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E-SCI Knowledge Framework in Community Water Resources Management

Nuttakit Iamsomboon[1*], Pattarawat Jeerapattanatorn[2] and Piya Duangpatra[1]

[1]Sustainable Land Use and Natural Resource Management Program,
The Graduate School, Kasetsart University, Bangkok, Thailand
[2]Department of Vocational Education, Faculty of Education, Kasetsart University,
Bangkok, Thailand

*Corresponding author: nuttakit.ia@ku.th
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Abstract

The focus of this research was to study a holistic approach to analyzing problems related to community participation in water resources management using a logical framework approach in the form of a problem tree and an exploratory factor analysis for proper water resources management. This research study aimed to design a framework for learning media that was appropriate for the basic knowledge of local people in a community in Samut Songkhram, a province in Central Thailand. The selected samples in this study were from 400 households, three water resources management specialists and two water resources management scholars in the community. The results found that the learning strategy development of the community regarding water resources management was limited in the evident mechanisms and was insufficient to apply to the process of resolving water resources management problems. However, water resources were considered as the most important environmental issue of the community, and we found four components of knowledge on water resources management: (1) effect, (2) solutions, (3) causes, and (4) importance, which are the most crucial for problem solving. The results of this research could be applied to develop a strategic model for other community learning in order to promote the sustainable coexistence between people and nature.

Keywords: Water resources management; Logical framework approach; Exploratory factor analysis

1. Introduction

For the last century, more than half of the world's population has encountered and suffered from the scarcity of water (Narasimhan, 2008). This phenomenon has created problems for society, economics, and country development. In terms of water usage, it could be seen that the agricultural sector might be responsible for most of the contamination in water resources (Appelgren, 2004). Similarly, in the manufacturing processes of the industrial sector, water is considered essential, and contaminated water released after these processes is the cause of water pollution (WWAP, 2015). With the rapid growth of human population, more water is being consumed; thus, more used water has been released into natural water resources, creating larger amounts of water pollution in such a way that these water resources are rapidly devastated, lowering the quality of the water and eventually turning those resources into polluted water that affects their surrounding ecosystem. For the last few decades, Thailand has unceasingly faced problems related to water resources, including droughts in arid areas, small reservoir storage capacity, water quality deterioration, and toxic waste contamination in water caused by nearby communities, manufacturing industries, and agro-industries. Additionally, the natural phenomenon of flooding also has a massive effect on the country's economics, environment, and people's way of life, and unfortunately, the trend is potentially increasing over geological time. These problems are thought to result from different factors, including lack of efficient water resources management, overconsumption of water, misbehavior in water usage, and climate change, as well as global warming, according to Khosa-art (2013). Therefore, it is a necessity and an obligation for those who are involved with these problems to resolve and find ways to efficiently manage water resources as well as to provide knowledge on water resources management to people in nearby communities; this approach would lead to sustainable development for both the community and its environment. It could be said that humans are considered to be one of the most vital factors to help resolve problems as they are capable of making wise decisions and have enough responsibility to create sustainability in their environment. According to UNESCO (2017), the objectives of this research paper were 1) to analyze problems related to community knowledge of water resources management by implementing a logical framework approach in the form of a problem tree and 2) to carry out an analysis on an appropriate holistic approach for water resources management with an exploratory factor analysis that would help determine the appropriate knowledge for the community about water resources management and further help design learning media that would be appropriate for the knowledge of the targeted community.

Section 2 presents the materials and methods, Section 3 details our results and discussion, and Section 4 contains our conclusions.

