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FACILITIES MANAGER'S INVOLVEMENT FOR ESTABLISHING DESALINATION PLANTS

YATAWATTA Y.J.M [1]* & SRIDARRAN P.[2]
[1, 2]Department of Facilities Management, University of Moratuwa, Colombo, Sri Lanka
[1]*jayaniyatawatta@gmail.com*, [2]*psridarran@gmail.com*

Abstract: This abstract presents findings from a mixed-methods study examining the integral role of Facilities Managers (FMs) in the establishment of desalination plants. Qualitative data was gathered from experts directly involved in establishing desalination plants. while quantitative data were gathered from FMs overseeing water treatment facilities. Non-probability sampling was used, with thirty-six questionnaires distributed. Through the literature, identified eight stages in desalination plant development: planning, design, tendering, construction, operation and maintenance, testing and commissioning, handover, and demolition. To assess the significance of FM roles, the Relative Importance Index (RII) was applied. Key findings related to the FM role are, risk assessment being crucial in the planning stage, contract document preparation in the design phase, and evaluating tender submissions during tendering. Resource allocation took precedence in construction, while maintenance schedule preparation was paramount during operation and maintenance. In the testing and commissioning phase, ensuring proper design, installation, testing, operation, and maintenance was critical. During handover, overseeing project documents was vital, and contributing to demolition decisions was crucial in the demolition stage. These results underscore the essential role of FMs throughout desalination plant projects. They offer insights for organizations and industry professionals, facilitating a better understanding of FM responsibilities at each stage and improving overall project management.

Keywords: *Desalination, Facilities Managers (FM), Relative Importance Index (RII) Role, Stages,*

1. Introduction

The establishment of a desalination plant requires meticulous planning, efficient design, smooth execution, and ongoing maintenance to ensure its successful operation (Morillo et al., 2014). In this complex process, Facilities Managers (FMs) play a crucial role in overseeing various stages and ensuring the optimal functioning of the plant (Goulden & Spence, 2015). However, the extent of their involvement and specific responsibilities in each stage have not been extensively studied. To bridge this research gap, a quantitative study was conducted to examine the involvement of FMs in establishing a desalination plant.

Desalination plants have gained significant importance in regions facing water scarcity, where they provide a sustainable solution by converting seawater or brackish water into potable water (Islam et al., 2018). The success of such projects depends not only on advanced technologies and engineering expertise but also on effective facilities management. FMs are responsible for overseeing the maintenance, operation, and safety of a facility throughout its lifecycle, making their involvement critical in the establishment of a desalination plant (Weeks & Leite, 2021). The objective of this study was to comprehensively assess the involvement of FMs in the different stages of establishing a desalination plant. The eight identified stages, namely planning, design, tendering, construction, operation and maintenance, testing and commissioning, handover, and demolition formed the framework for this investigation (Eadie et al., 2013; Tucker, 2017). Through a combination of literature review and industry expert consultations, these stages were established as the key milestones in the establishment process.

The perspectives of industry experts and FMs who work at industries and water treatment plants, this study aimed to provide valuable insights into the specific roles and responsibilities of FMs in each stage. The data collected through the distribution of questionnaires allowed for the assessment of the relative importance of various FM activities within each. This approach enabled a comprehensive understanding of the FM's involvement in establishing a desalination plant.

2. Literature Review

Facilities management can be defined as the tools and services that support the functionality, safety, comfort and sustainability of buildings, infrastructure, and real estate (International Business Machines Corporation (IBM), 2021).

*Corresponding author: Tel: +94 719911987 Email Address: jayaniyatawatta@gmail.com
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The infrastructure includes roads, highways, bridges, airports, water treatment plants and power plants (E Sub construction, 2021). One type of water treatment facility is desalination (Islam et al., 2018). There are stages when constructing the water treatment plants, such as planning, design, tendering, construction, commissioning, operation and maintenance, and demolition (Epic System, 2021). Here identified related FM roles in each stage.

