How MCDM method minimizes the gap between portfolio planning and portfolio implementation.

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Abstract: This paper is a case study that presents a comparison between portfolio planning and portfolio implementation in Tanzania power sector and suggests a Multi-Criteria Decision Making (MCDM) method, which can be considered as a balanced approach in minimizing the discrepancy between portfolio planning and implementation. The research is chiefly developed based on Analytic Hierarchy Process (AHP) approach, and the subsequent data collection and data analysis were tailored to suit this approach. An extensive literature review ranging from various scholar papers to corporate research reports is undertaken to establish the most relevant project appraisal criteria in Tanzania power industry. A total of 15 experts, took part in the survey in which the survey findings were integrated into the literature review toward structuring the proposed MCDM framework. The analysis of findings suggest the following insights; (1) inadequate cross-stakeholders engagement at portfolio planning stage observed in Tanzania power sector which is largely due to the confined and quantitative portfolio planning method; (2) MCDM should be used as a complementary method toward integrating non-tangible/qualitative variables into other quantitative criteria at the portfolio planning stage, which can mitigate the extent of deviation between portfolio planning and implementation; (3) It is crucial to employ MCMD as a decision support tool toward prioritizing major infrastructure projects at the portfolio planning stage to ensure the consistency between portfolio planning and implementation.

Keywords: Portfolio formulation, Portfolio planning, portfolio development, Multi-criteria decision making, MCDM, Analytic hierarchy process, AHP, Power master-plan.

1. Introduction

It is crucial for the governments to identify the right portfolio of infrastructure projects and have them implemented when the demand exists. This is because the current urbanization trend requires extensive infrastructure facilities while in contrast, the available resources for implementation are limited and often incapable of addressing this significant demand within a short period. To this end and considering the projected financing gap for the coming decades (Marcelo Gordillo, Mandri-Perrott, House, & Schwartz, 2016), governments should prioritize infrastructure needs and formulate a well-targeted portfolio of projects for implementation. However, large-scale public and infrastructure projects are often considered politically-sensitive (Patanakul, 2014) and received a high degree of public attention, which is due to a large amount of financing as well as the indirect social and environmental impacts (Zhai, Xin, & Cheng, 2009). The above rationales coupled with decision maker's behavioral circumstances (Wang, Wang, Zhang, Huang, & Li, 2016) can adversely influence the portfolio planning process where the selected projects may not be aligned with the actual need of the targeted society and only address the interest of a particular group of stakeholders or political party. Furthermore, the traditional project appraisal process is often costly, and high resources demanding (financially and technically), which motivates an inexpensive and non-systematic project selection method. Therefore, it is crucial to establish a systematic decision-making method that is cost-effective, less complex, relatively accurate, and capable of supporting a non-biased project selection.

Multi-Criteria Decision Making method is considered a practical approach for responding to this uncertain situation and poses a high level of confidence to the decision-makers by establishing a systematic project selection framework while the inadequate information is utilized toward portfolio development (Marcelo Gordillo et al., 2016). The MCDM incorporates the existing information into the variety of decision criteria and prioritizes the project alternatives by the judgment being made by the decision-makers. In fact, MCDM facilitates a decision support system (DSS) for the decision-makers and act as an interface between a qualitative selection and comprehensive project appraisal.

The MCDM is used for a group decision making where the input from every single individual should be considered equally. The advantages of group decision making are extensively argued among scholars, but what is evident in such systematic group approach is utilizing and combining the abilities, skills, knowledge, and expertise of every single participant toward a robust decision-making process. Variety of techniques can be used as part of every MCDM method to collect the decision maker's input in which each of the technique has its own pros and cons. However, irrespective of the technique being used for data collection, the outcomes derived from an MCDM method are highly reliable and often receive a decent degree of commitment from the stakeholders. This is because of their early engagement during the portfolio development stage which minimize deviation between planning and implementation.

2. Research motivation factors

The recent study undertaken by the IMF[1] has shown a significant degree of efficiency in Public Investment Management (PIM) within developed countries (Petrie, 2010) while, in contrast, the appraisal process in many developing countries is marginalized due to lack of standardized procedure, and project politicization. Despite all the efforts toward a systematic project appraisal, the practice is often motivated by the political intentions, and the subsequent impact is largely meant to address a particular interest which eventually encourages only little interest to strengthen domestic appraisal capacity (Petrie, 2010). For example, Schaaf et al., (2008) demonstrate how a political priority influences the road project selection in Cambodia and regardless of their socio/economic outcomes. This represents a less effective top-down approach practice in many developing countries where the infrastructure projects are not always selected based on their social and economic merits. Such project politicizations pose a high degree of inconsistency between portfolio planning and implementation as one political party may not be in support of the projects that are planned for development by another party. The selected infrastructure projects in African nations are often the result of elevated political interests in which this may dismiss the applicability of a systematic approach within such contextual settings. However, an MCDM framework can facilitate an intelligent decision-making method by integrating multi-dimensional issues.

Another key factor in motivating a multi-criteria decision-making approach toward introducing a well-aligned portfolio development mechanism is the growing feasibility of various project alternatives, which is due to recent technological achievements as well as the demand for sustainable project development from the multilateral donors. In the past, the project selection was limited to very few criteria, mainly financial metrics, and many project alternatives were not viable for implementation due to technological incapacity, the cost factor, and less demand for sustainability. However, nowadays, the project alternatives are diverse, often feasible, cost-effective and can be tailored to meet a certain degree of sustainability. The socio-environmental consideration increasingly becomes a pivotal point for every project financing, and no major investment can be finalized before the necessary safeguard are put in place. This has made the project appraisal process more complex, involving more criteria beyond the traditional cost analysis (Read, Madani, Mokhtari, & Hanks, 2017) and demands extensive cross-stakeholders engagement within a multi-dimensional decision-making context.

