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## Evaluating the Success of Information Systems in the Marine Fisheries Sector in Morocco

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### ABSTRACT

*This research is situated within the field of studies on the evaluation of Information Systems success. More specifically, it focuses on assessing the success of a Geographic Information System (GIS) used in the marine fisheries sector in Morocco. The study pays particular attention to post-implementation evaluation by exclusively considering users' perceptions and acceptance of the system. It seeks to understand the processes of assimilation, comprehension, acceptance, and evaluation by the actors who use the system. In this study, the user is deliberately placed at the forefront and at the center of the research questions.*

**Keywords:** Information System, Geographic Information System, Information Systems Success, VMS.



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### INTRODUCTION

The context of globalization in trade and economic activities has encouraged the widespread adoption of Information Systems (IS). Too often, this adoption is driven by urgency and implemented without prior questioning of internal practices. The deployment of Information Systems is frequently approached from a purely technical perspective, to the detriment of considering the organizational changes that occur within institutions. As a result, users find themselves compelled to use a system in their daily activities for which they are not adequately prepared.

Every organization expects to benefit from its Information System in order to improve its competitive position (strategic gains) or its internal efficiency (operational gains). However, to achieve the expected benefits, all stakeholders must be mobilized and, above all, must express acceptance of the system.

While it may seem reasonable to focus on the implementation of Information Systems, it is equally important to study the ways in which they are actually used within organizations (Uwizeyemungu, 2008). In this regard, post-project phases have become, although somewhat delayed, a particularly fertile field for researchers and practitioners who feel they have lost considerable ground following difficult integration experiences (Uwizeyemungu, 2008; Saint-Léger, 2004). Today, it is possible to understand the real success of a project only when the post-implementation phase reveals that the applied technology is neither underutilized nor diverted from its intended use by users or management (Pichat, 1990).

It is during the post-implementation phase that the expected outcomes of an investment can truly be measured. Were the objectives achieved—not only in economic terms such as budget compliance and adherence to planning, but above all in terms of users' appropriation and effective use of the new system? This phase provides a full measure of tool appropriation, changes in routines, and the acquisition and stabilization of new practices. However, diagnosis of this phase is often neglected (Uwizeyemungu, 2008).

Moreover, the fisheries sector in Morocco represents a highly important resource for the national economy. This sector is characterized by an integrated, open, and global development strategy, which cannot be achieved without the implementation of Information Systems. The Moroccan state has invested a significant amount of time and financial resources in Information Systems within a sector that had previously been reluctant to adopt new technologies.

The present study falls within the scope of research on the evaluation of Information Systems success and, more specifically, focuses on evaluating the organizational performance of a Geographic Information System (GIS) used in the marine fisheries sector in Morocco. Particular attention is given to post-implementation evaluation by exclusively considering users' perceptions and acceptance of the system. The study seeks to understand the processes of assimilation, comprehension, acceptance, and evaluation by the actors who use the system. The user is deliberately placed at the forefront and at the center of the research questions.

### **INFORMATION SYSTEMS EVALUATION MODELS: LITERATURE REVIEW**

In this section, we present the main models for evaluating the success of Information Systems. The objective is to examine the full range of existing models in order to develop a research model. We review evaluation models that we consider the most relevant for our study.

#### **The Information Systems Success Model of DeLone and McLean (1992)**

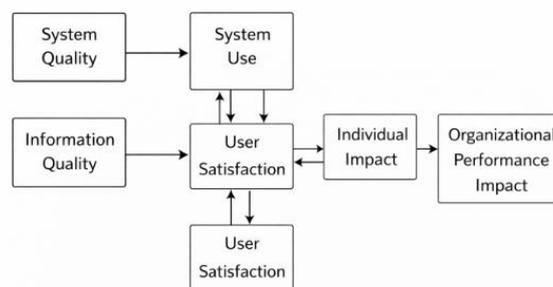
In 1992, DeLone and McLean (D&M), drawing on a comprehensive review of the literature, presented a model for evaluating Information Systems (IS) success. For them, assessing the success and effectiveness of an IS is essential for understanding and creating value relative to IS management (Michel, 2011). Their article and the proposed model quickly became an indispensable reference in the field of IS evaluation, although the model has been widely criticized. These criticisms prompted the authors to present an updated model that integrates several of the critiques.

The objective of DeLone and McLean (1992) was to propose a synthesis of existing research. They defined the concept of "IS success" and identified all variables that could have an effect on this dependent variable. To achieve this synthesis, the authors conducted a state-of-the-art review covering the period from 1981 to 1987, analyzing a total of 180 articles.

Based on these studies, DeLone and McLean revealed the processual nature of information. An information system creates information that is communicated to a receiver, who may be influenced by it. Information passes through a series of stages—from its production to its consumption (use), and finally to its influence on the individual or the organization.

From these analyses, DeLone and McLean identified six levels of indicators of IS success. They proposed a multidimensional model of IS success that recognizes success as a constructed process, which must incorporate both temporal and causal influences (Michel, 2011). According to DeLone and McLean, users utilize the system and the information produced by it, and they may or may not be satisfied with it. System use and the information produced, in turn, influence the user in the performance of their work, and these individual impacts subsequently influence organizational impacts. The model is process-oriented, as time is explicitly taken into account. It is also causal in nature, as it seeks to determine whether causal relationships exist among variables. For example, a high appreciation of system quality is assumed to lead to high user satisfaction.

Thus, DeLone and McLean propose a model that links six categories of variables, with interrelationships resulting in a success model that indicates causality flows in the same direction as the information process. In the model, system quality and information quality affect both system use and user satisfaction, which in turn are antecedents of individual impact. User satisfaction can influence system use, and conversely, system use can also affect user satisfaction. Individual impacts then lead to organizational impacts.