Table 1 FM related activities for establishing desalination plant

Stages	Facilities manager's Roles	References
Planning,	Creating project schedule Feasibility study Define project budget and timeline Identified resources needed, strategies and scope Do a risk assessment	(Kissflow project, 2021)
Design	Preparing schematic design Preparing contract documents Help to design equipment selection and layouts. and technology designs. Design Mechanical, electrical and plumbing	(Koutsogiannis, 2021;Western Michigan University, 2021)
Tendering	Prepare the tender document Discuss the issues of the tender document Advertising the requirement. Evaluation of the tender submissions. Overseeing the tender drawing	(International Association of Dredging Company (IADC), 2021)
Construction	Allocation of resources Prepare a construction budget and documents Checking the construction stages and activities Checking construction drawings Cost modelling	(Synuma, 2021; Target Jobs, 2021; Western Michigan University, 2021)
Operation and maintenance	Prepare maintenance schedule Prepare a maintenance budget Identifies inspection and maintenance requirements of the project. overseeing and agreeing on contracts and providers for services	(ASB design group PLC, 2016;Asia & Group, 2011;Limble, 2019;united states environment protection agency (EPA), 2021)
Testing and Commission	supervising staff members of a construction company and engineer firms make sure that designs, installs, tests operate, and maintains correctly checking project performance Approving high costs and installations Determines task deliverables have been fulfilled	(Ziprecruiter, 2021)
Hand over	Preparing the project status report Filing in the project handover checklist Completing outstanding documents and activities Handing over project documents and files Signing off the project handover checklist	(Project Practical, 2021)
Demolition	Prepare a demolition budget Managing demolition and taking a decision overseeing renovations or refurbishments drafting reports and making written recommendations for demolitions Award for the contract	(National Demolishion Association (NDA), 2017;Target Jobs, 2021)

3. Methodology

The rationale, appropriateness, validity, and amount of data required should all be considered while choosing a data collection strategy (Polonsky & Waller, 2015). According to the authors, secondary data can be found in a literature review, whereas primary data can be found via data collection techniques such as questionnaires.

3.1. QUALITATIVE DATA ANALYSIS

Interviews are a set of questions asked orally by interviewees to which the participants usually respond. Interviews were conducted among six (6) knowledgeable and experienced experts. Semi-structured interviews are preferable in this study because they will enable the researcher to re-question or repeat the interviewee's responses for additional explanations. Interviewing experts who are directly involved in establishing desalination plants and who are the persons introduce the desalination concept for Sri Lanka. The purpose of this expert survey is to pinpoint the activities associated with the establishment of a desalination plant within the specific context of Sri Lanka. Furthermore, the survey is employed to provide a comprehensive description of the roles undertaken by FMs in the process of establishing desalination plants in Sri Lanka.

Table 2: List of Experts

No	Interview code	Designation	Year of experience	Year of experience for the desalination
1	R1	Assistant General Manager of NWSDB (North Central Province)	21	10
2	R2	Water Treatment specialist of NWSDB	29	9
3	R3	Water Treatment specialist of NWSDB	23	9
4	R4	Engineer of NWSDB	25	10
5	R5	Engineer of NWSDB	24	9
6	R6	Engineer of NWSDB	26	10

3.2. QUESTIONNAIRE

The questionnaire was used to gather data from FM to identify the FM roles when establishing the plant. The quantitative data was collected from FMs working in hotels and apartments who are responsible for managing water treatment plants. Opinion and experience of desalination plant conducted and industries, FM were gathered through a questionnaire. Section A, a background of the information, Section B divides into eight implementation stages: planning, design, tendering, construction, operation and maintenance, testing and commissioning, handover, and demolition. The questionnaire was conducted the 36 of FMs currently working at the industries and water treatment plants.

