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# From Months to Days—An Efficient Microsoft-Excel Database: A Case of Dam Maintenance in United Arab Emirates

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**Abstract**

The subject of this study is the phenomenon of the success of an electronic program (Microsoft-Excel®) for the dam maintenance database. Project improvement includes three phases with a duration of 2 years. The current Excel programming is free, in contrast to specialized software, which costs hundreds of thousands of dollars. More than 6,000 cells were programmed with many smart logarithmic equations. The purpose of this study is to explain, in a practical and theoretical framework, the reasons that cause the distinguished project results (reduction of the completion of maintenance reports from months to 5–10 working days) with low-cost efficiency. Therefore, this leads to increasing the agility of maintenance work fulfilments (effectiveness). Particularly, 11 criteria were designed to compare the status of the project; before and after; improvement. Theoretically, this study adopted the case-study research approach. It aims at setting enablers (actions) that lead to a specific outcome (theory - model building) of the current practice. The study sample was represented by the project team themselves. As a result, the study model (theory) estimated six elements (variables). Generally, the reasons for the success included three elements: technical, managerial and personal factor. These factors led the maintenance project to achieve high efficiency, accuracy and effectiveness. As a comprehensive recommendation, if any global construction institution (such as the Dams Department) intends to implement a similar e-project, its focus should not be limited to the electronic aspect; rather, the managerial and personal aspect should be the focus. In addition, this e-project is a ready base for an optimized technological platform.

**Keywords:** cost performance, data combination, decision theory, maintenance performance, information management, value creation

## 1. Introduction

The subject of this study is the phenomenon of the success of the simplified electronic program for the dam maintenance database. Our purpose is to explain the reasons that led to our results. Our study simply shows the enablers of our project results, whether personal, managerial or technical skills. Our results mainly support the maintenance process at the Dams Department (Ministry of Energy and Infrastructure in the UAE). Our intention is to document this phenomenon to ensure its generalization and continuity. Therefore, this practice represents a guide for interested practitioners inside and outside the ministry. Generally, the final output of this effort is to describe the model (theory and cause-and-effect variables) around the achievement of the project's success. Building a theory is the purpose of any case study (Flyvbjerg, 2006; Ridder, 2017).

Our project is a practice-based innovation. Innovation is considered a distinct institutional pillar (Schillewaert et al., 2005). The innovative idea of this practice focuses on programming and implementing a simplified electronic program (Qarkaxhija, 2018), Microsoft-Excel, to increase the performance of the dam maintenance process (valued innovation). Accordingly, it is an innovative practice with an exceptional value for work. Thus, it is one of the qualitative leaps in dam management. This innovation caused a remarkable shift in maintenance performance. In order to overcome the current problem (low database performance), the maintenance process has improved from the traditional stage based on paperwork and lengthy constituent accounts to the stage of ultra-fast and accurate automated programming.

We chose Excel because it represents a database (data, facts and figures) of people with little experience and few budgets and with the work in both the private or public sector (Cornell, 2007; Qarkaxhija, 2018). Therefore, we selected this program to achieve high efficiency and accuracy of the maintenance database (Mayes, 2020;

Qarkaxhija, 2018; Salkind & Frey, 2021). This will ultimately achieve the effectiveness (maintenance work application) of periodic maintenance decisions (Karimi & Manteufel, 2010).

Generally, the ideal of the new electronic database, as pointed by Ullman et al. (1997) and Tsichritzis et al. (1982) is a program that interacts with all end users, applications, and the database itself to capture and analyse data. The new programmed database added several significant values, including high performance (efficiency and effectiveness), as well as being transferable to other institutions involved in dam management. Excel is available in all devices in the world. The other value of Excel is that it is a base for preparing a specialized program, according to advanced programming languages. This program is also distinguished by its effectiveness (maintenance work application). It has the advantage of its robust ability of building a long-term plan of dam maintenance (5 years or more), with an accurate distribution of quantities and budgets.

A new electronic maintenance database was applied in the scope of the Dams Department (Ministry of Energy and Infrastructure). According to the department data, dams supervised by the ministry constitute of 104 dams (with a storage capacity of approximately of 84 million square meters). Generally, dams are intended to preserve or divert water (http://www.efnms.eu/; Stephens, 2010).

Maintenance is of increasing importance (Omar et al., 2019). The term maintenance is defined as all activities related to the functional investigation of repairs and replacement of equipment, machinery and infrastructure for buildings and facilities (http://www.efnms.eu/). Therefore, dam maintenance must concentrate on preventive activities, to ensure an ideal level of the structural condition of the dams. In addition, it requires all works related to calibration and adjustment of dam techniques. Dams' channels and observational wells are also within the maintenance context. Note that the maintenance domain has several management models, and one of these models represents four components: the building, building components, building elements and building items (maintenance defects) (Omar et al., 2019).

In contrast, the same categorization is applied to dam maintenance. The dam maintenance process consists of three stages: assembly, analysis and classification and application of maintenance work (Figure 5). In the first stage, defects in dams are collected (termed as maintenance work). The second stage includes a complete explanation of the data (number, type, volume, quantity and cost). Finally, this case turns into reports and direct contractual orders to be followed by executing (closing) maintenance work through specialized companies (application phase). This third stage represents a major field effort, requiring substantial complex artwork. This concern motivated our project team to move towards innovative solutions. Accordingly, the team assumed that creating a programmed electronic database (Excel) (Appendix 2) would enhance the maintenance database, in terms of time, cost and effort (efficiency), to support maintenance effectiveness (support the implementation of dam maintenance decisions).

The dams' database generally consists of two axes (vertical and horizontal) (Figure 1). The vertical axis represents dams list, and the horizontal axis represents maintenance items. Each item is described by several elements, mainly size, cost and functional priority (priority of achievement). To feed the main interacted database automatically, several supportive databases were established, such as an items table, which describes each item by unit type and unit price (local market prices). Other supportive databases describe two types of data: the priority of dams and the priority of items. All of these database combinations facilitate exporting various smart reports, which contain detailed quantities and costs, supported by priority maintenance decisions.