**Figure 1.** Information Systems Success Evaluation Model (DeLone and McLean, 1992)

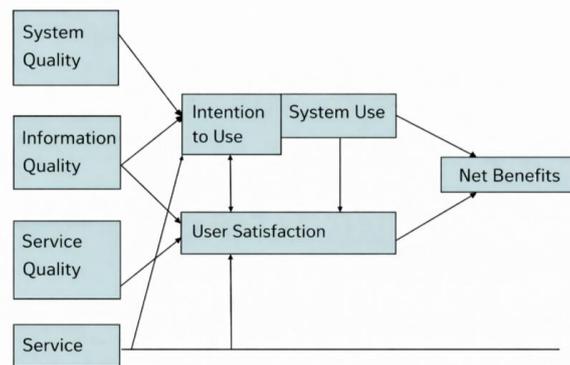
The model has generated hundreds of research studies that have developed, tested, and validated the original model. In light of this body of research, DeLone and McLean suggested, in 2003, an updated version of the model. The new model integrates an important dimension, namely service quality related to the IS, following the recommendations of Pitt et al. (1995).

Some studies have suggested removing the "use" construct from the DeLone and McLean model, arguing that system use is a behavior and should not be considered within a causal model (Seddon, 1997). Additionally, some studies have proposed rejecting this construct when IS use is mandatory. However, the

authors of the model continue to emphasize the importance of this construct and suggest that researchers should consider the nature, extent, quality, and appropriateness of system use.

- Given the relevance of Information System (IS) use as an appropriate measure for this complex variable (DeLone & McLean, 2003).
- Considering the difficulties in interpreting the multidimensional aspects of the usage variable, a distinction has been suggested between *use* as a behavior and *intention to use* as an attitude.
- Due to the multiplicity of impacts that an IS may generate (social impact, inter-organizational impact, etc.), the two dimensions individual impact and organizational impact—have been grouped into a single construct: *net benefits*.
- System use and user satisfaction are closely linked. Use precedes user satisfaction in a processual sense, while positive usage experience leads to higher user satisfaction in a causal sense. Similarly, an increase in user satisfaction leads to an increase in intention to use, and consequently to system use.
- As a result of system use and user satisfaction, certain net benefits are produced. These benefits, in turn, reinforce subsequent system use and user satisfaction.

These new feedback associations between constructs have been represented by new arrows in the model, as illustrated in the figure below.



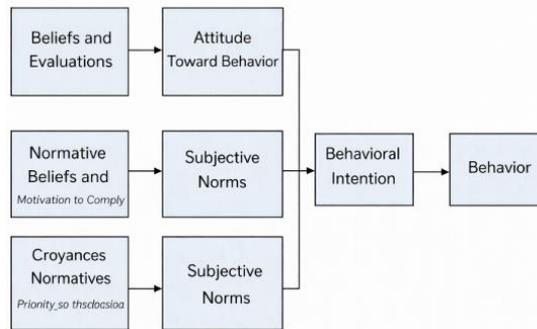
**Figure 2.** Updated DeLone and McLean Model (DeLone & McLean, 2003)

### **The Theory of Reasoned Action by Fishbein and Ajzen (1975)**

The Theory of Reasoned Action originates from social psychology and was developed by Fishbein and Ajzen (1975). This model defines the relationships among beliefs, attitudes, norms, intentions, and behaviors of individuals. According to this theory, an individual's attitude toward a behavior is determined by their behavioral intention to adopt it. This intention, in turn, is determined by the individual's attitude and their subjective norms regarding the behavior in question. Fishbein and Ajzen (1975) define subjective norms as the individual's perception of whether most people who are important to them think they should or should not adopt the behavior in question.

According to the Theory of Reasoned Action, a person's attitude toward a behavior is determined by their beliefs about the consequences of that behavior, multiplied by their evaluation of those consequences. Beliefs are defined as the individual's subjective probability that adopting a particular behavior will lead to specific outcomes. This model is based on the assumption that external stimuli influence attitudes, thereby modifying the structure of an individual's beliefs. The Theory of Reasoned Action has been widely used by many researchers in various fields

Studies on information technologies in recent years, particularly the work of Hartwick and Barki (Hartwick & Barki, 1994), have demonstrated the usefulness of the Theory of Reasoned Action in explaining information technology adoption behavior in organizational contexts. According to this study, in addition to attitude, subjective norms constitute an important determinant of technology adoption during the early stages of its implementation within an organization. In their findings, attitude and subjective norms together explained 72% of the variance in intention to use the system and 41% of the variance in actual system use.



**Figure 3.** Theory of Reasoned Action Model by Fishbein and Ajzen (1975)

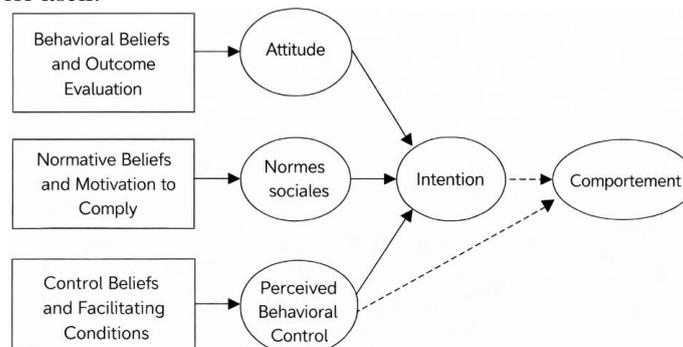
**Ajzen’s Theory of Planned Behavior (1985)**

The Theory of Planned Behavior (TPB), developed by Ajzen (1985), is an extension of the Theory of Reasoned Action. It was proposed to account for behaviors that are not entirely under an individual’s volitional control, that is, when constraints exist on the adoption of a behavior. Many behaviors require resources, skills, and opportunities over which individuals may not have full control. To address these barriers, Ajzen introduced a third variable: *perceived behavioral control*, which represents the degree of ease or difficulty associated with performing a behavior.

