Developing Water Management Model: Chi River Basin, Northeast Thailand

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A R T I C L E I N F O

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A B S T R A C T

Regarding the workshops for creating the twenty-year water resource management master plan: Chi River Basin, on September 2019 established by the Office of the National Water Resource, it has provided 37 approaches to manage the water from the Chi River within short and long terms. The purpose of this study aims to test and offer the water management model for the Chi River Basin by using confirmatory factor analysis (CFA). Three possible CFA models were compared through AIC and BIC values. The data was collected from 385 respondents. As a results, the final model includes twenty-seven water management approaches: twenty-four short-term approaches and three long-term approaches. The findings suggest that in the short term, the government mainly needs to set a systematic water management plan, set up a department and its committees for direct responsibility, and provide a budget to restore the river. Also, it is important to support the approaches offered in the model to maintain the river source and ensure that the people will have quality water to use sustainably. Therefore, in the long term, beside preserving and increasing the forest zone around the river head, the government should provide innovative wastewater treatment plants and water pumping systems.

1. INTRODUCTION

The Chi, the longest river in the country with a length of 765 kilometers, is the most important river of the Northeastern region of Thailand (Isan region). Its origin is on the Phetchabun mountain range, located in the Chaiyaphum province and it flows down along the east of the country to reach the Mun River at Ubon Ratchathani province [1]. According to twenty-year water resource management master plan for the Chi River, its flow path mainly covers seven northeast provinces: Chiyapoom, Kalasin, Khon Kaen, Maha Sarakham, Roi Et, Ubon Ratchathani, and Yasothon [2]. It, however, has a total watershed area of 49,273.86 square kilometers. Most of the watershed area is in 15 provinces of Northeast Thailand. Furthermore, the water from the Chi River is maintained and utilized in three key dams: Ubol Ratana, Chulaphon, and Lam Pao [3]. The Chi River is the main source of water for the people living on the Chi River Basin to use; however, these people have long experienced problems; for example, a lack of water resource because of droughts or a lack of reservoirs, inundations, an increase of chemical waste in the Chi River, and recurrent floods and droughts [2]. Severe flooding of the Chi River has occurred frequently. Based on historical data, significant inundations were not only in 1978, 1980, 1995, 2000, and 2001 [4] but also until recurrently 2017 [5] and 2019 [6]. The Chi River Basin has been heavily affected by floods for a long time [4]. The Kasikorn research center reported that the inundations in 2017 affected the large areas in many Northeastern provinces and caused economic loss, a total of 15,725 million baht or about 0.10% of GDP. The agricultural lands were worst hit, along with the commercial, industry sector and service sector [5]. The flood crisis in 2019 damaged agricultural areas, livestock, fisheries, transport infrastructure, and industry in the Northeast provinces, a total of 8,000 million baht. In a 20- year circle, this is the most of an estimated loss as the largest agricultural lands damaged, and recurrently most of the areas are on the Chi River Basin [6]. Unfortunately, it is alternating between floods and droughts for the Northeast people living on the Chi River Basin. Since the 2011 dramatic flood, the Northeastern region has also been impacted by droughts back-to-back. In 2016, after the dry season of the El Nino period, the northeast people reexperienced intense rainfall and flooding [7]. Flooding and drought related news are easy to find. In 2019, the New18 reported that Chiyaphum province declared the province's worst drought crisis in 30 years [8]. The water in the Chi River was dry more than 100 kilometers of the distance, intermittently, with no water flowing into the canal branches. Many villagers in Chiyaphum province have tried to store water for consumption and use until the next coming of rainfall [8,9]. Irrigation has managed water by draining 400,000 cubic

