

The “Ecological Approach” to GIS Implementation in Low Income Countries’ and the Role of Universities: Union of Municipalities of Joumeh Case Study

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Abstract—This paper explores the effectiveness of approaches used for the implementation of technology within central governments specifically Geographic Information Systems (GIS). It examines the extent to which various strategies to GIS implementation and its roll out to users within an organization is crucial for its long term assimilation. Depending on the contextual requirements, various implementation strategies exist spanning from the most revolutionary to the most evolutionary, which have an influence on the success of GIS projects and the realization of resulting business benefits within the central governments. This research compares between two strategies of GIS implementation within the Lebanese Municipalities. The first strategy is the “Technological Approach” which is focused on technology acquisition, overlaid on existing governmental frameworks. This approach gives minimal attention to capability building and the long term sustainability of the implemented program. The second strategy, referred to as the “Ecological Approach”, is naturally oriented to the function of the organization. This approach stresses on fostering the evolution of the program and on building the human capabilities. The Union of the Joumeh Municipalities will be presented as a case study under the “Ecological Approach” and the role of the GIS Center at the University of Balamand will be highlighted. Thus, this research contributes to the development of knowledge on technology implementation and the vital role of academia in the specific context of the Lebanese public sector so that this experience may pave the way for further applications.

Keywords—Ecological Approach, GIS, low income countries, technological approach.

I. INTRODUCTION

OVER the last decade, change has swept through the majority of organizations driven mainly by Information and Communication Technology (ICT) [1]. This ICT push formed a snowball-like effect that forced various organizations to follow the lead. To respond to this new trend of change, organizations invested heavily in acquiring innovative

technologies in the hope to reduce cost [2], increase productivity and functionality [1], and gain competitive advantage [3]. In Parallel, pressure was exerted on public sector organizations across the world in order to improve service delivery, thus become more efficient and more citizens focused. These dependents led to the rise of “Transformational Government – enabled by IT” that put the use of technology at the heart of public service reform [4]. Consequently, governments of big economies across the world with similar agendas followed the lead [4]. Besides, transformation in the public sectors was not limited to the first world nations in which they germinated [5] but also in many developing countries across the world. Developing countries implemented reform in their public sector by adopting the most advanced innovations devised by industrial countries [6].

Given that eighty to ninety percent of government information are geographically referenced, Geographic Information Systems (GIS) became among the major information technologies in which public investment is needed [7]. Hence, GIS became widely adopted in governments across the world [8]. Within municipalities, the implementation of GIS technology is of strategic importance and became a radical mainstream within their enterprise-wide Information Management (IM) strategy leading them toward E-Municipalities. The main objective from this implementation is the development of a Spatial Data Infrastructure (SDI) in an attempt to become more efficient and effective as related to data retrieval and analysis [7]. Within the specific context of developing countries, establishing an SDI at the municipal level is of high importance as it helps overcome the high centralization of the government. However, the strategic importance of GIS are yet to be realized fully [8]. In fact, the failure of GIS is prevalent within governmental and public sector institutions [9]. According to KMPG Information Technology report eighty five percent of GIS projects fail and forty five percent do not produce expected benefits [10]. Failure is mostly due to inadequate strategies in managing GIS implementation and diffusion in local government [7]. The implementation strategy falls under the umbrella of Technology Transfer that depends mostly on grants from international donors [11]. These donors organizations are bounded by a limited time frame to GIS project implementation, thus they deploy the “Big-Bang” implementation strategy [12]. This approach

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imposes on employees to give up their traditional working habits and diverge to new habits using GIS. As a result, employees feel threatened leaving their old work habits and they tend to resist the introduction of GIS [13]. Many authors argued that user resistance to GIS is directly associated with how GIS is being implemented in developing and low income countries (LIC) like Lebanon leading eventually to its failure [13].