Thus, according to this theory, the decision to engage in a behavior is subsequently linked to the individual’s intention to adopt that behavior. The concept of intention refers to the extent to which individuals consider the implications of their actions before deciding whether or not to adopt a behavior. Intention is the result of three conceptual determinants:

- **Attitude toward the behavior:** refers to the degree to which a person has a favorable or unfavorable evaluation of the behavior in question, including the assessment of its success or failure.
- **Subjective norm:** corresponds to the individual’s perception of social pressure, represented by what significant others think about whether the individual should or should not engage in the behavior.
- **Perceived behavioral control:** refers to the ease or difficulty of performing the behavior. It corresponds to the individual’s perception of the feasibility of the behavior in question. This perception of control over the situation is similar to Bandura’s concept of self-efficacy (Bandura, 1977), defined as the individual’s belief that they possess the necessary resources to adopt the behavior.

Each of these three variables is derived from the importance of a belief weighted by its evaluation. In other words, beliefs are the antecedents of attitude, subjective norm, and perceived behavioral control. Beliefs about the positive or negative consequences of a behavior or other attributes produce an attitude toward the behavior (*behavioral beliefs*). Beliefs about normative expectations of others generate subjective norms (*normative beliefs*). Beliefs about the presence of facilitating or inhibiting factors affecting behavioral performance lead to perceived behavioral control (*control beliefs*). This latter construct influences not only intention but also behavior itself.

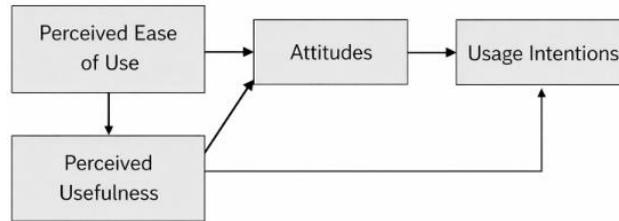


**Figure 4.** Ajzen’s Theory of Planned Behavior (1985)

**The Technology Acceptance Model (TAM)**

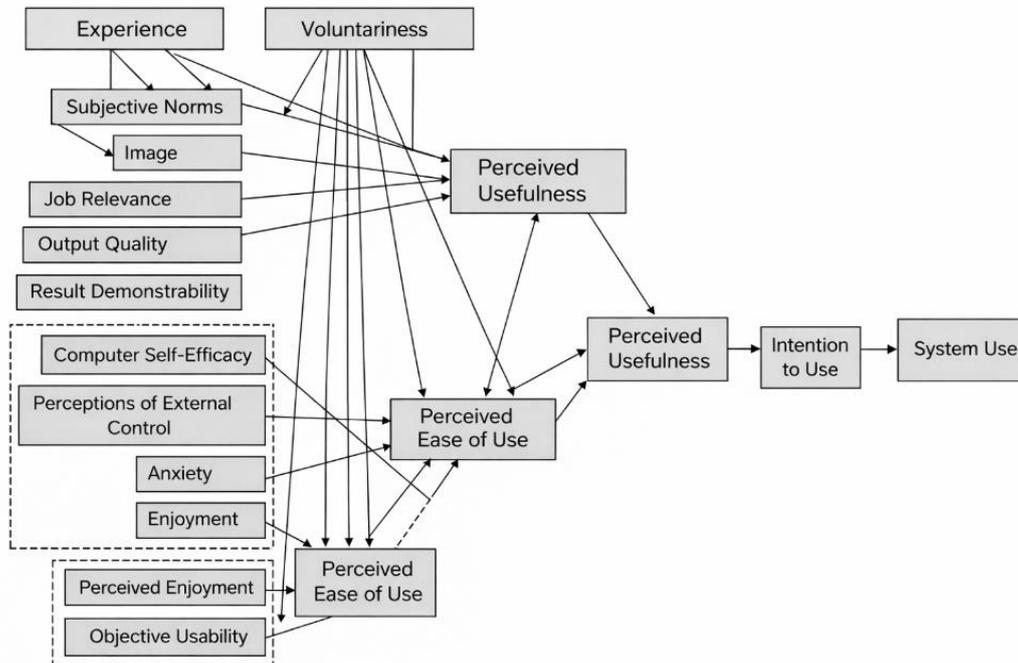
The Technology Acceptance Model (TAM), which is essentially grounded in the Theory of Reasoned Action, suggests that technology acceptance—operationalized through the evaluation of intentions to use a system—is mainly determined by two types of perceptions: *perceived usefulness* and *perceived ease of use*.

Perceived usefulness refers to the degree to which a person believes that using a system will enhance their performance (Davis, 1989). Perceived ease of use (PEOU), for its part, refers to the degree to which a person believes that using the system will require little or no effort (Davis, 1989). According to Davis and his collaborators (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989), both perceived usefulness and perceived ease of use have a significant impact on users' attitudes toward system use.



**Figure 5.** Technology Acceptance Model (TAM) by Davis (1989)

This model is recognized as one of the most conceptually robust, and numerous extensions and improvements have subsequently been proposed. In the year 2000, Venkatesh and Davis introduced Version II of TAM (TAM2) by incorporating certain antecedents of perceived usefulness, such as subjective norms (social influence), result demonstrability, image, and others. They also adopted a longitudinal perspective in this improved model. Venkatesh (2000) further extended the explanatory power of TAM by considering external variables related to perceived ease of use, such as computer anxiety, enjoyment, computer self-efficacy, perceptions of external control, and experience. In 2008, Venkatesh and Bala integrated TAM2 and Venkatesh's (2000) work on the antecedents of perceived ease of use to propose Technology Acceptance Model 3 (TAM3).



