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The mediating effect of effective decision making on the design of water resource management ICT model: The case of the management of Lake Victoria Basin

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Partial Least Square-Structural Equation Modelling (PLS- SEM) technique was employed to evaluate the mediating effects of effective decision making on water resource management policies and water resource management frameworks in the design of water resource management ICT model for an integrated water resource management of Lake Victoria Basin (LVB). Researchers took a quantitative approach using smart-PLS version 3. The sample size of 152 respondents was computed from a population size of 245 persons across districts within LVB. This study received feedback from different experts involved in the management of water resources in LVB. The findings of the study discovered that water resource management policies and water resource management frameworks are significant and had positive effects on the design of water resource management ICT model when subjected to a mediation of effective decision making. The three exogenous latent constructs without mediation wholesomely explained 39.1% of the variance (R^2) in the design of water resource management ICT model and 41.4% under the influence of a mediation. This study confirmed that effective decision making had a positive mediating effect in the relationship between the exogenous and endogenous variables. These findings can support practitioners and water managers engaged in the management of water resources in LVB and other water bodies elsewhere in the world.

Key words: ICT model, Lake Victoria Basin, PLS-SEM, integrated water resource management.

INTRODUCTION

The riparian countries that border Lake Victoria are Uganda, Kenya, Tanzania, Rwanda and Burundi (Odongtoo et al., 2018; Mongi et al., 2015). The lake basin provides major natural resources that are heavily utilized by its bordering countries for fishing, transportation, tourism, water supply and waste disposal among others (Dauglas et al., 2014; Linuma and Tenge, 2017).

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The regions have experienced a process of rapid urbanization with intensive economic activities over the years. These urbanization is at a rate of 3% per year, which is causing land pressures, depletion of natural resources and poor disposal of dangerous waste into the lake (Bakibinge et al., 2011).

There have been some worries that some countries within LVB are using the water resources without consideration of sustainability (UNDP, 2007). This ideally calls for better management mechanisms for water resources in LVB. The challenges require innovative responses, particularly in terms of policy strategies and decision-making processes that enhance the capacity of local people to adapt to new conditions (IPCC, 2007). There must be a strong system that enforces by laws and regulations that are harmonized nationally and regionally (Okurut, 2010). In this case, it is necessary to employ an effective water resource management ICT model that can enhance communication, information sharing and enforcement of laws in the management of water resources in LVB (Odongtoo et al., 2019).

LVB needs an integrated water resource management (IWRM) which is a process that helps in formulating and implementing a shared vision, planning and management strategies for sustainable water resources utilization (Mongi et al., 2010). This is done with due consideration of all spatial and temporal interdependencies among natural processes and water uses. In order to support planning and management decision, we need knowledge in various discipline such as climatology, hydrology, socioeconomic, environmental science and agro-science from various stakeholders, so as to make critical decisions that reflects shared vision for water resource utilization. Public policy actors can develop consensus and decide on shared vision strategies based on information generated and communicated by decision support systems (DSS) such as water resource management ICT model (Mongi, et al., 2015).

IWRM has a global approach to promote the coordinated development and management of water, land and related resources in order to optimize socio-economic welfare in an equitable manner without compromising the sustainability of vital ecosystems (Mwangi et al., 2014). It requires all stakeholders onboard with strong linkages among them. This therefore calls for a system that enhances coordination and management of water resources. The National Water Policy in Uganda was adopted in 1999 and sets the stage for WRM to guide development efforts (Nsubuga et al., 2014). The policy acknowledges the need for cooperation on trans boundary WRM issues and promotes decentralization of water management functions (Bakibinge et al., 2011). It calls for a strategy for cooperation among riparian states to agree on a common decision (Kunjuzwa et al., 2020). The WRM ICT model will enhance cooperation among stakeholders in the management of LVB.