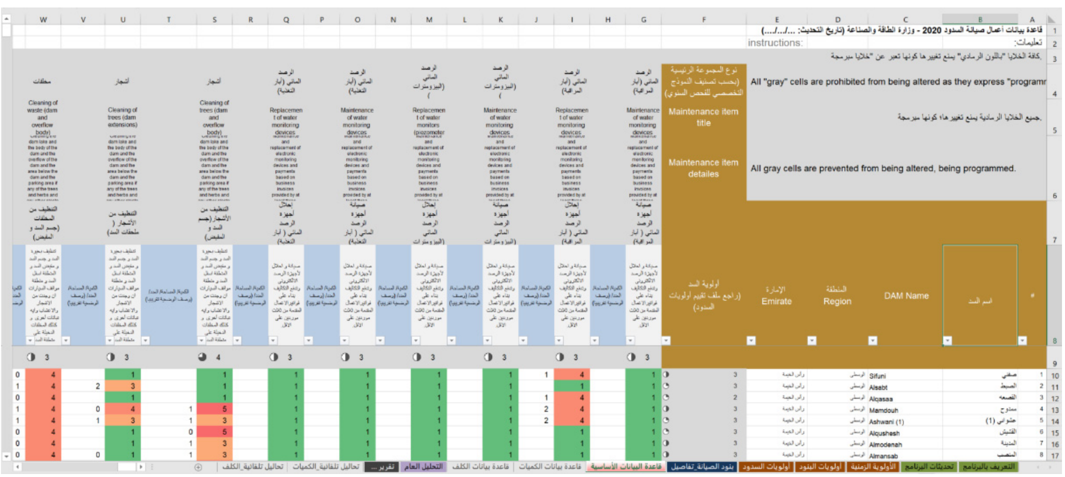

Figure 1. Electronic maintenance database

It is remarkable that the database includes a sub-file related to data analysis, which represents the final report. Practically, these reports are used to implement field maintenance work (Figure 2). The database also includes separate files of definitions and the methodology of using the database. These files represent a key factor to enhance knowledge transfer for all users.

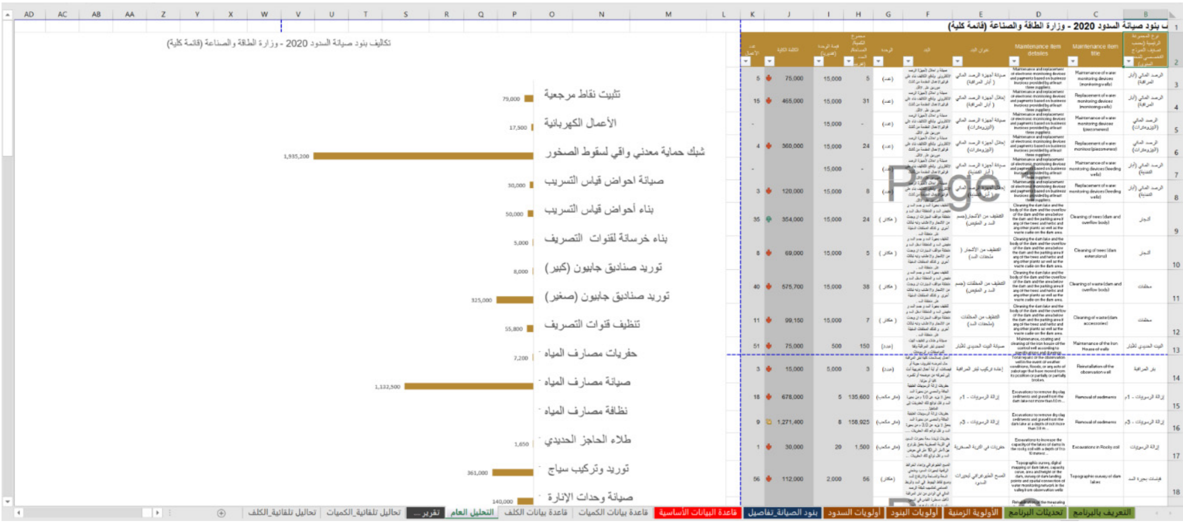

Figure 2. Maintenance Database Report (Main output)

## 2. Problem Statement

The current studied case is described mainly by its practical problems (low efficiency and effectiveness of the dam maintenance process). This was reflected in several detailed problems, including extended maintenance rules fulfilment (months), with medium or low accuracy, and the periodicity of completing this rule is considered modest (once a year). In general, the completion time was not disciplined, as it takes months in most cases. In addition, the previous way of maintenance reporting cannot build a long-term business plan (2 or 3 years at least). It is also evident that there was a limitation in the application of computational techniques such as: organizing data in Microsoft-Word® tables, a calculator, and sometimes an Excel program was used only in a supportive and modest way. The problem was also exacerbated by the lack of maturity of supporting input to the database, such as lists of items, their prices, and other important details. Also, the old method does not include documentation and clarity of maintenance work priorities, items, and dam priorities (this work is done solely by the dam experts in the Dams Department). This previous period of the project was also characterized by the sovereignty of the individual decision (not the group decision). These combinations of problems make maintenance data modest and conventional. Ultimately, these problems cause a weak maintenance performance (low maintenance work application) (Table 1). In general, the dam maintenance process lacks a sophisticated electronic program that can cover all of the detailed problems mentioned previously.

## 3. Study Questions and Objectives

We raised practical and theoretical questions: 'how did the project succeed'? and 'what is the theory that reflects holistically the project's success'? Accordingly, we adopted the following objectives: (1) build a detailed description of the practical reasons (enablers) which contributed to the success of the electronic dam maintenance database, and (2) build a theory (model) for the project's success.