**Figure 6.** Technology Acceptance Model 3 (TAM3) (Venkatesh & Bala, 2008)

**The UTAUT Model (Unified Theory of Acceptance and Use of Technology) – Venkatesh, Morris, Davis, & Davis (2003)**

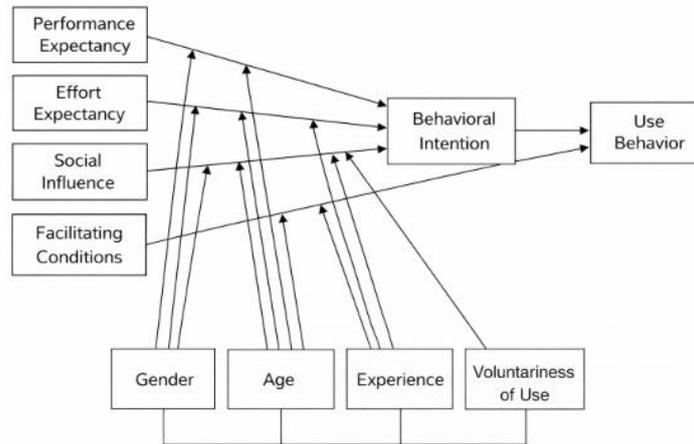
The Unified Theory of Acceptance and Use of Technology (UTAUT) aims to explain users' intentions to use an information system and their subsequent usage behavior. This model highlights three direct determinants of usage intentions: performance expectancy, effort expectancy, and social influence (the latter being significant only in contexts where system use is mandatory).

The results also highlight two direct determinants of actual use: intention to use and facilitating conditions (material and/or human conditions that facilitate the use of the system in question). Beyond these direct determinants, the findings reveal the significant influence of moderating variables, namely prior experience with the system, the voluntary or mandatory nature of system use, gender, and age (Venkatesh, Morris, Davis, & Davis, 2003).

The model was developed through the examination and consolidation of constructs from previous models used to explain information system usage behavior, including the Theory of Reasoned Action, the Technology Acceptance Model, motivation theory, the Theory of Planned Behavior, a combined model of the

Theory of Planned Behavior and Technology Acceptance, the personal computer utilization model, the diffusion of innovations theory, and social cognitive theory.

According to the authors, there is a significant influence of moderating variables—prior experience with the system, voluntariness of use, gender, and age. These moderating variables are defined as integral properties of the UTAUT model. Performance expectancy directly influences usage intention; however, the strength of this relationship is moderated by age and gender. Effort expectancy also directly influences usage intention, with the strength of this relationship likewise moderated by age and gender. The effect of social influence depends on the presence of the four moderators (age, experience, gender, and voluntariness of use), such that its effect may be non-significant when data are analyzed without integrating these moderators. The effect of facilitating conditions on system use is significant depending on the presence of the moderators age and experience.



**Figure 7.** Unified Theory of Acceptance and Use of Technology (UTAUT) Model (Venkatesh et al., 2003)

## EVALUATION OF INFORMATION SYSTEMS SUCCESS IN THE MARINE FISHERIES SECTOR IN MOROCCO: A FIELD STUDY

### Research Context

In Morocco, the fisheries sector occupies a significant position in the national economy. Its contribution to foreign exchange earnings and wealth generation makes it a strategic sector—not only for balancing the country’s trade balance, but also for contributing dynamically to development in terms of employment, food security, and income generation.

Accordingly, Moroccan authorities adopted the “HALIEUTIS” plan in 2009. This plan introduced major structural changes in the governance of the fisheries sector, focusing in particular on resource preservation, reform of the legal framework, modernization of the sector, and consolidation of seafood processing industries.

Among the major actions undertaken within the HALIEUTIS Plan was the introduction, in 2011, of the VMS (Vessel Monitoring System). This system is a Geographic Information System (GIS) dedicated to satellite-based monitoring of fishing vessels, providing fisheries authorities with regular data on vessel position, routes, and speed. The objective is to combat illegal, unreported, and unregulated (IUU) fishing and to meet the requirements of the European Union.

The establishment of border control mechanisms aims to restrict access to markets for products originating from illegal fishing and to preserve marine living resources and ecosystems. From a technical perspective, Vessel Monitoring Systems (VMS) are autonomous systems, independent of other onboard equipment. They transmit vessel positions to fisheries monitoring centers, thereby enabling control of fishing zones.

The communication system ensures the transmission of data between the transmitter/emitter-receiver installed on vessels and the monitoring center. Satellite use may or may not be involved in this system. Several tracking applications designed for terrestrial means use cellular telephony or HF radio (FAO, 2008).

Nevertheless, for the monitoring, control, and surveillance of fishing vessels, satellite communication systems are considered the most appropriate solution, as they offer the advantage of global coverage and high reliability.

In a satellite communication system, data are transmitted from the vessel to the satellite, then to a ground station. The ground station subsequently forwards the data to the monitoring center via a public data transmission network or a secure telephone network, using an international communication protocol such as X.25.

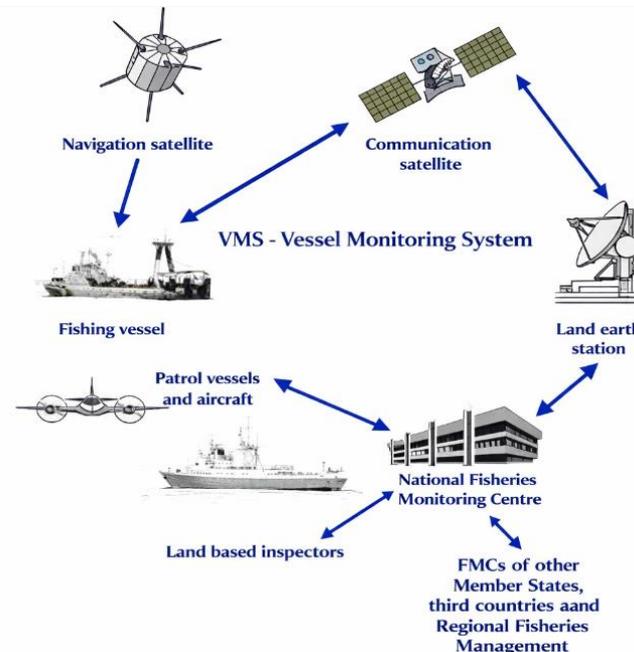
Within a Fisheries Surveillance Center (CSP), there must be a computerized monitoring station capable of collecting data received from the ground station, storing the data for later use, and analyzing them in order to

detect and extract situations of interest. This capability is particularly valuable for control officers, as it allows the presentation of relevant information, most often on a map-based interface. The integration of a Geographic Information System (GIS) specific to the CSP is therefore strongly recommended, especially to facilitate historical and statistical analysis of vessel positions as well as catch data.

