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Review Article

Application of Value Engineering to Identify and Solve Irrigation Water Allocation Problems

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ABSTRACT

Periodic assessment and monitoring of the functionality of irrigation scheme components is the popularly known approach for identifying and fixing existing or looming problems. For example the widely used quantitative metrics for irrigation water allocation performance assessment include equity, adequacy, and reliability of water supply. However, a qualitative metric that is seldom applied particularly in Nigeria is the value engineering method. A value engineering method is problem identification and solving approach commonly used to analyze the level of functionality of a given system or its components. The approach comprised the following phases; problem identification, system functionality analysis, creation, evaluation and development of value alternatives. A value engineering approach was applied to identify and solve the water allocation problem at Watari Irrigation Project (WIP), Kano Nigeria. Eleven (11) major problems related to water allocation were identified, and 27 solutions (ideas) were suggested, screened and reduced to 13 by the irrigating management experts. Five (5) value alternatives (VA) from the finally screened ideas were formed by putting 2 or 3 ideas as an integrated solution for a given problem. The 5 value alternatives include repairing water conveyance infrastructures, dredging water conveyance infrastructures, improving on-farm water management, conducting policy dialogue and alteration and creating awareness and sensitization campaigns. After scoring these value alternatives using a scale of 0 to 10 by another set of irrigation experts, dredging water conveyance infrastructures is having the highest score of 8.19 and hence, it requires urgent attention from the relevant authority.

REVIEW ARTICLE

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INTRODUCTION

The establishment of irrigation facilities was primarily to supplement rain season crop production to meet the food demand of the population. In line with the same reason, a huge investment has been made to develop irrigation schemes in the northern part of Nigeria (Shanono *et al.,* 2020). Such irrigation facilities were developed to achieve food security, economy and social well-being for the rural communities and the national economy among others (Raghava, *et al.,* 2011; Jubril *et al.,* 2017). However, irrigation schemes in Nigeria have been reported to perform far below their potential (Gorantiwar and Smont, 2005). The major issue attributed to this problem is poor maintenance by both farmers and managers (Cakmak *et al.,* 2009; Shanono *et al.,* 2021a).

The most common irrigation performance evaluation method is the periodic assessment and monitoring of the functionality scheme's components thereby identifying the existing and potential problems affecting the scheme (Cakmak *et al.,* 2009). Conventionally, the water allocation performance of a given irrigation scheme is often determined using a quantitative approach by computing the ratio of the water delivered to the water released at various levels (irrigation efficiencies). Other indicators for assessing water allocation performance include resilience, vulnerability, adequacy, equity and reliability of water supply (Shanono *et al.,* 2012). These water allocation performance indicators depend not only on the water availability for supply but also on reliable water conveyance and control infrastructures, appropriate water allocation methods, competent operators and farmers' level of compliance (Mellah, 2018). Apart from the water allocation performance evaluation criteria including infrastructural, institutional, operational, and participatory are also widely used to assess irrigation scheme performance (Shanono *et al.,* 2015). However, a qualitative approach that requires experts' knowledge and opinion which attracted little attention, especially in Nigeria is the Value Engineering (VE) method.

A value engineering (VE) method is problem identification and solving approach commonly used to analyze the level of functionality of a system, system components, operations, projects or processes. Initially, the approach entails diagnosing the system's problems and proposing solutions as value alternatives. These alternatives can then be adopted and applied by the relevant authorities thereby improving the performance of the system in terms of efficiency, reliability, sustainability, quality, safety, and life cycle costs. According to Atabay and Galipogullari, (2013) the VE is a technique directed toward analyzing the functions of a system or process to determine "best-value", or the best relationship between work and cost. The VE approach of system assessment was first introduced into the construction industry in the early 1960s. Traditionally VE is a value-enhancing tool rather than just a method of cost-cutting (Chen *et al.,* 2013). For example VE on projects can be used to gain not only cost reduction but also time savings, quality improvement etc. Thus VE is an interdisciplinary problem-solving method that focuses on improving the value of the functions required to accomplish the specific goals of a system under study (El-Nashar and Elyamany, 2017; Shanono *et al.,* 2022).

The VE method was used to evaluate and suggest solutions to the problem of inadequate water supply to the downstream farmers in Egypt. Solutions in the form of value alternatives that suggested the use of separate pipes to irrigate some sectors and to use of PVC pipes for field canals were proposed (El-Nashar and Elyamany, 2017). Hence, the VE method entails the identification of the problems affecting a given system, analyzing the state of the functionality of the system, and creating, generating, and evaluating value alternatives (solutions) for solving the identified problems.

