A Framework for Prioritizing Intervention Projects in Slums

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Abstract— Slums represent major national challenges in developing countries. Various intervention strategies can be adopted to upgrade and/or replace slums, but are often faced with serious challenges; including planning, construction, social, and economic challenges. Selecting the most suitable intervention strategies for each slum area and determining the priorities of these intervention startegies are important goals in the development process. This paper presents a novel and comprehensive framework that is capable of supporting planning authorities in identifying (1) the needed intervention strategies for the slums area and (2) the optimal priorities among these intervention projects. In the proposed framework, decision are made taking into consideration three main factors; namely (1) the priority package within which an intervention project can be classified; (2) the benefit to cost ratio for each project; and (3) the construction sequence within the same area. In lieu of this analysis, the proposed framework computes an urgency factor and a vector of benefits indices for each intervention project. This paper also presents an application example to demonstrate the potentials of the proposed framework.

Key words: Slums, Intervention Project, Urgency Factor, Benefits Index, and Priority Package

1 INTRODUCTION

Slums are heavily populated urban informal settlements characterized by substandard housing and inadequate living conditions [1]. Slum households suffer from one or more of the following conditions: (1) lack of access to clean water; (2) lack of access to improved sanitation facilities; (3) insufficient and overcrowded living area; (4) inadequate structural quality or durability of dwellings; and (5) lack of tenure security [2]. Slums form and grow in different parts of the world for various reasons, including the rapid rural-to-urban migration, economic stagnation and depression, high unemployment rates, poverty, informal economy, poor planning, natural disasters, and social conflicts [3].

Slums suffer from several planning, social, and economic challenges. First, planning challenges fall under one of two major categories. The first category is the lack of basic services, such as access to sanitation facilities and safe water sources, waste collection systems, electricity supply, paved roads and footpaths, street lighting, and rainwater drainage. The second category has to do with residence in substandard housing or illegal and inadequate building structures, which are often built with non-permanent materials unsuitable for housing given local conditions of climate and location [2]. On the other hand, social challenges vary according to the nature of the population and their backgrounds, traditions, customs, and relations. Social challenges form a social disorganization in slums. These challenges include (1) poor educational facilities (rundown schools, few teachers with insufficient qualifications, lack of facilities such as books and equipment, etc.); (2) high unemployment rates (partially attributed to lack of skills and low levels of education); (3) family problems (evidenced by high rates of divorce, separation, and illegitimacy); (4) personal degradation (including alcoholism and addiction); and (5) high crime rates [4]. Third, economic challenges are manifested in low incomes, irregular work opportunities, and high levels of child labor [2].

To address the aforementioned challenges, governments employ a number of intervention strategies. These strategies include (1) on-site redevelopment of informal areas; (2) redevelopment and relocation; (3) servicing informal areas; (4) sectorial upgrading; (5) planning and partial adjustment; and (6) participatory upgrading [5,6]. A review of several countries' experiences with upgrading of informal settlements and identifying their priorities show that governments have moved away from eradication and eviction policies that advocated the bulldoze of these settlements to the provision, enabling, and participatory policies [7]. Participatory upgrading is a more effective strategy used in the upgrading process and in determining intervention priorities, where the slum dwellers and the development partners are involved in re-planning and upgrading of the area and participate in the decision making. The success of this strategy depends on engaging all stakeholders in the processes of determining their priority needs and problems, deciding on interventions, implementing the upgrading measures agreed upon, and co-managing the improved community facilities [8]. It is important that all stakeholders agree on the upgrading objectives and on the respective interventions before starting any upgrading scheme. Upgrading also balances between priority needs of local residents of the informal areas (as determined through the participatory process) and the strategic vision of the government for the development of the city as a whole [2].

2 RESEARCH OBJECTIVE

Several studies have been dedicated to investigate slums from many aspects, including the social, environmental, urban, health, political, and economic aspects, as well as the construction costs of slums upgrading projects [9-22]. Despite the significant contributions of these research studies, there is little reported research on prioritizing slum intervention projects and strategies. For instance, one study presented a framework using an expert system to identify the best intervention strategies, such as demolition, upgrading, or conservation by calculating area an informality degree. This approach is applicable to cases when it is needed to prioritize interventions at the strategy level (e.g. upgrading utilities first), but is limited in its ability to prioritize intervention projects (e.g. which utilities upgrading project should receive a higher priority; water supply, sewage, or electricity upgrading?) [23]. Another study presented a framework that integrates urban and construction planning in an effort to identify the optimal slums upgrading plans what would maximize benefits to residents, minimize construction costs, and minimize the associated socioeconomic disruptions [24-26]. This study focuses on the computational implementation of the proposed integration, but still needs to be complemented with a methodology to identify the optimal intervention projects. To this end, this research supports decision makers in prioritizing slums intervention projects by proposing a new framework that adopts an objective and systematic procedure.