3.3. SAMPLING TECHNIQUE

Sampling is the process of selecting integral behaviours, occurrences, or events from a specified class of observation (Taherdoost, 2016). When data collection for the entire population becomes practically impossible, sampling approaches become important (Byrne, 2001). The research problem will determine the sampling method and the data to collect and analyze (Rowley & Rowley, 2014). This research focuses on FM involvement in establishing the desalination plant. The sample should consist of FM working at water plants and industries and having a bachelor's degree in FM at the University of Moratuwa. Because there is no probability associated with the population unit, nonprobability sampling was chosen, and selection is based on the researcher's judgment (Rowley & Rowley, 2014). Furthermore, a non-probability sampling strategy known as purposive sampling was selected as the most appropriate sampling technique for a questionnaire survey (Rowley & Rowley, 2014). The researcher's judgment determines respondents in the purposive sampling technique (Tongco, 2007). In conclusion, this study targets a sample consisting 36 of FM working at industries and water plants and having a bachelor's degree in FM.

3.4. QUANTITATIVE DATA ANALYSIS

Quantitative data gathered from structured questions of the questionnaire were analyzed as below. Quantitative data analysis using the Relative Importance Index (RII).

- FM involvement for establishing desalination plant

Identify some activities regarding establishing the plant such as planning, design, tendering, construction, operation and maintenance, testing and commissioning, handover and demolition. When using the IRR value, rank the activities to identify the most related FM. The RII method can rank attributes (Sambasiva & Soon, 2007). With RII, 5-point Likert scale results were translated into recognized priorities (Rooshdi et al., 2018). The following equation was used to calculate RII:

$$RII = \sum \frac{W}{AxN}$$

Equation 3.5 Relative Importance Index

Where W = Weighting given for each factor by respondents
A = Highest weight on the scale
N = Total number of respondents

4. Findings

There are eight stages to establishing a desalination plant: planning, design, tendering, construction, testing and commissioning, operation and maintenance, handover, and demolition. This study employed a questionnaire survey to prioritize activities related to FM. 36 FM practitioners ranked the list of activities under each stage of establishing desalination plants. The following sections describe the analysis of the findings.

4.1. PLANNING STAGE

The planning phase entails a more detailed development of the project to achieve the project's goal. Table 1 shows some activities in the planning stage.

Table 3:FM roles for planning stage

Name of the activity	RII Value	Rank
Do a risk assessment	0.9167	1
Identified scope of the project	0.7944	2
Feasibility study	0.7889	3
Define project budget and timeline	0.7500	4
Creating project schedule	0.7333	5

Table 3 shows that risk assessment was ranked with the most significant FM role with the RII value of 0.9167. Usually, the FM did the risk assessment. The FM plays a crucial role in risk management. Interviewee R5 stated, "*Before establishing the desalination plant, NWSDB do the risk assessments to identify the related risk.".* Interviewee R2 identified risks such as "*chemical risk* occurs *because we added some chemicals for maintaining the Ph levels of the water, workplace accidents, Slip and falls, transportation accidents, structural failures, mechanical malfunctions, technical risk, and natural risks like a tsunami."* The FM should manage those risks. Identified resources needed, strategies, and project scope was ranked second with an RII value of 0.7944. FM is involved in identifying and recording a list of specified project goals, resources, costs, and deadlines of the project. The FM is involved in some roles of the project manager. FM had a role to the prepared the project proposals. Thirdly ranked a feasibility study with RII value of 0.7889. Interviewee R5 stated, "*Before starting the desalination projects, NWSDB did the feasibility study including technical, economic, legal and social feasibilities. According to the feasibility study results, NWSDB got the decision that project should be done or not."* When doing the feasibility, FM should identify related criteria regarding desalination. Most of the FM involves identifying the technical and social feasibilities than the other feasibilities. Defining a project budget and timeline and creating a project schedule were ranked least (4^{th} and 5^{th}) with RII values of 0.7500, 0.733 respectively. These last activities are more related to the project manager than to the FM because creating project schedules and budget is the significant role of the project manager. In addition to that, identified some FM roles in the planning stage such as Checking alternatives (after risk assessment, if the risk is too high), Coordination management planning with BIM, defining roles and responsibilities of the staff, space management, planning project resource, prepare initiation phase documentation and supporting documentation.

4.2. DESIGN STAGE

The schematic designs and elevations are evaluated, amended, and expanded in the design stage to include all the features and specifications needed for construction. Table 4.8 shows some activities regarding the design stage.

