWSDB, a key stakeholder of the river basin has proposed a multi-purpose balancing reservoir in the upper catchment at Yatimahana [14] as the best option in an attempt to mitigate the expected severe water shortages in the near future due to the increasing demands, [11].

The objective of this reservoir project is to store the excess flows of the river during rainy seasons and then to release the required flows, under control, during the dry weather periods. The proposal acknowledges the importance of Integrated Water Resources Management (IWRM) and has considered irrigation, industry and hydropower sectors in addition to the water supply and sanitation sector.

Hydropower is proposed mainly as a strategy for achieving the economic viability of the reservoir project [11].

3. Application of 'Educated Trade-off' Framework

The application of the five steps of the 'Educated trade-off' framework for the change between the 'With project' and 'Without project' scenarios are described below.

3.1 Identification of the Multiple Stakeholders and the Natural Resource Uses/ Issues – Step 1

The issues and stakeholders show a significant variation spatially and temporally with regard to the resources uses of a river. Therefore, the most accurate scenario of the situation is possible through the bottom level (grass-root) stakeholder consultations. The methodology used for the identification of stakeholders and issues was to conduct sample surveys along the river banks at the smallest administrative unit (Grama Niladhari Division – GND) level [13], [14]. 'Method of key informants' as suggested by Grimble [5] was used in the identification of the stakeholder sample.

Ma Oya river basin belongs to 17 District Secretariat Divisions (DSD). The survey covered 145 GNDs situated along the river banks in the 16 DSDs from river estuary to Aranayake DSD (a location upstream of the proposed reservoir). Samples constituted of 427 stakeholders representing all sectors having a stake in the river including public administration, public and private institutions in the river resource use sectors, and representatives of social, political, religious, and ethnic groups of public at grass-root level.

The techniques used were a questionnaire and a structured interview [13]. The results of the survey facilitated the identification of the resource use patterns, critical issues, the environmental impacts already experienced and possible social and environmental impacts in future.

Bathing/washing, sand mining, drinking water through dug-wells, agriculture through ground water, waste disposal and rearing animals were the natural resource use sectors identified in most of the GNDs on both river banks. The other use sectors, which were more localised in nature, were the water supply schemes, industries, clay mining, dinking water (direct), inland fishing and tourism [13].

The already documented environmental and social impacts due to the different use sectors, range from drying up of springs used for drinking and household needs of the villagers at upstream to abandoned paddy lands (Figure 1), dried up wells (Figure 2), and large clay pits downstream [9], [13], [8].

Figure 1 – Abandoned paddy lands

Figure 2 – Dried up dug-wells

Five resource use sectors identified as threatened or as facing conflict situation at most number of GND locations by this study were: a) drinking water due to the drying up of dug wells, b) lands on the river banks due to severe erosion, c) sand mining due to inefficient regulatory framework, d) bathing and washing sector due to the high risk posed by deep pits beneath water level and pollution and e) environment. Use sectors such as mini-hydropower, tourism, sand and clay mining have created localised adverse impacts to the environment and the local populations [13].

3.2 Critical Bounds of Technical Requirements – Step 2

The engineering knowledge is utilized to estimate critical bounds of the technical requirements for utilization of the different resource uses. The critical bound of water use is defined as the minimum required volume that needs to be extracted to meet the need (e.g. irrigation, water supply) while the maximum volume not to exceed the assimilative capacity of the river or river valley is the critical bound for other uses (e.g. sand and clay mining, discharge of pollutant). Usually, when a project is proposed these bounds are estimated.

The estimates for critical bounds of the technical requirement for four use sectors as indicated in the project proposal are given in Table 1 for the 'with project' scenario.

Table 1 - Estimated Technical Requirements for Different Resource Use Sectors

User sector	2005	2015	2025
Water supply (m^3/d)	94900	152000	213500
Hydropower (m^3/s)	4.0	4.0	4.0
Irrigation (MCM)	36.07	36.07	36.07
Industries (m^3/s)	13000	18000	37000

(Source: Sweco Groner, 2004)

3.3 Economic Value at the Critical Bound of the Technical Requirement – Step 3

The proposal identified the economic benefits of the project from power generation, increased water sales, crop production, land value increases, generations of new business activities. The economic costs of the project are due to capital costs, which include construction costs of the dam and the powerhouse, refurbishment cost of electrical and mechanical components and land acquisition costs and recurrent costs. The analyses of the benefits and costs after correcting the mistakes made by the project consultants [11] yield an Economic IRR of 8.28% [13].

