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Strategic planning model for the construction and remediation of irrigation networks: A case study for Egypt

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ABSTRACT
Irrigation canal network problems are resulting from insufficient design, execution, and poor operation and maintenance. In this study, an attempt was made to evaluate the main problems of irrigation networks in Egypt and remediation measures for rehabilitation and optimal irrigation for 3.78 million ha. Recent studies, on the other hand, have shown that most of the existing networks, which have been constructed with colossal costs, suffer from various technical and social problems during the construction and operation processes. To achieve this purpose, (i) strategic planning methods and guidelines have been used to analyze and assess the irrigation networks; and (ii) field studies, visits, and organization of main and sub-main committees with stakeholder participation have been carried out, and (iii) review of literary works and holding of workshops have been applied. Based on the outcomes during the workshops and the main committee, all problems of irrigation systems were categorized into six main topics developing irrigation network systems; environmental assessment; improvement of design quality; improvement of supervision and execution; improvement of operation and maintenance; and monitoring of the system. For each topic, the existing problems in the networks were presented separately in the form of a problem diagram and then a target diagram was developed to optimize and modify the networks. An attempt was made to consider the different core criteria and set time priorities (short, medium, and long term) to determine the performance of the proposed executive and research strategies.

Keywords: *Strategic planning, Irrigation canals, Water losses, Canal lining, Environmental assessment, Egypt.*

1. Introduction

Water resources, as one of the most critical factors in promoting sustainable development, should be strongly addressed when preparing social, economic, and environmental sustainability strategies (Lalehzari et al. 2016; Lalehzari et al. 2020; Gabr 2022; Madleen et al. 2022). In all situations, water resource management must be reliable, productive, and sustainable, especially when considering irrigation and drainage networks. The high efficiency of irrigation and drainage networks helps to satisfy the optimal distribution of water in irrigation practices. As it is can be seen as a viable option for increasing the production of water supplies especially, in the arid and semi-arid regions (Raul and Panda 2013; Hosni et al. 2014; Halwagi 2015). The Nile's water is considered the principal source of water in Egypt, as, it constitutes about 95% of the total water available sources and the rest are groundwater and rainfall.

Currently, the estimated total available freshwater resources were around 60 km^3 y^{-1} (CAPMAS 2021). Estimated total water consumption in 2021 was roughly 80 km^3 y^{-1}, nearly 76.6% is used in the agriculture sector (Gabr 2021 and 2022) while the residual is allocated to urban and industrial uses. Under the current situation, irrigation water sources in Valley and Delta are 41.28 km^3 y^{-1} Nile freshwater plus 20 km^3 y^{-1} agricultural wastewater reuse and shallow groundwater used to irrigate a total area of 3.78 million ha (9.1 million feddans, one feddan = 0.42 ha). This involves 2.25 million ha of Old Fields, the Valley and Delta conventional agriculture, and

1,53 million ha of New Fields, including reclaimed land from the desert next to the Old Lands or in the oasis, North Sinai Development Project, Touskh Project ... etc. (MWRI 2005). Approximately 8 million feddans of these areas are under the main and secondary canals network and less than 1 million feddans are under modern irrigation systems (pressurized irrigation). Fig. 1 shows the water control structures across Egypt's Nile and Fig. 2 shows levels of management of the irrigation canals in Egypt, Mesqa irrigates 5 to 60 ha of land, branch canal irrigates 400 to 3000 ha of land (1000-10000 farmers and fewer than 15 villages), irrigation water management (IWM) district serves an area of 8,000 to 25,000 ha (40,000 to 100,000 farmers up to 12 branch canals and 30-100 villages) and the governorate level area serves a range of 200,00 to 500000 ha (more than 1000000 farmers, and more than 500 villages) (MWRI 2005).

More than 2.5 $Km^3\ y^{-1}$ of deep groundwater in the 1.5 million Feddan Project in the Western Desert are used since 2017 to meet water consumption shortages (Sefelnasr et al. 2015; Ahram 2020; Reiji et al. 2020). Because of the inefficiency of conventional irrigation techniques and water distribution schemes, more than 53% of the useful water is wasted and only 47% of the available water is used in agricultural production (François et al. 2019). Due to Egypt's unique climatic conditions, sustainable agriculture and food production are primarily dependent on feeding the ever-increasing population. This depends primarily on the efficient use of limited water sources. The 9.1 million faddans are currently under cultivation, representing less than 6% of the total area of Egypt. Fig. 3 shows the cultivated area and the annual cultivated crops and vegetable area for 3 agricultural cycles (seasons) per year.

The main crop in Egypt is Wheat with approximately 1.4 million ha planted each year, it is a key commodity for family and national food safety followed by Maize (White), Berseem (Alfalfa), and Rice. A second group forms the Sugar beet, Tomato, Potato, Orange, Sugar cane, and Cotton, each covering an area of about 200000 ha. While over the past 30 years production of Rice, Wheat, Vegetables, and Fruit diagrams (in the New Lands) has increased. Others such as Cotton and Berseem clover, on the other hand, were declined. Cropping patterns largely reflect the market and state subsidies, but Wheat, Maize, Rice, and Berseem's absolute predominance is a clear sign of the need to feed families and farm animals (CAPMAS 2021). Modern irrigation and drainage networks of high performance are considered one of the main and long-term strategies for water resources management to increase irrigated lands area. On the other hand, in Egypt, most of these networks that were implemented at a big cost are suffered from various operational problems which result in low performance. Egypt has good experience in developing water user groups for the management of irrigation water.

This includes a variety of geographical situations (groups in the oasis around tube wells, large-scale irrigation schemes in the Valley, Delta, and New Lands), water management arrangements (collective pumps for four to eight New Land farmers or tertiary canal Mesqa level in the Old Lands) and various scales (from the tertiary and the secondary (branch canal) to district level, around ten branch canals (Fig. 2).