## 4. Study Methodology

We applied two methodological approaches: practical and theoretical.

### *4.1 Practical Methodology*

Details are expressed in the project background and practices section. We designed 11 criteria to compare the status of the maintenance database; before and after; improvement (Figure 3; Figure 4; Table 1).

### *4.2 Theoretical Methodology*

In this study we adopted the case study approach. It aims at theory - model construction of the current practice (phenomenon). We chose this research strategy because the situation needs an in-depth study for a specific unit of analysis (Smith, 2018; Thomas, 2021) and because it is limited to a closed research framework (individual case or several narrow cases) (Smith, 2018; Thomas, 2021).

Smith (2018) advised that the case study should be conducted by a working group rather than an individual in order to ensure the achievement of the triangulation principle. Accordingly, this case study was carried out by a large working group that witnessed the developments of the project operations (case study).

The case study methodology aims to describe two aspects, a set of enablers (decisions and actions) that lead to a specific result (Eisenhardt & Graebner, 2007; Thomas, 2021; Yin, 1994), and this is what this study strives for. There are three approaches to the case study method (theory-building, theory development and theory testing). We applied the theory-building approach (Ridder, 2017). The methodology for case study research differs from other research methodologies such as data collection (Harrison et al., 2017; Merriam, 1991). The study sample was represented by the project team members themselves (Denzin & Lincoln, 2005; Merriam, 1991; Yin, 2009). Consequently, we collected our study case data through discussions among the team members. This team (study sample) has a full coexistence with the course of the study phenomenon (Carroll & Johnson, 1990).

Although the project focused on time efficiency, we believed that the project had a greater breadth of benefits. Likewise, we proposed multiple combinations of targets corresponding to a set of evaluation criteria, describing the project status before and after improvement. In addition, we applied the concept of cause-and-effect. Thus, we built a conceptual model to reflect the success of the project. The theory is an extraction of the case study method (Flyvbjerg, 2006; Hancock et al., 2021). The case study method concerns relationships and process (Thomas, 2021).

## 5. Project Background and Practices

The project background and practices aimed at describing all the details and component that shape and justify the study theory (result), as well, the practical phases of the project improvement.

### *5.1 Main Background*

The project started with the drafting of the project card (preparation and planning). This was followed by distributing the action plan to the team members. The individuals on the work team represented various personal traits, the most important of which was persistence and continuity, ensuring commitment to completing the project (according to a realistic, extended and flexible plan). The team was also characterized by innovation behaviour and facility with the art of time management, enabling the team to overcome the problem of congestion of work. Additionally, team cohesion and motivation were important elements of project success (Rasnacis & Berzisa, 2017).

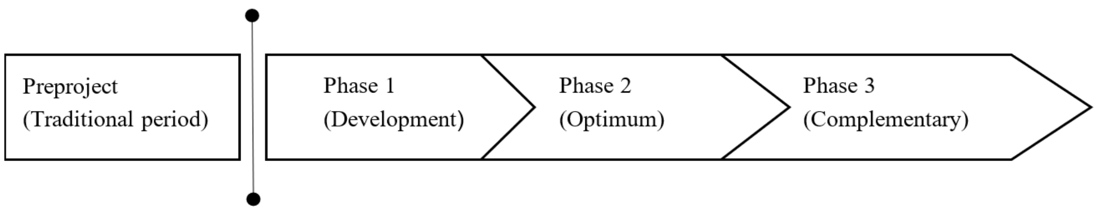


Figure 3. Project Improvement Phases

The preproject (traditional period) phase of the project was represented by a group of traditional work that is relatively unclear in terms of the processes, collecting and analysing and maintaining database data, and it lacks a high-performance computational software (for more details, see the problem statement above).

The first stage (development) was the introduction of electronic databases in their foundational form (using the Excel program with its basic features). The maintenance work in this stage lakes of the list of reference maintenance items. In addition, maintenance works were formulated by observations and self-formulations applied by field officers (the employees who collect data from the field). This requires a great effort to harmonize these observations statements with the maintenance work terms specified in the maintenance formal contracts. However, this stage was better than the previous traditional period which preceded it.

The second stage (optimum) was more advanced in terms of large expansion and integrative programming of Excel cells (more than 6,000 cells were programmed). All this supported an accurate establishment of the database entries (inputs) (Appendix 1). The most important enabler in the second stage was an accurate stating of maintenance items. These items were described by a large, comprehensive and accurate list of features (unit of measure and the price of the unit of measure for each item). It is remarkable that an important input was established, and that there were three types of priorities (time priority, items priorities and dams' priorities).

At the third stage (complementary), a detailed database was built (+2 new). Advanced software tools were added to what is available. This stage was distinguished by a comprehensive and accurate inclusion of the electronic program.

This stage started with completing the detailed data tables (as inputs), and then linking them with the main database. One of the most important detailed tables (input) of the main database is the one for maintenance items. This input was extracted from specialized forms (general and detailed) specified by the reference dam organizations (https://www.fws.gov). This was followed by the harmonization of the specialized maintenance items with the realistic items applied in Dams Department contracts. Thus, this harmonization increases the maintenance items accuracy. These items are the reference range within which maintenance work data are collected. Finally, the work team extracted 64 items, which is explained and defined in a detailed way (previously it was unorganized 32 items).

Additionally, we held several meetings of field and office staff to discuss and test the database. This was followed by an intensive workshop to realistically fill the database. Meanwhile, a team leader monitored three elements: (1) the correctness of the software program cells, (2) the smoothness of the usability of the program, and (3) the extent to which field officers accept the new database (adoption level). The team focused on acceptance of the program from its users (mainly field officers) because that kind of acceptance is considered an important factor to avoid potential change resistance. In this circumstance, we followed the methods of accompaniment and persuasion rather than the traditional compulsion method.