3.4 Environmental Cost at the Critical Bound of the Technical Requirement – Step 4

The net environmental cost of the 'with project' scenario is the difference between the environmental (including social) benefits due to the reservoir and the social and environmental costs of the other uses due to the reservoir project. It must be noted that net social and environmental costs referred to here are those, which are either not quantified or underestimated, in the economic analysis.

Survey carried out in step-1, the stakeholders identified major social and environmental impacts in five user sectors; Recreation, Rain fed agriculture, Dug-well, Industry uses and Tourism [12]. These impacts were valued using Environmental impact valuation methods [1].

Bo-ella water fall, which is a recreation site mainly for the local people is located at the dam site (Figure 3). The annual loss in the recreation sector by the inundation of the water fall by the proposed reservoir is estimated as Rs. 1.2 million per annum.

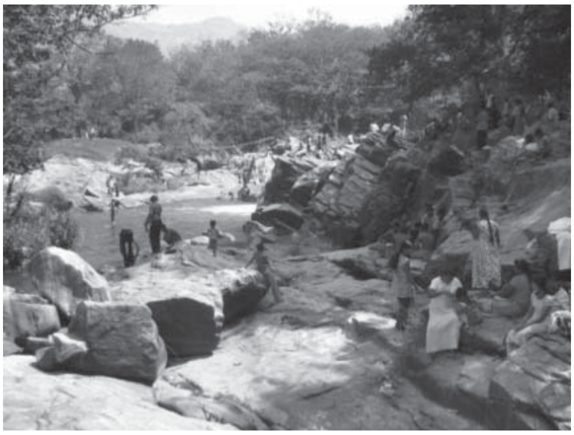

Figure 3 – Recreation at proposed dam site

The impacts to the rain-fed agriculture and the dug-wells depends on the variation of river water levels during the dry season which turn effects the ground water level in the vicinity. The analysis in the step-2 indicates the variations to the river water levels in the dry season due to the project has a marginal positive impact which is insignificant to be estimated in economic terms.

The industries are expected to benefit by the flood mitigation effect of the proposed reservoir due to the reduction of turbid water. This positive impact is valued at Rs. 0.45 million per annum.

The upper river reach has a significant tourist attraction at Pinnawala, where an elephant orphanage is operated. (See Figure 4). The high flows (floods) do not permit the elephants to use the river for bathing due to the risk of small elephants being washed away. In this instance the impacted sector are the business enterprises, which cater to the tourists, situated along the route taken by the elephants from the orphanage to the river and not the orphanage itself. The benefit of the proposed balancing reservoir due to reduced flood days to the tourism sector is estimated at Rs. 2.59 million per annum.

Figure 4 – Pinnawala Elephants in Ma Oya

The total Environment (including social) benefits of the project is therefore estimated as Rs. 1.84 millions per annum [13]

3.5 Combined value at the Critical Bound of the Technical Requirement – Step 5

The fifth step facilitates the estimation of a combined value for the 'with project' scenario by adding the economic value and the environmental (including social) cost. The addition needs to consider a suitable discount rate. For example, a discount rate of 10% which is a reasonable Minimum Acceptable Rate of Return (MARR) for infrastructure projects of this nature results in a negative Net Present Value (NPV) of Rs. 399.6 million for the 'with project' scenario. The EIRR of the project was 8.29% [13].

A significant benefit that has not been included in this analysis is the avoided social and environmental costs to the project beneficiaries.

4. Validation of the Framework as a Decision Making Tool

The validation of the 'Educated Trade-off' framework as a useful tool in decision making was achieved by testing the research hypothesis with data collected in a series of stakeholder consultation and education sessions [13].

4.1 Stakeholder Samples

The population represented by ten sectors of stakeholders as given in Table 2 were sampled. The basis of this selection was officers in the rank of 'Officer-in-Charge' of water extracting plants and above of the NWSDB and users of water supply schemes who would definitely benefit by the project as project proponents, various direct and indirect users whose impacts are unknown at present as project opponents and officers representing Government administration as neutral stakeholders [13].