The project appraisal process in many African countries is often less regulated and politically motivated. Furthermore, the expert judgment in project selection is largely sidelined due to the high degree of ambiguity in criteria used (Petrie, 2010), which is a common case among many developing countries. This lack of systematic approach can create an enabling environment for a corrupt practice during project selection and even though if the process is conducted in good faith, the outcomes would most likely be misaligned with the actual infrastructure needs.

On the other hand, the project appraisal process is highly influenced by the local circumstances as well as the contextual setting where the portfolio of projects is appraised. The literature review of various academic papers indicates that the decision-making process for project selection is tightly correlated with the national cultures (Petrie, 2010) as well as the industry (Christian, Hui, &

[1] International Monetary Fund

Kongkiti, 2014). Another factor affecting the project selection is the way the project appraisal is viewed from the stakeholders' perspectives. The infrastructure projects are largely meant to improve the life quality of the targeted communities while realizing the organizational strategies of all internal and external corporate stakeholders. The internal stakeholders are often referred to the project implementing body(s) or the operator, who receives the facility upon commissioning. The external stakeholders are repeatedly characterized by their limited stakes, which make them less influential over the project during implementation and operation phases. Derakhshan, Turner, and Mancini (2019) stress the fact that; the strategic decisions are operationalized at portfolio level and influence the approach toward external stakeholders, including the end-users. In other words, the external stakeholders are commonly put aside in traditional portfolio formulation method, and their views are not much taken into account. The drawback of such one-sided approach is that the criteria that are used for project selection are not broadened enough to address all stakeholders' concerns and therefore, the final product may not necessarily be favorable to all stakeholders including targeted communities. This disagrees with principles and definitive intention of the infrastructure projects where the objective is to bring more comforts to the society. Furthermore, the appraisal process for infrastructure development projects often demands stakeholders consensus in terms of trade-offs between various criteria, and this can be realized through a cross-stakeholder consultative approach rather than the traditional/qualitative method.

3. Research Objectives

The research objective is to develop an MCDM-based framework, utilize it toward portfolio appraisal within Tanzania power sector and comparing the findings from the proposed framework with the actual practice.

4. Research Philosophy & Methodology

The present study is exploratory by nature and sheds light on an existing phenomenon and investigate certain organizational deficiencies (Robson, 2002). The Analytic Hierarchy Process (AHP) method is used to examine the proposed hypothesis, and therefore further data collection and analysis are tailored to suit for this particular method. The criteria for project selection are gauged from various individual experts' standpoints, and the subsequent findings are further utilized toward developing a systematic project selection framework. Therefore, the research outcomes heavily depend on the quality of data collected from the survey respondents where each of the respondents rates every given criterion. This objective approach coupled with small sample size, real-life phenomenon, and generalizability of the findings (Collis & HUSSEY, 2003) can safely represent an Interpretivism paradigms approach that is undertaken as part of this study.

The MCDM method varies in terms of implementation technique, and different statistical analysis can be used to facilitate an evidence-based decision making and simplify the project appraisal framework. This includes but not limited to; weighted linear combination method (West

Churchman, Ackoff, & Smith, 1954), AHP (SAATY, 1980), ANP[2] (Saaty, 2005), PROMETHEE[3], etc., which all facilitate a non-biased decision-making method. The scholar research indicates a tendency toward using AHP for sustainable energy planning, followed by PROMETHEE (Pohekar & Ramachandran, 2004) as the most popular and widely used techniques. A broad range of academic papers is developed in response to increasing demand in using AHP for project appraisal. The study undertaken by Vaidya and Kumar (2006, p. 18) indicates that AHP is predominantly used for selection and evaluation themes and within engineering, personal and social categories which further confirms the applicability of the AHP for portfolio formulation in the infrastructure sector.

Analytic Hierarchy Process is a preferred method when it comes to decision making, optimization, risk assessment, etc. (Vaidya & Kumar, 2006). Analytic Hierarchy Process (AHP) facilitates data analysis by calculating the relative weight given to every criterion through several pairwise matrices as well as the subsequent project prioritization. In fact, with the help of AHP, the quantitative data are translated into a mathematical model (Vargas, 2010), which provides a framework for systematic project selection/ranking. Upon completion of the rating exercise and establishing the hierarchy of criteria; every criterion is pair wisely evaluated toward determining their relative importance as well as global weight (Vargas, 2010). Each of the identified criteria contributes toward project selection of which their extent of contribution is determined by utilizing the comparison matrices through obtaining the priory vector/eigenvector where the eigenvector is computed by averaging all criteria' weights. The proposed framework is further used for project prioritization through the same AHP procedure comprising; ranking, pairwise comparison, eigenvector, and consistency check for all candidate projects. The project prioritization is eventually concluded at the end of the process by prioritizing candidate projects.

The first step toward developing an MCDM framework through AHP is to decompose the problem(s) associated with the phenomenon. This would help to define the high-level goal and identify the criteria that should be considered to realize the desired objective. The aim is to structure a hierarchy of criteria where the ultimate goal, criteria, and alternatives are identified for further data collection and analysis. The prospective criteria in AHP method are highly correlated with the desired goal as well as the contextual setting where the AHP is utilized. The AHP can be used in a wide range of decision-making environments, e.g., project selection, evaluation, ranking, planning, cost-benefit analysis, forecasting. (Vaidya & Kumar, 2006). For this particular research, the AHP is primarily employed for portfolio formulation and therefore, a number of relevant criteria are taken into account.