After the program had matured, the field officers entered real data by applying focused monitoring in terms of the three aforementioned elements (correct programming, fluidity and acceptability). Finally, we exported the first copy of the database, with an official report highlighting the accurate description of the volume, costs and priorities of the overall maintenance works.

The team did not stop at this stage. They entered the third, complementary phase. The most important points regarding this additional progress were (1) expanding the database by adding two detailed tables (quantities database and cost database), and (2) building more flexible databases through the option called Pivot Chart, which also enabled more efficient screening of maintenance data (shorter time) (Slager & Slager, 2020).

To demonstrate the database success, we designed 11 evaluation criteria, which we set at their descriptive and quantitative levels through prominent comparisons between the predevelopment and post development stages. They were also based on the descriptive opinions of experts who went through all the aforementioned stages.

### *5.2 Project Practices*

Finally, it is necessary to clarify here some of the associated factors involved with the project development. We held more than 10 meetings and workshops, which included uniquely integrated change management and knowledge management. One of the advantages of the project leaders was the constant accompaniment by the focal team members. Regular and periodic meetings also ensured a continuous transfer of tacit knowledge. To ensure the sustainability of the database's usability, all data were stored in the shared file. Transferring knowledge was applied periodically through monthly and weekly meetings to specific individuals or the work group as a whole. We measured achievement times (5–10 days) via district monitoring. In addition, we confirmed data by a random field audit.

Field officers entered data primarily by relying on their memory and other general reports. This was more efficient than the traditional data collection by listing a holistic visit to all dams. Field officers have accurate information about their dams because of their intensive daily duties. This gives them the ability to accomplish the maintenance requirements in 5–10 days or less.

One of the practices we most often applied was the agile project-management approach, which relied on the lean project thinking method (Owen et al., 2006). Agile project management will occupy a great position in the 21st century (Bergmann & Karwowski, 2018). Agile project management has proven to be a tool of remarkable value in achieving rapid results, with high efficiency and reduced risk, not only for private projects but also for governmental projects (Fernandez & Fernandez, 2008; Wernham, 2012).

Hass (2007) mentioned that it is time to develop new ways of designing and delivering projects, rather than using the traditional methods based on tracking the sequential flow of activities. For this type of project, it usually difficult to identify all requirements in an integrated manner early in the project (Hass, 2007). Generally, the team approach was to develop a general plan which tends to give some but not all details, allowing the team to concentrate on achieving the main tangible outcomes of the project. According to Karlesky and Vander Voord,

(2008) and Cervone (2011), the resent project implementation is reconciled with the agile project management approach.

In general, agile project management is based on the method of accelerating the renewable development as well as on avoiding unnecessary practices (Cervone, 2011). The current project team characterized the project situation as complex and uncertain case. Thus, to ensure its success, it was necessary to adopt a dynamic transition of a variety of application methods (periodic programming of an electronic program). Additionally, the team fostered simplicity and speed, while giving substantial attention to users' feedback (Cervone, 2011; Fernandez & Fernandez, 2008).

One of the unique practices in this project was the phenomenon of 'informal leader'. Accordingly, the project manager could be called 'hidden agile leader'. A wide and varied studies of the hidden-leader phenomenon proved that this type of leader has a significant impact on a project's performance (Zhang et al., 2012). It is expected that this type of leader carries out four practical roles: mentor, coordinator, negotiator and process adapter (Shastri & Amor, 2017). The practice of 'informal leader' opens hope to many hidden leaders to continue reforming and developing their work without the need for official frameworks.

### *5.3 Project Objectives*

The general objective of our project simply put is to raise the performance, quality and accuracy of the dam maintenance database and reports. In addition, we have divided our general objective into several categories of detailed operational objectives. These objectives are related to efficiency, effectiveness, quality and accuracy (accuracy of inputs, accuracy of results and level of utilization of reports). We included other complementary objectives (Figure 4). In the following paragraph we present our detailed objectives' statement.

#### 5.3.1 The Effectiveness Objective

This objective is the ultimate purpose of the project, and all subsequent detailed objectives are serving it. It is represented by the effective treatment of dam maintenance problems and by applying maintenance contracts. It represents the tangible 'maintenance work application' (Figure 5).

#### 5.3.2 The Efficiency Objective

Three detailed objectives branch out from the efficiency objective: (1) time reduction objective (to reduce the duration of exporting database reports, (2) cost reduction objective (efficiency) (to reduce the operations cost of exporting database reports (or time versus money, cost of time), (3) foundation efficiency objective, the current Excel programming is free, in contrast to specialized software, which costs hundreds of thousands of dollars.

#### 5.3.3 Accuracy Objective

Four types of practices that led to project accuracy include (1) report repetitiveness (previously one report was initiated per year; now, maintenance reports have at least four revisions per year, and this achieved the reduction in the possibility of any data deficits); (2) priority management (building a cross-cutting of priorities ensures the perfection of classification of maintenance work according to its importance; the project team built three types of priorities—time, items, and dams' priority), (3) items description (maintenance work items were accurately classified and described in a quantitative manner, represented by items cards with an accurate numerical description being included, and linked programmatically with the database); (4) classification (the program will automatically export accurate maintenance reports, and the program user can sort the reports according to work needs, classification could be according to dam, item, geographical area, emirate, etc.).

#### 5.3.4 Innovation Objective

This aspect aimed to show the ability to innovate and simplify electronic databases on the maintenance process. This innovative value fundamentally reflects the efficiency and effectiveness of the maintenance process.

#### 5.3.5 Portability Objective

One of the symptoms of this innovative database is to transfer the expertise of the dam management team for similar parties, regionally and internationally.

#### 5.3.6 The Art of Agile Project Management Objective

The aim is to highlight the role of the art of lean project management and to demonstrate its ability to build a flexible work plan and achieve outstanding results.