Table 2 – Sectors, sample sizes and the responses (with their percentages)

	Sector	Sample	Responses (%)
1	Officials of NWSDB	20	13(65)
2	Users of pipe borne water	30	9(30)
3	Tourism sector	20	8(40)
4	Industrial sector	20	6(30)
5	Recreation sector	30	22(73)
6	Dug well users	30	26(87)
7	Paddy field owners / farmers	30	28(93)
8	Coconut land owners	30	25(83)
9	Environmental organisations	30	25(83)
10	Government administrative mechanism	60	56(93)
	Total	**300**	**218(73)**

The elements within each sector were selected randomly. Therefore, the sampling method is purposive random sampling. The distribution of the sample size within each sector and the number responded are given in Table 2. A total of 218 stakeholders responded which returned a response rate of 73%.

4.2 Stakeholder Workshops

Stakeholder consultations were made to ascertain the impacts of stakeholder education on the technical, economical and social and environmental aspects described in the 'Educated Trade-offs' framework. Twelve stakeholder workshops (Figure 5) were conducted along the river banks in order to validate the framework [13].

Figure 5 – Stakeholder workshop in progress

The stakeholder involvement level was high in the involvement continuum [8] as they are expected to make decisions. This led to the selection of scenario workshops and study circles as the appropriate technique for consultations [4].

The spatial distribution of workshops allowed the participation of stakeholders representing proposed project area and the entire down stream reach of the river.

The major education tool was a presentation which included data pertaining to technical, economical and social and environmental aspects of the proposed project in the form of illustrations of the stream network, the river basin area, the catchment area of the proposed reservoir and the ground water levels with reference to the dug wells, agriculture and proposed low flow weirs. The education also included rainfall data, project benefits and costs, the sectors expected to be threatened by the proposed reservoir.

A set of questionnaires were used as the tools to gauge the change of attitude of a stakeholder towards decision making as a result of an education session. Therefore, these sessions were designed to elicit the stakeholder views on the proposed project at 'Pre' and 'Post' education. The questionnaires were made easy to understand, short enough to hold the attention and the interest of the stakeholders, simple to respond by picking an answer from a set of given choices.

At both instances a stakeholder's stand on the project were obtained on the eleven point scale given in Figure 6.
The 'Post' education session questionnaire was included with seventeen factors on technical, economical and environmental aspects of the project (Table 3) which were discussed at the education session [13]. Each of these was evaluated on a five point scale by the stakeholders who accepted that their view on the proposed development project has been changed as a result of the stakeholder education session.

Table 3 - Technical, Economical and Environmental Factors and Their Symbols [12]

Factor	Symbol
Technical Information:	
River and location of cities	T1
Rainfall data	T2
Catchment area of the river and the reservoir	T3
Reservoir data such as dam height, capacity, water spread area	T4
Electricity generation data	T5
Knowledge above the tributaries in the downstream	T6
Future water demand at present intakes	T7
Economic Information:	
Expected net benefit for project	E1
Social and Environment Information:	
Sectors that would have direct impacts from the project	S1
Sectors that would have indirect impacts from the project	S2
Understanding of the economic value of 'Bo Ella' waterfall	S3
Understanding the extra income to the tourism sector at Pinnawala	S4
Understanding the profit that could be earned by the industrial sector as a result of the reduce number of days of turbidity	S5
No adverse impacts to the dug well sectors in the down stream areas	S6
Low weirs are helpful to maintain the water levels in dug-wells of the vicinity	S7
Understanding the reason for the absence of adverse impacts by the project to the crops such as paddy and coconut	S8
Education of good and bad impacts to the riverine environment	S9

The process revealed the impact made by each factor on the change of their view on the proposed project. Figure 7 shows the stakeholders attending to the questionnaires.

Very high liking		Moderate liking		Little liking	Indifferent	Little disliking		Moderate disliking		Very high disliking
+5	+4	+3	+2	+1	0	-1	-2	-3	-4	-5

Figure 6 - Eleven Point Scale

Figure 7 – Stakeholders expressing their views

4.3 Statistical Analysis

The sample consisted of 48 females and 170 males (ratio 1: 3.5). The average age of the sample was 49 years varying between 22 years to 80 years. 187 (86%) of the sample had received at least secondary education while 49 (22%) had received higher or tertiary education [13].