Table 4: FM roles for design stage

Name of the activity	RII Value	Rank
Preparing contract documents	0.7833	1
Help to design layouts.	0.7278	2
Design Mechanical, electrical and plumbing systems.	0.7111	3
Preparing schematic design	0.6778	4
Design technology designs	0.6389	5

Table 4 shows that preparing a contract document was ranked with the highest suitability for FM roles with RII value of 0.7833. One of the FM role is sourcing and overseeing the contract documents. All interviewees stated, the desalination plants were established by a foreign company named SUEZ. NWSDB and SUEZ had a contract to develop the desalination plant. Interviewee R6 stated, "*After preparing the desalination plant, they have another contract to operate and maintain it in 7 years".* Interviewees R3 identified that the "*NWSDB board is done the client and consultant role in the desalination project."* As a result, a contract document handler is required when establishing the plants. FM's significant role is document management. Help to design layouts ranked as second with an RII value of 0.7278. one of the FM roles is space management. The management, control, and monitoring of the physical places is space management. Interviewee R2 mentioned that "*Space management is a major key activity when establishing the desalination plant."* The interviewee R3 stated "*The plants are kept in a central location because easy to check, maintain, and repair regularly."* Before the installation, the space should be managed by the FM. The third role is selected design Mechanical, electrical, and plumbing systems with the RII value of 0.7111. Preparing schematic design and design technology ranked 4^{th} and 5^{th} with RII values, 0.6778 and 0.6389, respectively. The R1, R2, R3 and R5 state that design layouts, design equipment, design technologies are done by the design team of the SUEZ company. Interviewee R2 stated, "*The design team is responsible for designing every component of the plant."* The Interviewee R1 identified that the "*Design team is responsible for designing the sea water intake and brine discharge without harming the marine impact."* According to interviewee's statements, designing parts is more done by the design team. In addition to that, designing lighting for service building, designing a building considering occupation health and safety rules, preparing the document including Building dimensions and gridlines, defining the performance and material standards

required, always be aware of continuous progress, determining user requirements (plant operator) are the additional role of FM.

4.3. TENDERING STAGE

Tendering is a process in which potential contractors are encouraged to submit bids for specific infrastructure projects. Here show the FM roles regarding the tendering stage.

Table 5:FM roles for tendering stage

Name of the activity	RII Value	Rank
Evaluation of the tender submissions.	0.8278	1
Overseeing the tender drawing	0.7889	2
Discuss issues of the tender	0.7611	3
Prepare the tender document	0.7333	4
Advertising the requirement.	0.6167	5

Table 5 shows that evaluating the tender submission was ranked with the most significant FM role with RII value of 0.8278. After submitting the tender documents, an evaluation procedure must be conducted to determine the preferred tenderer. The FM contributes to the tender evaluation procedure." Interviewee R2 identified that "*There is a service building to run the plant. NWSDB hopes to outsource cleaning and security services to the plant.*" That interviewee R5 stated, "*NWSDB could use solar energy for the service building and should outsource them.*" That soft services tender submissions are managed by the under the FM. Overseeing the tender drawing was ranked second with RII value of 0.7889. Tender drawings are a series of comprehensive documentation created to help construct a project. FM involve in this activity to get the idea of the construction. Third ranked discussed issues of the tender with RII value of 0.7611. FM is involved to the discuss the issues with the tenderers. When getting the soft services for the plant, FM should discuss their issues with the tenderers. Prepare the tender document was ranked fourth with RII value of 0.7333. The tender report is the summarizes the tendering process and analyzes each submitted tender proposal. Most of the FM is prepared the soft service related proposals. The engineers should prepare the plant related proposal. Advertising the requirement was ranked least (5^{th}) with RII value of 0.6167. That advertising the requirements are done by the under the marketing team. In addition to that, preparing a pre-qualification list, discussing the prices of the contract and adjustments, supervising procurements, receipt and review of the tenders, preparing Pre-Qualification Questionnaire (PQQ), Evaluation of PQQ and sending Invitation to Tender (ITT) are other roles regarding FM in tendering stage.