The objective of this research is to present a novel framework for slums intervention projects, which is capable of (1) assessing the slum's conditions and identifying the needed intervention strategies, and (2) prioritizing the identified intervention projects taking into account practical budgetary constraints and construction sequencing. The following section provides a brief description of the proposed framework.

3 Proposed Framework

The proposed framework is designed in order to optimize slums intervention projects. The framework consists of two main phases: (1) framework hierarchical scaling system; and (2) framework implementation (optimizing intervention priorities). The two main phases of the framework are described in the following subsections.

3.1. Framework Hierarchical Scaling System

This framework presents a hierarchical scaling system designed according to the Egyptian Informal Settlement Development Facility's classifications to slum areas. The Egyptian Informal Settlement Development Fund (ISDF) classifies slums into unplanned areas and unsafe areas [27]. Unplanned areas are areas not subject to detailed planning and land subdivision, and are not compliant with planning and building laws and regulations. On the other hand, unsafe areas are characterized by posing risks to life, health, and tenure or by having inappropriate housing. These risks might be due to (1) severe deterioration over time; (2) using components made of makeshift material to build houses; (3) being located in sites subject to landslides, floods, or hazardous infrastructure (e.g. high voltage cables); or (4) being prone to risky health conditions due to the lack of safe drinking water or improved sanitations and due to industrial pollution. Unsafe areas are further classified into four grades of risk representing the urgency for intervention [27], as follows: (1) Grade 1 represents the first intervention priority and includes areas that threaten life such as those located in floodplain areas or at sliding geological formations, or under threat from railways accidents; (2) Grade 2 (second intervention priority) incorporates areas of unsuitable shelter conditions including buildings made of make-shift materials (e.g. shacks), sites unsuitable for building (e.g. solid waste dump sites), or ruined buildings; (3) Grade 3 (third priority) incorporates areas exposed to health risks, including those lacking access to clean drinking water or improved sanitation, located in the vicinity of industrial pollution, or located under electrical power lines; and (4) Grade 4 (fourth priority) includes areas of instability due to lack of tenure, such as areas located on the territory of state-owned land, sovereign quarters, or on the territory of endowments (Awqaf).

The proposed scaling system is classified hierarchically into three levels; namely priority packages, categories, and subcategories, as summarized in Table 1. There are five main priority packages in the proposed framework covering intervention projects addressing life safety, health, utilities/services, tenure, and convenience/aesthetics. The priority packages are used to ensure that any generated intervention plan complies with all relevant safety, health, and urban constraints. They are used to define high-level priorities among the proposed intervention projects. For instance, an intervention project that relocates families from an unsafe area (a life safety project) should receive a higher priority than an intervention project that improves streets lighting (a utilities/services project). As such, and given the typical limited available funds, intervention projects in higher-priority packages are given a higher priority than intervention projects in lower-priority packages.

In case of intervention projects within the same priority package, an urgency factor is computed for each project in order to assist in prioritizing funds allocation. These urgency factors are computed based on a number of criteria including the project category and subcategory, as will be described. In the proposed scale, there are seven main categories. Four categories correspond to the grades of ISDF's classification for unsafe areas. As such, these categories are life threats, property threats, tenure and health threats. The scale presents characteristics of unplanned areas as well as some lower-priority characteristics of unsafe areas within the remaining three categories, which include infrastructure/facilities issues, basic services issues, and non-structural building issues, as shown in Table1. Each category falls under one of the aforementioned five priority packages. Life threats projects and property threats projects fall under the life safety priority package. Health projects fall under the health priority package. Infrastructure/facilities projects and basic services projects fall under the utilities/services priority package. Insecurity of tenure projects fall under tenure priority package. And the non-structural building related projects fall under the convenience/aesthetic priority package.