PLS-SEM employs a good procedure to determine an associations and causal relationships between variables that are difficult to ascertain. It computes the path coefficient to assess the validity of the constructs. PLS-SEM is suitable for the analysis of quantitative data and it employs a robust bootstrapping technique to calculate the significance value of path coefficient (Shahid et al., 2018). It is therefore necessary to apply PLS-SEM to test the mediating effect of effective decision making in the relationship among the variables in the design of water resource management ICT model. The main reasons for using PLS-SEM is based on the fact that it is a non-normal data, formative measures, small sample size, and focus on prediction as the most prevalent reasons (Hair et al., 2012). There are some similar modelling software like Amos to analyze data but requires bigger sample size of at least 200 respondents, hence PLS-SEM is most preferred in this study.

Objective

The objective of this study was to apply PLS-SEM to evaluate the mediating effects of the effective decision making on the relationship between water resource management policies, water resource management frameworks and water resource management ICT model for an integrated water resource management of LVB.

MATERIALS AND METHODS

In order to evaluate the mediating effect of effective decision making in the relationship between variables in the design of water resource management ICT model, PLS-SEM was used. The proposed model was analyzed in two different ways: First: The model was analyzed before introducing the mediating variable and the hypothesized path was calculated together with the R^2. Second: A structural model comprises of the relationships between the latent variables was analyzed by calculating the hypothesized path and R^2 when the mediating variable was introduced. The latent indicators which were obtained from literature review was appropriately grouped into four categories basing on the nature of the measurements/constructs. These are; water resource management policies, water resource management frameworks, effective decision making and water resource management ICT model.

The three classified groups were called exogenous latent constructs and the fourth group was called endogenous latent construct. The conceptual model presenting the relationship between the three exogenous latent constructs and endogenous latent construct are as shown in Figure 1, which suggested that the model was influenced by three major constructs.

Study hypotheses

Base on the objective of the research, the hypothesis were formulated. Quantitative data to test the hypothesis was collected from experts in water resource sectors and was subjected to Smart-PLS test. Some of the hypothesis passed the test and was accepted while others that failed the test was rejected as shown in Tables 2 and 3. Hypothesis 1 (H_1). Water resource management policies is significant and positively related to Water Resource Management ICT model. Hypothesis 2 (H_2): Water resource