4.4. CONSTRUCTION STAGE

The construction phase includes the actual building process and related tasks such as landscaping, site removal, and site preparation. Here show the related activities regarding the FM profession.

Table 6: FM roles for construction stage

Name of the activity	RII Value	Rank
Allocation of resources	0.7778	1
Cost modeling	0.7000	2
Checking construction drawings	0.6889	3
Checking the construction stages and activities	0.6833	4
Prepare a construction budget and documents	0.6611	5

Table 6 shows that allocation of resources was ranked highest suitability for FM roles with RII value of 0.7778. Interviewee R4 stated, "*When choosing the materials for the plant construction, should have a less environmental impact.*" When establishing the desalination plant, material selection is a difficult procedure. FM can involve selecting materials for the construction because FM has good knowledge about materials and renewable energy sources. Cost modelling ranked second with RII value of 0.7000. Cost modelling helps and empowers enterprises to choose the most cost-effective method for producing the items. All interviewees stated the most cost is going to the plant's energy consumption. One of the FM's significant roles in energy management. So, FM can implement energy saving methods and reduce the operation cost of the plant. As the third role is selected, the Checking construction drawings with the RII value of 0.6889. FM isn't more involved in checking the construction drawings. Architects, designers, contractors, consultants, and engineers are more involved in those activities. Checking the construction stages and activities and

preparing a construction budget ranked 4th and 5th with RII values 0.6833 and 0.6611, respectively. FM is not much involved in checking construction stages because the engineers and QS do it. Most of the construction budgets are prepared by the QS. In addition to that, overseeing facility and site planning, checking service lines of service building, overseeing the concrete strength, checking to finish off the sites, overseeing the excavation procedures, client representative, task assignments, participating to the status meetings, updated project schedule, modification of project plans and ensuring that project meet environmental, health and safety standards and other government regulations are the additional roles of FM in the construction stage.

4.5. OPERATION AND MAINTENANCE

The functions, duties, and labour associated with daily operations, routine repairs, replacement of parts, structural components, and other activities required to maintain a plant to continue providing acceptable services and achieve its expected life are operations and maintenance. Here are the main activities regarding the FM.

Table 7: FM roles for operation and maintenance stage

Name of the activity	RII Value	Rank
Prepare maintenance schedule	0.8944	1
overseeing and agreeing on contracts and providers for services	0.8889	2
Prepare a maintenance budget	0.8833	3
Identifies inspection and maintenance requirements for the project.	0.8778	4
Managing renovations and refurbishments	0.8722	5

Table 7 shows that preparing the maintenance schedule was ranked with the most significant FM role with the RII value of 0.8944. One of the FM's major roles is operation and maintenance. Interviewee R2 stated, "*Plant's maintenance is done daily, weekly, monthly and annually."* The FM has the responsibility to prepare and update the maintenance schedule. Overseeing and agreeing contracts and providers for services were ranked second with RII value of 0.8889. Interviewee R3 stated, "*There is a service building to run the plant. We hope to outsource company to do the cleaning and security."* That interviewee R5 stated, "*NWSDB could use solar energy for the service building and should outsource them."* That all services agreements and contracts handle by the FM. Thirdly ranked a prepare a maintenance budget with RII value of 0.8833. The maintenance budget should be built with the latest data and information available to ensure controlled maintenance costs. The FM is involved in preparing the maintenance budget because operation and maintenance are the FM's critical activities. Identifies inspection and maintenance requirements ranked as a 4th with RII value of 0.8778. In my opinion, the additional inspections and maintenance requirements are identified by the equipment operators and the mechanical engineers. The Managing renovations and refurbishments were ranked least (5th) with RII value of 0.8722 because top management most takes renovation and refurbishment decisions. Identified the additional roles regarding the FM in the operation and maintenance stage such as ensuring the buildings and plants are kept in good condition, meet all safety and health regulations and legal requirements, management of changes to the operation and maintenance system to support end-users, monitoring of system performance, analysis of service contract and insurance policies, supervise maintenance activities, overseeing cleaning, waste disposal, brine discharge, and security while also keeping track of payments, budgets and increased energy efficiency.