Each category is further divided into a number of subcategories, as shown in Table 1. The urgency of each of these subcategories is represented using a range of urgency factor (UF) values. For instance, the property threats category is divided into the subcategories of (1) deteriorated buildings (with UF ranging between 65 and 75), which are subject to collapse whether under their functional loads or as a result of a natural disaster;

ISSN 2229-5518

(2) building of low resistance to natural disasters (with UF ranging between 55 and 65), which can support their functional loads but are not likely to resist forces of natural disasters; and (3) other less critical property threats (with UF ranging between 50 and 55).

The development of the proposed scale with its three hierarchical levels was supported by interviews with five experts in slums upgrading and development projects. The interviewees included one of the directors in ISDF, three scholars of slums upgrading an urban planning, and a project manager responsible for the construction supervision of a number of slums upgrading projects in Cairo, Egypt. Interviews were carried out separately and were conducted as guided conversations. The main objectives of the interviews were to explore slum characteristics and the experts' opinions in the proposed framework (including the proposed priority packages and categories of the proposed scale, as well as their order and urgency factors ranges). While, the five interviewees approved the proposed hierarchical classification, their common comment was about the urgency factors ranges of priority packages, categories, and subcategories. They concluded that these ranges should be left to decision makers to define. As such, the presented urgency factors ranges are to be used as guideline values and decision makers are allowed to set more appropriate value as they deem necessary.

Table 1
Components of the Proposed Framework Hierarchical Scaling System

Priority Package	Categories	Sub-categories	Range from	Range to
Life Safety			50	100
	Life Threats		75	100
		Area subjected to collapse - falling rocks - landslides	90	100
		Area subjected to flooding	83	90
		Area located near railway campus (prone to train accidents)	78	83
		Others (for any characteristics not stated in the above sub categories)	75	78
	Property Threats		50	75
		Deteriorated buildings area (cracks-concrete steel corrosion, etc.)	65	75
		Buildings of low resistance to natural disaster (earth quakes)	55	65
		Others	50	55
Health			30	50
	Health Threats		30	50
		Area characterized by lack of clean water or improved sewage	42	50
		Area located near electrical power lines	37	42
		Area located near industrial pollution	32	37
		Others	30	32
Utilities/ Services			5	30
	Infrastructure / Facilities		15	30
		Inadequate water supply	26	30
		Inadequate sewage system	22	26
		Poor road conditions	19	22
		Lack of electricity	16	19
		Lack of waste collection	15.5	16
		Others	15	15.
	Basic	In need of:	5	15
		Hospitals, clinics (Medical)	13	15
		Schools (Educational)	11	13
		Mosques (Religious)	9	11
		Markets (Commercial)	8	9
		Police Station (Governmental)	7	8
		Public parks	6	7
		Others	5	6
Tenure	Lack of Tenure		4	5
Convenience/ Aesthetic			1	4
	Non Structural Building issues		1	4
		Overcrowding and high density	3	4
		Unfinished buildings	2	3
		Improper building proportions	1	2
		Others	0	1

3.2. Framework Implementation Phase

The objective of this phase is to utilize the hierarchical scaling system presented in the first phase in order to identify the op-

ISSN 2229-5518

timal priorities among slums intervention projects. Selecting slums intervention priorities aims at maximizing the benefits to slum dwellers from the proposed projects. This is achieved by selecting (1) the upgrading projects with the highest impact (i.e. highest urgency factor) and (2) the projects that benefit the largest number of residents. Hence, a benefits index (B.I) is calculated for each project by multiplying its urgency factor (U.F.) by the number of residents that will benefit from the project, as shown in Eq. (1).

$$B.I. = U.F. * N \quad (1)$$

Where, B.I. is the benefits index per package, U.F. is the urgency factor (average value calculated from hierarchical scaling system), and N is number of residents affected by the project.

To achieve the objective of this phase, a series of data gathering and analysis steps are conducted followed by a prioritization process. First, data gathering and analysis include the following steps: (1) Calculate the urgency factor (U.F.) and benefits index (B.I.) for each project; (2) Input the budgeted cost for each project and then compute the ratio of budgeted cost to benefits (i.e. cost/B.I.); and (3) Generate the overall benefits index vector (O.B.I) for each project with respect to the priority packages, as shown in Eq. (2).