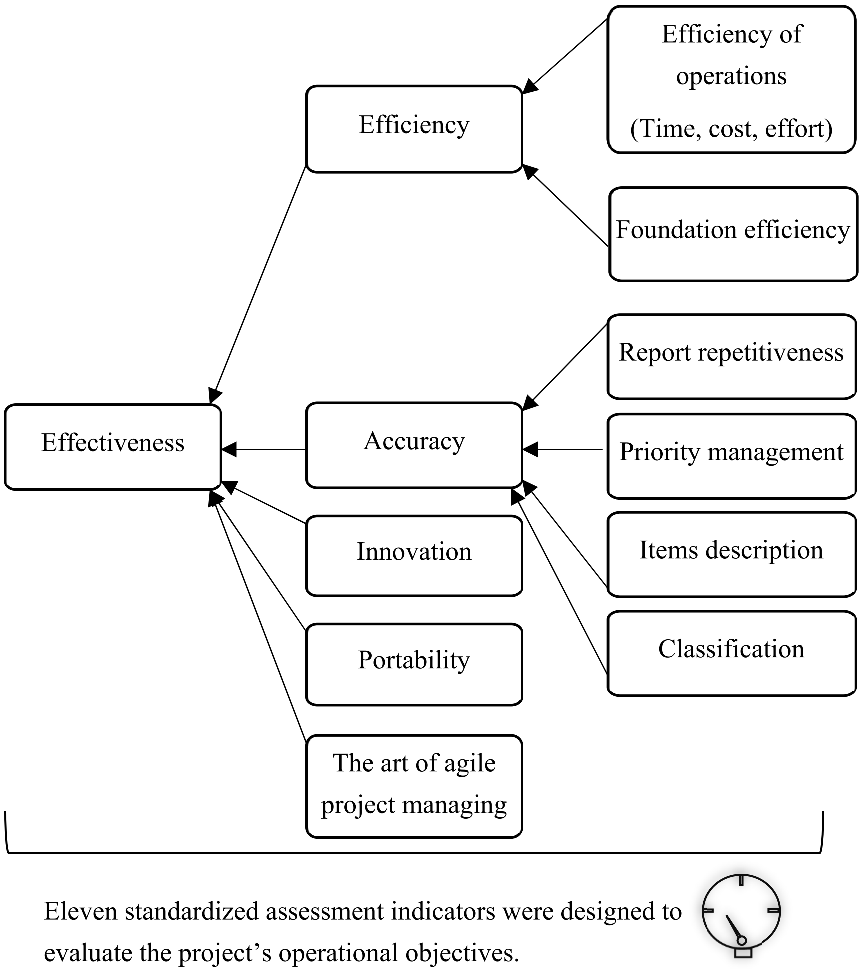


Figure 4. Network of project operational objectives and evaluation criteria

## 6. Result and Discussion

Results are organized in to two categorized aspects; practical (Figure 5, Table 1) and theoretical results (Figure 6).

### *6.1 Practical Results and Discussion*

Practical results are the tangible findings of the project. Our description of the practical results is based on the project objectives and 11 evaluation criteria. Additionally, we evaluated the quantitative and qualitative differences in all stages, from the traditional stage to the developmental stages (Table 1). Project criteria reflect the performance of project objectives, as they give an additional dimension to the scope of these objectives. Apparently, the pattern of work has changed completely from the stage of prolonged and uncontrolled procedures to the stage of data entry and the achievement of programmed, fast and accurate calculations and analysis of the maintenance process. Accordingly, the new project achieved a quantum leap in the time of completion (efficiency), from completion in months to completion in 5–10 working days only. This 5–10 day period also includes exporting the total maintenance report, whose completion does not exceed more than one hour as the longest time limit (it can be completed in only 20 minutes). The indicated completion time of 5–10 working days is related to the first filling of the database. Subsequent times could take two working days.

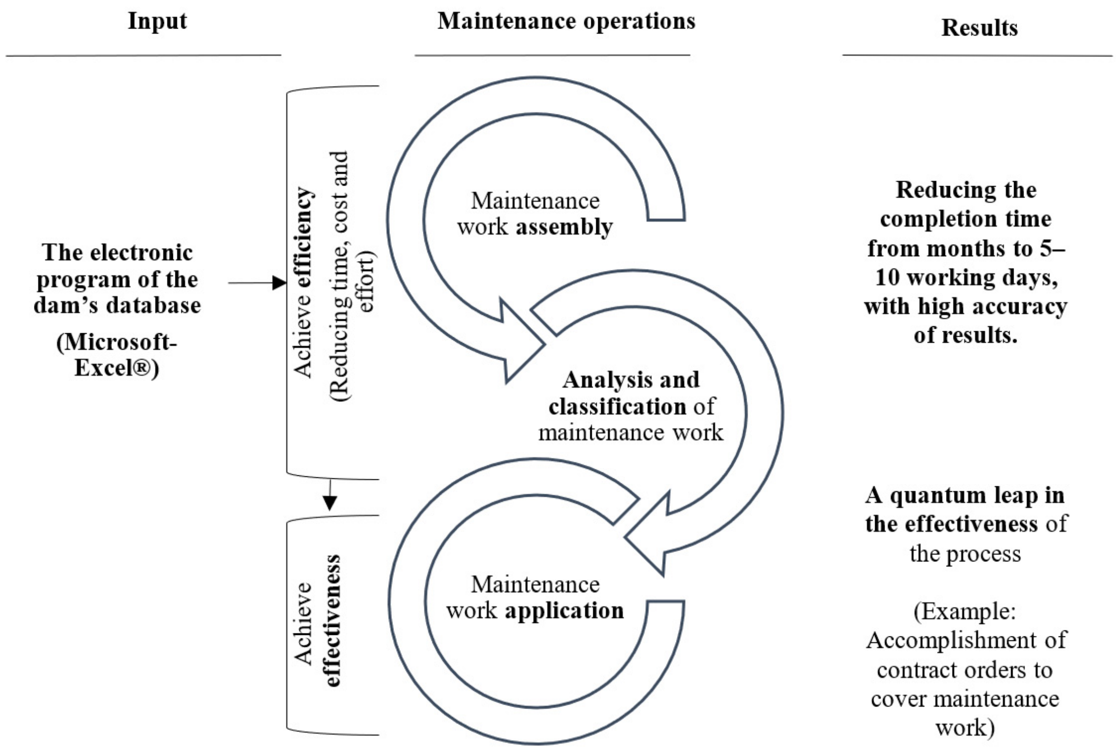


Figure 5. Dam maintenance process model and its correlation with inputs and outcomes

A general summary of the success of the electronic program (Microsoft-Excel®) in developing the maintenance process (maintenance database). Only the most prominent successes are shown in the results. For more information, it is necessary to refer to the 11 detailed criteria for results.