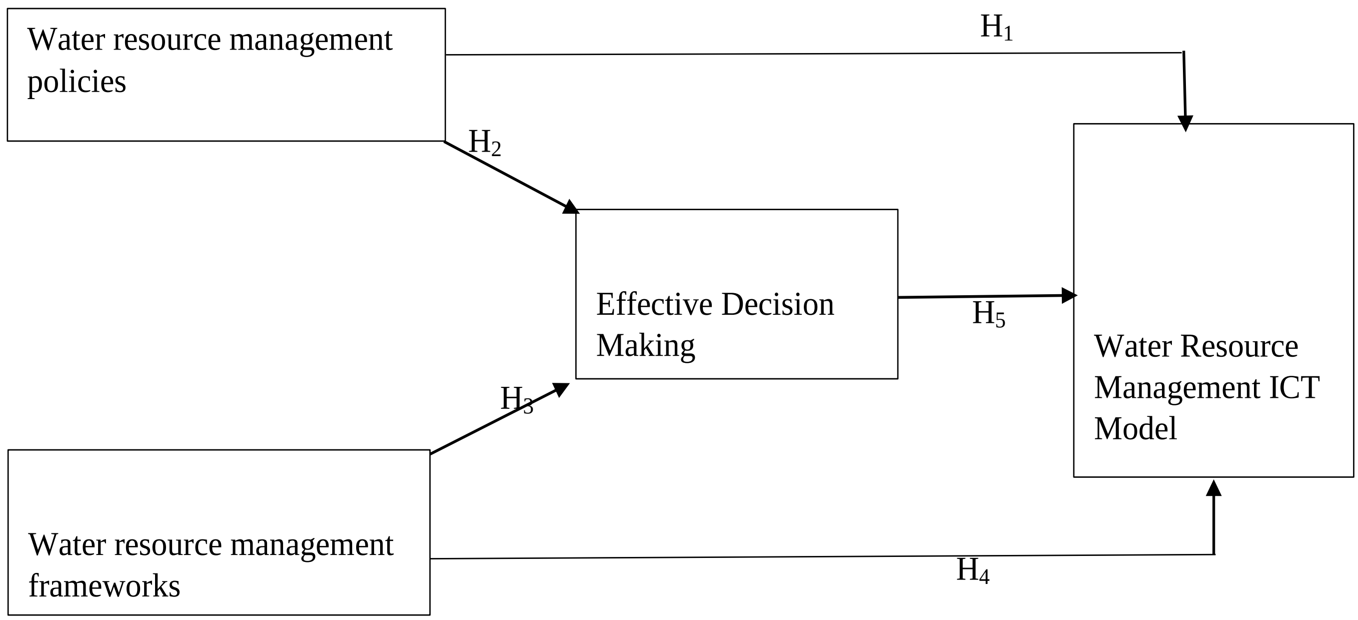

Figure 1. Conceptual model.

management policies are significant and positively related to effective decision making. Hypothesis 3 (H_3): Water resource management frameworks are significant and positively related to effective decision making. Hypothesis 4 (H_4): Water resource management frameworks are significant and positively related to Water Resource Management ICT Model. Hypothesis 5 (H_5): Effective decision making is significant and positively related to water resource management ICT Model. The format of the Figure 1, was adapted from Shahid et al. (2018).

Data collection

The data collection procedures involved three important steps. In the first step, we obtained the preliminary information through literature review of books, journal and conference materials. We then conducted a pilot study to gain a better insight and completeness to help modify the questionnaire. To ensure that we get rid of all the errors, we carried out different screening to check whether the data had problems of missing values, outliers and non-normality. This helped us to correct the problems in the data, so as to proceed with further process. The problem of missing values, outliers and non-normality were totally corrected.

Finally, we conducted a questionnaire survey to obtain the perception of respondents. Data collection was done in Buikwe, Jinja, Mukono, Kampala and Wakiso districts in Uganda. The above districts were chosen because they heavily depend on LVB for their livelihood but at the same time so much affected by decline in water resources due to harsh climatic condition that resulted from human activities. Key stakeholders that were engaged in this study included employees from: Lake Victoria Basin Commission, Lake Victoria Fishery Organization, District Water Officers, District Environment Officers, District Forestry Officers, National Environment Management Authority, Ministry of Water and Environment, National and Regional policy making and communication organs, Kakira Sugar Works, National Water and Sewerage Corporation and Key Community Leaders. To calculate the sample size, Slovin's formulae was used.

$$n = \frac{N}{1 + Ne^2}$$

where n is the sample size, N is the population size and e is the error margin. Population size of 245 was used with a degree of confidence 95% and error margin of 5%, generating a sample size of 152.

The questionnaire comprised of two sections. Section one consist of the respondents' personal information and section two was categorized into four groups in accordance with the nature of the factors/constructs: Water resource management ICT Model, Water resource management policies (strategies and frameworks), water resource management frameworks and effective decision making. The survey method was adopted to test the hypotheses proposed in this study. The questionnaires were self-administered to different stakeholders having experience of more than 5 years in water sectors including executives, managers, water engineers and IT officers. During this four months of data collection, valuable opinions from experts were incorporated in the model.

Data analysis

The hypothesized structural model in Figure 1 was analyzed using structural equation modelling -Smart-Partial Least Square (PLS-SEM) version 3. SEM has got many advantages as compared to other hierarchical regression approach to mediational analyses. First: SEM offers a better statistical tool to investigate latent variables with multiple indicators. Second: There are high chances of avoiding measurement errors in the model when examining relationships among variables. This helped in controlling complications from measurement errors and under estimation of mediation effect. Third: SEM approach helps in reducing complication of the model especially in a situation where more than one mediator and dependent variable are simultaneously being considered. Fourth: SEM sets a clear procedure that helps to ensure that all relevant paths are included and tested in the model

Table 1. Reliability and validity values.