Evaluating the current state of an irrigation scheme's components can certainly serve as a valuable step toward understanding the causes and effects of the existing problems. For example, since the inception of the Watari Irrigation Project (WIP) in 1982, the WIP has been declining in terms of water allocation performances at various levels, infrastructural decay, poor maintenance culture, and stakeholder conflicts among others (Shanono *et al.*, 2020; Shanono *et al.*, 2021b). Several approaches to irrigation performance evaluation have been applied to WIP. This approach includes the water allocation method, soil and water quality, operational, infrastructure and participatory (Shanono *et al.*, 2014; Shanono *et al.*, 2015; Nasidi *et al.*, 2016, Sabo *et al.*, 2021, Zakari *et al.*, 2021). None of these studies attempted to apply the VE. An effort toward applying the VE method to identify and solve irrigation water allocation problems can improve the overall performance of the scheme. The finding of this study is expected to generate a new set of information on the water allocation performance and develop a new set of solutions (value alternatives) that could inform relevant decision-makers. When these solutions are deployed as corrective measures, sustainable food production and national food security can be realized.

MATERIALS and METHODS

The step-by-step procedure of value engineering used to identified and solved water allocation problems at Watari Irrigation Project (WIP) comprised the following phases.

Problems identification phase

This phase involves the identification of problems affecting irrigation water allocation in the study location (Watari Irrigation Project WIP, Kano State, Nigeria. The problem identıfication was conducted using site visits, interviews with farmers and questionnaires administered to irrigation managers and operators. Some of the facts generated include previous and latest conditions of the water conveyance and distribution canals, night storage reservoirs (where water is stored at night and used by the farmers during the day), water allocation method used as well as the other water control structures. It is important to note that this phase is the basis for this kind of study as stressed by Shanono *et al.*, (2022).

Functional analysis phase

In this phase, the functional performance of the irrigation scheme components was assessed. This procedure involves analysing what a component shall do (intended function) not how it is doing (current function). The identified functions were analyzed and determined if it requires improvement, renovation or replacement. After the analysis, as many as possible solutions were suggested to serve as room for multiple options that can improve the water allocation performance of WIP.

Creation phase

The alternatives for solving the identified irrigation water allocation problems are created in this phase. This phase involves brainstorming with irrigation scheme managers, experts and other stakeholders to identify new ways to accomplish the optimum operation of the irrigation scheme component under study. It entails exploring the various ways to perform the functions identified in the function analysis phase. It allows the proposing and brainstorming of the existing and alternative methods thereby, developing a list of potential solutions to the problems (ideas).

Evaluation phase

After the brainstorming in the previous phase, the identified ideas for solving the problems were displayed, evaluated and voted and a list of ideas was produced and those with merits were developed into value alternatives using 4 idea-screening steps as provided by El-Nashar and Elyamany (2017). The 4 idea-screening steps include Go and No Go, Champion, Go for It and Trade-off Analysis. The screened ideas were further subjected to another screening based on the performance characteristics of each idea. The selected performance characteristics include water saving, adequate water supply, less cost and easy maintenance.

Value alternatives phase

In the value alternative development phase, the selected ideas were moulded and expanded into workable solutions. Comparison matrix to calculate the weights of evaluation criteria (C). A scale of 0 to 5 was used to express the importance of each evaluation criterion relative to others. The weighing was conducted by irrigation and water management experts. For example, if a score of 5 is assigned to C_2 against C_1, it indicated that C_2 is extremely important compared to C_1. If a score of 0 is assigned to C_{n-1} against C_2 it indicated that both C_{n-1} and C_2 are equally important. If a score of 3 is assigned to the C_n against C_{n-1}, it indicated that evaluation criterion Cn is more important than C_{n-1} by a score of 3 out of 5 as sown in Table 8. Thus, a score of 1, 2, 3, or 4 is assigned to the comparison matrix for in-between values. The assigned weights were summed up for each of the developed value alternatives.

A questionnaire was administered to evaluate the screened value alternative (VA) using evaluation criteria (value alternative scoring). A score between 0 and 10 was assigned against each evaluation criterion. Irrigation experts having great experience were employed to assign these scores. The weights of evaluation criteria were then calculated by dividing evaluation criteria scores by total evaluation criteria scores. For each expert response, the score of each VA was multiplied by the relevant weight of evaluation criteria obtained above. The total score was calculated for each VA and arrived at a VA with the highest score as proposed by El-Nashar and Elyamany (2017).