At the stakeholder meetings it was found that 67% (145) of the sample were unaware of the proposed reservoir project prior to the meeting. Irrespective of the awareness 67% (145) thought that they would get positive impacts from the project than at the present situation (Table 4) and 97 (44%) expected negative impacts (Table 5). Two sample elements each did not respond reducing the total sample to 216 [13].

The major reasons for expecting positive impacts are the expectation that the project would result in undisturbed, good quality water and expansion of water supply schemes as quoted by 62(43%) respondents. The other reasons are; extra benefits such as electricity for the area, quoted by 34(23%) and flood control and reduced erosion, quoted by 28 (19%).

Table 4 - Awareness Vs Expectation of Positive Impacts

Awareness	Expect positive impacts	Do not expect positive impacts	Total
Yes	50 (70.4 %)	21 (29.6%)	71
No	95 (65.5 %)	50 (34.5 %)	145
Total	145 (67.1%)	71 (32.9%)	216

(χ^2_1= 0.5197, p=0.471)

Table 5 - Awareness Vs Expectation of Negative Impacts

Awareness	Expect adverse impacts	Does not expect adverse impacts	Total
Yes	35 (49.3 %)	36 (50.7 %)	71
No	62 (42.8 %)	83 (57.2 %)	145
	97 (44.9 %)	98 (45.4%)	216

(χ^2_1= 0.8233, p=0.3642)

The three major reasons for expecting negative impacts are

- Expectation of reduced flow to downstream areas - 30 (25%)
- Relocation at the project area - 22 (19%)
- Expectation of negative impacts for dug-well users - 16 (14%)

The details of the analysis performed on the changes made to the 11-point scale between 'pre' and 'post' education sessions of the stakeholders who accepted that the education session made an impact on them are given in Table 6 for the three groups of stakeholders: project proponents, project opponents and neutral

Even though 169 have claimed they have been impacted by the education session only 104 (61%) had shown a change in the scale point at the 'post' stakeholder education questionnaire.

Table 6 - Impact of Stakeholder Education

Group	Category	Number	Impacted	Increased Liking	Decreased Liking	No Change	Extreme Scale Points
Proponents	1	13	8	2	1	5	2
	2	9	7	1	1	5	5
	Sub Tot.	**22**	**15**	**3**	**2**	**10**	**7**
Opponents	3	8	8	6	2	0	0
	4	22	17	5	1	11	9
	5	6	6	5	0	1	0
	6	26	21	12	1	8	6
	7	28	20	9	6	5	5
	8	25	18	7	3	8	7
	9	25	19	7	2	10	7
	Sub Tot.	**140**	**109**	**51**	**15**	**43**	**34**
Neutral	10	56	45	28	5	12	9
	Grand Total	**218**	**169**	**82**	**22**	**65**	**50**

Out of the 75 who indicated no changes in the scale point between 'pre' and 'post' sessions, 50 had opted for extreme scale points (+5 or -5) at the 'pre' education session. The scale limits the option of such a stakeholder to indicate his increased liking or disliking as a result of the education session.

The responses of the three stakeholder groups, indicating whether they were impacted or not, were subjected to Chi-square test in order to verify that the impact of education session has any significant association with any particular group of stakeholders. Table 7 shows distribution of responses accepting/rejecting the impact of education session. The Chi-square value (χ^2 =1.37) indicates that there is no association between the type of the group and the status of impact.

Table 7 - Frequency Table of Group vs. Status of Impact

Group	Impacted	Not impacted	Total
Proponents	15 (68.2%)	7 (31.8%)	22
Opponents	109 (77.9%)	31 (22.1%)	140
Neutral	45 (80.4%)	11 (19.6%)	56
Total	169 (77.5%)	49 (22.5%)	218

(χ^2 =1.37, p = 0.5041)

The percentages of stakeholders who declared that they received an impact due to education are 68.2%, 77.9% and 80.4% in the groups' proponents, opponents and neutral respectively. Thus it is concluded that the education has directly impacted all three groups in similar intensity.