Variable	Composite reliability	Average variance extracted
Water Resource Management ICT Model	0.887	0.761
Water Resource Management Policies	0.850	0.740
Water Resource Management Frameworks	0.818	0.695
Effective Decision Making	0.831	0.714

(Cheung, 2008). The capability of evaluating several latent constructs with various manifest variables and also being the best technique for multivariate analysis makes a smart- PLS more preferable in statistical analysis. Since our sample size was less than 200 respondents, we decided to adopt the use of smart-PLS that has capacity to analyze data of smaller sample size as compared to other SEM software like Amos that requires sample size of 200 respondents and above. Smart-PLS is commonly applied in regression models, covariance models, correlation model, path analysis and confirmatory factor analysis (Shahid et al., 2018). In this study, the sample size was 152 and therefore justifies the use of Smart-PLS. Smart-PLS has a two-step procedure that involves the evaluation of the outer measurement model and evaluation of the inner structural model (Henseler et al., 2009).

RESULTS AND DISCUSSION

Model testing

Reliability

Reliability refers to an assessment of degree of consistency which corresponds to the same measurements of at least two different people (Hair et al., 2011). It involves measuring internal consistency which looks at the consistency among variables. The objective of the reliability test is to ensure that the responses are not too different over a period of time. The latent indicators should be measuring the constructs with high correlation for a good internal consistency. The measurement of internal consistency using Cronbach (1951) indicates that the reliability of about 0.70 and above is acceptable (Nunnally and Bernstein, 1994). The observed variables with an outer loading and a composite reliability of at least 0.708 are acceptable and should therefore be retained, while those with values less than 0.708 should be dropped (Shahid et al., 2018). However, indicators with weaker outer loadings are sometimes retained on the basis of their contribution to the content validity. As shown in the Table 1, the values of composite reliability of all variables ranges between 0.818 and 0.887 which are greater than 0.70, hence confirmed the degree of consistency which correspond to the reliability of the variables in the measurements of water resource management ICT model. Composite Reliability (CR) values should be at least 0.7 to be used for internal consistency evaluation in the construct reliability.

Validity

After the reliability test, validity test needs to be carried out. Validity is the extent to which measurement values accurately represent the empirical concept. It is the degree to which a measurement accurately represents what it is supposed to be (Hair et al., 2011) . Validity measures the constructs which came out of the formulated concept of the study (Hair et al., 2010). To establish a convergent validity on the construct, average variance extracted (AVE) was used (Henseler et al., 2009). It is the grand mean value of the squared loadings of the indicators associated with the construct. It is computed as the sum of the squared loadings divided by the number of indicators. AVE value of at least 0.50 shows that the construct explains more than half of the variance of its indicators and should be accepted (Hair et al., 2011). The Fornell-Larcker criterion is a very good approach for assessing discriminant validity. The square root of the AVE of each construct should be higher than its highest correlation with any other constructs. Relevance of outer weights (T- Value > 1.645).

It compares the square root of AVE values with latent variable correlations. The square root of each construct's AVE should be greater than its highest correlation with any other constructs for the findings to confirm the cross-loadings assessment standards (Shahid et al., 2018). This provides acceptable validation for the discriminant validity of the model. As shown in Table 1, the average variance extracted for all variables ranges between 0.695 and 0.761 which are all greater than 0.50 and the values of composite reliability ranges between 0.818 and 0.887 which are all bigger than 0.7. Hence, it provides acceptable validation for the discriminant validity of the model.

Mediation test

The mediation testing procedures were carried out on hypothesis by introducing the effective decision making as a mediator variable. The bootstrapping approach based on Partial Least Square Structural Equation Modelling was used. This bootstrapping approach ignores the assumptions of sampling distributions and also enables the use of a small sample data (Hair et al., 2011, 2013). Partial Least Square was used for both

Table 2. Unmediated model.

	Beta	Mean	STDEV	T Statistics	P Values
Effective Decision Making → Water Resource Management ICT Model	0.302	0.299	0.086	3.516	0.000
Integrated Water Resource Management Frameworks → Water Resource Management ICT Model	0.209	0.216	0.115	1.815	0.070
Water Resource Management Policies → Water Resource Management ICT Model	0.239	0.236	0.116	2.065	0.039

Table 3. Mediated model.