[2] Analytic Network Process
[3] Preference Ranking Organization METHod for Enrichment of Evaluations

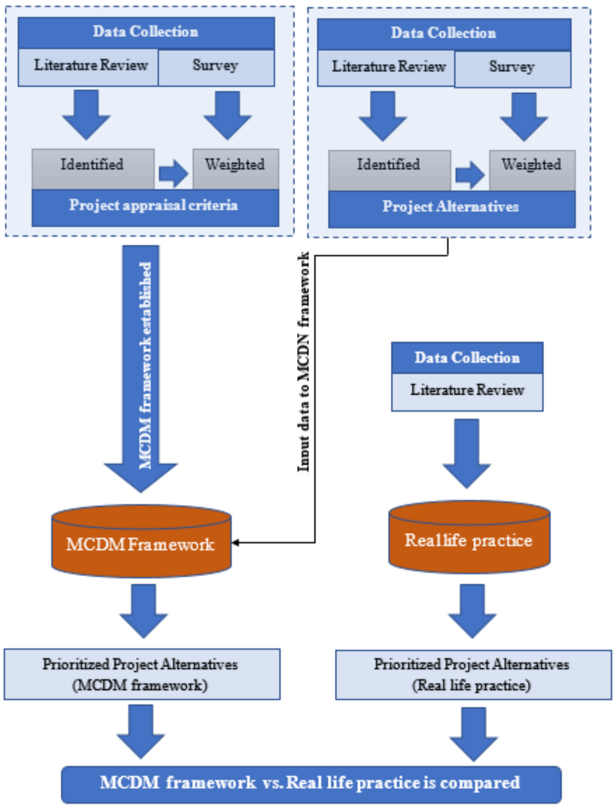

Figure 1, Conceptual framework of the research

For a better-tailored set of criteria, it is crucial to study the targeted phenomenon and understand associated goals and constraints. Every organization develops a set of project selection criteria that are aligned with corporate strategy (Vargas, 2010) and it is therefore important to closely investigate the prospective organization in terms of overall strategies and desired objectives. To that end, the high-level strategy for the key stakeholders in Tanzania power sector is studied to attain a broad view on the various project selection criteria. The key stakeholders in Tanzania power sectors are; Ministry of Energy and Minerals, TANESCO[4], REA[5], multilateral banks, e.g., World Bank (WB), African Development Bank (AfDB), EuropeAid. The Ministry of Energy and Minerals as the prime stakeholder in power sector has already defined the overall strategy/objective in Tanzania power sector of which this has taken into account toward developing the project prioritization criteria and portfolio development.

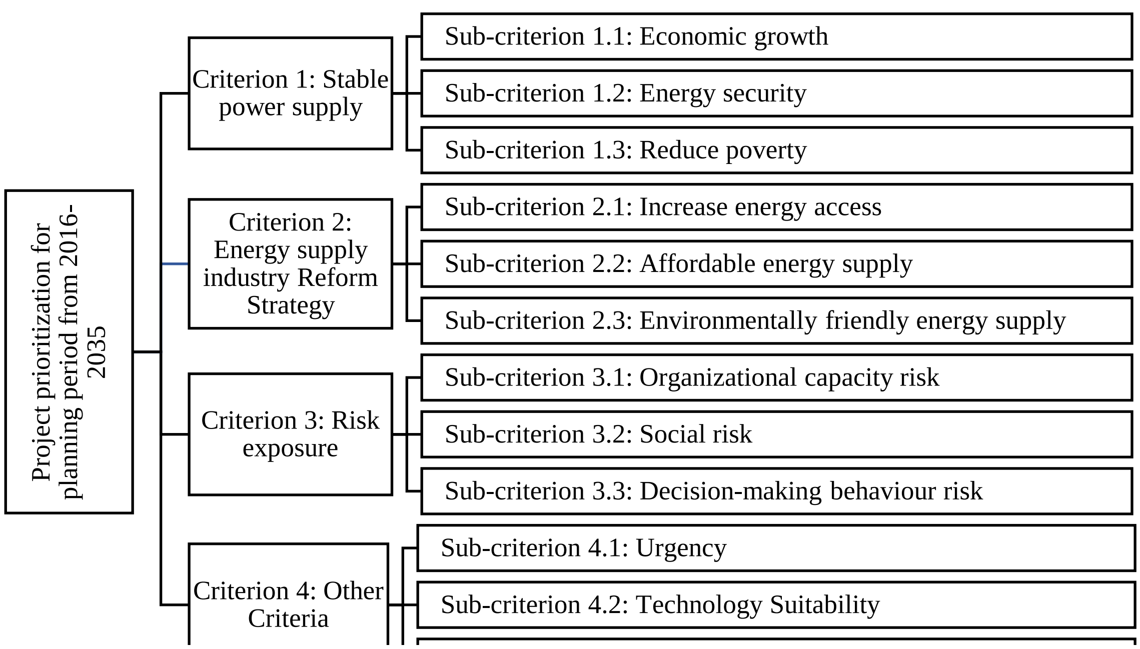

Figure 2, Hierarchy of criteria/sub-criteria for Project prioritization for the planning period from 2016-2035

[4] Tanzania Electric Supply Company Limited
[5] Tanzania Rural Energy Agency

identified, they should be organized into a hierarchy to establish the linkage between each alternative and set of criteria. The goal here is to prioritize four nominated projects to be implemented within four-year investment periods from 2016-2035 as part of Tanzania power infrastructure development plan. The criteria are the principles that should be taken into account while prioritizing the nominated projects. The alternatives are the candidate projects that should be prioritized based on the identified criteria.

Candidate projects	
Project Alternative 1	Project Alternative 2
Future Combined cycle gas turbine power plant (940MW)	Stiegler's Gorge HPP (1,048MW)
Project Alternative 3	Project Alternative 4
400kV Tanzania-Mozambique power interconnection	Mbeya Geothermal Plant (100MW)

Table 1, Candidate project alternatives

5. Developing the MCDM framework through AHP method

5.1. Decomposing the decision-making problem

The Tanzania Ministry of Energy and Minerals in consultation with various key stakeholders has identified; 448 power infrastructure projects comprising 72 generations, 133 transmission and 243 substation projects (MoE, 2016) that should be implemented from 2016 – 2040 to meet the government objectives. The challenge here is; how to appraise this huge number of projects and have them organized in various portfolio categories for financing and implementation. Probably, the project prioritization and selection should be done through a bottom-up approach where the project implementing bodies (TANESCO and REA) define the portfolio of projects to be implemented for every planning period (short, mid and long-term plans) and make the recommendation to Ministry of Energy and Minerals for inclusion into the annual budget. It is assumed that the selected projects for each planning period given in power master plan, 2016 update (MoE, 2016) are appraised internally and through intensive consultation with other stakeholders including Ministry of Energy and Minerals.