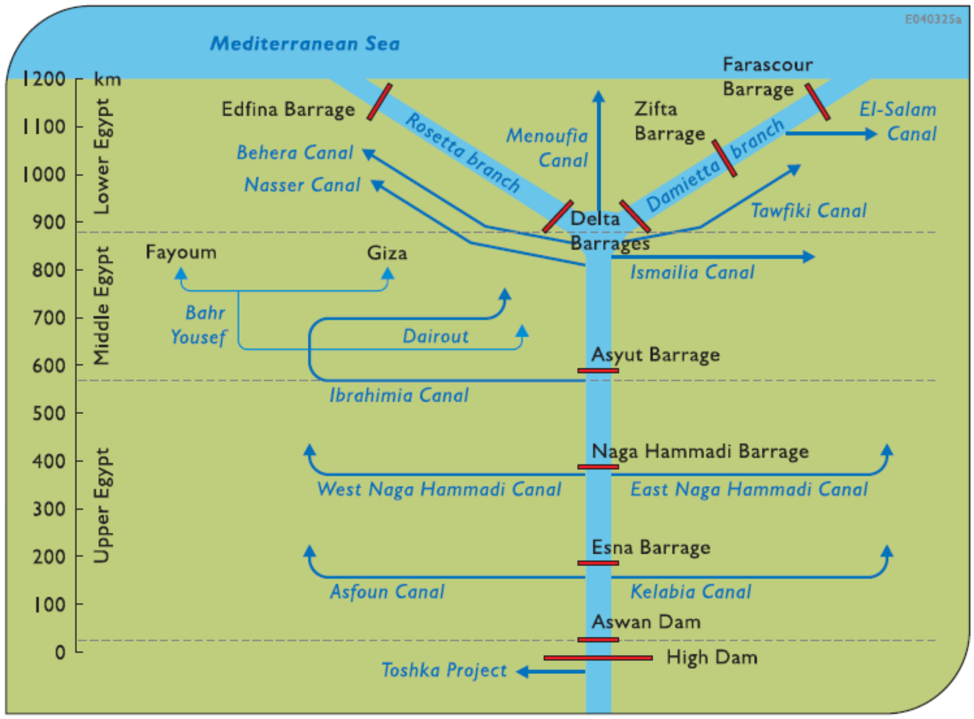

Fig. 1: Water control structures across the Egypt's Nile

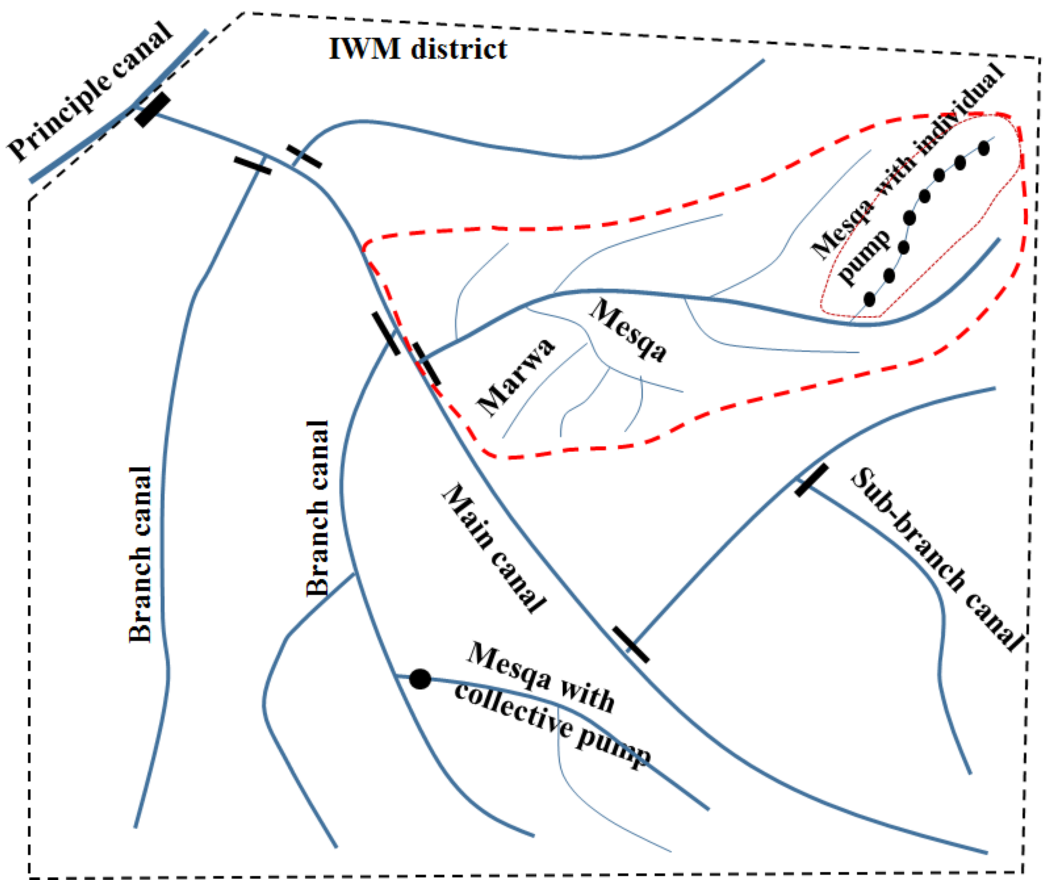

Fig. 2: Irrigation water management levels (IWM) in Egypt.

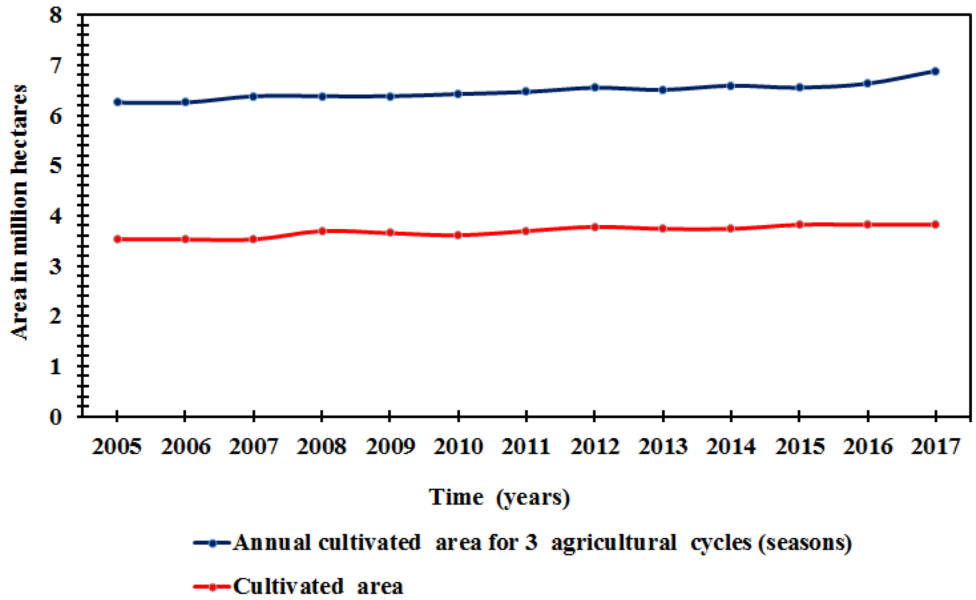

Fig. 3: Cultivated area and annual cultivated crops and vegetables area for minimum of 2 agricultural cycles (seasons) in Egypt (CAPMAS 2021).