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meters of water from Lahan Lake to the Chi River to prevent the villagers from having a shortage of water; however, this may not be enough during the dry season. Also, the municipality has consequently needed to use water from Lam Pa Thao reservoir [9]. The villagers on the banks of the Chi River, connecting Chaiyaphum and Khon Kaen provinces, has been suffering due to running out of water and rice fields now infertile for more than 2,080,000 square meters (1,300 rai); therefore, a long-distance pump with a capacity of 3,000 cubic meters with 8,000 liters per minute has been installed by the district officers in order to pump water from the Chi River to fill in the water reservoirs for the village waterworks. In fact, the water level in the Chi River was very low and less every year; thus, the water used for consumption and agriculture has been exhausted [10]. In the same year, the Yasothon province also encountered the worst drought of the Chi River in 20 years; consequently, the governor needed to request the water from the Lampao dam which took a week to reach the 3 medium-sized reservoirs of Yasothon and the mass of water would be reduced about 30% [11]. Repeatedly, the Northeastern people experience a flood situation covering 6 provinces: Roi Et, Maha Sarakham, Ubon Ratchathani, Amnat Charoen, Yasothon, and Mukdahan. The flooding has damaged up to 52 routes [12]. Presently, the Northeastern people are suffering from a flood situation. Matichon Online's news reports that the Chaiyaphum are suffering due to the worst flood ever in 50 years [13]. In some areas, the water is 5 meters in height. Thousands of people are waiting for help as they are trapped in those areas. Patients in the hospital also need to be moved out as the water spilled into it. However; the large mass of water flows out to the Nakorn Ratchasima province. Also, it has continuous heavy rainfalls and its flooded roads are completely cut off due to the large mass of water. Thus, the governor team needs to not only provide pumps to release the water to available reservoirs, but increase floodways, divisions, or levees also [14]. It seems that the problems of floods and droughts in the Northeastern region, especially on the Chi River Basin have never ended.

The Office of the National Water Resource established the consortium about the Chi River's problematic issue on 4-5 August 2020 which a total of 585 people consisting of the related government and non-government representatives, community leaders, farmers, and the villagers associated with water-resource management were invited. The data of 355 collected from the meeting showed that around 90% of the respondents experienced drought situations, both in dry seasons (89.58%) and rain seasons (64.51%). Also, around 86% of the respondents encountered floods [15]. The Office of the National Water Resource, Regional Office 3 established the workshops for creating the twenty-year water resource management master plan (2561-2580): Chi River Basin, 2020-2022 fiscal year, on 5-6 and 16-17 September 2019 [2]. The invited members including the Chi River Basin committee, the representatives from local administration organizations, and the representatives from other related public and private sectors are gathered for brain-storming. As the results, the twenty-year water resource management master plan (2561-2580) for the Chi River Basin provides 37 approaches to manage the water from the Chi River and they are applied into this research as 37 indicators.

The purpose in this study aims to provide the water management model best fit for the Chi River Basin by comparing CFA models, confirmed by Akaike Information Criterion (AIC) and Bayesian Information Criteria (BIC) with six goodness of fit criteria. The AIC and BIC can be commonly used to compare the relative fit of the models, regardless of whether the models are nested or not [16]. The final/selected model also reveals the key indicators of water management for the Chi River Basin. The policy makers and local leaders can opt for the final model to manage Chi's water or other similar water sources. These would be beneficial for the people living on the Chi River Basin.

2. LITURATURE REVIEW

2.1. Theorical concepts

The conceptual framework in this study is based on the integration of three related theories. The tragedy of the commons firstly purposed by William Forester Lloyd in 1833 [17]. The underlying concept is related to common resources such as a water resource, mountain, or natural fields. They are open access; thus, all can claim to utilize them, based on rational choice theory without uncoordinated actions. The depletion of the common resource leads to "the tragedy of the commons". G. Hadin (1968) [18], E. Ostrom (1990) [19], and S. J. Lansing (2006) [20] embrace this concept and purpose the solution. To avoid over-exploitation of common resources and depletion, private or government ownership is the key. Another theory of the logic of collective action offered in 1965 by M. Olsen [21] in "the logic of collective action: Public goods and the theory of groups". A group needs collective actions and incentives to succeed its goal; however, each group may frequently include free riders. The third concept of network governance is the approach to collect and distribute information or problems via agents [22]. The network governance is characterized by informal social systems [23]. The cooperation among a government organization, non-governmental organization (NGO), private sector, or international institutions is a form of network governance management [24].