4.6. TESTING AND COMMISSIONING STAGE

Commissioning is the process of ensuring that all systems and components of a significant piece of equipment, a process, or something similar are planned, installed, and tested according to the operating requirements of the client. Here shows testing and commissioning activities related to the FM profession.

Table 8: FM roles for testing and commissioning stage

Name of the activity	RII Value	Rank
Make sure that designs, installs, tests, operates, and maintain all sites parts correctly	0.8389	1
Checking project performance	0.8278	2
Determines if certain task deliverables have been fulfilled	0.8000	3
Approving any significant expenses or equipment installations.	0.7889	4
Supervising staff members of a construction company and engineer firms	0.7667	5

Table 8 shows that Ensuring staff designs, installs, tests, operates, and maintains all site parts correctly were the most suitable FM roles with RII value of 0.8389. All interviewees stated the desalination plant was established by a French company named SUEZ. SUEZ had responsible for operating seven years after establishing the plant. After seven years, they handover the plant's operation to the NWSDB. After seven years, the NWSDB will do the commissioning before signing the handover contracts. The FM is involved in the commissioning stage to do some testing and evaluation. Interviewee R6 stated, "*The desalination plants did chemical testing, water quality testing, plant performance testing, and brine discharge testing.*" FM is directly involved in plant performance testing. The water treatment specialists did that other testing. Checking project performance ranked as second with an RII value of 0.8278. The FM is involved to measure the equipment performance. FM has a responsibility to do the equipment maintenance, and FM is the person who knows about the equipment performance correctly. The third role is selected to determine if certain task deliverables have been fulfilled with the RII value of 0.8000. Approving any significant expenses or equipment installations and Supervising staff members of a construction company were ranked as 4th and 5th with RII values 0.7889 and 0.7667, respectively. However, the commissioning team does these 3rd, 4th and 5th activities. The interviewee R5 mentioned that "*The NWSDB is outsourced the commissioning team to do the plant commission.*" So, these final three responsible should be taken by the commissioning team. The additional roles of FM identified include overseeing cleaning, verifications, leak tests, performance evaluation, and functional tests are essential for bringing a newly installed plant, checking routine operation, identifying performance related issues, and overseeing the commission process.

4.7. HANDOVER STAGE

A handover occurs when a project to install, create, or modify an asset is completed. This stage usually entails the client formally accepting the asset and then transferring construction from the contractor to the client. Here show activities related to the FM.

Table 9: FM roles for handover stage

Name of the activity	RII Value	Rank
Handing over and overseeing project documents and files	0.8000	1
Signing off the project handover checklist	0.7889	2
Completing outstanding documents and activities	0.7778	3
Preparing the project status report	0.7722	4
Filing in the project handover checklist	0.7444	5

Table 9 shows that handing over and overseeing project documents and files was ranked with the highest suitability for FM roles with RII value of 0.8000. One of the FM's significant roles in maintaining the documents (contract, operation and maintenance). When the project handover process, FM should handover all documents for the evaluating process, and FM has the responsibility to oversee the whole document submitted by the construction company. The second-ranked role is the Signing off the project handover checklist with RII value of 0.7889. FM have responsible for the handover all documents for the evaluation process. After the evaluation, FM should check the correction of the documents and make sure that the construction company submitted all their documents. After the accepted document, sign off the handover checklist. The third role is selected to complete outstanding documents and activities with the RII value of 0.7778. Preparing the project status report and Filing in the project handover checklist were ranked as 4th and 5th with RII values 0.7722 and 0.7444, respectively. Most of the documents are prepared by the top management in the handover process. The top management prepares status reports, checklists, and outstanding documents. Additional roles can be identified regarding the FM such as, checking the system is working and inspecting the system during the defect liability period, doing a presentation about the whole process, identifying the parties involved in the handover process, Preparing the document including a deadline of handover and communication plan.

4.8. DEMOLITION STAGE

A building's demolition is the act of purposefully destroying it to construct something different in its place. Here are some activities regarding the FM profession.