RESULTS AND DISCUSSION

Problems identification

The problem identification phase led to the identification of many problems found to be affecting water allocation in Watari Irrigation Project (WIP). The two major problems include poor water delivery downstream of the irrigation project and illegal water abstraction by the farmers whose farmlands were initially considered non-irrigable areas (Shanono *et al.*, 2021a). Several problems related to water allocation at WIP were identified and eleven (11) major ones are presented in Table 1.

Table 1. Summary of major identified problems after the site visit and brainstorming.

The case that was investigated	S/No.	Identified Problems
Poor water allocation performance at Watari Irrigation Project (WIP), Kano State, Nigeria	1	Siltation and weed infestation of the main canal
	2	Cracks and breakages of the main canal
	3	Frequent damage to the main canal as it crosses a river
	4	Siltation and weed infestation of the distributary canal
	5	Broken water control gates
	6	Siltation and weed infestation of the night storage reservoir
	7	Inappropriate water allocation method currently use (continuous flow)
	8	Diverting water illegally to places considered non-irrigable
	9	Overirrigation by upstream and midstream farmers
	10	Lack of participation in project maintenance by the farmers
	11	Lack of effective system monitoring and evaluation by the managers

Functional analysis

The function of each component of water conveyance infrastures of WIP was classified as either primary function (the most important function performed by the component) or secondary function (to categorize function as required or unwanted). The required functions are essential to support the performance of the irrigation project in terms of water allocation whereas the unwanted functions are the negative ones caused by the method used to operate the scheme. The results obtained from the functional analysis of the problem at hand was conducted summarised as shown in Table 2.

Table 2: Functional analysis and classification of irrigation water allocation structures.

Item	Functions	Primary Functions	Secondary Functions	
			Required	Unwanted
The cross-section area of the main canal	Convey the required volume of water to the distributary canals	√		
The cross-section area of the distributary canal	Distribute the required volume of water to the field channels	√		
The cross-section area of filed channels	Deliver water to the farm plots to be used by the farmers	√		
Unlined canals	Cause seepage			√
Climate change	Cause high evaporation rate			√
Water flow control gates	Control the amount of water diverted		√	
İmprovised water flow control gates	Replacing the damaged ones		√	
Water allocation method	The rule for sharing water among farmers		√	
Currently adopted water allocation method/strategy	Cause over-irrigation by farmers			√
Water application method	Scheduling when and how much to irrigate		√	
Surface flow (water conveyance method))	Poor irrigation efficiency, water wastage			√
Monitoring and evaluation strategy	Checking if the water-sharing rules are followed		√	
Participatory irrigation management	Commitment from all stakeholders toward project maintenance		√	
Conflict among stakeholders and conflict resolution	Fighting among stakeholders (farmers, managers, herdsmen etc)			√

Creation of ideas

After brainstorming with WIP managers, irrigation experts and other stakeholders, twenty-seven (27) ideas were generated. The generated ideas were coded and tabulated as shown in Table 3.

Table 3. Summary of generated ideas after brainstorming.

Code	Ideas
Id_1	Construct another main canal
Id_2	Repair/lining the main canal with concrete
Id_3	Dredge the main canal to remove silt and weeds
Id_4	Repair broken main canal where it crosses a river
Id_5	Construct a new canal to bypass the river
Id_6	Construct another water distributory canal
Id_7	Lining the surface of the distributary canal with concrete
Id_8	Dredge the distributary canal to remove silt and weeds
Id_9	Increase water discharge at the canal intake
Id_{10}	Redirect drainage water to irrigate
Id_{11}	Use PVC pipes to convey water to the farm plots
Id_{12}	Adopt in situ water conservation methods downstream
Id_{13}	Use tanks (trucks to convey water to downstream farmers
Id_{14}	Use separate pipes to convey water to downstream farmers
Id_{15}	Dig wash bore wells at downstream as an alternative source of water
Id_{16}	Replace high- with low-water consumptive use crops
Id_{17}	Use effective control gates/valves at each farm to control water use
Id_{18}	Use modern irrigation methods with high water use efficiency
Id_{19}	Abandon some farm plots the downstream
Id_{20}	Repair or replace the damaged water control gates
Id_{21}	Dredge the night storage reservoir to remove silt and weeds
Id_{22}	Change the water allocation method to rotational
Id_{23}	Enlighten upstream farmers on the risk of over-irrigation
Id_{24}	Punish or penalize those diverting water illegally
Id_{25}	Encourage dialogue and participatory irrigation management
Id_{26}	Increase water price
Id_{27}	Develop and deploy an effective monitoring strategy

Evaluation of ideas

The results obtained from the evaluation procedure were presented according to the 4 idea-screening steps as follows.