2.2. Related previous research

In the past forty years, scholars have attempted to understand and solve the tragedy of the commons. The study [25] examines three cases in the USA: the governance of the radio spectrum, establishment of Yellowstone National

Park, and western water law. The tragedy of the commons provides a vivid explanation for continuous exhaustion of the river source. The research [26] analyses a case of Jinhua River. It suggests the government not only exploit planning and price mechanisms but also manage river property rights, transection cost, and compensation systems. This is essential as resources are excessively used. An accepted approach to maintain the sustainable exploitation of common-pool resources (CPRs) is a collective action management. Its explanation is presented through a case of the Irish fishermen who are impacted from the expansion of commercial finfish farms [27]. The world commission on dams, the global environmental facility, the Kyoto protocol, and the United Nations global compact are the successful examples of a network governance management [24]. Overall, the network governance management with a collective action approach alleviates the tragedy of the commons.

As recurrent floods and back-to-back droughts on the Chi River Basin, Northeast Thailand related to the issue of the common resource, the office of the national water resource, regional office 3 employs network governance management with collective action by bringing 197 Chi-River networking members to establish the approaches for the Chi-River-Basin water management stated in the current twenty-year water resource management master plan (2018-2037). By the means of such qualitative research, the master plan concludes 37 approaches of water management [2] categorized into two groups: 28 short-term (1-5 years) and nine long-term (6-20 years). Those approaches applied into this quantitative study to statistically confirm as presented in Fig. 1. below:

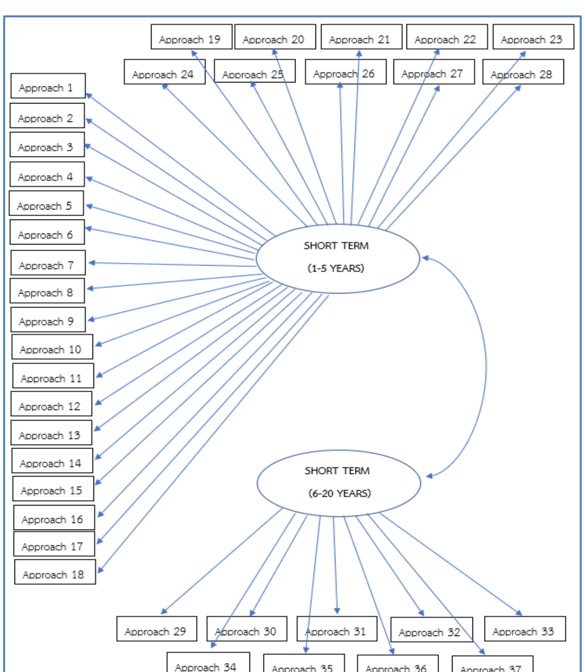

Fig. 1. Conceptual framework of water management.

Research hypothesis (H1): To compare CFA models based on the collected data, the model fits of the CFA models are not equivalent.

3. METHODOLOGY

3.1. Research design

The current research is quantitative and employs a cross-sectional survey design, to collect data at one time, using questionnaires. The statistics tool of Confirmatory Factor Analysis (CFA) is used to test if the offering model fits well with the collected data. The study opts for the two criteria of AIC and BIC for comparing the CFA models [28], [32] and six fit indices as shown in Table 1.

Table 1. Goodness of fit

Fit criteria	Level	Source
Ratio of chi-square (x^2)/(df)	<3.00	
Comparative fit index (CFI)	>.90	[29]
Normed-fit index (NFI)	>.90	[29]
Goodness-of-fit (GFI)	>.90	[29]
Root-mean-square error of approximation (RMSEA)	<.07	[29]
Standardized root mean square residual (SRMR)	<.08	[29]
Akaike Information Criterion (AIC)	Lowest	[16, 29]
Bayesian Information Criterion (BIC)	Lowest	[16, 29]

3.2. Delimitations

The study is delimited to the Chi River Basin; therefore, it focuses on the seven Northeast provinces, Thailand, associated with the Chi River Basin effects: Chiyapoom, Kalasin, Khon Kaen, Maha Sarakham, Roi Et, Ubon Ratchathani, and Yasothon [2].

In identifying the benefits of rapid turnaround and economy of design, this study is delimited to administering a survey design with self-reported measures [31].

This research examines one key latent variable "water management" with 37 observed-variable indicators [2] that are separated into two groups/factors (Short term-ST and Long term-LT). The ST factor includes 28 observed-variable indicators and the LT factor has 9 observed-variable indicators.