It will be a far-reaching effort and beyond the intention of this paper to examine how this extended number of projects are selected and prioritized for implementation. However, in order to test the hypothesis of this research, and evaluate the degree of conformity of the proposed AHP-based framework with the actual practice, a total of four sample projects from the investment period of 2016 - 2035 are selected and fed into the proposed framework. The outcomes indicate the extent of agreement in terms of project prioritization order between the research hypothesis and what is formulated in power master plan, 2016 update. The author further examines the degree of agreement between portfolio formulation and implementation by taking into account the findings from the proposed MCDM as well as the real life practice in Tanzania power sector.

5.2. Data collection

Both primary and secondary sources of data are taken into account for data collection. The primary data is obtained through the questionnaire forms, while the literature review is extensively used for secondary data collection. The prime intention of the literature review is to identify the research variables through a qualitative method. The questionnaire forms are developed by incorporating the findings from the literature review and further utilized toward a quantitative data collection. The combination of these two contrasting data collection methods represents a mixed research method. However, the integration of findings is not intended all the time in the mixed methods as suggested by (Bryman, 2007), which is the case for the present research. The qualitative data are collected from secondary sources (Literature review) to define a number of variables as well as a rating system of which the final outcomes (project prioritization) are purely quantitative.

a) Literature review

The literature review is one of the primary research methods for every exploratory research undertaking (Saunders, Lewis, & Thornhill, 2009) and an alternative methodology toward establishing project selection criteria for every AHP-based approach.

- **Project prioritization for planning period from 2016-2035**

The need for a sustainable and reliable infrastructure increasingly becomes a vital tool to foster economic growth in various developing countries. The power infrastructure is considered a key

Cost of	Five-year investment cost (million USD)					Total
	Short-term plan	Mid-term plan	Long-term plan			
	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	
Generation	6,671	4,660	9,459	10,325	7,883	**38,998**
Transmission Lines	3,717	814	714	1,197	152	**6,593**
Substation	1,207	465	417	422	1,126	**3,637**
Total	**11,595**	**5,939**	**10,590**	**11,945**	**9,160**	**49,229**
% of Each Period	24%	12%	22%	24%	19%	100%

Table 2, Summary of investment costs

economic development factor, and extensive efforts are taken place in Tanzania to improve the electricity access rate. The Government of Tanzania (GoT) has set a goal to increase the capital per income to USD 1,500 (from USD 1,043 in 2014) by 2021 and improve the electricity connection to 60% of the population. (MoE, 2016). To achieve this goal, the GoT should embark on extensive power infrastructure implementation ranging from generation, transmission, and distribution projects to ensure all power infrastructure development projects are harmonized as necessary. However, despite this noticeable gap in power infrastructure, the GoT is also struggling with inadequate resources in terms of both investment and human resources capital which could potentially pose more constraints on the planned power development program. A joint effort was undertaken by the Ministry of Energy and Minerals, TANESCO, REA and other key stakeholders in energy sectors, suggests the need for over USD 49,229 Million investment until 2040 to ensure the projected power development program is achievable.

The combination of short-term, mid-term and long-term plans suggests a total of USD 49,229 Million investment, which entails a huge number of generation, transmission and distribution/rural electrification projects in which they should precisely be identified and appraised for implementation. This represents a total of 72 generation projects, 133 Transmission line projects, and 243 Substation projects (MoE, 2016) that should be implemented from 2016 - 2040. This large amount of investment can pose various risks to the economy if not properly managed, and the desired outcomes might not be realized if the portfolio formulation is not aligned with economic and social needs.

b) Survey

The survey is also considered another effective method for exploratory research (Saunders et al., 2009), which is utilized to examine the proposed research hypothesis. The collected data is used to facilitate weighting exercise for every project selection criterion. The Survey forms are conceptualized as per AHP requirement (Saaty, 2005) and further developed by using Microsoft Excel and upon establishing the project selection criteria as well as project alternatives through the literature review. The survey respondents are requested to pair wisely rate the identified criteria and project alternatives. The rating takes place in a quantitative manner where the participants provide a relative rating for each criterion as well as the alternatives. The scale of relative importance (Saaty, 2005) is used for the survey data collection, and every survey participant was requested to provide a rating from 1 – 9 for every given criterion/alternative according to his/her expert judgment. This indicates the relative importance of each criterion/alternative in comparison with other criterion/alternative (Vargas, 2010). The table below illustrates this in greater details.

Scale/Response	Numerical rating	Reciprocal
Extremely Preferred	9	1/9
Very Strongly preferred	7	1/7
Strongly preferred	5	1/5
Moderately preferred	3	1/3
Equally preferred	1	1

Table 3, Scale of Relative Importance

5.3. AHP computation method

The analysis of data for the AHP method begins right from data collection and upon structuring the hierarchy of decision making as discussed earlier. The survey respondents are requested to conduct pairwise comparison for all the comparison matrices given. Once all the criteria are rated by the survey participants, then they should be normalized to obtain the relative weight for every criterion/project alternative. The normalization is done by utilizing the following equation for the comparison matrices.

$$Sum(C_i) = \sum_{i=1}^{n} C_{ij}$$

n = Number of criteria or project alternatives to be rated

$$X_{ij} = \frac{C_{ij}}{Sum\ (C_i)}$$

- **Approximate Eigenvector**

The relative weights between each criterion are calculated by the arithmetic average of all criteria (Saaty, 2005). This approximate calculation determines the contribution of each criterion toward the overall decision-making objective. The approximate calculation is widely used to determine the Eigenvector. This is because the exact calculation is only used for specific cases, while the difference between the exact value and approximate value is less than 10% (Kostlan, 1991). The calculated values for each Eigenvector determine the relative weight of every criterion comparing the overall objective (Vargas, 2010).