Mediated model coefficients	Beta	Mean	STDEV	T Statistics	p (Sig.)	Verdict
Effective Decision Making → Water Resource Management ICT Model	0.250	0.254	0.111	2.260	0.024	Significant
Integrated Water Resource Management Frameworks → Effective Decision Making	0.455	0.448	0.072	6.289	0.000	Significant
Integrated Water Resource Management Frameworks → Water Resource Management ICT Model	0.236	0.242	0.112	2.113	0.035	Significant
Water Resource Management Policies → Effective Decision Making	0.345	0.347	0.086	4.015	0.000	Significant
Water Resource Management Policies → Water Resource Management ICT Model	0.298	0.278	0.111	2.690	0.007	Significant
Specific indirect effects	**Beta**	**Mean**	**STDEV**	**T Statistics**	**p (Sig.)**	**Verdict**
Integrated Water Resource Management Frameworks → Effective Decision Making → Water Resource Management ICT Model	0.114	0.114	0.053	2.137	0.033	Significant
Water Resource Management Policies → Effective Decision Making → Water Resource Management ICT Model	0.086	0.090	0.049	1.755	0.080	Not Significant

prediction and variance based oriented modeling technique. The procedure for carrying out a mediation testing is two folds. First: Test whether the direct relationship between independent variables and dependent variable without the mediator is significant (Hair et al., 2014). Second: Test the model by introducing the mediator variable to find out whether it is significant.

Unmediated model

The variables used to measure the unmediated model are; water resource management policies, effective decision making and integrated water resource management frameworks. As shown in Figure 2, water resource management policies has (β =0.239, p= 0.039). P-value being less than 0.05, makes it significant and a better determining factor to influence water resource management ICT model. Consequently, effective decision making has (β = 0.302, p= 0.000), p-values being less than 0.05 makes it significant and positively related to water resource management ICT model. However, integrated water resource management frameworks were also tested. The beta value was 0.209 and p-value was 0.070 (β = 0.209, p = 0.070). Since p-value is greater than 0.05 (0.070>0.05), it is not significant and thus not a better measure for water resource management ICT model. The three exogenous latent constructs (water resource management policies, water resource management frameworks and effective decision making) wholesomely explained 39.1% (R^2 =0.391) of the variance in the design of an effective water resource management ICT model.

Mediated model

Figure 3 shows a mediated model. The mediator variable is the effective decision making. The variables that were used to measure mediated model are; water resource management policies, effective decision making and integrated water resource management frameworks. The test result shows that water resource management policies had a path coefficient (β =0.298, p = 0.007). Since p-value is less than 0.05, it is significant and positively influenced the design of water resource management ICT model. Effective decision making had a path coefficient (β =0.250, p =0.024). Since p-value is less than 0.05, it is significant and positively influenced the design of water resource management ICT model. Also, integrated water resource management frameworks (β =0.236, p = 0.035) having a p-value less than 0.05, it is significant and therefore positively related to the design of the model. Also integrated water resource management framework is significant and positively related to effective decision making (β =0.455, p =0.000 < 0.05) and water