In Lebanon, the U.S. Agency for International Development (USAID) in partnership with the State University of New York/Center for Legislative Development (SUNY/CLD) funded in 2001 a municipal reform program : The “Lebanon Relief and Redevelopment Project” [11]. A central component of this program is the implementation of GIS within the Lebanese municipalities. The main objective of the GIS development is to ameliorate the development capabilities of the Lebanese municipalities to better serve citizens [11]. The scope of the project was only limited to the conversion of the municipal data both maps and tables and integrate them into a municipal GIS. Basic training under this program was allocated to municipal employees who were not involved in the GIS development process. In a survey conducted by the GIS Center at the University of Balamand in 2014, it was found that the majority of these municipalities failed to

maintain long term sustainability of the program. Reasons for discontinuing GIS usage spanned from the inappropriateness of the training, the complexity of the program, the lack of continual funding to maintain the work, or the lack of personal motivation among public sector employees.

II. LITERATURE REVIEW

A. GIS Implementation at the National Level: The Politico-Administrative Framework

The horizontal diffusion of GIS within developing countries and LIC governmental and public sector national level follows a politico-administrative path. Ramasubramanian argued that the diffusion of GIS “is not an amorphous cloud of activities independent of the government” [14]. On the contrary, GIS diffusion follows a “series of administrative decisions” [14] that are embedded in programs reflecting the government political agenda [14], [15]. Hence, [14] developed a politico-administrative framework for GIS implementation in developing countries governments as seen in Fig. 1. Since international organization provide the funding for GIS development, they tend to govern its implementation strategies and depict the way it will be used.

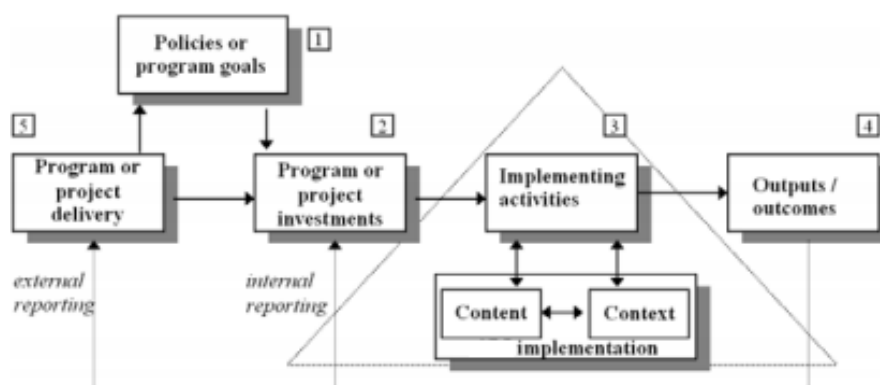


Fig. 1 Politico-Administrative framework to GIS implementation [14]

The strength of the framework lies in its ability to place the GIS implementation within the grand context of national or regional policy implementation [14]. This framework shows how GIS implementation is embedded within the “politico-administrative” framework hence providing a realistic insight on the GIS implementation process in developing countries like the case of Lebanon.

B. GIS Implementation Strategies at the Local Level: The International Transfer of Technology (ITOT) Versus the Ecological Approach

A major concern in any GIS project is the roll out of GIS within organization [16]. Therefore, the implementation strategy of GIS and its roll out to users within an organization is crucial. Five implementation strategies exist within the information system literature spanning the most revolutionary to the most evolutionary [17]. The “Bing Bang” strategy is the most revolutionary and requires the total discontinuing of the

old work habits and the adoption and use of the new technology. The strategy creates an instant organizational change and encompasses a great risk on the company due to user resistance of the new system [16]. The “Parallel Running” approach allows the running of both the old and new systems until the technological change is reached. “Phased Introduction”, “Trials and dissemination” and “Incremental Evolution” are additional implementation strategies used for GIS that are more evolutionary and time consuming [16]. Fig. 2 shows the various implementation strategies and their impact on organization.

Recognizing the uncertainty and the change that accompany the introduction of GIS within organization, many authors suggest a more evolutionary approaches to GIS implementation [18], [19]. Table I shows the various strategies for GIS implementation in organization using an evolutionary approach [20]. All of these approaches are used within

developed country context and do not reflect the GIS implementation strategies in developing country.