O.B.I = {B.I.(life safety), B.I.(health), B.I.(utilities/services), B.I.(Convenience/Aesthetic) (2)

Second, slum intervention priorities are identified while taking into account three main considerations, in the following order:

Priority Package: Projects in a higher priority package must be upgraded before any projects in a lower package;

Cost/ B.I. Ratio: Projects in the same priority package will be upgraded according to (cost/ B.I.) ratio; and

Construction Sequence: Poor construction sequencing can result in rework, which wastes the limited upgrading budgets. For example, if a road pavement project is completed before a sewage-upgrading project in the same area, then the road will be affected by the excavation works during the sewage-upgrading project. This will require repaving the road.

In order to illustrate the use of the proposed framework in prioritizing upgrading projects, an application example is presented in the following section.

4 Application Example

The objective of this application example is to demonstrate the potentials of implementing the proposed framework in part of Manshiet Nasser. Manshiet Nasser is a squatter settlement entirely built on government owned land in Cairo, Egypt, with a population of about 300,000 [28,29], as shown in Fig. 2. In this paper, one of the major areas in Manshiet Nasser is studied, which is Ezbet Bekhit. The following section provides a brief description of this area.

4.1. Ezbet Bekhit Settlement

Ezbet Bekhit area is estimated at 42 feddans (which is equivalent to 17.64 hectares). It has a population of 37,000 inhabitants [29]. It is strategically located in a crossroad. On its northwest side lies the highway connecting Cairo downtown to Nasr City and its northeast border is Tayaran Street terminating at a security forces camp. It is surrounded from the east and south sides by other areas within Manshiet Nasser. The main topographic features of the area are characterized by sharp edges and mountain cliffs. Ezbet Bekhit has no access from the south and west sides and the sharp cliffs constitute a potential risk from falling stones as shown in Fig. 1 [30].

Literature reviews, site visits, meetings and interviews with residents and relevant authorities are used in this case study. The following are some of the characteristics of Ezbet Bekhit.

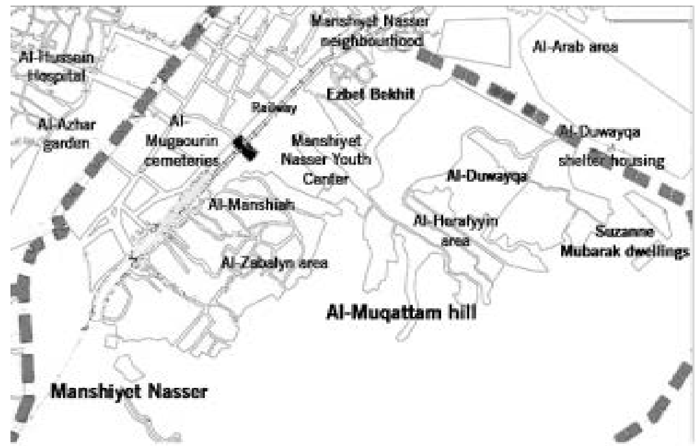

Fig.1 Manshiet Nasser
(Source: Ministry of Housing, Utilities and New Communities, 2011)

4.1.1 Location and Housing Condition

Due to the closeness of Ezbet Bekhit location to sharp cliffs as shown in Fig.2, there is a potential of falling rock hazards. Residents located in houses subjected to falling rocks form about 10 percent of the area population. The houses have been constructed in unplanned patterns. Table 2 [31] shows the common building materials in the area. Parallel to the highway there are multi-story buildings of up to five floors built to acceptable construction conditions, whilst the area that has difficult topographic features and lacks basic infrastructure systems accommodates the worst type of housing and the poorest residents.

Table 2
Housing Condition in Ezbet Bekhit
(Source: Household Sample Survey 2003 held by Manshiet Nasser District Team)

Dwelling Characteristic	Percentage of Houses
Reinforced Concrete Roof	81
Tin Roof	12
Wood Roof	7
Bamboo Roof	1
Cement Floor	36
Tile Floor	46
Dirt Floor	18
Combination of Reinforced Concrete Roof and Cement or Tile Floor	72
Brick or Reinforced Concrete Columns	82
Concrete Bearing Walls	15

Fig. 2 Informal Housing in Ezbet Bekhit

4.1.2 INFRASTRUCTURE

Ezbet Bekhit suffers from insufficient infrastructure services, especially in terms of potable water and sewage systems as well as paved roads. 29 percent of the households are not connected to the public water system in Ezbet Bekhit. A partial sewerage network was introduced to Ezbet Bekhit, using which 78 percent of households are connected informally to the main network. The roads have no specific planning pattern. They have been developed randomly following the pattern of housing construction. Most roads are very narrow, and there are almost no open spaces. Households connected to unpaved roads are 60 percent, as shown in Table 3 [32]. On the other hand, the electricity service in Ezbet Bekhit is remarkably good, with all buildings (and most dwelling units) connected and metered.