The data of this study was collected in November 2021.

3.3 Population and sample

The population in this study are the people who live on the Chi River Basin and are affected by the disaster from the Chi River. By calculating from the population in each of the districts which the Chi River passes by, it is roughly a total of 3,958,091 people [33]. According to Krejcie and Morgan table (1970), the population exceeding one million people requires at least 384 representatives for the sample size [34]. The data collected in this study is 385 as the sample size.

3.4. Instrumentation

The instrument in this study was initially processed by a focus-group, qualitative research technique [2]. The instrument in this research was approved by the IRB of Udon Thani Rajabhat University on 11 November 2021; however, it was developed through a pilot test process with launching 30 initial questionnaires. As a result, wording in each item is checked if it maintains the same meaning and is easy to understand for the participants. Mainly, Cronbach's alpha values need to be examined and confirm its internal consistency reliability. The alpha value of the short-term latent variable gains .956 and the alpha value of the long-term latent variable is .845. Its value should exceed .70 [35].

The self-administered paper questionnaire includes a total of 44 items, composed of three sections: demographic data in section 1, two factors/latent variables in section 2, and two-open-ended questions in section 3. All of the items in section 2 were evaluated on six-point Likert type scale ranging from 1 "strongly disagree" to 6 "strongly agree" [32]. The section 3 is the optional answer.

3.5 Data collection

To ensure the sample was representative of the population, the three research networking teams lived in different provinces. They separately traveled to all of the seven Northeast provinces to collect data by administering a convenience sample technique. The data of 385 completed questionnaires was gathered and sent to the researchers.

Table 2. Items of short-term water management measure

Name	Item detail
ST1	To build breakwaters to protect the river banks.
ST2	To increase the ground water levels.
ST3	To install a water distribution system.
ST4	To preserve the forest around the river head.
ST5	To have one organizational center to manage a whole water system.
ST6	To empower the related laws.
ST7	To develop an application software for water management.
ST8	To install a flood warning system.
ST9	To raise environmental awareness.
ST10	To allocate crops suitable to land plots.
ST11	To decrease invasiveness into the river.
ST12	To set a systematic water management plan.
ST13	To clearly limit the river bank borders.
ST14	To change the laws and procedures not consistent with water management approaches.
ST15	To increase irrigated areas.
ST16	To make the government's water management approaches consistent with the community's one.
ST17	To provide a chance for the people in the area to participate in the management of the river water.
ST18	To provide water management approaches suitable to area context.
ST19	To update water information efficiently.
ST20	To set up a committee for managing the river and its branches.
ST21	To encourage the people to have discipline and a sense of belonging.
ST22	To set a fund for restoring the river.
ST23	To support the group of farmers and other water users to be stronger.
ST24	To support organic agriculture.
ST25	To support the people to grow groundcover.
ST26	To enforce the related laws and taxation of polluted water.
ST27	To set up a department to follow up, examine, and assess water quality by using effective tools.
ST28	To enforce the intruders of the river's forest origin.

Note: ST1-ST28 = the 28 approaches of short-term water management.

Table 3. Items of long-term water management measure

Name	Item detail
LT1	To divert the water from other rivers such as the Khong and Loi Rivers into the Chi River.
LT2	To increase the areas of water detention basins.
LT3	To increase water collection capacity around the river head.
LT4	To increase the amount of water held in revisors.
LT5	To establish more dams, water revisors, and check dams.
LT6	To establish the sluices of the Chi River.
LT7	To preserve the forest around the river head and increase the size of the national parks, with the purpose to control the speed of the river.
LT8	To create innovations such as solar powered wastewater treatment plants or water pumping systems.
LT9	To build water treatment plants in communities located next to the Chi River banks.

Note: LT1-LT9 = the 9 approaches of long-term water management.