Cost (efficiency) also showed a significant progress. The savings in time (as mentioned previously) reflects the savings in costs. The free establishment cost of the Excel program is also considered a remarkable advantage. In contrast, establishing a new specialized program costs hundreds of thousands of dollars.

As for accuracy, the new program, compared to traditional paperwork, ensures extremely accurate output because it performs mathematical operations automatically based on programmatic algorithmic equations. Thus, it avoids potential human errors. In addition, the programming organization builds up the ability to sort maintenance work according to the volume of work and the corresponding budgets. The program has also enabled the maintenance plans to be upgraded from a short-term operational framework to a long-term strategic framework. The new maintenance plan evolved in time into a plan for the next 5 years, detailed in terms of turnover and budgets.

With regard to managing priorities, the feature has progressed from an unclear description of priorities to a quantitative level of setting priorities. This is represented in the three-part priority network of time, item and dam. One of the most important features of the new database is its renewal and timeliness flexibility (the number of maintenance reports). The new program allowed the data to be renewed on a daily or weekly basis and at any time of the working year.

A significant development by the project team has been applied related to the maintenance process technologies. Work has moved away from the traditional calculator or from using the modest features of Excel (addition, multiplication, etc.). Recently, Excel is used with most of its advanced features (six technical features were applied by the team). The most important feature was the expanding of the use of cell programming (Appendix 2).

For this project we implemented both team management and change management. Group opinion versus individual opinion is a dominant culture in the project management. All team members have an obvious involvement in common roles and work plans. Change management was reflected in permanent accompaniment practice, in which the team committed all its activities as face-to-face interactions. We organized daily workshops, which ensured the smoothness of all changes, as well as full adoption of the project idea by the team member.

We also considered the concept of knowledge management, by implementing and organizing the concept of both tacit and explicit knowledge. These aspects existed in all project phases. Tacit knowledge management was achieved through an effective exchange of knowledge and skills through more than 10 workshops and periodic meetings. Explicit knowledge management was achieved by combining the maintenance database and its various files into one single file (our current database— programmed Excel). In addition, all updated files of the project (programmed Excel) were kept in a formal common shared file, which belongs to the Dams Department. All team members have access to this shared file.

Table 1. Comparisons between all stages of electronic maintenance database development (before and after development)

| # | Evaluation criteria | Previous Position | Phase 1 | Phase 2 and Phase 3 |
|---|---|---|---|---|
| | | **Traditional** Situation | **Development Status** 2019 | **Ideal and Complementary** 2020 |
| 1 | **Efficiency: Completion time** | **Unknown** - estimated by **months** (uncontrolled duration) | Total of **2 months** (1 month data collection, 1 month data entry and revision) | <u>**5–10 working days**</u><br>This period is for the first time of entering data. The periodic update may take up to 2 days. |
| | **Efficiency: Cost**<br>(Cost of operations and start-up cost) | - | - | <u>Cost of operations:</u> Reducing the cost of work **from months to the cost to 5–10 working days.**<br><u>Cost of incorporation:</u> **Zero cost,** Excel software is available in all computers, compared to complex software, which costs hundreds of thousands of dollars. |
| 3 | **Accuracy: Frequency of maintenance reports**<br>(Renewal and time flexibility) | Once a year | Once a year | 4-12 times a year (can be reduced for a month or a few days and weeks when needed) - **high time flexibility**. |
| 4 | **Accuracy: Prioritization** | Priority management is done in a discretionary manner (mostly by **individual expert**) | Priority management estimated from the **priority of the items.**<br>**All employees were involved.** | Accurate and **multi-priority quantitative evaluation**. Building three cross-priority priorities: time priority, item priority, and dam priority. Priorities have been sustainably and proactively assessed by **clear standards** from management experts, so that their application process is facilitated by any future management officer. |
| | **Accuracy: items characterization** | 32 items (**moderate applicability**) - | 32 items<br>**Preliminary exploration** phase for the development of this old items | **64 items**<br>Well-organized items. Classified by general and detailed items, based on specialized classifications of global dam organizations |
| 6 | **Maintenance strategy**<br>**(Long term)** | Don't support long-term activities | Supports the long-term activities | Hold an advanced support of long-term activities (5-year). With high data resolution (priority, quantity and value). |
| 7 | **Software development** | Using **Word®** tables, traditional calculator, | Creating an Excel electronic table® | Create **advanced and interconnected electronic tables** to extract a |

| | | | | |
|---|---|---|---|---|
| | | sometimes Excel. | programmed with **basic applications** | high-resolution database (3 detailed database).<br>Remarkable avoidance of human errors in calculations and analysis (also linked to accuracy). |
| 8 | **Number of technical features used** | **Traditional features** (summation and multiplication ... Etc.) | A number of **3** feature (basic Excel programming features (filtering, cell coding and colouring). | A number of **6** Features (see Appendix 2**)** |
| 9 | **Decision making** | Individual decision | The project team has the key role | Advanced team management; with clear and integrated developed roles and business plans, using the 'art of agile project management'. |
| 10 | **Change Management** | - | - | Constant **accompaniment** and persuasion, which has made the management of change smoother (more than 10 workshops and regular meetings). |
| 11 | **Knowledge Management** | Unclear | Relatively clear | Excellent transfer of **tacit knowledge** (organized meeting and workshops).<br>**Explicit Knowledge** was highly considered (electronic shared files). |

Note: The second and third phases were considered as a single phase because of their great similarity.