Over the past 30 years, several projects have attempted to organize farmers, improve the interface/coordination between farmers and irrigation managers, or develop "water boards" at the district level to ensure that all stakeholders are involved (MWRI 2002; Molle and Rap 2014; El Quosy 2006) reported the problems related to irrigation water management in the irrigation networks for Egypt's Nile Delta New Lands. These problems are the deterioration of the concrete lining, damage to control structure gates, weeds growth, and sedimentation problems of irrigation networks. Furthermore, the arrival of sewage and sweeping into the canals, disregard for canals limit. Those problems can therefore be categorized as design problems, quality of building materials, geotechnical properties of bed soils, execution, operation and maintenance, and social problems.

François et al. 2019 reported that the New Land Upgrade Strategy in Egypt began in 1978, the majority of which was to reclaim 200000 feddans west of the Delta, the irrigation water source is the Nasr Canal which feeds from the Nubaria Canal. However, in 1980, the World Bank 1980, reported that the performance of the reclaimed land was insufficient, the main problem was not the unsuitable soil for crop production, but rather the technical design inadequacies such as insufficient drainage system. The Bank has suggested a project which would present an institutional change while improving the technical requirements of the design, agricultural services, and settlement pattern of the small farm. Furthermore, land reclamation projects restarted in 1981/1982 with the El Shabab Project to reclaim some 33500 feddan and the Salhiya Project to reclaim 23,000 feddan located on the eastern side of the Delta (Meyer 1998).

On the west side, the World Bank has funded a project known as Bangar Sukar which is the extension of the Nasr Canal cultivation area. The irrigation system was gravity irrigation (basin irrigation) the irrigation system was designed for good land leveling, adequate supervision during the implementation phase, and a program for training the farmers, so it is expected that the overall irrigation efficiency will be satisfactory" World Bank 1980. Water logging causes a serious problem occurred in many locations as the large quantities of irrigation water that are applied to the soil result in rising the groundwater levels of the aquifers, these are consequently led to soil salinization (François et al. 2019; Gabr 2018 and 2019). In addition, high groundwater levels result in the uplifting force during the winter closure for periodic maintenance works of irrigation and drainage networks as the water levels in the upstream main canals are decreased, these activities led to the destruction of the concrete linings of the main canals.

Other problems related to environmental issues in sandy soil reclaimed lands as the activated wind that coated crops with sand and were combated by planting rows of Casuarina trees as a windbreaker (Molle et al. 1995). In addition, problems of the low reclaimed land soil characteristics such as the Tina plain region in the North of Sinai and the sandy soil that have low water carrying ability and contain minerals such as gypsum, calcium carbonates, selenium, and boron (Hosni et al. 2014; Gabr 2019). To date, a variety of studies and research measures have been carried out in various areas of irrigation and drainage networks have taken place. Any of these experiments did not, however, help to overcome the previous problems.

In this study, an effort was made to assess and address the issues with Egypt's irrigation networks during the stages of construction, operation, and maintenance for 3.78 million ha of rehabilitation and optimal irrigation. Moreover, to offer methodical management and analysis approaches that employ strategic planning principles to address these issues. In order to accomplish the study's goals, (i) strategic planning is reviewed, (ii) the components of Egypt's current irrigation network system are analyzed, (iii) issues and issues relating to irrigation systems are addressed, and (iv) strategic planning is used to optimize Egyptian irrigation networks construction, operation, and maintenance.

2. Material and methods

2.1 Study Area

Egypt has devised a water-resources strategy that might cost up to EGP 900 billion by 2050, including the lining and rehabilitation of irrigation canals. The plan is based on a four-pronged National Water Resources Plan that runs through 2037 and focuses on rationalizing water usage, increasing water quality, providing additional water resources, and establishing an environment conducive to effective water management. Fig. 4 shows the irrigation canal network in Egypt's Delta. Wastewater treatment, seawater desalination, and the transition from surface to sophisticated irrigation systems are among the projects underway to expand the water system's capacity. MWRI was rehabilitated and lined with 3,134 km of irrigation canals.

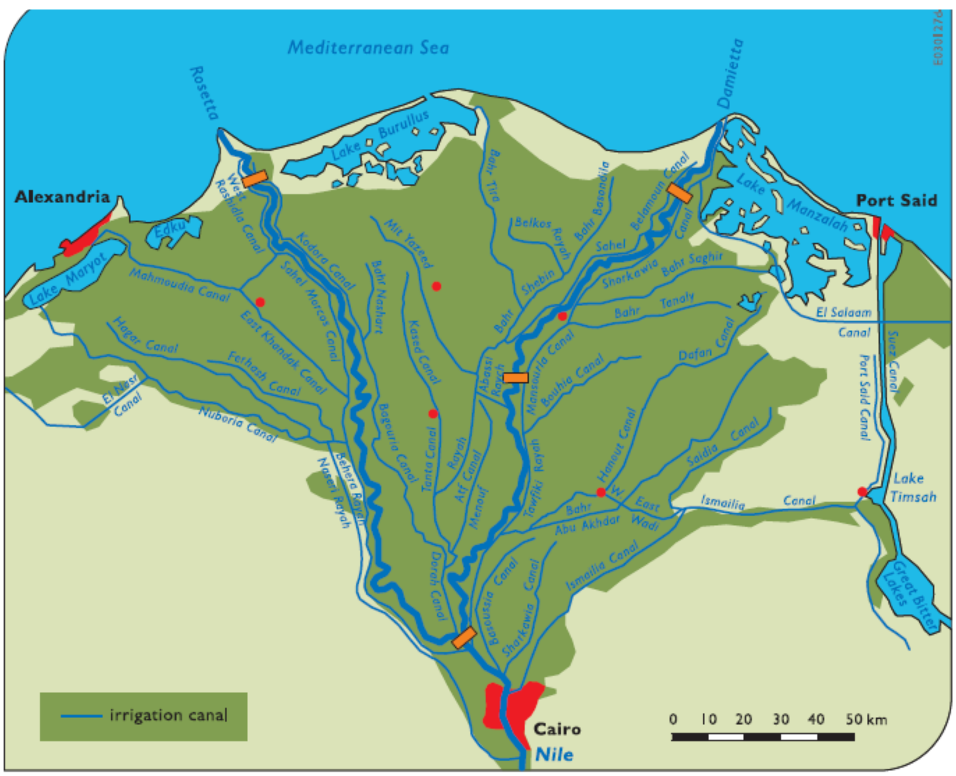

Fig. 4: Irrigation canal network in Egypt's Delta

The ministry's plan to expand water development projects and use contemporary irrigation techniques includes the restoration of irrigation canals. The ministry is now rehabilitating 4,589 km of irrigation canals and is planning to restore another 1,880 km, with a total of 20,000 km to be rehabilitated. Many types of canal lining were implemented according to the soil characteristics as plain concrete lining, pitching covered with plain concrete, and reinforced concrete lining (Fig. 5).