The VMS project, implemented within the framework of the HALIEUTIS plan, initially involved the purchase and installation of 1,500 positioning and localization devices (DPL) onboard fishing vessels. It primarily targeted coastal trawlers, frozen cephalopod vessels, and offshore shrimp trawlers. In 2012, a second acquisition of 750 DPL units was carried out to generalize onboard installation across fishing vessels, notably longliners, seiners, and purse seiners.

Furthermore, the National Center for the Surveillance of Fishing Vessels (CNSNP) was established in 2013 with the objective of strengthening and modernizing the system for monitoring, control, and surveillance, both upstream and downstream of the fisheries product value chain, through satellite-based means (VMS). Operators at the National Center conduct daily monitoring of the activities of authorized national and foreign vessels. They perform visual monitoring and database queries, and they report cases of suspected violations to center inspectors. These inspectors then analyze vessel tracks and VMS-related data and subsequently produce reports to take the necessary measures against potential offenders, in accordance with current regulations.

Monitoring of fishing vessels at the CNSNP is rigorous and is carried out by visually categorizing vessels by color according to fishing gear type and activity zones. The fishing fleet is classified within the system as follows: trawlers, frozen cephalopod vessels, coastal trawlers, seiners, longliners, shrimp trawlers, pelagic trawlers, purse seiners, dredgers, and authorized foreign vessels. Controlled zones are mapped to enable specific visual monitoring, including: cephalopod fishing zones, marine mammal protection zones, fishing prohibition zones, and permitted distance-to-coast zones. The figure below summarizes the operating principle of a VMS.



**Figure 8.** Operating Principle of a Vessel Monitoring System (VMS)

### Research Problem

At a time when everything seems to have already been said about Information Systems (IS), it remains important to examine how IS are actually used within organizations. Consequently, post-implementation phases of IS have now become a fertile field for both researchers and practitioners (Uwizemungu, 2008).

Indeed, it is during the post-implementation phase that it becomes possible to truly measure the outcomes of such investments. Have the objectives been achieved—not only in financial and scheduling terms, but above all in terms of users' appropriation and actual use of the new system?

Several studies have shown a decline in expected performance following IS implementation during the first months of system use (Burton-Jones & Gallivan, 2007; Shang & Seddon, 2007; Davenport et al., 2004). This illustrates the difficulty inherent in evaluating the success of Information Systems. In fact, system implementation may be the result of a decision taken by hierarchical authorities without prior consultation with personnel (Pupion & Leroux, 2006), which can lead to rejection of the system by its future users. However, when properly mastered, Information Systems can provide numerous benefits to the organizations that use them.

Our research falls within the field of studies on the evaluation of Information Systems success. The objective is to conduct a post-implementation evaluation of the VMS used in the fisheries sector in Morocco.

**Adopted Research Model**

In order to address our research problem, we examined the theoretical evaluation models proposed in the literature. We focused on process-oriented evaluation models that take into account multiple dimensions and causal relationships evolving over time. Through our literature review, we sought to identify the key variables determining an Information System success evaluation model in the fisheries sector, as well as the relationships among these variables.

We therefore formulated the following research sub-questions:

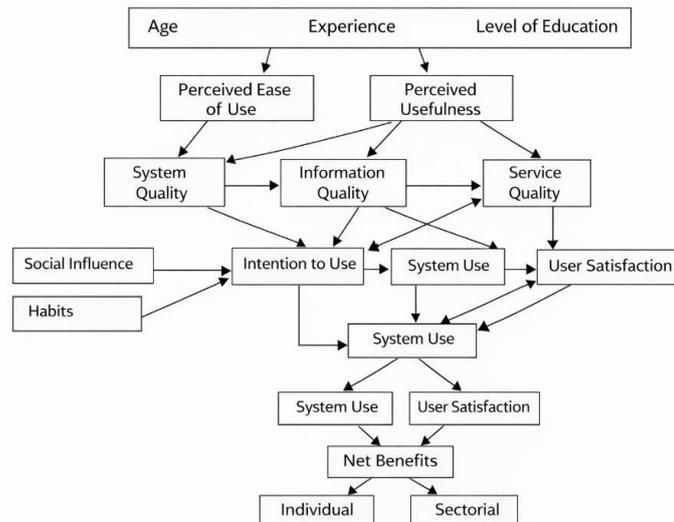
- What are the main variables to be considered in successfully evaluating IS success in the fisheries sector?
- What are the relationships among these variables?
- Do individual characteristics influence the perception of IS success?
- Is there a specific user profile that exhibits a better perception of IS in the fisheries sector?

To address our research problem, we draw inspiration from the IS success model proposed by DeLone and McLean (1992), as this model appears to be the most appropriate for our research context. However, IS success particularly in the fisheries domain—is influenced by social and behavioral variables. We therefore consider it essential to take into account factors that influence both the intention to use and actual system use.

For this reason, we also draw on two additional models: the Theory of Reasoned Action and the Technology Acceptance Model, which allow us to integrate behavioral and perceptual dimensions into the evaluation of Information Systems success.