Step I: Go or No Go - The outcome is based on whether an idea is practicable (Go) or not (No Go) and was suggested by the group of experts as presented in Table 4.

Step II: Champion - The practicable ideas in step I (Go) was further thought of by the experts and decided if it is workable within time and resource limitations thereby supporting (Yes) or rejecting (No). After the screening in Steps I and II, the 27 initially generated ideas were reduced to 15 as presented in Table 4.

Table 4. Go or No Go and Champion evaluation criteria.

Code	Ideas	Go or No Go	Champion
Id_1	Construct another main canal	Go	No
Id_2	Repair/lining the main canal with concrete	Go	Yes
Id_3	Dredge the main canal to remove silt and weeds	Go	Yes
Id_4	Repair broken main canal where it crosses a river	Go	Yes
Id_5	Construct a new canal to bypass the river	Go	No
Id_6	Construct other water distributary canals	No Go	
Id_7	Lining the surface of the distributary canal with concrete	No Go	No
Id_8	Dredge the distributary canal to remove silt and weeds	Go	Yes
Id_9	Increase water discharge at the canal intake	Go	No
Id_{10}	Redirect drainage water to irrigate	Go	No
Id_{11}	Use PVC pipes to convey water to the farm plots	Go	Yes
Id_{12}	Adopt in situ water conservation methods downstream	Go	Yes
Id_{13}	Use tanks (trucks to convey water to downstream farmers	No Go	
Id_{14}	Use separate pipes to convey water to downstream farmers	No Go	
Id_{15}	Dig wash bore wells at downstream as an alternative source of water	Go	No
Id_{16}	Replace high- with low-water consumptive use crops	Go	No
Id_{17}	Use effective control gates/valves at each farm plot	Go	Yes
Id_{18}	Use modern irrigation methods with high water use efficiency	Go	No
Id_{19}	Abandon some farmlands the downstream	No Go	
Id_{20}	Repair or replace the damaged water control gates	Go	Yes
Id_{21}	Dredge the night storage reservoir to remove silt and weeds	Go	Yes
Id_{22}	Change the water allocation method to rotational	Go	Yes
Id_{23}	Enlighten upstream farmers on the risk of over-irrigation	Go	Yes
Id_{24}	Punish/penalize those diverting water illegally	Go	Yes
Id_{25}	Encourage dialogue and participatory irrigation management	Go	Yes
Id_{26}	Increase water price	Go	Yes
Id_{27}	Develop and deploy an effective monitoring strategy	Go	Yes

Step III: Go for it - In this step, the pros and cons of each accepted idea were extensively discussed and debated if it has any advantages and disadvantages and takes the average voting. The 15 screened ideas were further reduced to 14 as summarised in Table 5.

Table 5. Classification of the screened ideas as advantages or disadvantages and vote for the acceptance of the idea.

Code	Ideas	Advantages	Disadvantages	Average Vote
Id_2	Repair/lining the main canal with concrete	a. Reduce seepage losses b. Minimize friction losses c. Increase the velocity of flows	High cost of construction	Accept
Id_3	Dredge the main canal to remove silt and weeds	a. Increase carrying capacity b. Increase the velocity of flows		Accept
Id_4	Repair broken main canal where it crosses a river	a. Decrease overflows b. Reduce losses by seepage	High cost of construction	Accept
Id_8	Dredge the distributary canal to remove silt and weeds	c. Increase carrying capacity d. Increase the velocity of flows	High cost	Accept
Id_{10}	Use PVC pipes to convey water to the farm plots	a. Reduce seepage losses b. Minimize friction losses c. Increase the velocity of flows	High cost	Accept
Id_{11}	Adopt in situ water conservation methods downstream	a. Require little effort b. Low cost		Accept
Id_{16}	Use effective control gates/valves at each farm plot	a. Control water use in each farm b. Record water use in each farm		Accept
Id_{20}	Repair or replace the damaged water control gates	a. Control water use in each farm b. Record water use in each farm		Accept
Id_{21}	Dredge the night storage reservoir to remove silt and weeds	a. Store more water b. Reduce water shortage risk	High cost	Accept
Id_{22}	Change the water allocation method to rotational	a. In rotational, farmers can irrigate only when they are scheduled		Accept
Id_{23}	Enlighten upstream farmers on the risk of over-irrigation	a. Farmers can understand too much water application can adversely affect yield		Accept
Id_{24}	Punish or penalize those diverting water illegally	a. Enforce adherence to laws	This may lead to conflicts	**Reject**
Id_{25}	Encourage dialogue and participatory irrigation management	a. Achieve adherence to laws through dialogue b. All stakeholders to have ownership and feel responsible		Accept
Id_{26}	Increase water price	a. Farmers can opt to reduce costs by regulating irrigation		Accept
Id_{27}	Develop and deploy an effective monitoring strategy	a. Enforce adherence to laws	This may lead to misunderstanding	Accept