3.6 Data analysis

It is divided into three parts: data screening, demographic data, and comparisons among confirmatory factor analysis models. Firstly, the data are explored to check for missing data, outliers, and basic assumption of normality. Next, the demographic data of the sample to be described through the use of descriptive statistics. Lastly, the CFA models are compared. The CFA model selected must be validated by CR and AVE values as well as Cronbach' alpha [32], [36]. The CR and AVE should be higher than .50 [37], [38]. The AMOS software does not directly provide CR and AVE values; however, they can be computed through the application of these formulas [37]:

$$CR = \frac{(\text{sum of standardized loading})^2}{(\text{sum of standardized loading})^2 + \text{sum of indicator measurement error}}$$

$$AVE = \frac{\text{sum of the squared standardized factor loadings}}{\text{sum of the squared standardized factor loadings} + \text{sum of indicator measurement error}}$$

The fit criteria in this study represents a good fit of the final model [32], [36-37]. For modifying the model, a factor loading of less than .60 should be excluded [38]. If its value is higher, that indicates less error [38].

4. RESULTS

4.1. Data screening

The valid total number of all observed variables is 385. No missing value found is checked by using a frequency function in SPSS. The outliers of all quantitative observed variables, including Likert-scale variables are checked by using a leaf and stem tool and boxplots. Also, the data has no extreme outlier. The normality assumption can be examined by skewness and kurtosis values as multivariate normality is difficult to test [28], [32]. Skewness values should not be less/more than ±2 and kurtosis values should not be less/more than ±7 [39]. The skewness and kurtosis in this study do not violate the normality assumption. Table 4 below statistically describes all of Likert's scale variables.

Table 4. Descriptive statistics of observed variables

Variable	Min	Max	Average (SD)	Skewness	Kurtosis
ST1	1	6	5.37 (.85)	-1.80	4.39
ST2	1	6	4.77 (1.25)	-1.39	1.81
ST3	1	6	5.30 (.78)	-1.46	4.12
ST4	1	6	5.38 (.77)	-1.59	4.66
ST5	1	6	5.34 (.79)	-1.12	1.54
ST6	1	6	5.21 (.93)	-1.54	3.59
ST7	1	6	4.82 (1.15)	-1.14	1.38
ST8	1	6	5.40 (.76)	-1.34	2.62
ST9	2	6	5.37 (.74)	-.98	.62
ST10	1	6	5.20 (.85)	-.97	1.08
ST11	1	6	5.37 (.81)	-1.94	6.47
ST12	1	6	5.35 (.81)	-1.52	3.77
ST13	1	6	5.29 (.79)	-1.37	3.15
ST14	1	6	5.25 (.91)	-1.36	2.11
ST15	1	6	5.22 (.99)	-1.98	5.29
ST16	3	6	5.39 (.76)	-1.14	.78
ST17	3	6	5.34 (.73)	-.83	.05
ST18	1	6	5.29 (.76)	-1.16	2.44
ST19	1	6	5.24 (.86)	-1.49	3.65
ST20	1	6	5.22 (.89)	-1.58	4.15
ST21	1	6	5.35 (.76)	-1.13	1.97
ST22	1	6	4.90 (1.31)	-1.32	1.14
ST23	2	6	5.24 (.83)	-.85	.07
ST24	2	6	5.09 (.96)	-.86	.07
ST25	1	6	5.30 (.90)	-1.36	2.03
ST26	1	6	5.09 (1.20)	-1.49	1.95
ST27	1	6	5.30 (.86)	1.96	6.44
ST28	1	6	5.35 (1.01)	-1.88	3.85
LT1	1	6	4.48 (1.80)	-1.02	-.39
LT2	1	6	4.80 (1.35)	-1.15	.67
LT3	1	6	4.68 (1.39)	-1.07	.57
LT4	1	6	4.75 (1.31)	-1.03	.56
LT5	1	6	4.69 (1.43)	-.94	.00
LT6	1	6	5.00 (1.20)	-1.08	.39
LT7	1	6	5.34 (.86)	-1.47	2.49
LT8	1	6	5.33 (1.03)	-1.98	4.43
LT9	1	6	5.24 (1.13)	-1.96	3.96

4.2. Demographic data

Regarding the information from the five demographic data questions for the sample, male and female percentages are almost equal. The average age is about 51 years old, ranging from 18 to 82 years. Half of the sample holds the highest degree lower than M6 (53.20%). Most of them are farmers (45.70%) and self-employed people (23.40%). Also, most of their incomes are less than 10,000 baht per month. In fact, 37.70% of the sample participants earn 5,000 baht and lower, and 30.10% is between 5,001 and 10,000 baht.