The Unified Theory of Acceptance and Use of Technology (UTAUT) and the Technology Acceptance Model (TAM) are combined in our approach. In addition, to address the specific needs of the fisheries sector and to adapt the model to the particular characteristics of stakeholders operating in this domain, we incorporate new explanatory variables that we consider important, namely level of education and habits.

In our model, system use is also considered an explanatory variable of net benefits. It is preceded by intention to use and is influenced by service quality. User satisfaction is treated as the final explanatory variable of net benefits and is influenced by the three quality-related variables. Net benefits are defined as the final dependent variable of our research model. For this study, net benefits are considered at two levels: the individual level and the sectoral level. Individual benefits concern gains and advantages experienced by users as a result of system use, while sectoral benefits refer to improvements and positive impacts observed in the fisheries sector through the use of the VMS.



**Figure 9.** Adopted Research Model

**Model Variables**

**Quality-Related Variables**

The three Information System (IS) quality dimensions—system quality, information quality, and service quality—are recognized as essential for assessing IS success. They are considered independent variables that explain user satisfaction and system use (or intention to use) (DeLone & McLean, 1992, 2003).

**Intention to Use**

This variable refers to an individual’s intention to adopt a usage behavior. Given the mandatory nature of the VMS, intention to use is not considered a prerequisite variable for system use. However, our exploratory

research revealed that several stakeholders refused to use VMS technology despite regulatory constraints. We therefore decided to retain this variable and assign it significant importance.

**System Use**

System use is identified as the most important substitute variable, that is, the final explanatory variable that most strongly accounts for system success (Sabherwal et al., 2006). In our model, system use is also treated as an explanatory variable of net benefits.

**User Satisfaction**

User satisfaction is considered the final explanatory variable of net benefits. It is influenced by the three quality-related variables.

**Net Benefits**

Net benefits are defined as the final dependent variable of the research model. In this study, net benefits are analyzed at two levels:

- Individual benefits, which reflect gains and advantages experienced by users as a result of IS use;
- Sectoral benefits, which represent improvements and positive impacts observed in the fisheries sector through the use of the VMS.

**Social Influence**

Social influence refers to the degree to which a user perceives that important others—particularly individuals within their immediate environment—believe they should use the information system. This variable plays a crucial role in our model, as our exploratory study showed that users tend to be highly cohesive and unified. We assume that even if a single actor accepts the technology, they may influence their surrounding environment, leading others to adopt or abandon system use.

**Habits**

Habits result from learning processes and refer to repetitive and automatic behaviors that may occur without conscious deliberation. In the Moroccan fisheries sector, habits are highly prevalent and can significantly influence intention to use.

**Perceived Usefulness**

Perceived usefulness was defined by Davis (1989) as the user’s subjective assessment of the likelihood that using an application or information system will enhance task performance within the organization. It corresponds to the strength of an individual’s belief in the potential benefits of technology use in terms of performance improvement. In our model, there is a direct relationship between perceived usefulness and both IS quality and information quality.

Perceived Ease of Use is defined by Davis (1989) as the degree to which a user expects an application to be easy to use. It reflects the user’s belief that using a technology requires little or no effort. In our model, there is a direct relationship between perceived ease of use and system quality.

Moderating Variables. We selected age, experience, and level of education as moderating variables for our model. These moderating variables directly influence perceived usefulness and perceived ease of use.

**RESEARCH METHODOLOGY**

To evaluate the success of VMS implementation in the marine fisheries sector in Morocco, we conducted two studies: an initial exploratory qualitative study and a second hypothetical–deductive quantitative study (currently in progress).

In this article, we focus exclusively on the qualitative survey. During our study, we used various sources of information, including internal documents, digital documents, and procedural manuals. We also employed several qualitative methods, notably questionnaires and semi-structured interviews with the relevant stakeholders.

**Table 1. Number of Interviews by Interviewee Function**

Number of semi-structured interviews	Interviewee function
3	Senior officials within the Ministry of Marine Fisheries
39	Fishing vessel owners operating in the Tangier, Larache, and M’diq regions (13 trawlers, 13 longliners, and 13 sardine vessels)
1	Senior manager at SOREMAR, the national maritime operator that won the 2010 tender for equipping coastal and offshore vessels with VMS

## **RESULTS OF THE QUALITATIVE SURVEY**

### **Assessment for the Fisheries Sector**

According to the three senior officials interviewed within the Ministry of Marine Fisheries, the implementation of the VMS represents a genuine success. The system has had several positive impacts. Indeed, the VMS has enabled rapid contact between fishermen and control authorities and has led to the detection of numerous irregularities. Thanks to the VMS, several vessels positioned in prohibited zones engaged in illegal and unregulated fishing have been detected throughout the Kingdom. Another significant outcome highlighted by the same source concerns emergency response speed in the event of maritime accidents. Several vessels in distress have benefited from rapid intervention and rescue thanks to the VMS, as their positions at sea are already known and communication with the monitoring center is facilitated.

Accidents in the fisheries sector are frequent, but fishermen assess their working conditions as being less risky than they actually are (Bye & Lamvik, 2007).

Another positive impact of the VMS is its contribution to the creation of a scientific research database concerning the fleet, fishing trips, vessel positions, and targeted species. Thus, the VMS has provided the National Institute of Fisheries Research (INRH) with data on fleet activity zones and vessel positioning for various species.

For example, the INRH has discovered that frozen offshore cephalopod trawlers operate over a very wide range, with activity zones mainly located between Larache and El Jadida, at depths ranging from 100 to over 1,000 meters. Coastal frozen trawlers operate from the coastline to greater depths and generally frequent the same zones as offshore frozen trawlers.