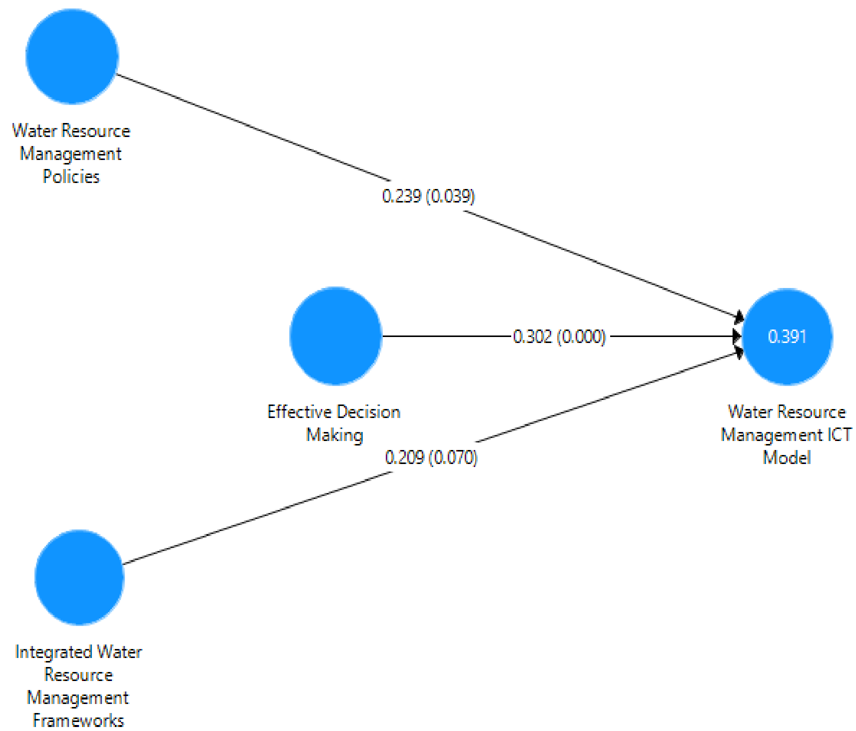

Figure 2. Graphical representation of unmediated model.

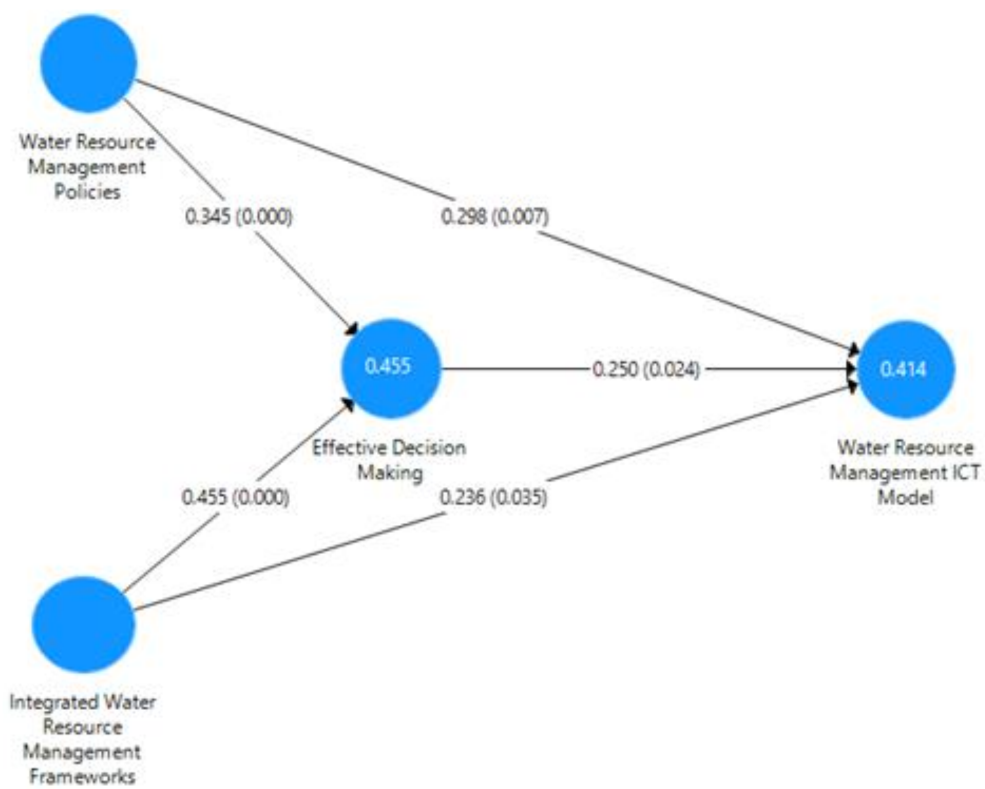

Figure 3. Graphical representation for a mediated model. Mediating effect of the effective decision making on the relationship between water resource management policies and water resource management ICT model.

resource management policies is significant and positively related to effective decision making (β = 0. 345, p =0.000 <0.05) since all their p-values are less than 0.05.

Table 3 shows the specific indirect effect between water resource management policies and water resource management ICT model by introducing the effective decision making as a mediator variable (β = 0.086, p =0.080). Since the p-values is greater than 0.05, it shows that introducing the mediator variable has no significant effect on the relationship between water resource management policies and water resource management ICT model.