$$W_{ij} = \frac{\sum_{j=1}^{n} X_{ij}}{n}$$

- **Consistency check**

As mentioned earlier the validity of any AHP-based research is highly influenced by the expert judgment being made by the respondents and therefore it is important to ensure the survey participants are consistent in rating the criteria/alternatives. The consistency check (Saaty, 2005) is calculated as per the following equation, and any CR ration less than 10% is considered a consistent response.

$$CR = \frac{CI}{R1}$$

CR: Consistency Rate

Number of evaluated criteria	1	2	3	4	5	6	7	8	9	10
R1	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Table 4, Random Consistency Indices

CI: Consistency index

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

λ_{max}: $Maximum\ Eigenvalue$

n: Number of criteria/alternatives

- **Obtaining the global eigenvector for sub-criteria**

It is crucial to gauge each sub-criterion's contribution toward its parent Criterion. Therefore, the global weight for each sub-criterion can be obtained by multiplication of the associated values to the parent criterion (Vargas, 2010) as exhibited in below table.

a) Data analysis for 4×4 comparison matrix for the Project alternatives

The desired framework for project prioritization is developed, once the comparison matrices for all criteria and sub-criteria are pair wisely weighted by the survey participants. At this point, we should have the decision-making problem decomposed into a hierarchy, the associated criteria are weighted by the identified experts/survey respondents, and the prospective project alternatives are introduced for further analysis. Similar analytical approaches, as already employed for hierarchy level 1 and 2, should also be followed for the project alternatives. The only difference here is that all the project alternatives should pair wisely compared and weighed against one another for each sub-criterion as already rated under hierarchy level 2.

b) Calculating final priority for each project alternative

Once the weighting exercise and analysis are done for all project criteria, sub-criteria, and project alternatives, they all should be integrated to produce the project prioritization. This can be done by multiplication of Global eigenvector to each project alternative's weigh (Vargas, 2010).

5.4. Aggregating the expert judgments

The expert judgments obtained through the survey and from every single individual are not considered a valid consultative finding until the expert's views are aggregated toward the final decision-making objective(s). Once the data are collected from the survey participants, they are synthesized by employing the methodology discussed earlier, and as proposed by Saaty (1980). This is considered a valid approach when the judgment of only one expert is taken into account. However, this is not the ultimate intention of the AHP method, and in fact, the aim here is to collect various expert's views on a particular subject matter and have them aggregated and produce a combined decision.

The choice of aggregation method is correlated with the data collection/survey approach and in which how the group of survey participants is viewed. In principle, the aggregation can be done through three different methods, namely (Forman & Peniwati, 1998, p. 166):

1) "aggregating the individual judgments (AIJ) for each set of pairwise comparisons into an 'aggregate hierarchy;
2) synthesizing each of the individual's hierarchies and aggregating the resulting priorities (AIP), and;
3) aggregating the individual's derived priorities in each node in the hierarchy."

The AJJ and AIP are the most common aggregation methods, while the third method is less meaningful and not frequently used (Forman & Peniwati, 1998).

The AIJ applies when the group of survey participants is considered as a single individual, and they all make the judgment through a consensus manner. This is very much applicable when we have all the survey respondents gathered in a forum, and they all consensually do the rating for every given comparison matrix. In contrast, the AIP method is used when each survey participant acts on its own right and independent from the other individuals, which is the case for this particular research. The survey respondents for this research have received the questionnaire forms individually and provided their judgments independently, and nobody was influenced by another's decision.

Furthermore, there is another condition to be satisfied when deciding on the best suitable aggregation technique, which is the conformity of the aggregation method with the Pareto principle, as suggested by Saaty (2005). According to the Pareto principle; "in many situations, 80 percent of the effects or outcomes come from only 20 percent of the sources or causes" (Wiesenfelder, 2013). In other words, the condition of unanimity on the decisions made should be met (Ossadnik, Schinke, & Kaspar, 2016) in any chosen aggregation method. As for the case of this research, AIP is used as the preferred aggregation method, which entirely satisfies the Pareto principle (Ossadnik et al., 2016). To synthesize the judgments within AIP context, both arithmetic and geometric means can be used to generate the aggregated result. However, the geometric mean is considered more consistent with the definition of both judgments and priorities in AHP (Forman & Peniwati, 1998) and highly recommended by many researchers (Teknomo, 2017) of which the same method is employed for this research.

6. Discussion

The weighting exercise for each criterion as well as project alternatives is done by the expert judgment being obtained through the survey. Total of 19 survey respondents was identified and briefed about the survey in which they all received the questionnaire forms. However, only 15 survey participants provided their feedbacks within the time given for data collection. Below table demonstrates a brief summary of survey respondents' profiles.

All the survey participants received the three main questionnaire forms where they provided their expert judgments by rating project selection criteria (Hierarchy level 1), sub-criteria (Hierarchy level 2), and the project alternatives. The rating exercise is done through a number of pairwise comparison matrices that are given to each survey respondent, and the subsequent analytical process is performed as per the AHP computation formula as developed by Saaty (2005).

Survey Respondents	Highest Education	Profession	Project management experience (years)
Participant 1	MSc	Water Engineer/GIS Specialist	7
Participant 2	PhD	Consultant Environmental Specialist	10
Participant 3	BSc	Electrical Power Engineer	4
Participant 4	MSc	Engineering	15
Participant 5	MSc	Civil and water resources Engineer	0
Participant 6	MSc	Electrical Engineer	21
Participant 7	MSc	Engineer	10
Participant 8	PhD	Civil Engineer	1
Participant 9	MSc	Architect	3
Participant 10	BSc	Environmentalist	30
Participant 11	Diploma	Engineering	25
Participant 12	MSc	Hydrologist/Civil Engineer	8
Participant 13	BSc	Electrical Engineer	3
Participant 14	MSc	Engineering	15
Participant 15	PGDip	Power system Engineer	10

Table 5, Brief profile of the survey participants

6.1. Findings from the proposed MCDM method

The stable power supply can support poverty alleviation, economic growth, and energy security (MoE, 2016) of which this understanding is incorporated into the proposed MCDM framework. The finding indicates that poverty reduction is considered the most important measure that should be considered while appraising a project and under the main criterion of stable power supply which agrees with the emphasis given to the poverty alleviation in the national five-year development plan. (MoF, 2016). The economic growth and energy security are considered the second and third important factors under the same criterion, respectively. The survey participants have given the highest emphasis on the increase energy access, followed by affordable energy supply and environmentally friendly energy supply sub-criteria.