The VMS has also made it possible to determine that offshore frozen trawlers operate over a very large activity range: 54% of their landings occur at the port of Agadir, while 46% are landed at the port of Tangier. In contrast, the activity of coastal frozen trawlers is more concentrated at the port of Tangier (58%), compared to 42% operating from Agadir. Fishing zones for coastal frozen trawlers operating from the port of M'diq are located between Fnideq and Jebha, at depths ranging from 70 to 360 meters.

According to studies conducted by the National Institute of Fisheries Research (INRH), a slight increase in fishery resource stocks has been recorded for certain species since 2012. The central sardine stock, for example, showed improvement from 2012 and, by 2014, returned to a state of full exploitation after a period of overexploitation in previous years (INRH, 2014).

Moreover, the increase in exports of fisheries products—amounting to 15.5 billion dirhams in 2014, representing a 7% increase in value and a 4% increase in volume compared to 2013—has also been linked to the restoration of confidence among European countries. This confidence is associated with strategies aimed at guaranteeing the origin, traceability, and identification of fisheries products.

However, officials interviewed within the Department of Marine Fisheries reported having identified several cases of sabotage of the VMS communication link. Indeed, some vessels attempted to circumvent the system by using fraudulent techniques to render the onboard communication device inoperative. Several techniques were identified, including disconnecting the power supply to the VMS beacon battery, concealing the antenna with plastic material, deliberately dropping the device at sea, and intentionally damaging the equipment. In such cases, officials from the Ministry of Marine Fisheries conduct investigations to determine the causes of the malfunction or shutdown of the device and to establish responsibilities for the purpose of imposing sanctions.

### **Assessment from the Perspective of Fishermen**

Among the 39 fishing vessel owners interviewed, 10 did not perceive the usefulness of the VMS and declared that they were forced to use and invest in a technology they considered ineffective. Five vessel owners argued that the AIS system, which operates on a similar monitoring principle, is far less costly and provides the same level of control and services. Meanwhile, the remaining 24 vessel owners viewed the VMS as a useful and mandatory technology for national development and the conservation of fishery resources, as it helps reduce or halt illegal practices that some fishermen had previously engaged in.

Nevertheless, all interviewed vessel owners questioned the regulatory framework governing VMS operation, existing regulations, and the investment costs required. They also highlighted several constraints, which were echoed by fishermen's associations and can be summarized into four main points:

- **A single company holds a monopoly over VMS installation and maintenance, and costs are very high.** The satellite-based positioning and continuous monitoring system is currently managed by SOREMAR, the sole maritime radio-electronic operator in Morocco. This company holds a monopoly over installation, monitoring, maintenance, and repair operations. This monopoly imposes significant constraints on vessel owners due to high maintenance and repair costs, as well as substantial time losses in the event of equipment failure. These delays are primarily attributed, according to the interviewed vessel owners, to an insufficient number of technicians. Operators in the fisheries sector strongly criticize this monopoly and describe the situation as unacceptable.

- **Annual maintenance and subscription fees are excessive.** According to the interviewed vessel owners, the project initially planned to equip all vessels with a modem, with installation costs included. However, vessel owners were surprised to receive a ministerial notice indicating that installation and maintenance costs would be borne by them starting in November 2013. They also reported that communication and subscription fees are exorbitant and are considered additional charges imposed after the installation of satellite tracking devices onboard vessels. Vessel owners stated that they felt trapped and were required to pay a costly annual subscription, while denouncing a lack of transparency on the part of the supervising ministry particularly since the billing details were not clearly explained.

These costs are likely to increase, since in addition to annual subscription fees, vessel owners are required to pay for the following:

- SMS messages sent every 15 minutes when the vessel exceeds authorized fishing zones;
- 600 MAD for VMS deactivation and reactivation fees in the event of shutdown due to failure, sabotage, or intentional interruption of the device;
- 2,000 MAD for device uninstallation and reinstallation.

Vessel owners state that the total annual cost varies by fishing activity and ranges between 30,000 and 40,000 MAD (excluding taxes).

In order to analyze these costs in greater detail, we contacted the company SOREMAR to better understand the pricing structure. This national operator, which was awarded the public tender in 2010 to equip coastal and offshore fishing vessels with VMS, operates through 13 agencies located in Moroccan ports and specializes in the repair of navigation aid equipment and radio communication systems onboard vessels.

The operator effectively holds a monopoly over all installation, repair, and maintenance activities related to the equipment. Since November 2013, all installation, subscription, and maintenance costs have been borne by vessel owners. Fees related to messages automatically sent by the positioning device are charged at 1.17 MAD per message. These fees must be paid in advance at the beginning of each year. At the end of the year, a reconciliation is conducted between the flat-rate subscription and the actual invoice. Subscription fees are calculated based on estimated activity, as follows:

With an estimated annual activity period of 200 to 220 days per year, annual subscription rates vary according to vessel type:

- Trawlers: required to send 12 messages every 24 hours; subscription fee: 7,000 MAD
- Sardine vessels: required to send 9 messages every 24 hours; subscription fee: 5,500 MAD
- Longliners under 5 gross tons: required to send 6 messages every 24 hours; subscription fee: 4,800 MAD
- Longliners over 5 gross tons: required to send 12 messages every 24 hours; subscription fee: 7,000 MAD

However, if the actual cost is calculated strictly on the basis of message price  $\times$  number of messages per day  $\times$  number of operating days per year, the resulting amount is significantly lower—less than half of the flat-rate subscription fee. According to a source at SOREMAR, this discrepancy is explained by the existence of several additional messages that are automatically generated and added to the invoice under specific circumstances.

For example, when the vessel's power supply is cut or interrupted, the battery switches to sleep mode and automatically sends a message stating "enter mode sleep." The device reactivates after the two regulatory hours required to send a positioning message. When power is restored, another message is automatically sent indicating "leaving mode sleep." If the antenna is covered by any object, a message is automatically sent indicating a loss of positioning signal, followed by a second message when the antenna is uncovered.