Fig. 5: Concrete lining for branch and distribution canals

2.2. Strategic planning

The strategic planning model used in this research involves defining a mission, setting objectives and aims, and developing plans to accomplish those aims and objectives. This framework consists of three key stages which formulate strategy, the strategy of execution, and the strategy of evaluation. Fig. 6 shows the research phase diagram to solve a problem. Then, short-term goals are selected based on the strategy's long-term objectives for implementing executive policies.

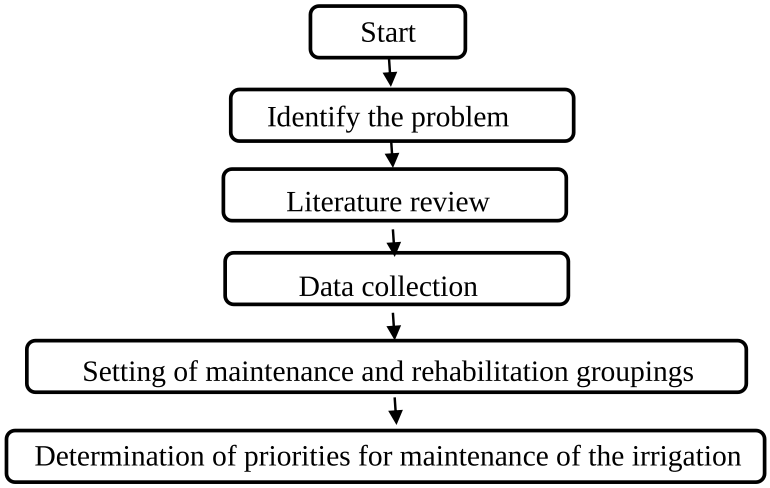

Fig. 6: Research phase diagram

Finally, they implemented and evaluated the selected policies. Strategic planning includes as follows various organizational phases or stages, FAO 1996:

1- Revision of the required topics are based on the existing irrigation networks information and the country irrigation networks development statistics, structure and performance from a desk study of available documentation and limited field visits as, (i) nature of existing irrigation systems location, extend and river basin administrative boundary; the history for the public and private sectors and their respective roles in the development of the irrigation networks; (ii) present and past performance versus technical potential, in terms of command area developed, area utilized, water use efficiency, cropping intensities and patterns and the crop production if lower than expected, the reasons for this; (iii) the contribution of irrigation to gross domestic product (GDP) and to agricultural output, and any macro-economic distortions with specific impacts on the subsector; (iv) the present and past performance versus technical potential, in terms of the area of control developed, the area used, water efficiency, crop intensities and patterns, and crop production if the reasons are lower than expected; (v) marketing arrangements and prices; (vi) the contribution of irrigation to GDP, agricultural productivity and any macroeconomic fluctuations with unique consequences for sub-sector growth; (vii) Adequateness of water sources, and the operation and maintenance systems; (viii) races and campaign arrangements; (ix) studying the project environmental impacts as water-logging, erosion and sedimentation, soil salinization, pollution or depletion of surface or groundwater supplies and biodiversity losses; (x) the social influence of current growth and related gender problems for direct and indirect beneficiaries, generated or foregone health and jobs opportunities; (xi) strategies to minimize the adverse impacts and the degree of their performance.

2- Researching and evaluating the limits of the problems and making a question diagram.
3- Definition of the objectives of the study or drawing the objective diagram.
4- Identify the study's strategic goals and objectives as priorities.
5- Preparation of premises and plan implementation.

2.2.1 Central planning committee formation

Considering the role and impact of the central coordination committee on the program's success; significant attempts have been made to identify the main and successful contributors and the people who are directly or indirectly winners with respect to the program results. The experts from the organizations were then invited to join the central planning committee. The main stakeholders and governmental organizations concerned with irrigation networks were identified as the Ministry of Water Resources and Irrigation (MWRI); Ministry of Agriculture and land reclamation; Ministry of Electricity and Energy; Ministry of Environment; Holding Company for Drinking Water and Sanitary; Ministry of Health and Population; Ministry of Defense; Ministry of Interior; developers and contractors; Colleges and the centers of education; Organizations for research and extension; Stakeholders; and Local Government.

2.2.3. Formation of the program's scientific sub-committees

After deciding on the key members of the organizing committee, the preparation for the committee's meetings began. The first meeting of the central committee identifies the details of thorough debate and claims on the goals of the strategic planning and different issues of the irrigation and drainage networks. Following the presentation of the participants' different opinions and brainstorming, it was concluded that the breakdown of irrigation and drainage networks projects back to the following four axial themes: drainage and environmental aspects, irrigation and drainage network management aspects, construction material aspects, and structural and construction aspects. Then, four sub-committees on related issues.

2.2.4. Subcommittee on irrigation and drainage policy

It is responsible for choosing the equipment required for the irrigation system based on the crop patterns intended to irrigate and its cost-effectiveness. It has become increasingly clear that the design process should start with looking at how users operate the system. Then, this should be designed to provide the optimum arrangement for water efficiency, operating efficiency, and maintenance. The tasks related to this committee include evaluating the operation and maintenance issues of the networks and determining their performance of government policies, legal, social, economic, and other administrative aspects related to irrigation and drainage networks. In addition, the other tasks of the working group were to identify and plot topic issues and goal diagrams.

2.2.5. Drainage and Environment sub-committee

This committee's job task consists of evaluating the environmental effects of irrigation and drainage networks in various districts of the country, using marginal resources, planning, implementing, and running drainage systems. Organizing and drawing the diagrams of problems and goals, and prioritizing research projects on several drainages and environmental issues have been identified as the main tasks of this working group.

2.2.6. Committee of construction material

This committee's tasks include evaluation and analysis of the viability and efficiency of construction and consumable products in irrigation and drainage networks, including asphalt, aggregates, concrete, soil, chemicals, tubing, stabilizers, plastics, metals, rubber, geomembrane, geosynthetics, etc. In addition to evaluating their application and check-in, various structures.

2.2.7. Structural and construction committee

This committee's responsibilities include reviewing the existing issues regarding the design and execution of various regulatory, diversion, conveyance distribution water structures, and pumping stations. Furthermore, to prepare a modern database for the traditional and modern irrigation networks, and to identify and draw the problems and objectives diagrams. Successful implementation requires the involvement of all parties in the preparation and delivery process to create a sense of ownership and consequent interaction with the project. This allows the project planning process to give the lenders and consumers flexibility to engage in the development phase, or ideally guide it, and any possible losers to have a real influence on decisions that affect their future. Users' control and responsibility are impossible to be fulfilled when they feel that the initiative will fulfill their perceived needs and have an equity interest-that are, paying or carrying any of the construction costs (FAO 1996).

3. Results and Discussion

Following the construction of the above main and subcommittees, numerous meetings and seminars were held to address and assess the current situation, and the issues raised in terms of the advantages and drawbacks of the networks being applied. In the main committee, the outputs of subcommittees were analyzed and examined. Instead, taking into account the development programs of the government, the overall key aim of the strategy was made, and the strategic steps and the study topics required to achieve the targets were defined according to the current circumstances and subjects.