Step IV: Trade-off study – After a long and extensive deliberation with irrigation water management experts, the final alternatives to solve the identified and screened water allocation problems in the Watari Irrigation Project were selected. These alternatives were considered based on the performance characteristics of each idea. The selected performance characteristics include water saving, adequate water supply, less cost and easy maintenance. The idea Id_{10} was removed because it will consume a huge amount of money. The 14 screened ideas were further reduced to 13 as summarised in Table 6.

Table 6. Trade-off analysis of the performance characteristics of an idea to select the final alternatives to solve irrigation water allocation problems at WIP.

Code	Ideas	Performance Indicators				Voting
		Save water	Less cost	Adequate supply	Easy maintenance	
Id$_2$	Repair/lining the main canal with concrete	√		√	√	Accept
Id$_3$	Dredge the main canal to remove silt and weeds	√	√	√	√	Accept
Id$_4$	Repair broken main canal where it crosses a river	√		√	√	Accept
Id$_8$	Dredge the distributary canal to remove silt and weeds	√	√	√	√	Accept
Id$_{10}$	Use PVC pipes to convey water to the farm plots	√		√	√	**Reject**
Id$_{11}$	Adopt in situ water conservation downstream	√	√	√	√	Accept
Id$_{16}$	Use effective control gates/valves at each farm plot	√		√	√	Accept
Id$_{20}$	Repair or replace the damaged water control gates	√	√	√	√	Accept
Id$_{21}$	Dredge the night storage reservoir to remove silt and weeds	√		√	√	Accept
Id$_{22}$	Change the water allocation method to rotational	√	√	√	√	Accept
Id$_{23}$	Enlighten upstream farmers on the risk of over-irrigation	√	√	√	√	Accept
Id$_{25}$	Encourage dialogue & participatory irrigation management	√	√	√	√	Accept
Id$_{26}$	Increase water price	√	√	√	√	Accept
Id$_{27}$	Develop and deploy an effective monitoring strategy	√	√	√	√	Accept

Value alternatives development

Five (5) value alternatives (VA) from the thirteen (13) finally screened ideas were formed by putting 2 or 3 ideas as an integrated solution for a given integrated problem. Thus, the 13 screened problems were merged to form 5 value alternatives as summarized in Table 7.

Table 7. Value alternatives for solving the identified problems affecting the performance of irrigation water allocation problems at WIP.

Value Alternatives (VA)	Group of Ideas
VA$_1$ (Repair water conveyance infrastructures)	Id$_2$, Id$_4$ and Id$_{20}$
VA$_2$ (Dredge water conveyance infrastructures)	Id$_3$, Id$_8$ and Id$_{21}$
VA$_3$ (Improve on-farm water management)	Id$_{11}$ and Id$_{16}$
VA$_4$ (Conduct policy dialogue and alteration)	Id$_{22}$, Id$_{25}$ and Id$_{27}$
VA$_5$ (Create awareness and sensitization campaign)	Id$_{23}$ and Id$_{26}$

Comparison matrix was used to assign weight in-between values and calculate the weights of evaluation criteria (C) as summarised in Table 8.

Table 8. Comparison matrix for weighing the evaluation criteria (C).

Evaluation criteria (C)		C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
Adequacy of supply (C_1)	C_1		C_2 / 3	C_3 / 2	C_1 / 4	C_5 / 4	C_6 / 3	C_1 / 3	C_8 / 2
Durability (C_2)	C_2			C_2 / 3	C_2 / 2	C_5 / 1	C_6 / 2	C_2 / 1	C_2 / 3
Maintainability (C_3)	C_3				C_3 / 3	C_3 / 2	C_3 / 1	C_7 / 3	C_8 / 1
Constructability (C_4)	C_4					C_4 / 1	C_4 / 1	C_7 / 4	C_4 / 2
Sustainability (C_5)	C_5						C_6 / 2	C_5 / 3	C_5 / 2
Environmental impact (C_6)	C_6							C_7 / 2	C_8 / 2
Water saving (C_7)	C_7								C_8 / 1
Safety and health (C_8)	C_8								

The assigned weights were summed up for each of the developed value alternatives as summarised in Table 9.