2. Materials and Methods

2.1. Study Area

This research study selected three different areas of the Samut Songkhram Province, including the Bang Chakreng subdistrict in the Mueang district, the Khwae Om subdistrict in the Amphawa district, and the Kradung Nga subdistrict in the Bang Khonthee district. This province is considered to be the smallest province located in the central region of Thailand, as seen in Figure 1. To select locations for this research study, representatives from government sectors related to water resources management at the community level, district level, and province level, including the Samut Songkhram Provincial Administrative Organization, Irrigation Project Design,

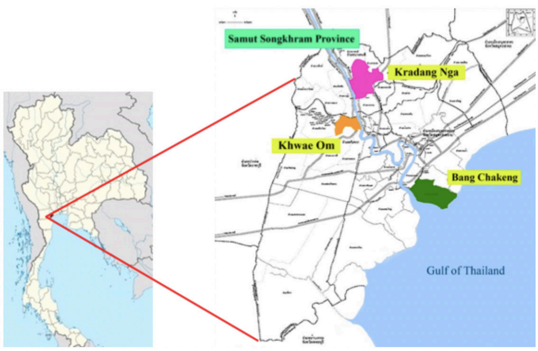

Figure 1. Location of the case study area

Samut Songkhram Office of the Permanent Secretary, and Samut Songkhram Agricultural Extension Office, were interviewed. Most of the interviewees agreed that the selected areas for research studies mentioned above possessed the greatest problems with water resources management, while the community in the area lacked knowledge and were unable to successfully resolve these problems.

2.2. Population and samples

The population and samples used in this research were representatives from three different subdistricts, including 1820 households from Bang Chakreng, 626 households from Khwae Om, and 1957 households from Kradung Nga, for a total of 4403 households. Implementing the Krejcie and Morgan (1970) random sampling technique, 351 households were selected, and more households were added to the sampling used in this study, so that the final sample totaled 400 households. Additionally, three water resources management specialists in the community as well as two water resources management scholars were selected for the study as the study's purposive samples.

2.3. Methodology

This research was an integration of quantitative research and qualitative research to conduct a study on an analysis of factors that are appropriate for designing and providing knowledge on water resources management to local communities. As seen in Figure 2, the research procedures were divided into two parts, including:

Part 1. Analyzing problems in community knowledge towards water resources management.

The research procedures could be divided into two steps as follows:

In the first step, the procedures were started by collecting data from documentation and relevant theories based on community knowledge towards water resources management, as well as surveying the locations where problems in community knowledge currently occur. Second, the analysis of problems in community knowledge about water resources management was conducted by implementing the logical framework approach (LFA) (Duangpatra, 2003). In this research, the problem analysis step of the LFA was primarily employed to acquire the problem tree outcome. Specialists and scholars were invited to join the LFA workshop to exchange views with respect to knowledge about water resources management; thus, the knowledge gained would further be used to fulfill the objectives of this research, which aimed to find appropriate ways to manage water resources.

Part 2. Analyzing appropriate knowledge towards water resource management in the community.

The research procedures were divided into six steps as follows:

Step 1: Study data were collected from the documentation, relevant theories, and literature reviews to identify, determine, and design an appropriate questionnaire. Step 2: The terms on knowledge of the community about water resources management were indicated and defined, and the concepts, theories, and results of problem tree analysis from the first part were implemented. This step explained the definitions of the operational terms that could be applied to create a knowledge framework based on water resources management in later stages. Step 3: The questionnaire was designed using a 5-point rating scale corresponding to the Likert scale questionnaire, which was divided into two sections, including general information on respondents and community knowledge on water resources management. The questionnaire consisted of 80 questions. Step 4: The content validity of the questionnaire was presented and validated by three experts to determine the correlation between the components of knowledge and operational definitions in detail. For the applicability of the questionnaire, the Index of Item-Objective Congruence (IOC) must be greater than or equal to 0.5 according to Rovinelli and Hambellton (1977). This questionnaire was found to have an IOC ranging between 0.00 to 1.00, meaning