3.1 Analysis of the existing system of irrigation and drainage networks

The Nile's water is diverted through eight grand barrages on the river to about 31000 km networks of public canals and about 80000 km of private Mesqas equipped by nearly 22000 water control structures, MWRI 2002, in order to allocate irrigation water to schemes. On the other hand, about 16700 km of drains convey the produced return excess irrigation water. Water delivery and disposal are implemented by 583 main pumping stations, in addition to the 3.6 million diesel pumps used by farmers. This "mechanism" was not only very expensive and difficult to put forward but will be continuously managed and improved due to specific problems such as local water scarcity or soil salinization. Recently total annual water consumption on the field, upstream canals, and downstream High Aswan Dam (HAD) for crops and vegetables has been approximately 50 km^3 y^{-1} (Fig. 7) (CAPMAS 2021). For the next 20 years, MRWI issued its new National Water Resources Strategy (NWRP 2017), where it carries out a series of significant transitions. It stresses that government agencies, the private sector, and civil organizations as well as individual farmers and water users for domestic water will have to find ways to cope with the growing water scarcity.

The National Water Resources Plan foresees about a 10% reduction in the amount of water available for crops. This suggests that, in conjunction with the rapid rise in crop evapotranspiration, farmers would have to select crops or farming systems that use less water, minimize crop intensity or tolerate sub-optimal yield. The NWRP 201, cleverly terminates and expands the 2030 strategy of the Ministry of Agriculture and Reclaimed Lands and its expansion target of 3.1 million faddan. This strategy depended on a 50 to 80% increase in the average plot-level irrigation efficiency. However, rapid measures to address Egypt's future water needs are determined by a committee formed under the Prime Minister's decision in 2016. This decree includes a "Save 10 km^3 of Water by 2030" strategy, showing the lingering political attractiveness of great but unrealistic promises. A further noteworthy change is the attempt to decentralize water management towards the governorates by assigning them specific amounts of water through a bulk allocation system.

As mentioned before and presented in Table 1, it is obvious that the total area under the operating and construction includes 2.25 million ha of Old Lands) the traditional farmland of the Valley and Delta) and 1.53 million ha of New Lands which includes the reclaimed lands from the desert adjacent to the Old Lands or in the oases. It can be concluded that traditional irrigated land is a large portion of arable land and should be considered and modified by improving irrigation methods and design, as well as modern networks. In addition, it is necessary that conventional networks be updated and improved in order to maximize the productivity of water usage. Additionally, the operating networks' general specifications were determined as details shown in Fig. 2. After (HAD) was built, the function of the canals changed from flood spreading to providing irrigation water to the land parcels. Clearwater released by the (HAD) and increased use of fertilizers has promoted the growth of weeds in irrigation and drainage systems. Consequently, the focus of maintenance needs shifted from removing earthen channel siltation to aquatic weed control, USAID 1986. In 1983, 57 million Egyptian pounds (US$ 28 million at 1983 value) is the annual expense of channel operation (World Bank 1986).

The proposal, with a loan from the World Bank investing US$ 130 million over 8 years, aimed at implementing to introduce "modern channel maintenance practices," replacing the traditional system of removing siltation by excavation, weed mowing, herbicide treatment, and desilting. It was based on similar projects implemented with Dutch assistance after 1978 (biological weed control, preparation of workers of the Egyptian Public Authority for Drainage Schemes (EPADP), US$ 140 million from different USAID programs of the United States Department for International Development, and a program sponsored by the Canadian International Development Agency (CIDA). The World Bank funded seven drainage projects from 1973 to 1999, as well as Channel Maintenance Projects and a National Drainage Project.

3.2 Issues and problems surrounding irrigation and drainage systems

To classify the major issues involved with different networks, all problems of different networks were listed in the subcommittees with details, and then analyzed in the main committee. The common problems of the networks were evaluated and categorized for four on the basis of discussion and challenges during the various meetings. n this way the problems were classified at various levels based on their importance and frequencies. Then a diagram named problem diagram was drawn for each topic showing the most likelihood and frequency of problems on different levels. Fig. 8 typically shows the summarized problem diagram for the irrigation and drainage network management aspects.

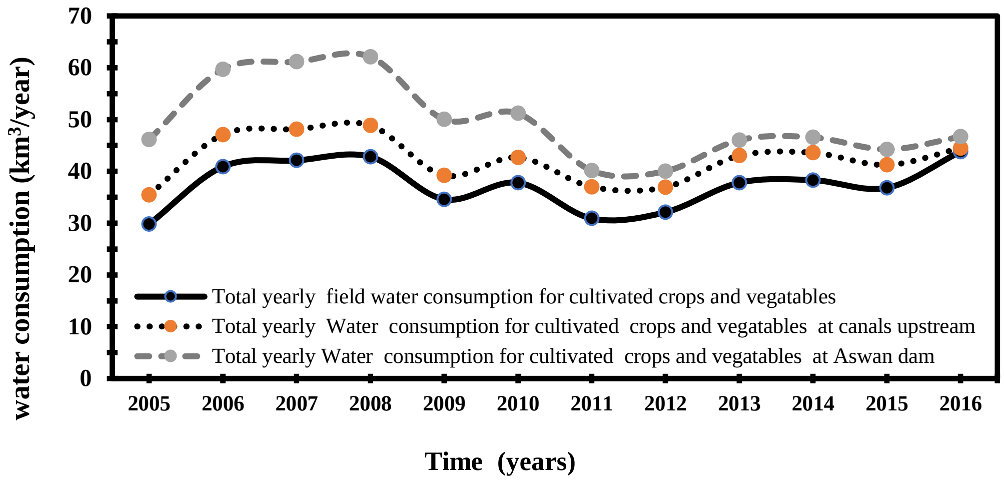

Fig. 7: Total yearly water consumptions at field, upstream canals, and downstream High Aswan Dam for the cultivated crops and vegetables.