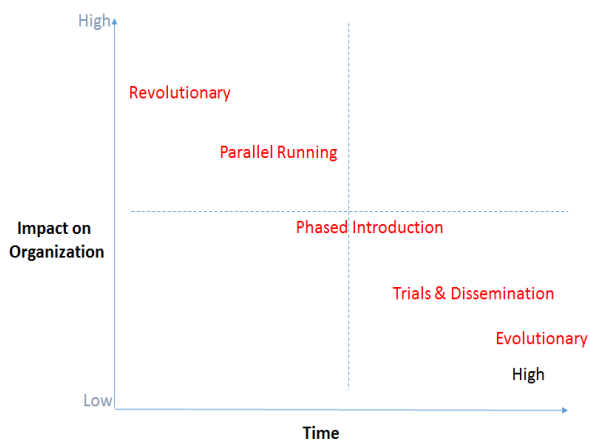


Fig. 2 Implementation strategies

TABLE I
 VARIOUS STRATEGIES FOR GIS IMPLEMENTATION WITHIN ORGANIZATION

Strategy	Basic Characteristic
Dual – Track	Two steps development: short term and long term. Iterative prototyping. Early results are delivered Takes both the technological and the organizational change requirements.
Iterative prototyping	Greater change responsiveness by users. Low level of risks.
Three – phase implementation process	Persuasion, familiarization and globalization. Incremental implementation using pilots.
Incremental implementation & Re-engineering	Process automation and organizational change. Incremental approach
Proactive Approach	GIS implementation is composed of five nonlinear phrases
Goal alignment approach	Define goals to improve the strategic position of organization
Organizational approach	Improve management practice : Sociotechnical system design
Adaptation Model	Adaptation process. Prototyping, assessment, development

The GIS implementation strategy in developing countries falls under the umbrella of Technology Transfer from developed countries through funded projects. This approach is often referred to as the “Technological Approach“ defined as “one which is focused on the acquisition of technology, often in showcase organizational structures superimposed on existing governmental frameworks, with little regard for the development of indigenous capabilities and the long term resources required to maintain its activity” [12]. The building blocks of the “Technological Approach” are:

- Big Bang
- Top-Down approach to implementation
- Highly Centralized
- Revolutionary
- Short Term
- Imposed
- Technology Driven

It was realized that under this approach that the majority of GIS projects fail to achieve long term sustainability [21].

Thus, funding organizations tried to develop new strategy for GIS implementation given the limited time frame restriction. The “Ecological Approach” was developed by the United Nation (UN) & USAID as purely experimental approach for funded GIS project in the context of developing countries [12]. The “Ecological Approach” is defined as one that “is naturally oriented to the function of the organization, the physical and human resources it can muster, and the manner in which these resources can be shaped and strengthened to foster the evolution that is envisioned” [12]. The building blocks of this approach are:

- Bottom-Up approach to implementation
- Empowerment of users
- Evolutionary and phased planning of implementation
- Long Term
- Participatory focusing on learning and user input
- Problem oriented
- Process oriented

Unfortunately, the ecological approach was not widely adopted due to the restriction in project delivery time frame imposed by international donors [12].

The complexity in developing a functional GIS system requires the presence of highly skilled personnel from various disciplines. Thus, Academia played a central role in promoting the GIS technology by providing training and through building the necessary capacities of human resources [22]. At this stage, the role of academia in endorsing the ecological approach became vital. The partnership between the funding organizations, the public sector, and the universities’ research centers can break this deadlock. This partnership plays a positive role in promoting the “Ecological Approach” to GIS implementation leading to its long term sustainability. The power of this partnership will be elaborated hereunder through one case study.

III. CASE STUDY: THE UNION OF MUNICIPALITIES OF JOUMEH

Within the Lebanese Republic, development efforts have always been directed toward the capital and major cities. These highly centralized policies led to high discrepancies in the social welfare of various Lebanese areas [22]. Joumeih represents the perfect example of such underdeveloped and deprived region in Lebanon. It is located in the Northern region within the Akkar Caza as shown in Fig. 3.

The union of Municipalities of Joumeih is composed of eighteen villages of an area of 98 km² approximate [22]. It is characterized by a rich ecosystem and green diverse landscape [22]. However, it lacks the necessary infrastructure to maintain its resources due to central government policies. This has resulted in acute lack in the main living sectors such as education, healthcare, commercial, and industrial. Hence , this community has suffered from various problems such as illiteracy, unemployment, poverty and the loss of social and professional opportunity[22].