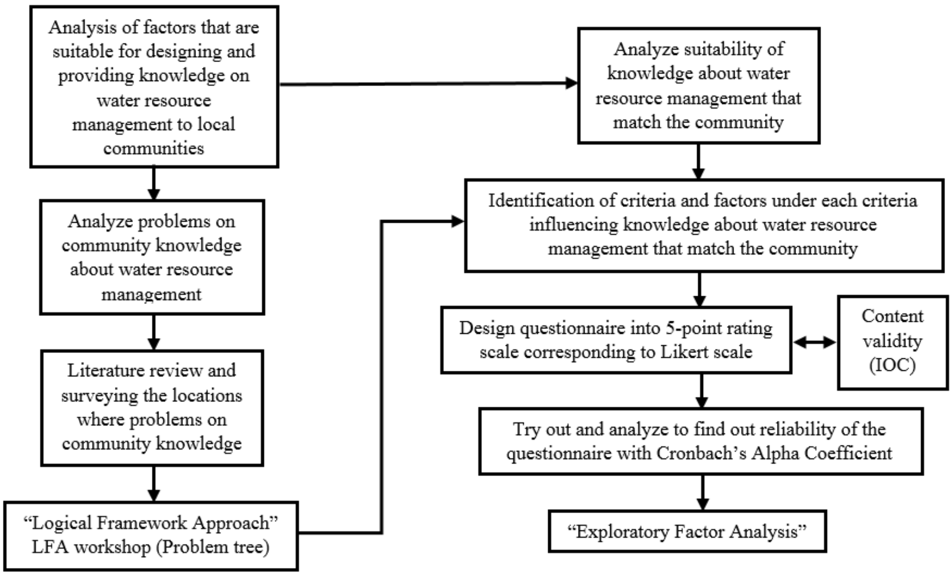

Figure 2. The conceptual framework for an analysis of factors appropriate for the design and to provision of the knowledge about water resource management for the local communities

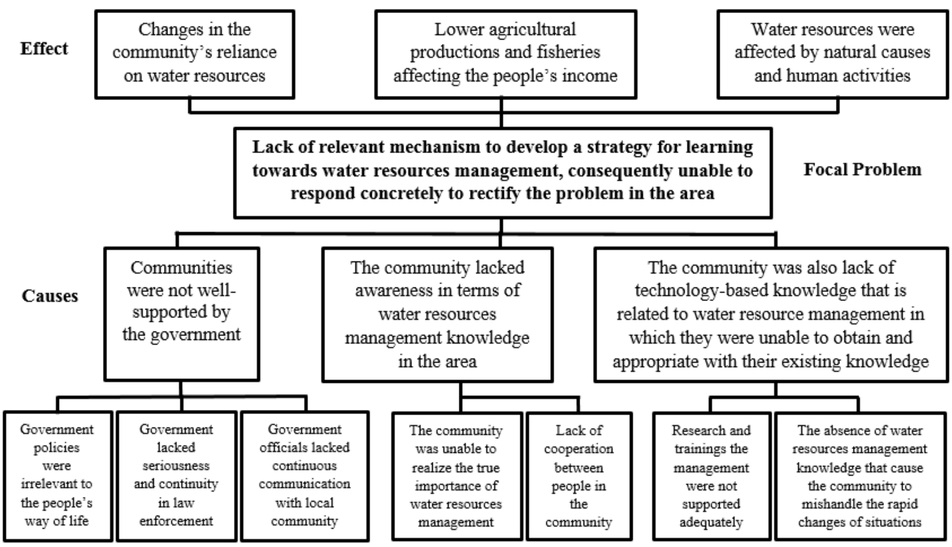

Figure 3. The application of the LFA's problem tree technique to formulate the hierarchical relationship between causes, the focal problem, and consequent effects on water resources management

that 40 questions in the questionnaire could be applied to conduct this research. Step 5: A trial session was conducted with a 30-person nonsample group and further analyzed to determine the reliability of the questionnaire with Cronbach's alpha coefficient, where the result showed that the reliability value was 0.933. Step 6: In the final step, an exploratory factor analysis (EFA, principal component analysis (PCA, varimax, and factors were statistically applied to analyze the information based on the appropriate knowledge towards water resources management in the community, and the results were then analyzed to generate and establish the names for the new variables (Field, 2009; Williams and Brown, 2010; Taherdoost, *et al*., 2014), relevant theories, and literature reviews to determine and design an appropriate questionnaire.