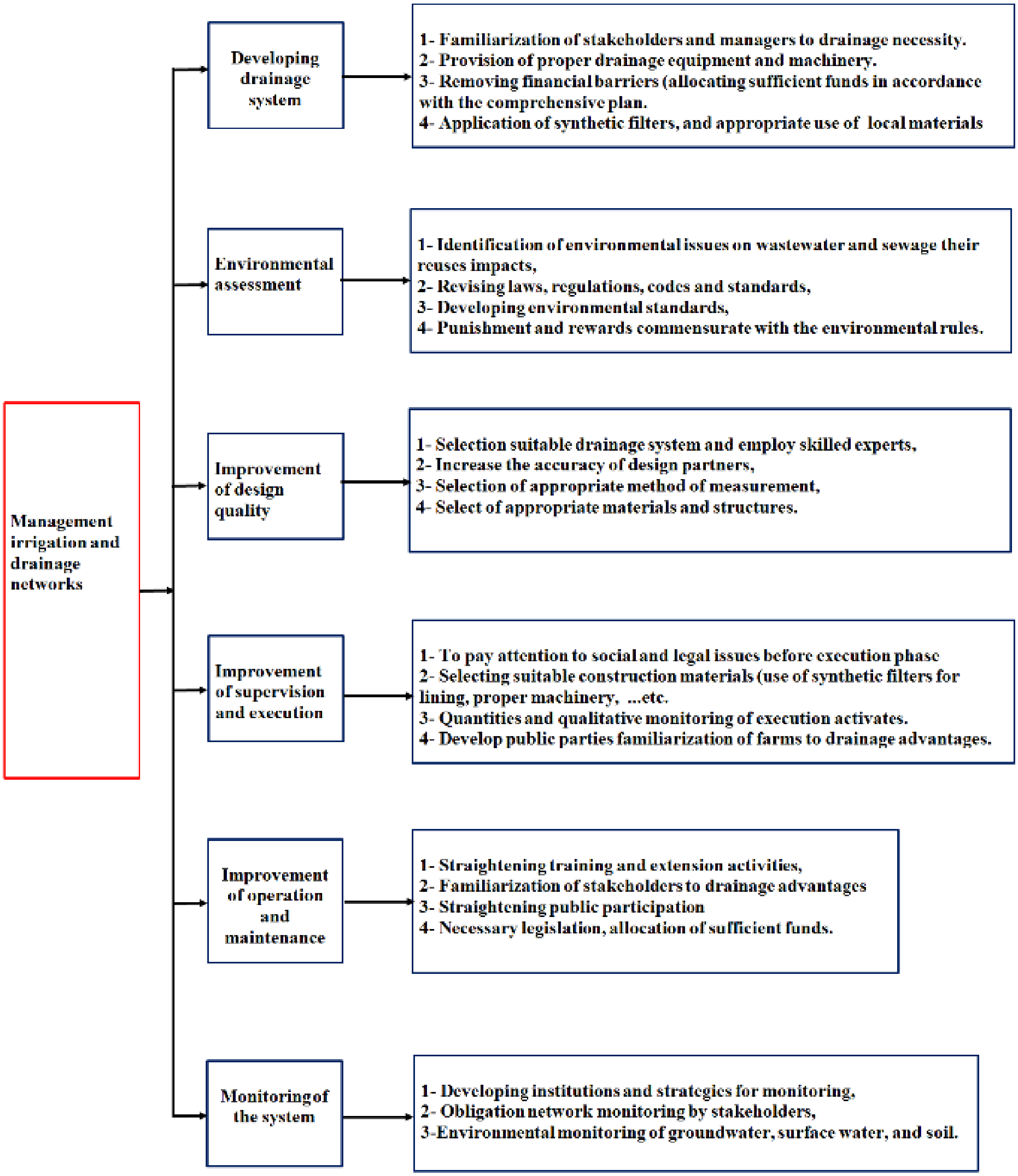

Fig. 8: Typical problem diagram for irrigation and drainage Network management aspects.

3.3 Place Strategic plan for the optimization of irrigation and drainage networks

After identifying the problems of the different stages of design, implementation, operation, and maintenance of irrigation and drainage networks and the scope of the literature review at the national and international levels, the goals and objectives were identified and established to overcome the impacts of various issues. Thus, the ultimate objectives of the program were decided as follows according to the topics and based on the given problem diagrams and considering the available approaches are (i) designing modern networks in detail; (ii) enhancement of the management system for execution during runtime; (iii) use of new approaches to plan, execute and run the networks properly; (iv) improvement of the existing networks; (v) providing appropriate, local standards and guidelines for the networks; (vi) improvement of stakeholder economic, social and cultural conditions; (vii) Improvement of the quality of materials; (viii) appropriate and detailed evaluation of the efficiency of the irrigation and drainage system construction networks; and (ix) evaluation and improvement of surrounding irrigation and drainage networks. A diagram called an objective diagram was drawn proportional to the problem diagram, showing different goals at different levels to overcome the problems, in addition to each topic (Fig. 8). In addition, Fig. 9 shows the strategic planning flow chart for desilting of the main and lateral desilting channels. And Fig. 10 shows a strategic planning flowchart for canal repair of slope protection.