As GIS is considered the perfect tool for local development due to its capabilities in revealing trends and in simplifying the decision making process, it was decided to harness the power of GIS for developmental purposes within the Joumeih

region. Unlike the “Lebanon Relief and Redevelopment Project”, this project requires the collection of considerable

demographic and social information directly from the local residents within the Union of Joumeh municipalities.

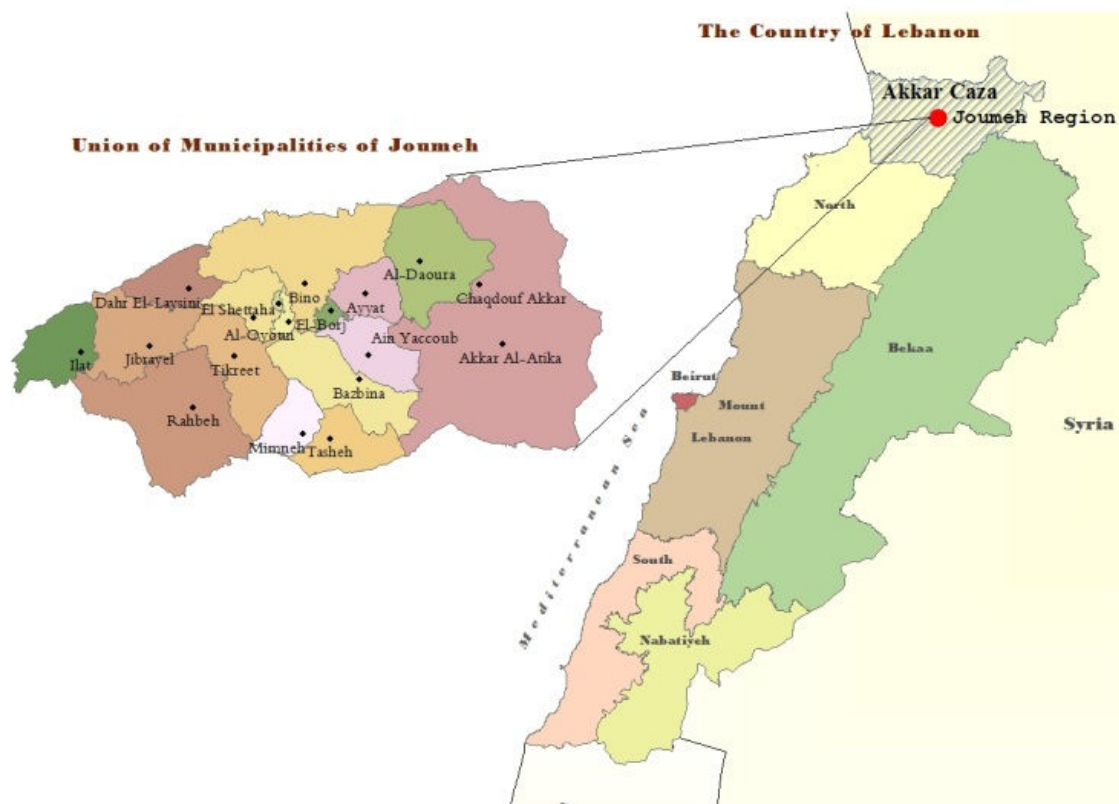


Fig. 3 Map of Lebanon and the Union of Municipalities of Joumeh

On the pragmatic side, developing a GIS with this breadth and depth is not a simple task especially within developing or low income countries. Many factors can hinder the development of GIS such as:

1. *The technological factors* specifically those associated with Data collection and Data management and integration [23]. One of the major problems in Lebanon and other LIC is the difficulty in developing the spatial data infrastructure since it is challenging to collect geographically referenced data. The majority of maps available in Lebanon are from old inaccurate paper ‘blue print’ maps due to the lack of digital maps such as CAD. Parallel to the physical data, the collection of socio-economic data is very expensive and difficult due to the lack of trust between citizens and surveyors. Concerning data management and integration, this is also problematic since this requires special attention to the scale of different maps and the design and fields within the database. This process requires skilled personnel with technical knowledge that is rather scarce in Lebanon.
2. *The organizational factors* dominated most of the GIS literature and are considered very influential in the success or failure of GIS implementation and in how GIS is utilized [23], [24]. The organizational factors can be divided into the external environment and the internal