3. Results and discussion

3.1. Results of Analyzing Problems in Community Knowledge towards Water Resource Management

By collecting data from the documentation and relevant theories based on community knowledge about water resources management, as well as by surveying the locations where problems in community knowledge exist and inviting five specialists and scholars to join the LFA workshop to help solve the problems, contribute new knowledge and develop better planning, it was evident that the existing problems in water resources management are in some ways negatively affecting society, the economy, and the environment of the country. Based on the application of the problem tree analysis to determine the causes and problems, the results showed that the main focal problem is the lack of a relevant mechanism to develop a strategy for learning about water resources management, consequently leading to the inability to concretely respond to rectify the problem in the area. As seen in Figure 3, based on these existing problems, the integration of knowledge between the community and government representatives could be applied to resolve the existing problems as well as to raise awareness of how important water resources management is, to make both sides cooperate and finally succeed in the objectives, as mentioned by Anderson (1999) and Novotny (2003). All of the mentioned problems would then be endorsed by the attendees in the designated workshop and those problems would be applied into a problem tree as data for designing appropriate knowledge of water resources management for the community.

3.2. Results of Analyzing Community Knowledge towards Water Resources Management

EFA is a statistical method that is used to identify appropriate community knowledge components concerning water resources management. Data were collected from documentation and relevant theories, and the results were analyzed in the form of a problem tree (referred to in Section 3.1) that could be used as a framework for designing a research tool. Further details are described below:

A group of samples in this research possessed common characteristics; 45% of the interviewees lived in the Kradung Nga subdistrict, Bang Khonthee district; 41% in the Bang Chakeng subdistrict, Mueang district; and 14% in the Khwae Om subdistrict, Amphawa district. Concerning the gender of the interviewee, the number of women was higher than the number of men, which were equivalent to 60.5% and 39.5%, respectively.

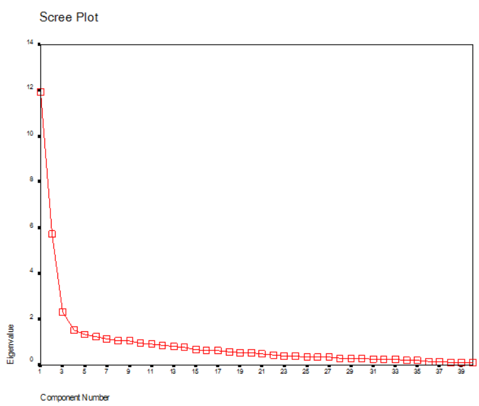

Figure 4. Scree plots of eigenvalues

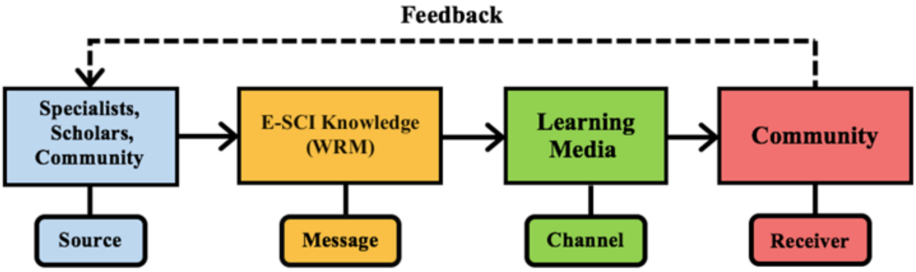

Figure 5. The E-SCI Knowledge Framework in community water resource management.