Table 3 Infrastructure Services in Ezbet Bekhit
(Source; Central Agency for Public Mobilization and Statistics, 2008)

Infrastructure Services	% of households connected to service
Water	
Tap in Dwelling	71%
Tap in Neighbor's Dwelling	5%
Public Taps	14%
Wells using pumps	10 %
Sanitary Drainage	
Connected to Main Network	78%
Household Septic Tank	22%
Electricity	
Connected to Main Network	99%
Not Connected to Main Network	1 %
Roads	
unpaved	60 %
Paved	40 %

4.1.3 BASIC SERVICES

As shown in Table 4 [33], basic services are available, including health care services (such as hospitals, clinics and pharmacies), schools, markets, etc. So, there is no current need for upgrading projects in the field of basic services.

Table 4 Basic Services in Manshiet Naser
(Source: Manshiet Naser District, 2014)

Services	Number
Health services	
Hospital	1
Health centers	4
Clinics	45
pharmacies	49
Educational services (Schools)	35
Religious services	
Mosques	34
Churches	9
Commercial services (Markets)	5
Governmental services	
Police station	1
Post station	3
Car parking area	11
Garden	3

4.2 FRAMEWORK IMPLEMENTATION

This section provides a brief description of the application of the proposed framework to Ezbet Bekhit. Below is a summary of the data gathering efforts:

- 10% of households (3700 inhabitants) are located in houses subjected to falling rocks.
- 29% of households (10730 inhabitants) suffer from water supply shortage.
- 22% of households (8140 inhabitants) are in need of a sewage system.
- 1% of households (370 inhabitants) suffer from shortage of electricity.
- 60% of households (22200 inhabitants) suffer from unpaved roads.

Data gathering and analysis steps are then conducted using the abovementioned data and using reasonably assumed projects costs. The results of these steps are summarized in Table 5. In addition, Table 6 shows the computed overall benefit index for these upgrading projects.

Table 5 Framework Calculations of case study

Project description	Number of impacted residents	Cost (million LE)	U.F.	B.I. = U.F *N	Priority package	Cost / B.I.	Priority
New buildings project (Relocate slum residents)	3700	18	95	351,500	1	53	1
Water supply project	10730	3.6	28	300,440	3	12	2
Sewage upgrading project	8140	2.7	24	195,360	3	14	3
Electricity project	370	0.5	17.5	6,475	3	77	5
Roads pavement project	22200	10	20.5	455,100	3	22	4

Table 6 The overall benefit index for the proposed upgrading projects

Project description	Priority package	O.B.I				
		Life Safety	Health	Utilities/ services	Tenure	Convenience/ Aesthetic
New buildings project (Relocate slum resident)	1	351,500	0	0	0	0
Water supply project	3	0	0	300,440	0	0
Sewage upgrading project	3	0	0	195,360	0	0
Roads project	3	0	0	455,100	0	0
Electricity project	3	0	0	6,475	0	0

The priorities of the proposed upgrading projects were determined according to two main prioritization considerations. First, offering residents in hazard prone areas new housing locations falls within the first priority package. As such, the first project shown in Table 5 received the highest priority. Second, the remaining projects all fell within the third priority package. As such, these projects were prioritized based in their cost/B.I. ratios. Table 5 shows the computed priority for each of the proposed five intervention projects.

4.3 Extended Implementation

The proposed framework can be extended to prioritize upgrading projects spread among various slums areas. To demonstrate this capability, the proposed framework is applied to an extended set of projects, as follows: (1) The first group of projects represent the five upgrading projects of Ezbet Bekhit, as discussed above; (2) the second group represents the upgrading projects executed under the umbrella of Informal Settlement Development Facility (ISDF); and (3) the third group represents an assumed set of upgrading projects. Table 7 shows the three groups of projects sequentially. This table also shows the prioritization recommendations after applying the proposed framework to these projects. Further, Table 8 shows the computed overall benefits index for these upgrading projects.