Table 10: FM roles for demolition stage

Name of the activity	RII Value	Rank
Contribute to the demolition decision	0.7500	1
Overseeing renovations or refurbishments	0.7444	2
Award for the contracts	0.7333	3

Drafting reports and making written recommendations for demolitions	0.7056	4
Prepare a demolition budget	0.6222	5

Table 10 shows that Contribute to the demolition decision is the most significant FM role with the RII value of 0.7500. After the lifetime is over, the final stage is the demolition stage. The FM contributes to the decision-making procedure. Interviewee R5 mentioned that *"Desalination plant lifetime is 20 years. After 20 years, should need to make a demolition, refurbishment or renovation decision".* FM should participate in the decision procedure and submit all operation and maintenance documents to take the decisions. Overseeing renovations or refurbishments was ranked second with RII value of 0.7444. Interviewee R6 described that, *"Couldn't demolish the plant because NWSDB has a responsibility to provide water to people and industries. Couldn't prepare another project instead for the desalination plant. Most of the time, we go to renovations and refurbishment procedures."* According to the statement, NWSDB couldn't prepare another project instead of the desalination plant because NWSDB is responsible for providing pure water for people. The FM has the responsibility to oversee the refurbishment and renovation procedures. Third-ranked award for the contracts with RII value of 0.7333. That most of the demolition, renovation and refurbishment contracts are made by top management. However, FM participates in the contract making procedure. Drafting, making written recommendations for demolitions, and preparing a demolition budget were ranked least (4th and 5th) with RII values of 0.7056, 0.6222 respectively. The financial department and top management are preparing the budgets and reports. Additional FM roles are identified; waste is generated approximately when the plant is demolish. The waste can damage the land, sea, and air. Furthermore, waste removal transportation might harm the environment due to GHG emissions. FM is responsible for making a report including the social and environmental effects of plant demolition. After the report, FM can oversee other demolition options like recycling and reuse.

5. Discussion

Five activities were recognized in each stage through extensive literature review, and all respondents (36) from the questionnaire survey were asked to rank the identified activities.

Planning stage - Most significant FM role in a planning stage is the risk assessment. According to the Crespo Márquez et al., (2009), One of the primary responsibilities of the FM's is conducting risk assessments. The FM plays a crucial role in risk management. one of the significant FM roles in identifying and evaluating the risk. Identified resources needed, strategies, and project scope was ranked second. Thirdly ranked a feasibility study. The additional roles and responsibilities are identified such as Coordination management planning with BIM, defining roles and responsibilities of the staff, setting and priorities the goals, Planning project resources.

Design stage - Preparing a contract document was ranked with the highest suitability for FM roles. Moreover, Talamo & Atta, (2019) Identify the preparing contract documents is one of the key roles of FM's during the design stage. One of the FM major roles is document management. Most of the services are outsourced when developed a plant. The FM should handle the outsourced contract documents. Help to design layouts ranked as second; The third role is selected the Design Mechanical, electrical and plumbing systems. The additional roles and responsibilities are identified, designing lighting for service building, designing a building using health and safety rules, preparing the document including Building dimensions and gridlines, defining the performance and material standards required. Koutsogiannis, (2021) also identify the several roles of the FM's in design stage.

Tendering stage - Evaluate the tender submission was ranked with the most significant FM role in tendering stage.FM involves to the evaluate and choose the best tenders for soft services. According to the Liu et al., (2016) identified, FMs are directly involved in tender submission and tender evaluation. Overseeing the tender drawing was ranked second, Third-ranked discussed tender issues. The additional roles and responsibilities are identified from responses, discussing the contract prices and adjustments, Receipt and review of the tenders, preparing Pre-Qualification Questionnaire (PQQ), Evaluation tender submission and sending an invitation to Tender (ITT).

Construction stage - Allocation of resources was ranked highest suitability for FM roles because FM manages the materials and resources. Literature suggested that FMs provide facilities and create a more comfortable environment for managers and laborers at the construction site (Koleoso et al., 2017).Cost modelling ranked second, checking construction drawings ranked third. The additional roles and responsibilities are identified, overseeing facility and site planning, checking service lines of service building, client representative, Task assignments, updated project schedule, ensuring that projects meet government regulations and standards.