*6.2 Theoretical Results and Discussion*

Project background and practices reveal the study's theory (Figure 6), which consists of six themes (components). The most important themes are the technical, managerial, and personal enablers. These themes caused the successful establishing and implementing of the electronic program of the dam-maintenance database (Excel). Ultimately, all of the mentioned themes achieved efficiency, accuracy and effectiveness of the results. Technical enablers represent mainly an efficient, simple and available technique (Excel); advanced Excel features; skilful team partners in programming Excel; accurate maintenance items; international dams' organizations reference and, several databases inclusion. Managerial enablers consist of applying a modern management tool represented by agile project management, change management, knowledge management, extended and flexible planning, time management, organizing, precise criteria, obvious objectives and managing priorities.

Personal enablers consist of several attributes and values such as distinguished project leader (hidden agile leader-informal leader), accountability, coherent team and project team management values, persistence, continuity, commitment, innovation, motivation, accompaniment, persuasion and giving close attention to users' feedback.

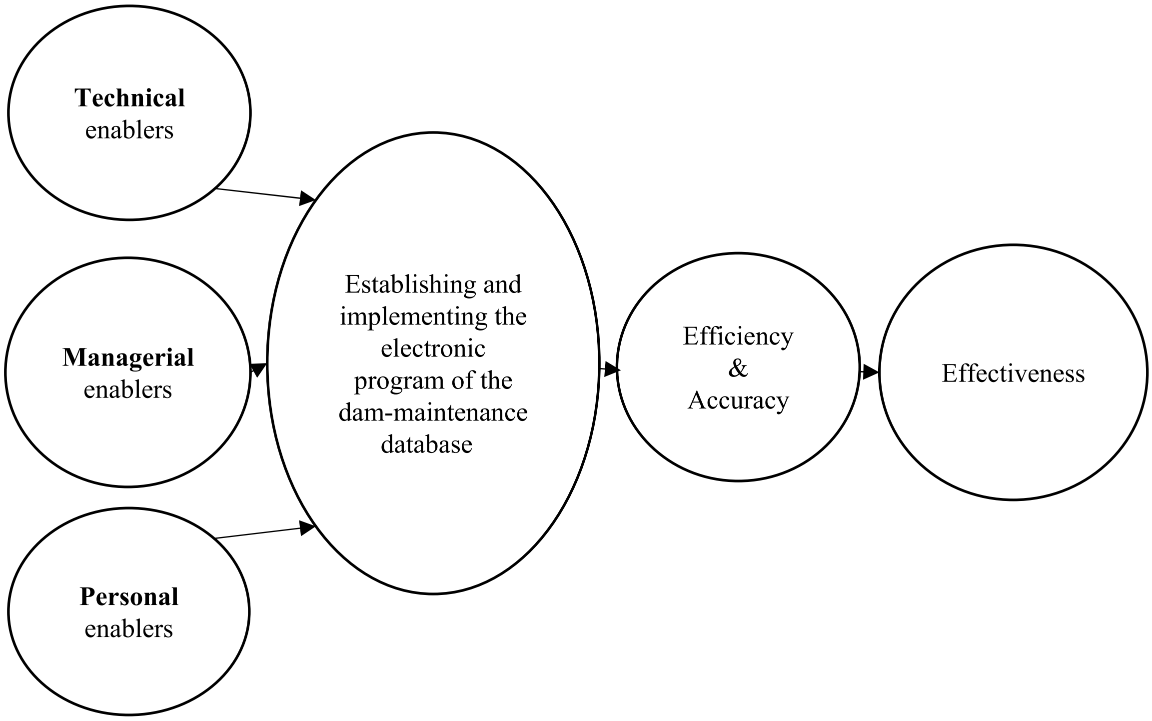


Figure 6. Case study theory (Microsoft-Excel® Database of Dam Maintenance in United Arab Emirates)

## 7. Recommendation

If any institutions intend to implement a similar project, they should not concentrate only on the electronic (technical) aspect. Other enablers, mainly managerial and personal, are crucial. One of the potential shortcomings is the lack of continued innovative development in the program. Accordingly, it is necessary to invest in the database by uplifting it to a specialized program designed according to modern programming languages. We also strongly recommend upgrading our project to an integrated technological platform. This platform contains an electronic application and many supporting devices (field data entry panels), with organized roles distributed among the platform users. In sum, we recommend three phases of improvement: (1) Excel Programmer → (2) specialized program → (3) integrated electronic platform.

The failure to continue with the new program (a natural desire to return to the old) is expected. Therefore, to ensure a sustainable development of the program several procedures should be applied. We suggest framing the project as the cornerstone of the continuity of the program. For instance, the project could be included as a primary goal of the head of the dam- maintenance section. Stating goals could affect behaviour (Steg et al., 2014). Behavioural change is a concern particularly for maintenance managers in the developing countries (Ogunbayo et al., 2022). Improving the capabilities of the project team in Excel skills is pivotal. Therefore, the team should be subjected to a specialized course in Excel to ensure updating the program continuously.

Understanding the culture surrounding maintenance management is the latest application of that domain (Ogunbayo et al., 2022). Note that maintenance management has evolved (1940–2020) in five phases:

(1) Fix after it breaks.

(2) Fix before it breaks.

(3) Improve its value.

(4) Maintain management optimization.

(5) Understand the culture of maintenance management.

And in this case, it is crucial to ensure a sophisticated leadership and team values (culture). Again, the technical aspect is not the only influencer of success.

To achieve an effective exchange of experiences, this electronic program should be circulated to dam institutions inside and outside the country. Therefore, it is recommended that Excel file be available online to dam institutions.