Regarding to the top three age variables, 25.5% were 60 years old and above, 23.5% were 30 to 40 years old, and 23.0% were 41-50 years old, respectively. In terms of occupation, agriculture was the first on the list at 30.0%, trading at 18.0%, and private employees at 16.5%. Most participants (83%) did not have part-time jobs, but those with part-time jobs composed 17.0% of the sample group. For educational background, approximately 35.0% possessed an elementary education degree, 23.5% had a high school degree, and 22.5% had a secondary or vocational/higher vocational degree. Those respondents residing at the target location for more than 10 years accounted for 85.5% in total; 8.0% had lived there for 5-10 years, and 6.5% for 1-5 years.

Regarding the community knowledge of water resource management, statistically, it could be found that the mean and standard deviation values were high at $\overline{X}$= 3.68, S.D = 0.54, where a similar finding was made by Bhumkittipitch and Ohgaki (2018), in which the method of sustainably developing in the community is to create learning and understanding; the most influential factor that helped promote and support learning was local people who possessed willingness to develop their learning and were motivated to create good interactions and cooperation among themselves. Effective improvement occurred when people and knowledge were integrated. Integrated learning is the process of making connections among concepts and the experiences of learners (Voulalas and Sharp 2005). In addition, when investigating the initial data prior to component analysis, the Kaiser–Meyer–Olkin measure of sampling adequacy (KMO) was applied for statistical calculations, and the results in Table 1 illustrate that the KMO statistical numbers were 0.845, higher than 0.80, meaning that all variables were highly related, corresponding to the theory proposed by Kim and Muller (1978). These variables were able to be implemented to analyze the components, as mentioned in the objectives of this study. For Barlett's test of sphericity, the approximate chi-square values for testing were 10605.693, with a statistical significance of 0.05. It could be assumed from the results of the correlation matrix of the variables that they were related to one another, and thus, a correlation matrix could be implemented to analyze the components.

The researchers had been attempting to extract components with a PCA. When determining the number of components and orthogonal rotation with the varimax method, it could be found that good component must have eigenvalues higher or equal to 1, and three or more variables must be comprised of eigenvalues ranging between 1.236-7.528, and the percentage of cumulative percentage of variance was 68.064. This result indicated that 40 factors in the questionnaire were applicable for measuring the relationships of nine related components, as illustrated in Table 2.

Once eigenvalues and component values were observed, it could be found that when reaching the fifth component, eigenvalues tended to decrease, as seen in the form of a straight line parallel to the X axis. According to the Scree Test (Cattell, 1966), when the line in the graph of eigenvalues and the number of components starts to become straight, the number of components will stop increasing, and there will be no more than the finishing value, as shown in Figure 4. Moreover, when considering factor loading values of 0.30 and above (Hair *et al.*, 2006) the variables of each component are shown in Table 3.

With a low IOC index and lack of variable details, the fifth component was eliminated whereas other components were used for describing community knowledge related to water resource management as shown in Tables 4-7.

In Table 4, "Effects" describes the 13 mentioned variables with factor loadings ranging between 0.474 to 0.824, eigenvalues of 7.528, and a variance percentage of 18.820. Based on these results, it could be concluded that all 13 variables were considered useful for describing the component; moreover, this component could eventually be used to describe the variance value of community knowledge on water resources management, which was equivalent to 18.820%. Additionally, when this variance value was compared with the eigenvalues and the four other components, this component was ranked first. This result also corresponded to the water pollution scenario that many countries in the world are indeed facing and by which these countries are being threatened. Examples of this water pollution are the release of agricultural waste, such as fertilizers and pesticides, which may create health problems in humans. It is suggested that a water treatment system should be provided to help preserve natural resources, and educational programs on the effects of water pollutants should be provided, which should be held as quickly as possible (Alrumman *et al.*, 2016).