Operation and maintenance stage - Preparing the maintenance schedule ranked the most significant FM role. FM should manage and update the daily, monthly and annual maintenance activities. Secondly ranked, Overseeing and agreeing with contracts and providers for services. Thirdly ranked a prepare a maintenance budget. The additional roles and responsibilities are identified, monitoring system performance, managing service contracts, insurance policies and budgets, supervising maintenance activities, overseeing cleaning, waste disposal, brine discharge, and security, Ensuring health and safety and increased energy efficiency. Facilities managers major role is the implement

equipment and machineries predictive and preventive maintenance (Ensafi et al., 2023). Moreover, FMs has resposible for Building operations like cleaning, security, maintenance and grounds management, Return-to-work processes and policies, Emergency and disaster mitigation and response, Sustainability planning, Project management and budgeting, Real estate management and space planning (Booty, 2006).

Testing and commission stage - Ensuring that staff designs, installs, tests, operates and maintains all site parts correctly ranked as the most significant role of FM. FMs are directly involve to the commissioning The FM knows the installations and design. Checking project performance ranked as second; The third role is selected to determine if specific task deliverables have been fulfilled. The additional roles and responsibilities are identified, Do the leak tests, performance evaluation and functional tests, check operation of the plant, identify issues related to performances and oversee the commission process. Moreover, Booty, (2006) identified additional activities related to this stage FM's play a crucial role in overseeing the meticulous design of the commissioning process to ensure that newly constructed or retrofitted facilities, along with their various systems and components, seamlessly align with the original design intent, meet the specific requirements of the client, and rigorously adhere to all relevant codes, standards, and regulatory guidelines.

Handover stage - Handover and overseeing project documents and files was ranked with the highest suitability for FM roles because one of the FM's significant roles is document management. According to the Liyanage & Egbu, (2005) identified Typically, facilities managers are actively engaged in the realm of document management. During the handover stage, it is the responsibility of facilities managers to oversee the preparation and meticulous verification of documents pertaining to the desalination plants. The second-ranked role is the Signing off of the project handover checklist. The third role is selected to complete outstanding documents and activities. The additional roles and responsibilities are identified, check the system, do a presentation about the whole process, identify the parties involved in the handover process, Prepare and check the document and communication plan.

Demolition stage - Contributing to the demolition decision is the most significant FM role. FM knows about the current condition of the plant and the building. Overseeing renovations or refurbishments was ranked second, Third-ranked Award for the contracts. The additional roles and responsibilities are identified, make report including the social and environmental effects of plant demolition. After the report, FM can oversee other demolition options like recycling and reuse. According to the Dixit et al., (2016) mentioned that FMs typically take on the responsibility of managing construction and demolition waste. This entails tasks such as calculating carbon emissions and implementing eco-friendly waste management practices, including the principles of Reduce, Reuse, and Recycle (3R).

6. Conclusion

The literature review identified the desalination establishing stages and related activities. Used the questionnaire survey to collect data for identifying the most significant activities related to the FM. Through RII identified the most significant roles related to the FM. The open-ended questions identified the other related activities from the respondents. The literature review identified eight stages of establishing a desalination plant: planning, design, tendering, construction, testing and commissioning, operation and maintenance, handover, and demolition. Doing a risk assessment is the most relevant activity in the planning stage. Preparing a contract document was ranked with the highest suitability FM role in the design stage. Evaluating the tender submission was ranked as the most significant FM's role in tendering stage, allocation of resources was ranked as the most significant FM's role in the construction stage, preparing the maintenance schedule was ranked as the most significant FM's role in operation and maintenance stage, Ensuring staff designs, installs, tests, operates, and maintains all site parts correctly was ranked as the most significant FM's role in testing and commission stage, handover and overseeing project documents and files was ranked as the most significant FM's role in handover stage and Contribute to the demolition decision is the most significant FM's role in demolition stage.

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