Hypothesis Testing: In order to find whether the improved access to information through the Educated Trade-offs framework has significantly impacted the majority of the stakeholders a hypothesis test was carried out using binomial distribution.

The research hypothesis:

H_0: Stakeholder involvement in decision making on development projects in a river basin remains the same or becomes lesser with improved access to information through the Educated Trade-offs framework.

H_1: Stakeholder involvement in decision making on development projects in a river basin is rationally impacted with improved access to information through the Educated Trade-offs framework.

For the purpose of this study the term 'rationally impacted' is defined as the majority (more than 50%) of stakeholders being impacted. Hence, the null hypothesis is rejected at 5% significance level.

(Z_{Computed} - 9.87 > $Z_{(\alpha = 0.05)}$ - 1.645)

Technical, Economical and Environmental aspects: An analysis was carried out using 'percentage of responses' to find the factors (Table 3) which have influenced most on the above changes in stakeholder views.

The most influential technical factors were 'catchment data' (T3), 'reservoir data' (T4) and 'rainfall data' (T2) while the least impact had been from the location of River and cities (T1). The net benefit of the project had been a considerable impact towards the change in decision making accepted by the stakeholders.

In the social and economical sphere 'the understanding of the indirect positive impact of the low flow weirs on the dug-wells in the vicinity' (S7) had caused the major impact. The next two contributory factors had been the understanding of the facts that the project does not negatively impact the downstream dug-wells and the reason for the absence of adverse impacts on crops such as paddy and coconut.

Influence on spatial locations: Further analyses were carried out to establish the influence of each factor depending on the spatial locations.

Accordingly it was found the education on river location (T1) has made the least impact while education on catchment area of the river and the reservoir (T3) and future water demand at present water intake (T7) have been the major technical factors that had contributed towards changing their decision making.

In the group of social factors the stakeholders in the upper reach has identified the education on impacts to dug wells in the down stream areas (S6) and assurance on that there would not be adverse impacts, had been the factor that had influenced most to change their decision making. The stakeholders from the middle reach of the river basin identified the factor S4 (Understanding the extra income to the tourism sector at Pinnawala) as the factor that has influenced them most while the stakeholders from the upper reach identified the factor S7 (Low flow weirs are helpful to maintain the water levels in dug-wells of the vicinity) as the factor that has influenced them.

5. Conclusions

The objectives of this paper were to present a case study of the Ma Oya basin where the 'Educated Trade-off' framework [13] was applied and to demonstrate its validity and effectiveness as a tool for decision making by the stakeholders.

The application of the five step Educated Trade-off framework demonstrated its versatility by capturing sectors that were ignored by the traditional analysis done by the project consultants [11]. In addition, it highlighted the importance of capturing the costs and benefits of all stakeholders in the river basin not just those impacted by immediately around the project area.

The stakeholder consultations at pre-education session showed that 67% (145) of the sample expected some positive impacts while 55% (118) expected some negative impacts by having the proposed reservoir. The Chi-square test proved that these expectations of positive or negative impacts are independent of the stakeholders awareness about the proposed project (Table 4 and 5; χ^2_1= 0.5197 and χ^2_1= 0.8233).

The stakeholder consultations at post-education sessions established that 169 (77.5%) of the sample were influenced by the education of technical, economical and social and environmental aspects of the proposed development project. The Chi-square analysis (Table 7) proved that there is no association between the type of stakeholder groups (project proponents, project opponents and neutral) and the status of influence.

Hypothesis testing validated the research hypothesis 'Stakeholder involvement in decision making on development projects is rationally impacted with improved access to information through the 'Educated Trade-offs' framework at 5% level of significance. Thereby validate the 'Educated Trade-off' framework for stakeholder decision-making in development projects.

The analysis into the individual technical, economical, and social and environmental factors used for stakeholder education showed that the factors that influenced the stakeholders most were the ones that directly addressed the negative impacts they expected.

The same factors analysed on spatial locations showed a clear variation in the identification of most influenced social and environmental factor. The factors that were identified as the most influenced by the three groups upper, middle and lower were the ones that were directly related to the anticipated negative impacts in their respective locations.

The above analysis of the individual factors further strengthens the research hypothesis and the 'Educated Trade-off' framework as an effective decision-support tool for stakeholder involvement in sustainable water resources development.

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