Table 5. Demographic data of the sample

Demographic data	Number	Percent
Gender	385	100
Male	187	48.60
Female	198	51.40
Age: Average = 50.63 (13.23), Range = 18-82		
Highest degree	385	100
Lower than M6	205	53.20
M6 or equal	89	23.10
Diploma	28	7.30

Bachelor	56	14.50
Master	6	1.60
Doctoral	1	.30
Career	385	100
Unemployed	37	9.60
Farmer	176	45.70
Self-employed	90	23.40
Employee in private sector	37	9.60
Employee in public sector	28	7.30
Civil servant	17	4.40
Income/month	385	100
5,000 and lower	145	37.70
5,001-10,000	116	30.10
10,001-15,000	51	13.20
15,001-20,000	17	4.40
20,001-25,000	9	2.30
25,001-30,000	27	7.00
30,001-35,000	14	3.60
More than 35,000	6	1.60

4.3. Confirmatory factor analysis models (CFA models)

The initial CFA model includes 37 observed variables for two factors/constructions. The short-term factor (ST) contains 28 variables and the long-term factor (LT) consists of nine variables.

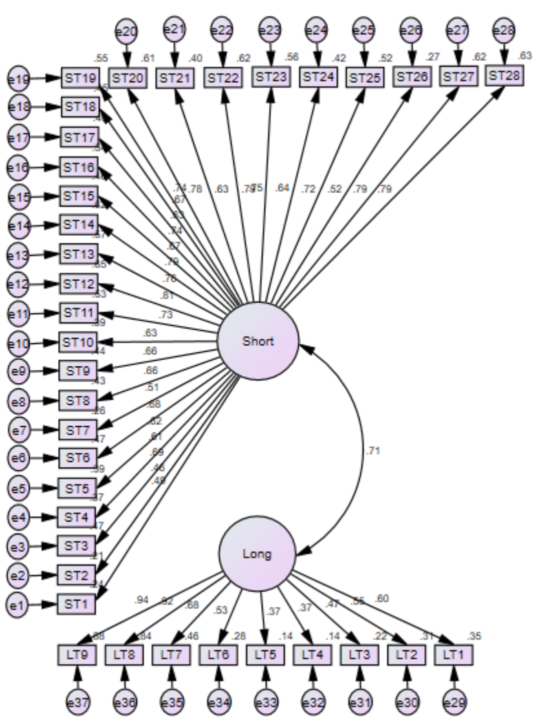

Fig. 2. Initial CFA model (Model 1).

The factor loadings lower than .60 would be excluded, shown in Table 6. As the results, four short-term variables are excluded (ST1-ST2, ST7, ST26) and six long-term variables are taken out (LT1-LT6).

Table 6. Factor loadings of CFA models

Initial model			Revised model
Variable	**Factor loadings**	**Decision**	**Factor loadings**
ST1	.492	Excluded	-
ST2	.459	Excluded	-
ST3	.686	-	.677
ST4	.609	-	.604
ST5	.621	-	.620
ST6	.684	-	.675
ST7	.512	Excluded	-
ST8	.659	-	.658
ST9	.662	-	.663
ST10	.625	-	.618
ST11	.727	-	.726
ST12	.807	-	.807
ST13	.756	-	.753
ST14	.786	-	.782
ST15	.675	-	.671
ST16	.736	-	.739
ST17	.635	-	.640
ST18	.671	-	.676
ST19	.741	-	.740
ST20	.781	-	.778
ST21	.629	-	.631
ST22	.788	-	.786
ST23	.746	-	.745
ST24	.645	-	.641
ST25	.720	-	.720
ST26	.520	Excluded	-
ST27	.789	-	.785
ST28	.793	-	.791
LT1	.595	Excluded	-
LT2	.553	Excluded	-
LT3	.472	Excluded	-
LT4	.370	Excluded	-
LT5	.369	Excluded	-
LT6	.525	Excluded	-
LT7	.679	-	.663
LT8	.917	-	.911
LT9	.937	-	.963

The initial CFA model excluded 10 observed variables (four ST and six LT variables) is presented as the revised CFA model (Model 2), shown in Fig. 3.