The findings indicate that the decision- making behaviors of the government decision makers

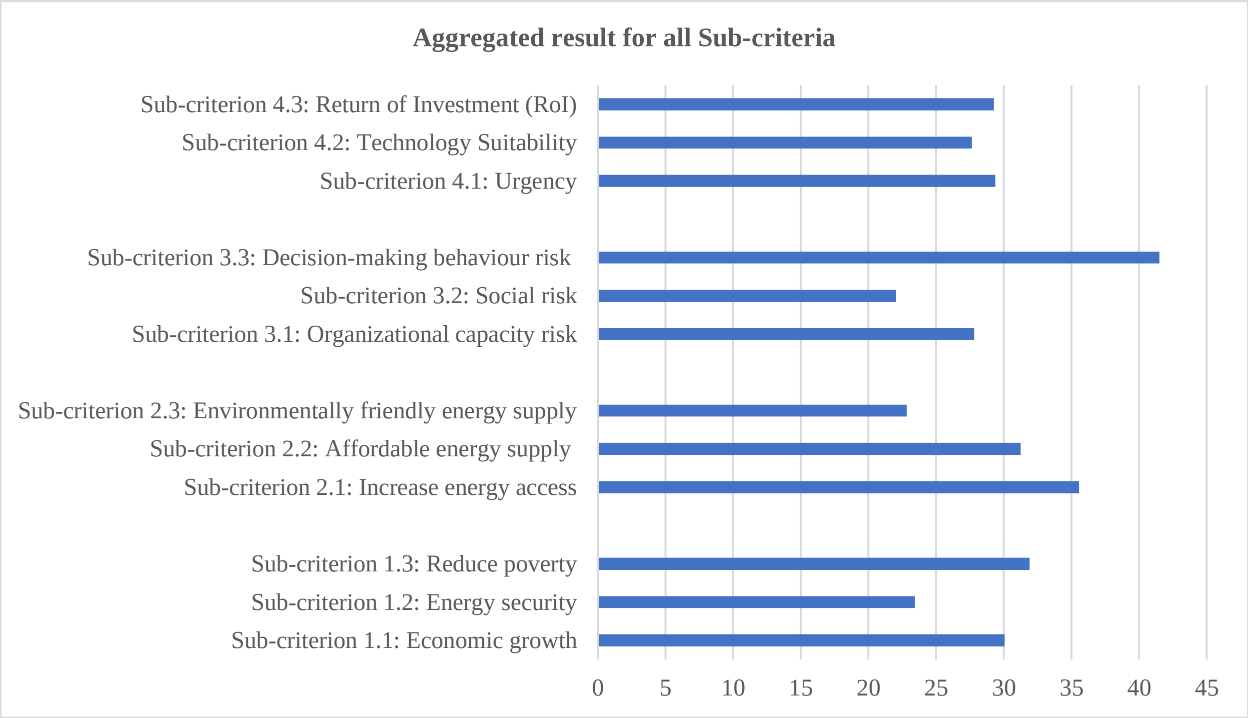

Figure 3, Aggregated result for all Sub-criteria

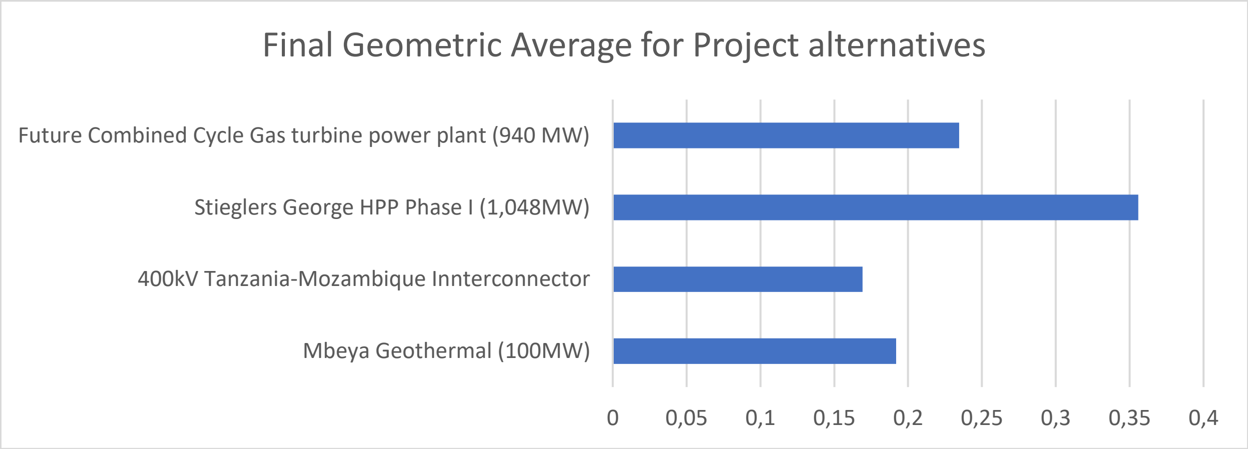

Figure 4, Final Geometric average for Project alternatives

(Wang et al., 2016) are considered the most critical risk factor that should be considered during project appraisal. This agrees with the earlier proposition of project politicization (Warner, 2014) and potential political influence (Wang et al., 2016) over the appraisal process. The organizational capacity risk followed by social risk has received a lesser degree of importance. The findings here have further exhibit an interesting fact from the survey participants' point of view as the urgency of the infrastructure project is received the highest rating. This closely followed by project profitability or Return of investment, which indicates the importance of economic factors for project appraisal.