- organizational context factors [24]. The external factors within the developing countries public sector specifically Lebanon encompass the availability of funding and the necessary legislations to endorse SDI developments [24]. The financial problems are considered among the major barriers to GIS implementation in Lebanon. Thus, it is first necessary to secure capital or ensure funds for GIS implementation. On the other hand, the internal organizational contextual factors encompass institutional inertia, culture, structure in addition to politics and power conflicts among different user groups [25], [26]. In Lebanon, an important organizational factor is the lack of commitment and support from top management leading to the loss of interest in GIS usage among employees. Thus, it is vital to gain top management support from the beginning. Another major organizational issue is associated with the changes induced by GIS implementation especially with the Big Bang approach. Thus, employees tend to become resistant to the change especially with lack of involvement in the GIS development process which is the case in Lebanon under the “Lebanon Relief and Redevelopment Project”.
3. *The human factor* specifically the lack of human-capital is considered one of the main reasons why GIS is not utilized within governmental organizations in Lebanon.

Training is considered vital in overcoming this barrier. However, GIS training is very costly and requires the allocation of funds. Initial and basic training will not resolve this issue since extensive and continual training is required.

To overcome these obstacles, it was decided to shift from the traditional method (Technological Big-Bang approach) for GIS development in Lebanon. Thus, instead of outsourcing the GIS work, it was decided to develop the GIS internally from scratch hence adopting an ecological approach. To achieve this goal it was decided to bring in partners from various areas in order to fill the gap in the above mentioned problems. These partners came from:

- **International Organization:** United Nation Development Program (UNDP) responsible for setting development policies given the necessary data.
- **Governmental Organization:** Lebanese Council for Development and Reconstruction (CDR). The CDR is responsible for the implementation of development projects within Lebanon.
- **Non-Governmental Organization:** Fares Foundation responsible for the funding of development projects specifically with Akkar Region.
- **Private Academic Institution:** The University of Balamand GIS Center. The Center is one of the leading research centers in Northern Lebanon in the field of GIS. The main objective of the center is to promote the use of GIS in the region by directing its efforts towards the local community through research, development, and capacity building. The responsibilities of the GIS Center were to come up with a strategy for GIS development, database design, data entry, cartographic map development, and training. The GIS Center created a core that incubated all partners within the process of GIS development. Its main role was to come up with an innovative solution to every difficulty that came along the process of GIS development. The support on both the technical organizational and human level created a boost for the work to proceed in the right direction without losing its scope and objectives.
- **Public Institution:** The Union of Municipalities of Joumeih that that are represented by the head of each of the eighteen municipalities in the Joumeih region. These municipal presidents were very supportive and keen in adopting GIS within their municipalities. The municipalities' main contribution was the field survey collection. A major challenge in these local communities was to build a trust between the surveyor and the local community members in order to share information. Therefore, the provision of personnel from the local community was a key for the success of field data collection. Public School teachers along with municipalities' employees from the Joumeih region were recruited for data collection. This participatory approach made the employees of the municipalities more involved

in the process of GIS development. They felt connected to the work and more committed to its long term success. Employees received gradual training in each phase of the GIS development from the GIS Center at the University of Balamand. They also participated in the data entry process and cartographic map production.

The GIS development project for the Union of Municipalities of Joumeih was a phased work that spanned over a period of a year and a half approximately and resulted in constructing a comprehensive socio-economic-demographic GIS for the deprived region of Joumeih to be used for purposes of development. When the initial phase was accomplished, the GIS were handed to the Union of Joumeih Municipalities under the continual and permanent support from the GIS center at the University of Balamand. Data from the GIS was analyzed and used for various development projects afterward.

Currently, this project is still viable with regular update and upgrade. Employees were keen and committed to the success of this work as they felt connected to its development. Unlike other Lebanese Municipalities who couldn't maintain the long term sustainability of the GIS, the "Ecological Approach" proved to be more sustainable.

IV. CONCLUSION

The case study presented herein clearly shows that the "Ecological Approach" to GIS implementation represents a good model for GIS development in LIC. In such context, establishing the right partnership between local, international, and academic institutions leads to its long term sustainability.

The partnership between various parties created the necessary backbone of support to such project. The role of Academia cannot be undermined as it played a central role in endorsing the "Ecological Approach".

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