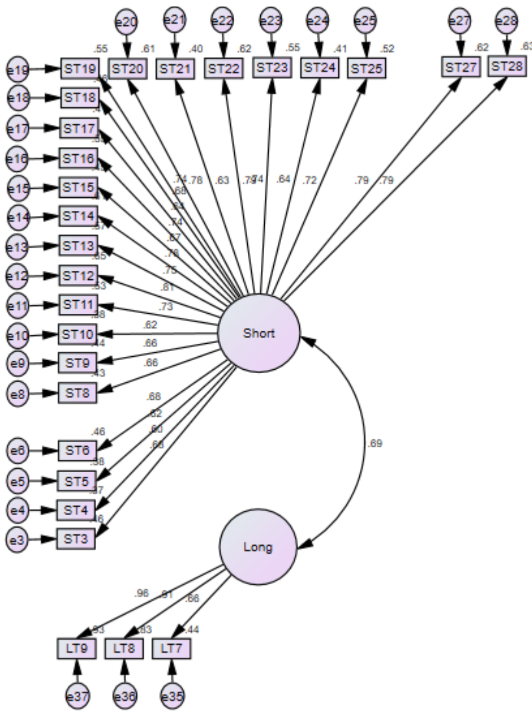

Fig. 3. The Revised CFA model (Model 2).

Table 7 illustrates the comparisons of fit criteria for all CFA models. The revised CFA model (Model 2) provides better goodness of fit values and the AIC and BIC values are lower as presented.

Additionally, the modification indices (MI) provided by AMOS program suggest that most error terms are correlated as they are related in their activities and may have similarity of meanings. The revised CFA model with correlated error terms suggested by MI equals Model 3 as shown in Fig. 4 below:

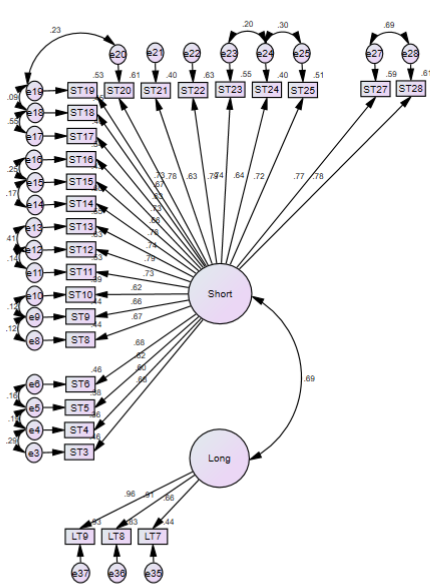

Fig. 4. The model 2 with MI (Model 3).

Table 7. Comparisons of fit criteria

Fit criteria	Model 1	Model 2	Model 3
(x^2)/df	4.39	4.93	3.44
CFI	.74	.81	.89
NFI	.69	.77	.85
GFI	.64	.70	.80
RMSEA	.10	.11	.08
SRMR	.07	.07	.06
AIC	**2911.04**	**1706.82**	**1202.54**
BIC	**3188.26**	**1909.12**	**1461.03**

Table 8. Factor loadings, validity, and reliability of the final CFA model

Variable	Factor loadings	AVE	CR	Cronbach's alpha
Short-term Factor		*.53*	*.99*	*.95*
ST3	$.678^{***}$			
ST4	$.601^{***}$			
ST5	$.619^{***}$			
ST6	$.678^{***}$			
ST8	$.666^{***}$			
ST9	$.663^{***}$			
ST10	$.624^{***}$			
ST11	$.725^{***}$			
ST12	$.794^{***}$			
ST13	$.743^{***}$			
ST14	$.777^{***}$			
ST15	$.656^{***}$			
ST16	$.734^{***}$			
ST17	$.630^{***}$			
ST18	$.673^{***}$			
ST19	$.731^{***}$			
ST20	$.779^{***}$			
ST21	$.633^{***}$			
ST22	$.793^{***}$			
ST23	$.744^{***}$			
ST24	$.636^{***}$			
ST25	$.717^{***}$			
ST27	$.771^{***}$			
ST28	$.779^{***}$			
Long-term Factor		*.73*	*.89*	*.88*
LT7	$.663^{***}$			
LT8	$.912^{***}$			
LT9	$.962^{***}$			

Note: $^{*}p<.05$, $^{**}p<.01$. $^{***}p<.001$.