Mediating effect of the effective decision making on the relationship between water resource management frameworks and water resource management ICT model

The test result shows that specific direct effect on integrated water resource management frameworks is significant and positively influenced water resource management ICT model after the introduction of effective decision making as a mediator variable (β = 0.114. p = 0.033). The two exogenous latent constructs (water resource management policies, water resource management frameworks) and a mediator variable gave rise to R^2 = 0.414 which means that they wholesomely explained 41.4% of the variance in the design of water resource management ICT model.

Mediating effect of a mediator variable

In comparison, the two models (unmediated and mediated) have two different values of the variances (R^2) that explained the overall influence of latent variables (exogenous) onto endogenous variables. The value R^2 of unmediated model is 39.1% while R^2 of mediated model is 41.4%. This shows an improvement of 2.3% which implies that there was a positive mediating effect of effective decision making on the two variables (water resource management policies and water resource management frameworks) in measuring a dependent variable called water resource management ICT model.

Goodness-of-fit index (GOF)

Goodness of fit index is a way of verifying that the model sufficiently explains the empirical data (Henseler and Sarstedt, 2013). It is applied as an index for a complete model fit. GOF values should lie between 0 and 1 where 0.1 (small), 0.25 (medium) and 0.36 (large) according to the rating by the global validation of the path model (Shahid et al., 2018). A good model fit shows that a model is plausible. A model fit is calculated by using a geometrical mean value of the average communality (AVE) and the R^2 values. The equation is:

$$\mathrm{GOF} = \frac{\sqrt{\mathrm{AVE} \times R^2}}{2}$$

From the calculation in Table 4, the GOF index for water resource management ICT model was measured at 0.549 which shows that empirical data fits the model satisfactorily and has a substantial predictive power.

Business benefit

In accordance with the complete analysis of unmediated and mediated model, some of the hypotheses were statistically significant and hence were accepted while others failed the analysis and were rejected. The results of this study support a richer and an accurate picture of how important a mediator variable is, in improving the overall influence of independent variables (exogenous) on the dependent variable (endogenous). It is therefore important to consider effective decision making as a mediator variable in water resource management ICT model for an integrated water resource management of Lake Victoria Basin.

Limitation and constraints of the study

Researchers were not in position to visit all the countries of the East African Community due to logistical constraint.

Conclusion

The key contribution of this study was to apply PLS-SEM to evaluate the mediating effect of the effective decision making on the relationship between water resource management policies, water resource management frameworks and WRM ICT model for an IWRM of LVB. Also, the study aimed to examine the fundamental issues affecting constructs observed by water experts in LVB. The results of the study revealed that water resource management policies, water resource management frameworks and effective decision making are significant and positively related to the design of WRM ICT Model. Also the study shows that WRM policies and WRM frameworks had a significantly positive influence on the effective decision making. The final SEM results revealed that the overall variance R^2 of unmediated variable = 39.1% and R^2 for a mediated model is 41.9 % showing an improvement of 2.3% on the variance that explained water resource management ICT model. Therefore, water resource managers should pay more attention on water resource management policies, water resource management frameworks and a mediator variable called effective decision making during the design of water

Table 4. Goodness of fit index calculation.

Variable	Average variance extracted	R^2
Water resource management ICT model	0.761	0.414
Water resource management policies	0.740	
Water resource management frameworks	0.695	
Effective decision making	0.714	
Average values	0.7275	
AVE X R^2	0.3011	
GOF	0.549	

resource management ICT model for an integrated water resource management in Lake Victoria Basin.

Recommendation

The study recommends special attention on water resource management policies and water resource management frameworks when designing water resource management ICT model for an IWRM of LVB. Furthermore, the study recommends introducing a mediator variables in the design of the model since it leads to improvement of the overall variance that positively influence endogenous variable. Lastly, the study recommends an introduction of effective decision making as a mediator variable in the design of WRM ICT model.

Future studies

Future studies may focus on analyzing the factors that may affect utilization of water resource management ICT model for an integrated water resource management of in LVB.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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