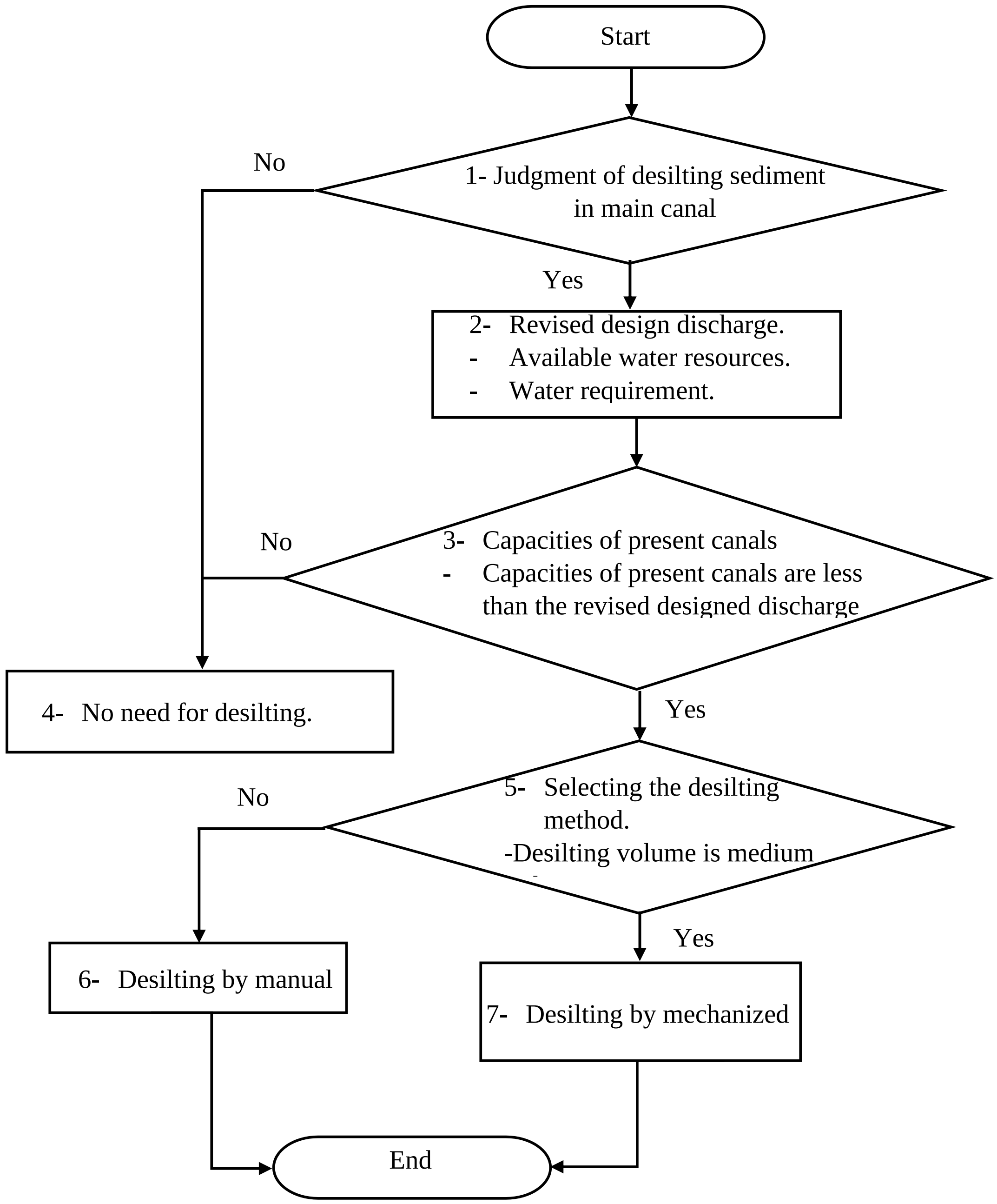

Fig. 9: Strategic planning flowchart for desilting in main and lateral canals.

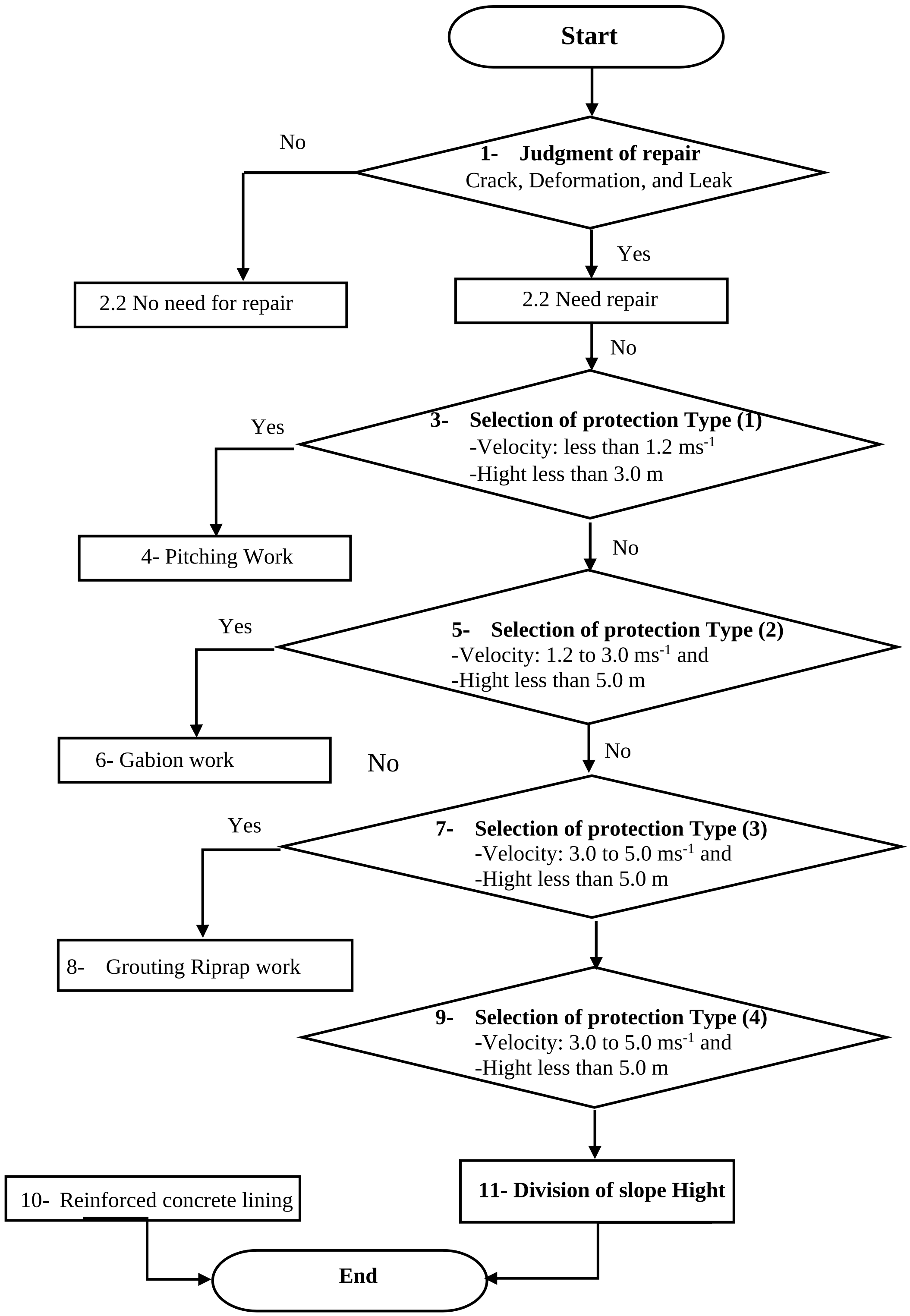

Fig. 10: Strategic planning flowchart for canals repair of slope protection.

3.4 Derailed executive plan strategy

Following the selection and setting of strategic targets, priority was given to a number of organizational steps that do not entail any analysis and can be implemented by an administrative authority in compliance with time-based guidelines like short, medium, and long strategies.

3.5 Evaluating short-term plan strategy

Succeeded short-term plan strategy should be satisfied (i) beneficiary participation in all project phases; (ii) coordination between the executive works and research divisions; (iii) use of subnet ducts and piping networks; (iv) the geotechnical investigation of the network bed should be given special attention; (v) strong interest in environmental studies makes it compulsory across the whole network; (vi) seminars and workshop lectures on various topics related to networking; (vii) distribute funds needed to restore and reconstruct existing networks; (viii) create a repair and maintenance executor for irrigation and drainage networks; (ix) creation of modern and dynamic irrigation and drainage databases; (x) eviting the use of picture maps for initiatives that accept different project requirements; and (xi) winter preparation of the water sources in non-agricultural seasons.

3.6 Evaluating medium-term plan strategy

Succeeded medium-term plan strategy should be satisfied (i) amendment of laws relating to the successful use of water supplies in the region; (ii) efficiency evaluation of planned irrigation and drainage projects; Creating water, the coordination and cooperation among the concerned ministries with water; (iii) using the of affordable and suitable materials; (iv) completing of subnets; (v) strengthen and developing the structure of water user associations; (vi) monitoring networks periodically; (viii) including flow measurement in the important parts of irrigation and drainage systems; and (ix) Lining and conventional channels.