By comparing the AIC and BIC values, the CFA model 3 provides the lowest values. Furthermore, it's goodness of the six fit indices: (x^2)/df, CFI, NFI, GFI, RMSEA, and SRMR also provides the values closest to the acceptable levels. Therefore, the model 3 is selected as the final CFA model.

The AVE values higher than .50 confirms the convergent validity of the final model. The CR value presents its composite reliability and Cronbach's alpha provides its consistency reliability.

Table 9. Discriminant validity of final CFA model

Factor/Latent variable	ST	LT
Factor 1: ST	.53	
Factor 2: LT	.48	.73

Note: The diagonal elements are the average variance extracted. The off-diagonal elements are the square correlations between factors.

5. DISCUSSIONS

According to the results in Table 7., the Model 3 composed of the rest of 24 ST variables and three LT variables provided the lowest AIC and BIC values. This suggested that the Model 3 is the most suitable fit to the data collected in this study. Although, the initial total of 37 water management approaches (observed variables) were the results from the brainstorming of the representatives from the public and private sectors, not all of them are agreed by the people living on the Chi River Basins. It is important that the government allow the people in the communities to participate in modeling the water management or it will be useless/ineffective. Ten approaches (observed variables) were omitted: From that perspective, in short term (1-5 years), building breakwater to protect the river banks, increasing the ground water levels, developing an application software, or enforcing the related laws and taxation of polluted water cannot be effective solutions. Instead, the significant water management approaches respectively should be:

1. To set a systematic water management plan (.794).
2. To set a fund for restoring the river (.793).
3. To set up a committee for managing the river and its branches (.779).
4. To enforce the intruders of the river's forest origin (.779).
5. To change the laws and procedures not consistent with water management approaches (.777).
6. To set up a department to follow up, examine, and assess water quality by using effective tools (.771).
7. To support the group of farmers and other water users to be stronger (.744).
8. To clearly limit the river bank borders (.743).
9. To make the government's water management approaches consistent with the community's one (.734).
10. To update water information efficiently (.731).
11. To decrease invasiveness into the river (.725).
12. To support the people to grow groundcover (.717).
13. To install a water distribution system (.678).
14. To empower the related laws (.678).
15. To provide water management approaches suitable to area context (.673).
16. To install a flood warning system (.666).
17. To raise environmental awareness (.663).
18. To increase irrigated areas (.656).
19. To support organic agriculture (.636).
20. To encourage the people to have discipline and a sense of belonging (.633).
21. To provide a chance for the people in the area to participate in the management of the river water (.630).
22. To allocate crops suitable to land plots (.624).
23. To have one organizational center to manage a whole water system (.619).
24. To preserve the forest around the river head (.601).

In long term (6-20 years), the people view that the establishment of dams, water revisors, or the similar things to store more water is not a good idea. Rather, these three water management approaches are the sustainable keys:

1. To build water treatment plants in communities located next to the Chi River banks (.962).
2. To create innovations such as solar powered wastewater treatment plants or water pumping systems (.912).
3. To preserve the forest around the river head and increase the size of the national parks, with the purpose to control the speed of the river (.663).

6. CONCLUSIONS AND RECOMMENDATIONS

In sum, this study is offering the water management model with 24 short-term approaches and three long-term approaches, confirmed by the data collected from the people who live on the Chi River basin. The offered model mainly suggests in short term, the government needs to set a systematic water management plan, set up a department and its committees to directly take responsibility for the water management from the Chi River, and provide a fund or a budget to restore the river water source. Also, it is important to support the water management approaches in the model to maintain the river source and ensure that the people will have quality water to use sustainably. Therefore, in long term, beside preserving and increasing the forest zone around the river head, the government should provide innovative solar powered wastewater treatment plants and water pumping systems.

Additionally, the findings recommend the government or policy makers allow the people to participate in the water management and future research may apply the offering model to other natural water sources.

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