Table 7 Framework Calculations for the Extended Set of Intervention Projects

Project description	Number of impacted residents	Cost (million LE)	U.F.	B.I. = U.F *N	Priority package	Cost / B.I.	Priority
New buildings project (Relocate slum resident)	3700	18.5	95	351,500	1	53	1
Water supply project	10730	3.6	28	300,440	3	12	6
Sewage upgrading project	8140	2.7	24	195,360	3	14	7
Electricity project	370	0.5	17.5	6,475	3	77	14
Roads project	22200	10	20.5	455,100	3	22	10
Sudan Street Buildings	859	3.8	70	60,130	1	63	3
Soufi village sewage project	3,160	0.6	24	75,840	3	8	5
Alaweyet elSsawy village sewage project	2,500	1.2	24	60,000	3	20	9
Ezbet Maamoun village sewage project	3,000	1.3	24	72,000	3	18	8
Mohamed Mishrif village sewage project	700	0.7	24	16,800	3	42	13
Buildings Project (Falling rock hazard)	1,000	4	95	95,000	1	42	2
Hospital Project	5,000	2.5	14	70,000	3	36	12
Sewage upgrading Project	200	2	24	4,800	3	417	15
Roads Project (1)		1	20.5	4,100	3	244	16
Total		3		8,900		337	
Telephone Lines Project	100	0.8	15.25	1,525	3	525	17
Road Project (2)		0.5	20.5	2,050	3	244	18
Total		1.3		3,575		364	
New buildings project (Industrial pollution hazard)	10,000	2	34.5	345,000	2	6	4
School Project	5,000	1.7	12	60,000	3	28	11
Building painting project		0.2	2.5	12,500	5	16	19
Total		1.9		72,500		26	

ISSN 2229-5518

Table 8 The Overall Benefit Index of the Extended Set of Upgrading Projects

Project description	Priority package	O.B.I				
		Life Safety	Health	Utilities/ services	Tenure	Convenience/ Aesthetic
Buildings project (E.B) (Relocate slum resident)	1	351,500	0	0	0	0
New buildings Project (Falling rock hazard)	1	95,000	0	0	0	0
Sudan Street Buildings	1	60,130	0	0	0	0
Buildings Project Industrial pollution	2	0	345,000	0	0	0
Soufi village sewage project	3	0	0	75,840	0	0
Water supply project (E.B)	3	0	0	300,440	0	0
Sewage upgrading project (E.B)	3	0	0	195,360	0	0
Ezbet Maamoun village sewage project	3	0	0	72,000	0	0
Alaweyet elSsawy village sewage project	3	0	0	60,000	0	0
Roads project (E.B)	3	0	0	455,100	0	0
School Project	3	0	0	60,000	0	0
Hospital Project	3	0	0	70,000	0	0
Mohamed Mishrif village sewage project	3	0	0	16,800	0	0
Electricity project	3	0	0	6,475	0	0
Sewage Project	3	0	0	4,800	0	0
Roads Project (1)	3	0	0	4,100	0	0
Telephone Lines Project	3	0	0	1,525	0	0
Roads Project (2)	3	0	0	2,050	0	0
Painting building Project	5	0	0	0	0	12,500

There are a number of noteworthy observations based on the results reported in Table 7:

- The priorities of upgrading projects are calculated according to: (1) priority package; (2) cost/ B.I. ratio; and then (3) construction sequencing.
- The five upgrading projects of Ezbet Bekhit (new buildings, water, sewage, roads, and electricity projects) received the priorities of 1,6,7,10,14 when compared to the extended set of projects presented in Tables 7 and 8.
- For the area that includes both sewage and roads upgrading projects (project #13 in Table 7), although the cost/B.I. ratio of the roads upgrading project is less than that of the sewage upgrading project, but it received a lower priority than the sewage project. This is attributed to the cost implications of the construction sequencing.

5 Conclusion and Future Recommendation

This paper presented a comprehensive framework for the selection of slum intervention strategies and their priorities. The main objectives of this system are to identify (1) the needed intervention strategies for the slums area and (2) the optimal priorities among these intervention projects. The framework consists of two main phases, including (1) framework structuring (generating input data) and (2) framework implementation (optimizing intervention priorities). An application example is presented to demonstrate the potentials of the proposed framework. The framework identified the priorities of the proposed intervention projects according to the priority package, cost/ B.I. ratio, and construction sequencing considerations. Future work will include investigating the time and cost dimensions in more detail and how to accelerate the benefits delivery to residents.

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