In Table 5, "Solutions" describes the 14 mentioned variables, weighing between 0.478 to 0.790, with eigenvalues of 6.875, and a variance percentage of 17.188. Based on these results, it was concluded that all 14 variables were considered useful for describing the components. Particularly, as the thirty-fourth variable, the elimination of weeds and water hyacinth in rivers, this variable was ranked first because it had the highest correlation with the components. As mentioned in WWAP (2018), water resource problems can be resolved if the whole population cooperates and participates in improving water quality and helps to reduce water pollution with alternative methods, including lowering the massive amount of waste products in their community and

Table 1. Kaiser–Meyer–Olkin measure of sampling adequacy and Barlett's test of sphericity

Kaiser–Meyer–Olkin measure of sampling adequacy	Bartlett's test of sphericity		
	Approx. Chi-Square (x^2)	df	Sig
0.845	10605.693	780	0.000

Table 2. Total variance explained

Component	Rotation Sums of Squared Loadings		
	Eigenvalue	Percentage of Variance	Cumulative Percentage
1	7.528	18.820	18.820
2	6.875	17.188	36.007
3	3.028	7.571	43.578
4	2.368	5.921	49.499
5	1.718	4.295	53.794
6	1.617	4.043	57.836
7	1.594	3.986	61.822
8	1.261	3.152	64.974
9	1.236	3.090	68.064

Table 3. The number of items in each component

Component	Items
1	7, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24
2	25, 26, 27, 28, 29, 30, 31, 33, 34, 35, 36, 37, 39, 40
3	8, 9, 10, 11, 13
4	2, 3, 4
5	1, 5, 6

Table 4. Component 1 "Effects"

Items	Item Label	Factor Loading	Ranking
17	Biological diversity and the decrease of marine life in water sources	0.824	1
18	The declining numbers of "fireflies" was an indicator of an incomplete ecosystem	0.817	2
22	Negatively affecting a community's quality of life	0.760	3
24	Insufficient food sources for living organisms	0.744	4
19	The endangerment of manta rays	0.743	5
23	Changes in local people's lifestyles and occupations	0.735	6
21	Changes in the colors of the water and high turbidity in natural water sources	0.719	7
12	Expansion of urbanism and tourism	0.659	8
14	Low water conditions in rives	0.641	9
16	Contaminating water sources with wastes released from households	0.571	10
15	Industrial, livestock, fisheries, and other places with high risks of polluting water sources	0.570	11
7	The degradation of coastal resources	0.565	12
20	Vanishing profession of sugar production from coconut and aquacultures	0.471	13

water resources and eliminating weeds and water hyacinth in rivers to help reduce water pollutants. In addition, this component could eventually be used to describe the variance value of community knowledge on water resources management, which was equivalent to 17.188%. When this variance value was compared with the eigenvalue and the other four components, this component was ranked second.

In Table 6, "Causes" describes the five variables mentioned above with factors weighing between 0.437 and 0.697, eigenvalues of 3.028, and a variance percentage of 7.571. Based on these results, it could be concluded that all five variables were useful for describing the component. In particular, the ninth variable, referring to the increase in population in the community, was ranked last because it had the lowest correlation with the component. As mentioned in Khatun (2017), water resources problems could result from different causes, but for the Murshidabad area where the research was conducted and that is located at the most northern district in the West Bengal State, India, the most critical causes of water pollution are the release of waste from agricultural sectors rather than the industrial sectors. It could be assumed from the case that population density was not the most important factor in creating water pollution. Moreover, this component could eventually be used to describe the variance values of community knowledge

Table 5. Component 2 "Solutions"

Items	Item Label	Factor Loading	Ranking
34	Elimination of weeds and water hyacinth in rivers	0.790	1
35	Digging an irrigation ditch in one's own area	0.782	2
27	Promoting ecotourism	0.771	3
29	Knowledge of the "three-water" ecosystem	0.743	4
26	Organic agriculture, reduction of chemical use	0.689	5
30	Preservation of river banks and growing more trees	0.679	6
31	Promoting aqua-tourism and agro-tourism	0.665	7
40	Practicing the economic philosophy of sufficiency on water usage	0.638	8
28	Promoting tourism conservation	0.628	9
36	Encouraging the implementation of local knowledge to water resources management	0.597	10
33	Promoting and supporting participation of the community in water resources management	0.596	11
37	Initiating water treatment before releasing it to water sources	0.584	12
25	Segregation of waste and installation of septic tanks in households	0.509	13
39	Construction of bamboo walls to reduce the impact of erosion by water waves	0.478	14