The final list of prioritized projects is the product of the proposed MCDM and represents an evidence-based decision that is being made by a group of experts. The geometric mean is employed to average the approximate eigenvectors for all the project alternatives as obtained through the survey and from each survey participants.

7. Analysis of data

The collected data through the literature review is largely used toward structuring the proposed MCDM by identifying the project selection criteria. The survey data collection is then utilized toward understanding the degree of importance (weighting) of each criterion. The combination of these two data collection approaches has facilitated creation on the MCDM for Tanzania power sector. At a later stage, the project alternatives are fed into the MCDM framework where the findings help to respond to the following research objectives.

- Weighing exercise for identified criteria, to be undertaken by survey respondents;
- Utilizing the MCDM-based framework toward prioritizing the candidate projects and Comparing the findings from the proposed framework with actual practice

7.1. Utilizing the MCDM-based framework toward prioritizing the candidate projects and Comparing the findings from the proposed framework with actual practice

The proposed project appraisal framework generates a prioritized list of projects for implementation for the planning period 2016 – 2035. The candidate projects are selected from the Tanzania power master plan – 2016 update, where each of these projects is prioritized for implementation based on a certain assumption made while formulating the master plan for the same planning period.

7.2. Analysis of findings of the proposed MCDM

We need to have a deep dive into the findings obtain from the proposed MCDM to better appreciate the result. The bottom-up approach is taken into account while analyzing the findings, which helps to understand the basis of the achieved outcome. This begins with analyzing the aggregated result for all sub-criteria, as discussed further.

Reviewing the findings from a broader picture and through a comparative approach, demonstrate some interesting insights about the concerns provided by the survey participants. The decision-making behavior risk has received the supreme concern for project appraisal in Tanzania power sector. The outcomes also suggest that poverty reduction, energy access augmentation, and project urgency should be considered as the second, third, and forth crucial metrics in project appraisal. In contrast, the social risk, environmentally friendly energy supply, and energy security received the minimum degree of attention respectively.

The final project ranking genuinely represents the survey participants' views about the project appraisal criteria. The review of the literature suggests that; the Stiegler's Gorge HPP is a major infrastructure project with a high degree of social and environmental sensitivity.

Furthermore, this project is considered a game-changer infrastructure undertaking in Tanzania power sector as upon completion will augment the power generation as double as the current capacity. The survey findings imply the minimum importance over social and environmental risk factors while the prime attention is given to the decision-making behavior risk, energy access and poverty alleviation elements which are quite in line with the aggregated result of the survey.

The decision-making risk is considered the most important project appraisal criteria from the

Project	**Targeted year for completion (Master plan – 2016 update)**	**Likely/actual Implementation status**	**Planned Vs. Likely/actual (as of 2019)**
400kV Tanzania-Mozambique Interconnector	2020	Yet to be started. Likely to be completed by 2032	Inconsistent
Mbeya Geothermal power plant (100MW)	2025	Construction started and to be commissioned by 2025	Consistent
Future CCGT Power plant (940MW)	2030	Negotiation with prospective developers is underway. The government seems confident to proceed with the proposed implementation plan	Consistent
Stiegler's Gorge HPP I (1,048MW)	2035	Construction is started by early 2019 and to be completed by 2022	Inconsistent

Table 6, Comparison between Planning and Likely/Actual project implementation order

survey respondents' perspectives. Qi and Liu (2017) introduce six influencing factors in decision-making behavior risk, namely; Emergency knowledge, rational thinking, relevant experience, time pressure, decision-making procedure, and factual information. These factors, coupled with the high probability of project politicization in Tanzania as a natural resources-dependent state (Petrie, 2010) fairly demonstrate why this criterion has received that high degree of concern. In other words, a project appraisal is politicized, where the decision is solely taken to gain a certain political interest of which in such circumstances there is always low degree of attention as to how the decision-makers satisfy these six influencing factors.

7.3. Analysis of findings of the Real-life practice

As stated earlier, there is always a high chance of deviation between planning and implementation stages, of which this is exhibited in below table for planning period 2016 – 2035 for Tanzania power sector.

The above findings suggest some degree of inconsistencies between planning and actual/likely implementation status in Tanzania power sector. The result can be a representative of the project prioritization in Tanzania, which indicates a significant disagreement between planning and implementation. Only two projects out of four are set for implementation as per planning order stipulated in the power master plan. From a broader picture, the outcome here is a combination of both quantitative and qualitative methods. The power master plan, 2016 update is primarily developed through engineering computation for both generation expansion plan and least-cost transmission expansion plan, which are largely derived by quantitative data analysis. In contrast, the actual/likely project implementation is highly influenced by the qualitative decision-making elements and marginalizes the quantitative rationale established in power master plan.

7.4. Real-life practice vs. MCDM method

The comparison of the findings between the power master plan and MCDM method indicates a large degree of inconsistency between the project prioritization order obtained from either of the approaches. Having a closer look at the power master plan suggests that; the generation expansion planning is developed by utilizing quantitative inputs as well as engineering modeling approaches such as; population forecast, foreign exchange rate, GDP projection, etc. The load flow study is also employed as a prime tool in developing and identifying potential power transmission/distribution projects. The financial/economic variables are also considered in conjunction with all technical/engineering metrics for the planning purpose.

Project	Prioritized projects for implementation (Ranking)		
	Real-life practice		MCDM method
	Actual/likely	Master plan–2016 update)	
Stiegler's Gorge HPP I (1,048MW)	1	4	1
Mbeya Geothermal power plant (100MW)	2	2	3
Future CCGT Power plant (940MW)	3	3	2
400kV Tanzania-Mozambique Interconnector	4	1	4

Table 7, comparison of findings between real-life and MCDM method for candidate project alternatives

In contrast, the intangible elements such as; risk and socio/environmental factors, organizational capacity, etc. are not considered as a variable in prioritizing the projects, and only a limited degree of mitigation measures are suggested to address the potential risk factors. This implies the fact that the power master plan is chiefly developed by utilizing tangible/quantitative metrics which discourages a cross-stakeholder consultation approach. This one-sided, quantitative approach exhibits a significant deviation with MCDM method, which is capable of integrating both quantitative and qualitative variables.