3.7 Evaluating long-term plan strategy

Long term plan strategy is evaluated through (i) changing crop patterns trends to allow better use of water and soil; (ii) land equipment and modernization; (iii) transition of network control to the water users assassinations (WUAs) of water users; (iii) to concurrently research and enforce the networks and dams; (iv) modern networking applications; (v) develop highly skilled staff equipped with irrigation and drainage control labs Projects; (vi) reform regulations to discourage the crushing of land; and (vii) contractors organized to facilitate contractors.

3.8 Comprehensive research plan

Many issues are exacerbated by the lack of commitment to basic applied science. Therefore, carrying out the applied research is necessary (before or during) the implementation and operation of the networks. The research priorities for different axial topics were determined separately on the basis of the problem and objective diagrams:

3.9 Research priorities on the management aspects

The research priorities on the management aspects are (i) identification and evaluation of the economic, social, and cultural issues and problems in the irrigation networks that provide a playbook to address them; (ii) development of sustainable networks with the participation of WUAs; (iii) search and review of the information required using the information technology networks in network management; (iv) study on compiling detailed and incorporated guidelines for developing and changing irrigation and drainage networks; (v) investigation of the effects of unified management on dam and irrigation and drainage systems design and construction; (vi) studying and analyzing hydraulic structure's issues; (vii) research and review of the use of new systems and network automation.

3.10 Research priorities on drainage engineering and environmental aspects

Irrigation and drainage schemes typically have a significant effect on the environment of the region in which they are situated, and an estimate will be included in the study of the expected predicted changes to occur. Special attention should be paid to categorizing every effect on downstream farming, threatened wildlife, and the prevalence of water-borne diseases, for instance, malaria or schistosomiasis. For groundwater irrigation schemes, the probable effects on the groundwater depth and quality of the aquifer should be noted in addition, to (i) the quality management of wastewater and non-conventional water; (ii) compilation of the relevant specifications to carry out the correct drainage system and to decide design parameters; (iii) assess the environmental consequences of irrigation and drainage building and service stages, and reduce their adverse effects. Research on determining the design criteria for the sewage system; (iv) research on assessing the architectural requirements for the drainage network; and (v) look for irrigation and drainage network protocols, criteria, and partner methodologies.

3.11 Research priorities on construction materials

Research priorities on construction materials are (i) set standards for high-quality concrete of all types; (ii) formulate effective remediation plans for broken concrete; (iii) for irrigation and drainage schemes to improve the quality of the materials used; (iv) assess of performance and technical requirements of irrigation equipment; and networks of drainages; (v) study and the use of building techniques and the forms of construction supplies for the lining of canals and other buildings; (vi) investigation of the geotechnical features of irrigation and drainage networks; (viii) work into supplying good filters and the field of soil stabilization research; and (ix) setting the required criteria for replacing the network collector made of concrete with the use of plastic pipes in the subsurface drainage system.

3.12 Priorities in structural research

Priorities in structural research are (i) identify modern irrigation network infrastructure (supply structures, conveyance, and water distribution); (ii) evaluate the efficiency of traditional and modern transmission and distribution; (iii) provide national code and aggregate conditions; (iv) evaluate the legal issues of the modern network; (v) traditional irrigation network rehabilitation and modification; (vi) appraisal of pumping station technical and hydraulic problems; and (vii) technical and hydraulic evaluation of the canal in winter and springs in the country. Irrigation and drainage schemes typically have a significant effect on the environment of the region in which they are situated, and an estimate will be included in the study of the expected predicted changes to occur. Special attention should be paid to categorizing every effect on downstream farming, threatened wildlife and the prevalence of water-borne disease, for instance malaria or schistosomiasis. For groundwater irrigation schemes, the probable effects on the groundwater depth and quality of the aquifer should be noted in addition, (i) quality management of wastewater and non-conventional water; (ii) compilation of the relevant specifications to carry out the correct drainage system and to decide design parameters; (iii) assess the environmental consequences of irrigation and drainage building and service stages, and reduce their adverse effects. Research on determining the design criteria for the sewage system; (iv) research on assessing the architectural requirements for the drainage network; and (v) look for irrigation and drainage networks protocols, criteria and partner methodologies.

3.14 Research priorities on construction materials

Research priorities on construction materials are (i) set standards for high quality concrete of all types; (ii) formulate effective remediation plans for broken concrete; (iii) for irrigation and drainage schemes improve the quality of the materials used; (iv) assessment of performance and technical requirements of irrigation equipment; and networks of drainages; (v) study and the use of building techniques and the forms of construction supplies for the lining of canals and other buildings; (vi) investigation of the geotechnical features of irrigation and drainage networks; (viii) work into supplying good filters and the field of soil stabilization research; and (ix) setting the required criteria for replacing the network collector made of concrete with the use of plastic pipes in the subsurface drainage system.

3.15 Priorities in structural research

Priorities in structural research are (i) identify modern irrigation network infrastructure (supply structures, conveyance and water distribution); (ii) evaluate the efficiency of traditional and modern transmission and distribution; (iii) provide national code and aggregate conditions; (iv) evaluate the legal issues of the modern network; (v) traditional irrigation network rehabilitation and modification; (vi) appraisal of pumping station technical and hydraulic problems; and (vii) technical and hydraulic evaluation of the canal in winter and springs in the country.

Conclusions

In assessing and analyzing the subjects and difficulties associated with the performance of the irrigation network's construction, operation, and maintenance, it was found that some of the irrigation network problems result from insufficient execution, and some others result from failure to conduct the research required. Consequently, the steps needed to meet the goals set were explained in the proposal when two aspects of the executive orders and analysis requirements were made available.

It should be noted that priority was given to programs offered in each section, based on several criteria. Based on strategic planning, the important criteria used to present the executive actions and the research priorities required were as (i) network members engaging in the various levels (water boards association) of water-scarce adaptation; (ii) use of a simple, local construction; (iii) the application of simple and practical techniques; (iv) secondary network accent; (v) taking into account conditions for early returns; and (vi) the program was also prioritized according to the time required for executive and research activities, including short, medium and long-term activities.

Furthermore, certain important points in the optimization of irrigation and drainage networks can be addressed as follows on the basis of an overall discussion evaluation. The success and good operation of the networks are largely dependent on the farmers' and other beneficiaries' participation in all phases of the initiatives. Every network should be required to do a geotechnical assessment and environmental evaluation. The networks must be periodically monitored, and their performance must be evaluated. As part of a master plan, several network components should be created and executed simultaneously or in parallel. Consideration should be given to quality control and improvement concurrently with network physical development. Collaboration and having similar policies among various governmental organizations is a key factor in the growth and effectiveness of the networks.

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