Table 6. Component 3 "Causes"

Items	Item Label	Factor Loading	Ranking
10	Water pollution created by motor boats and cargo ships	0.697	1
13	Water encroachment	0.670	2
8	Water waste from households	0.571	3
11	Wastes and garbage thrown into the rivers	0.542	4
9	Increase of population in the community	0.437	5

Table 7. Component 4 "Importance"

Items	Item Label	Factor Loading	Ranking
2	Agricultural, including plantation and livestock, water sources for marine life such as fish	0.800	1
3	Important transportation routes to date, such as rivers and canals	0.741	2
4	Tourist attractions with fresh and clean water	0.722	3

on water resources management, which was equivalent to 7.571%, and when this variance value was compared with the eigenvalue and the four other components, this component was ranked third.

In Table 7, "Importance" describes the three variables mentioned above that possessed a factor loading ranging between 0.722 to 0.800, eigenvalues of 2.368, and a variance percentage of 5.921. Based on these results, it could be concluded that all three variables were considered useful for describing the component. In particular, the second variable referring to plantation, raising livestock, and water sources for marine life, such as fish and others, corresponded to the sustainable development of water resources, and as such, water resources were considered to be vital and to benefit humans by its contribution to agriculture, livestock water sources, and others. Therefore, water resources, as the heart of development, were proposed to be known as central to the development of civilization by Gopal and Agarwar (2003). The fourth variable, which consisted predominantly of tourist attractions with fresh and clean water, was ranked last as it had the lowest correlation with the component, and this result complemented the work of Kim (2002), who found that tourism did have effects on the community; tourism creates a great deal of pollution that may affect landscapes and eventually cause critical problems for the people in the community. Furthermore, this component could be used for describing the variance (5.971%) of community knowledge about water resources management; when this variance was compared with the eigenvalue and the four other components, this component was ranked fourth.

4. Conclusions

In this research, a framework was used to present the conclusion because the framework is appropriate for the community in Samut Songkhram Province of Thailand and helps the reader easily understand and apply the results. The result is efficiency for a specific community; consequently, the next study should focus on the differences in community context, type of terrain, and duration. A knowledge framework towards water resources management for a community was created using the results from the analysis of the problems of community knowledge regarding the LFA in the form of a problem tree, and the results of the community knowledge regarding water resources management were analyzed by implementing an EFA, an approach that can be applied to those elements to determine the priority of problem-solving. Thus, the assumption of the framework on the knowledge towards water resources management of the community in Samut Songkhram Province could be concluded through “E-SCI Knowledge”. E knowledge (Effects) represents the factors that affect the community and its environment, S Knowledge (Solutions) represents ways of resolving water resources management problems, C Knowledge (Causes) represents the factors that lead to difficulties regarding water resources in the community, and I Knowledge (Importance) represents the importance of water resources to the community. The results of this study would be applied to participatory, two-way communication between water resources management specialists and the community as well as between water resources management scholars and the community, using researchers as a medium to gather ideas and create a concrete method to communicate information about water resources management in the Samut Songkhram Province of Thailand. The method described here might be carried out with Berlo’s model of communication using the SMCR model (Berlo, 1960), where specialists in the community, scholars, and the community itself (S-Source) act as transmitters of E-SCI Knowledge (M-Message) through learning media (C-Channel) to the community (Receiver) and assess the results (Feedback). To complete the elements of communication, communication must occur between the sender and the receiver, which is called two-way communication, as shown in Figure 5. The method aimed to develop a strategic model for the community’s learning to promote a sustainable coexistence between people and nature. For the recommendations of this study, learning media about community water resources management should be provided and taught to the participants of the study to enhance proper understanding and further application to other types of resources and for sustainable support of the learning process of the community itself in the future.

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