Interestingly, there is still a significant degree of inconsistency between the project prioritization order, proposed in the master plan and what is done or likely to be done in real-life practice. The GoT seems determined to follow the implementation order, proposed in a power master plan for both Mbeya Geothermal power plant (100MW) and Future CCGT Power plant (940MW). However, the implementation order for the two other project alternatives (400kV Tanzania-Mozambique Interconnector and Stiegler's Gorge HPP) are substantially changed in comparison with power master plan but, it is quite in line with the findings from the proposed MCDM framework.

This significant deviation between portfolio planning (Master plan - 2016 update) and likely/real-life practice indicates how differently the planning is viewed from each approach. As stated earlier, Power master planning in Tanzania is primarily done through commonly used engineering methods where the input and variable are largely quantitative. However, strategic thinking should also be integrated into such tactical portfolio planning while in contrast, the employed engineering/numerical based method is incapable of addressing this viewpoint. On the other side, there is a lesser degree of inconsistency between the MCDM method and real-life/likely practice. This is because the MCDM can capture the intangible inputs/variables toward supporting a strategic decision-making approach. (Malmqvist & Palmquist, 2005).

8. Conclusion

The present research examined the project prioritization results that are obtained through the proposed MCDM method and real-life practice, as discussed. The findings suggest that both qualitative and quantitative approaches largely influence the project prioritization/selection in Tanzania power sector. At first glance, this may appear a well-balanced method, but the challenge is the inconsistency between the planning and implementation stages. The project selection/prioritization at the planning stage in Tanzania power sector is largely motivated by a quantitative approach which discourages a cross-stakeholder consultation. This one-sided planning approach facilitates a technical project due diligence and provides necessary technical insights that should be considered for project prioritization. However, it does not adequately cover the other critical and non-tangible project selection elements. What is apparent here; is inadequate attention given to the stakeholder's expectations/concerns and cross-dimensional risks which pose less confidence to the stakeholders when it comes to implementation. This eventually results in an inconsistent approach between portfolio planning and implementation as the implementation does not follow the initial planning due to ignoring other project selection variables. In conclusion, a significant disagreement is observed between the findings of the proposed MCDM and the outcomes derived from power master plan. However, there is some degree of consistencies between the proposed MCDM and the actual/likely practice in Tanzania power sector, as discussed earlier.

9. Recommendations

The findings suggest an inadequate degree of cross-stakeholder consultation for portfolio formulation at planning period within Tanzania power sector. The lack of effective consultative approach at the planning stage demotivates the stakeholders to commit to the initial planning when it comes to implementation. It is, therefore, crucial to develop a systematic mechanism which allows the integration of the stakeholder's views into the quantitative planning approach. The MCDM method can facilitate such integration platforms and allows the stakeholders to independently express their concerns/expectations over portfolio formulation. It is worth to note that, the MCDM method should not be used as a tool to derive the final prioritized list of the project but can be utilized as a decision support system in conjunction with other commonly used project selection/prioritization methods.

Furthermore, MCDM method can become very complex when dealing with a large number of metrics and project alternatives, which implies the unsuitability of this method as the prime portfolio formulation tool. However, MCDM can appropriately be employed as a decision support system to prioritize the large-scale infrastructure projects for a certain planning period. This is because:

a) There is often a narrowed list of major infrastructure projects within every planning period. This is because of the high degree of complexity as well as the need for extensive financial resources. This leaves the decision-makers with very a few numbers of candidate projects to choose from of which the MCDM method is well capable of addressing the project prioritization challenge;
b) The major infrastructure projects play a critical role in realizing the overall sector's strategy, and therefore, any changes in their implementation order can directly influence the other down-stream projects. The MCDM facilitates the cross-stakeholder and multi-dimensional project prioritization approaches which maximizes the consistency between planning and implementation stages.

As for the case of this research, Stiegler's Gorge HPP is considered a critical and major power infrastructure project in Tanzania power sector, which is because its large projected generation capacity. The power generation would raise as double as the current capacity in 2019 when the Stiegler's Gorge HPP is commissioned of which this development can substantially impact the current master plan as well as the subsequent project implementation. As a result of this development, the current power master plan, as well as the prioritized list of projects, would dramatically be overhauled, once the Stiegler's Gorge HPP is energized and connected to the national grid. However, this evident misalignment between planning and implementation could have been mitigated by gauging the findings from master plan against an MCDM-based method.

10. Research Limitations and Guidance for Future Studies

The portfolio formulation for infrastructure projects demands a multi-dimensional method where both tangible and intangible elements are incorporated. This research provides a high-level view on the integration of MCDM with other portfolio planning methods for infrastructure projects. Further detailed research will be required to examine how MDCM can be integrated into the commonly used master planning approaches. This will ensure that the quantitative metrics are considered in conjunction with qualitative variables at portfolio planning stage. The cross-stakeholder engagement at portfolio formulation stage is crucial in order to maintain the consistency between portfolio planning and implementation. It is, therefore, worth studying the MCDM's role and its contribution in facilitating the stakeholder engagement platform at the portfolio planning stage.

About Author

Mostafa KERAMATIKERMAN is a project management professional with a career spanning over 14 year experience in power sector. He has served within the industry through various technical and managerial capacities. He possess extensive experience in the planning and management of various power projects, financed by multilateral development banks. He has been the member of the project development committee (PDC) for IEEE Smart village (ISV) program and also lead expert for several working groups within the ISV-PDC. Mostafa was awarded with a Master of Science Degree in Project Management from the University of Liverpool, UK in 2019 of which the present paper is a condensed version of the dissertation that was submitted originally for the purpose of award.

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