We also recommend designing a guidebook with brochure as an instructional manual for users as well as a downloadable video package explaining how to use the program. In addition, it is preferable to hold a workshop.

To increase the applicability of the three priorities of the program, it is important to innovate a smart comprehension link between them (instead of dealing with each separately). This enables the user to estimate one final priority view. Ultimately this idea would reinforce field decisions. Items priority was evaluated by the Dams Department expert. However, we recommend adopting a clear standard by which to evaluate the priorities of the items.

The current database possesses a high capability to design a long-term plan of maintenance work and budgets. However, it needs an innovative idea to include the life span of the maintenance items within this concept. The project team addressed this issue considering that the average age of maintenance items is four years. However, more accurate details of life span should be applied for each item separately. Then this inclusion should be automated to the database directly.

Maintenance management has different models and concepts and is known to be affected by several cultures (Ogunbayo et al., 2022). The current study contributes to conceptualizing a model within a particular environment that would widen the horizon of ideas for practitioners. It is advisable to merge this study's theory with other theories obtained from a practical case study (preferred in the dam-management domain) or from a theoretical approach (Eisenhardt & Graebner, 2007).

## 8. Conclusion

The subject of this study is the phenomenon of the success of an electronic program (Excel) for the dam-maintenance database. The purpose of the study is to explain, in a practical and theoretical framework, the reasons that explain the project results (reduction of the completion of maintenance reports from months to 5–10 working days) with low-cost efficiency. This leads to raise the agility of maintenance work fulfilments (effectiveness). As a result, the study's model (theory) estimated six elements (variables). Three factors led to success: technical, managerial and personal factor. These factors led the maintenance project to achieve high efficiency, accuracy and effectiveness. As a comprehensive recommendation, if any global construction institution (such as a dams department) intends to implement a similar e-project, its focus should not be limited to the electronic aspect; the managerial and personal aspects are also important in this process. In addition, this project is a ready base for optimizing the technological platform.

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**Appendix**

Appendix 1. List of supporting inputs for the dams' maintenance database

| # | Portal | Importance |
|---|---|---|
| 1 | Details of dam maintenance items | These details represent an indicated card for each item. Most importantly, each card includes a quantitative value for each item. In addition, items values are linked to the database by automatically calculating. The most important values for each item are the unit of measurement and the unit of price in Dirhams. |
| 2 | Time priority | The time priority determines the actual level for the completion of the maintenance work (completed, in progress, not completed). Completion level is reflected through specific colours indicators. |
| 3 | Item priority | Item priority is based on the cost of the repairing of the selected item (maintenance work) or the consequences of the damage when it occurs. The location of the item regarding the dam parts is considered as well when stating the priority. |
| 4 | Dam priority | Special standards have been developed for grading consisting of four criteria: (1) dam storage capacity, (2) property importance behind the dam (downstream), (3) annual water catchment sized (recent time, expected in future) and (4) dam age. |
| 5 | Introducing the program | This sheet is a knowledge guide to how the software is used. |
| 6 | Monitor software updates | Refers to updated versions of the database. |

Appendix 2. List of innovative applications

| # | Innovative Application (by importance) | Importance |
|---|---|---|
| 1 | Expanded cell programming * | Considered as the core of the project's innovative development, where more than 6,000 cells are programmed. This facilitates calculations and data analysis. |
| 2 | The development of a comprehensive maintenance items | Items were developed through a combination of (1) maintenance items according to the classifications of international specialists that belong to the dam's domain, (2) current contractual (legal) maintenance items, (3) field experience applied in the UAE environment. The development of the new items has an extended benefit. It is the cornerstone of the development of the more specialized 'maintenance item cards' system. Additionally, items were expressed in Arabic and English language so that everyone (in several countries) could use it easily. |
| 3 | The development of several priorities for the maintenance items | This enhanced the effectiveness of the decision in that it has made it possible to apply priorities in contractual orders as well as to sort them out in the budget and in the long-term plan (the next 5 years). |
| 4 | Setting standards to decide dam priorities | Setting standards for the priorities of dams facilitates taking all decisions related to their maintenance work. Additionally, examining this priority would also have an extended benefit for other dam-management operations. |
| 5 | Development standards for time priorities (achievement) | The time priority determines two issues: (1) the level of urgency to accomplish the maintenance work, and (2) the level of work accomplishments. This priority is presented via several colours in the program. This helps the beholder to capture directly the work to be implemented sooner or later. |
| 6 | Total link between program inputs and the basic maintenance database * | A database cannot function smoothly unless it is linked with solid digital inputs. Accordingly, these inputs have been developed as the main feeder for main database data. |
| 7 | Create a separate quantities database | Both quantities and costs databases are emanating from the primary database. These sub-databases were automatically changed as soon as any change was |

| | | |
|---|---|---|
| 8 | Create a separate costs database | made to the main database. In general, this procedure resulted in a valuable sorting of the quantities and budget of maintenance. Finally, it has enhanced the export of more accurate and adjustable reports toward user requirements. |
| 9 | Introduction of the Pivot Chart feature * | The Pivot Chart feature has enhanced reports efficiency. This feature achieved greater selectivity and ease of exporting the required reports and curves (Clark, 2020). |
| | Including 5-factor scaling feature * | Usually, maintenance work is graded in the program manually in terms of time priority (grades are stated according to five levels). This practice would cause human entering errors (often more than five). The grading options are limited by the system (quick evaluation list). |
| 10 | Filtration * | The filtration tool supports the quick sorting, in terms of user requirements. This feature is the most critical tool of the program. |
| 11 | Cell colorization feature and guiding arrows * | The automatic colouring feature and directional arrows support instant visual perception. It helps users to grasp quickly the presents weaknesses of maintenance items. Mainly, it reduces the effort of screening and searching. |

*Note*: (*) = Electronic features used in Excel.