When a vessel enters a prohibited zone, the frequency of message transmission changes: positioning messages are then sent automatically every 15 minutes, resulting in a significant increase in the annual subscription cost. With regard to maintenance and repair costs, the company offers vessel owners the option of an annual maintenance package priced at 4,000 MAD. However, the operator acknowledges that this offer is not profitable if all or the majority of vessel owners subscribe to it.

Only a minority of vessel owners subscribe to the annual maintenance contract. In most cases, only professionals who rely on this annual package do so. Some fishermen prefer to contact SOREMAR only when a breakdown actually occurs, despite the resulting high service costs.

The operation of the VMS installed onboard vessels requires, for example, an antenna and a battery. If a malfunction requires replacement of these components, the antenna costs 12,000 MAD, while the battery costs 6,000 MAD. When all these expenses are taken into account—along with 600 MAD for VMS deactivation in the event of shutdown and 2,000 MAD for reinstallation—it becomes clear that the annual cost of the VMS can reach up to 40,000 MAD, as reported by the interviewed vessel owners.

Vessel owners also complain that the system has not been generalized to all vessels. Indeed, since the introduction of the VMS, the Moroccan fishing fleet has gradually integrated this localization system by segments. Today, regulations require all vessels to be equipped with a functional VMS beacon, with the

exception of artisanal fishing boats. Professionals in the sector call for the generalization of VMS to the artisanal fishing segment and describe this exemption as unfair. However, current VMS regulations do not require artisanal fishing boats to be equipped with the device.

In fact, Article 1 of the decree of the Ministry of Agriculture and Marine Fisheries No. 3338-10 of 10 Moharram 1432 (16 December 2010) concerning the vessel positioning and localization system specifies that for vessels with a gross tonnage of less than two units, and vessels that do not have a continuous electrical power supply with a nominal voltage of 32 V within a voltage range of 10–32 V, the VMS is not mandatory.

However, these vessels must be equipped with an emergency location radio beacon operating at a frequency of 406 MHz and using the international satellite system for location, search, and rescue (COSPAS–SARSAT), which enables the transmission of distress signals via satellite. This requirement is not specific to Moroccan regulations but is international in scope. According to officials from the Ministry of Marine Fisheries, this exception exists because artisanal fishing vessels do not have a continuous power supply and therefore cannot install a VMS beacon, which requires a constant power source. Moreover, these vessels generally catch small quantities of fish, and their annual turnover is significantly lower than that of larger fishing vessels, making it impossible for them to bear the fixed annual costs of the VMS.

### **Fines and Severe Sanctions in Case of Infringement**

According to vessel owners, fines related to the deactivation or malfunctioning of the VMS, or in cases where illegal, unreported, and unregulated (IUU) fishing is detected, are excessive and should be revised downward. In this regard, Dahir No. 1-73-255 of 27 Chaoual 1393 (23 November 1973), which forms the regulatory framework for marine fisheries, provides for severe penalties that may include imprisonment.

Fines range from 120 MAD to 8,000,000 MAD, depending on the severity of the offense and the gross tonnage of the vessel. Administrative sanctions are also предусмотрены, including suspension, annulment, and/or revocation of fishing licenses.

Example: Any person who fishes or attempts to fish fish, mollusks, sea urchins, or crustaceans without authorization is punishable by three months to one year of imprisonment and/or a fine ranging from 5,000 to 1,000,000 MAD. Any activities other than those specified in the fishing license are subject to sanctions.

- **In the event of failure to maintain a logbook** or omission of required entries, the fishing license for small pelagic vessels may be suspended for a period not exceeding **three months**.
- **In the case of recidivism** (within two years following a final conviction), the penalties of fines and imprisonment are doubled, and seizure and confiscation procedures are applied to catches, vessels, fishing gear, nets, and all accessories used to commit the offense or transport fishing products.
- Any person engaging in illegal fishing is punishable by **three months to one year of imprisonment** and a fine ranging from **5,000 to 1,000,000 Moroccan dirhams**, or one of these two penalties, if the individual fishes during prohibited periods, seasons, places, or hours, or fishes within restricted limits.

It should be noted that **bonuses and incentives** are granted when offenses are detected and lead to convictions or settlements with reporting officers, maritime authorities authorized to negotiate, and officers under their authority, as well as to any person who contributes to the detection of offenses, inspection, seizure, safeguarding, and conservation of prohibited fishing gear, equipment, and bait.

### **CONCLUSION**

The objective of this research was to conduct a post-implementation evaluation of an Information System developed in the marine fisheries sector in Morocco, specifically the Vessel Monitoring System (VMS). Accordingly, we carried out a qualitative study involving key stakeholders. The aim was to understand the processes of assimilation, comprehension, acceptance, and judgment by the various actors using the system.

Based on the findings of this survey, it appears that the VMS is not always fully assimilated by its users. Although the project dates back to 2011, it remains one of the main concerns of fisheries professionals and continues to be the subject of discussion and debate. In our view, this situation reflects a conflict arising primarily from a lack of shared understanding of interests and from divergent perceptions among stakeholders, who often struggle to engage in constructive dialogue.

Nevertheless, these controversies are reassuring, as they occur in almost all countries implementing a VMS for the first time. This resistance to change concerns not only localization devices. More broadly, beyond technical issues, fishermen interviewed expressed highly critical views of the information and communication systems made available to them, which they believe primarily serve maritime authorities.

In conclusion, we emphasize that the main obstacle to the effective use of the VMS onboard Moroccan fishing vessels is economic in nature, with investment costs representing the principal barrier. Following this study, we propose that an open and sincere dialogue be established among the stakeholders concerned. Although this process will not occur without friction, it should ultimately lead to satisfactory outcomes for all parties and contribute to the preservation of marine ecosystems and fishery resources.

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