Table 9. Weight of evaluation criteria and value alternative score.

Evaluation criteria (C)	Weight	VA_1	VA_2	VA_3	VA_4	VA_5
Adequacy of supply (C_1)	0.11	9	9	9	7	7
Durability (C_2)	0.19	7	9	5	4	5
Maintainability (C_3)	0.13	4	8	7	6	7
Constructability (C_4)	0.06	7	7	8	5	4
Sustainability (C_5)	0.16	8	9	8	9	9
Environmental impact (C_6)	0.11	6	7	7	8	7
Water saving (C_7)	0.14	9	8	9	9	9
Safety and health (C_8)	0.10	7	7	7	6	9
Total	**1.00**	**57**	**64**	**60**	**54**	**57**

Value alternative scoring

After scoring the value alternative by multiplying the each weight by the corresponding score, the total score was calculated for each VA and arrived at a VA with the highest score as shown in Table 10. Second value alternative (VA2): dredging water conveyance infrastructures was found to have the highest score of 8.19 as it requires less cost, can be done within short period and hence, it requires urgent attention from the WIP authority. This results is not in line with the solution offered by the El-Nashar and Elyamany (2017) who suggested the use of separate PVC pipes to irrigation bramch of the irrigation scheme.

Table 10. Scores of value alternative.

Evaluation criteria (C)	Weight	VA_1	VA_2	VA_3	VA_4	VA_5
Adequacy of supply (C_1)	0.11	0.99	0.99	0.99	0.77	0.77
Durability (C_2)	0.19	1.33	1.71	0.95	0.76	0.95
Maintainability (C_3)	0.13	0.52	1.04	0.91	0.78	0.91
Constructability (C_4)	0.06	0.42	0.42	0.48	0.30	0.24
Sustainability (C_5)	0.16	1.28	1.44	1.28	1.44	1.44
Environmental impact (C_6)	0.11	0.66	0.77	0.77	0.88	0.77
Water saving (C_7)	0.14	1.26	1.12	1.26	1.26	1.26
Safety and health (C_8)	0.10	0.70	0.70	0.70	0.60	0.90
Total	**1.00**	**7.16**	**8.19**	**7.34**	**6.79**	**7.24**

CONCLUSION

The existing water allocation problems known to adversely affect the performance of Watari Irrigation Project (WIP), Kano Nigeria were identified, analyzed and solutions were also suggested using value engineering approach. Primarily, two major problems were identified which include inadequate water supply downstream of the irrigation project and unauthorized water abstraction by the farmers. These two problems are as a results of many other problems related to water allocation at WIP and this study identified and selected eleven (11) major ones. Afterwhich, functional analysis of the major water conveyance infrastructures was conducted through an extensive brainstorming. Twenty seven (27) solutions (ideas) to these 11 problems were suggested (the creation phase). The 27 proposed solutions were subjected to screening by the water and irrigation management experts and reduced to 13 (the evaluation phase). Five (5) value alternatives (VA) from the finally 13 screened ideas were formed by putting 2 or 3 ideas as an integrated solution for a given problem. The 5 value alternatives include repairing water conveyance infrastructures, dredging water conveyance infrastructures, improving on-farm water management, conducting policy dialogue and alteration and creating awareness and sensitization campaigns. After scoring these value alternatives using a scale of 0 to 10 by another set of irrigation and water management experts, dredging water conveyance infrastructures is having the highest score of 8.19 as it requires less cost, can be done within short period and hence, it requires urgent attention from the WIP authority. Thus, value engineering method can be said to be a good system problem identification, analizing and solving tool. It guides in finding optimum solutions by focusing not only the basic function of the system but also economic and time constraints.

DECLARATION OF COMPETING INTEREST

The authors declare that he has no conflict of interests.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

The authors are responsible for all parts of this article (all of them participated in aspects of the article).
Nura Jafar Shanono: Investigation, conceptualization, methodology, formal analysis, data curation, writing-original draft, review, and editing, visualization. **Nuraddeen Mukhtar Nasidi:** Investigation, methodology, formal analysis, validation, review, and editing, visualization.

ETHICS COMMITTE DECISION

This article does not require an Ethics Committee Decision.

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