Integrated Channel Maintenance with Stakeholders Participation (Case Study)

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Abstract: Participation of water user associations (WUAs) is considered the key factor contributing to the long term maintenance sustainability of branch open irrigation channels. Therefore, this paper describes a new experience and study of management program for sustainable branch canals maintenance through involvement of water users and stakeholders (irrigation officials and beneficiaries). The principal study of the project is to situate and examine a comprehensive open waterways maintenance strategy that incorporates technical civil works with related social activities that consider social dimensions of water users. This strategy aims to guarantee maintenance process sustainability while in parallel provide social activities for farm organic residuals elimination and conversion into compost and biogas; that consequently would reduce farm expenses and enhance life style. The study was implemented in four branch canals that cover four different regions in Egypt. The implemented integrated channel maintenance program comprised of three principal directions; (1) branch canal rehabilitation (2) aquatic weeds management and (3) increase public awareness with capacity building of water user association members. The general impression regarding the experience of teaming up beneficiaries with irrigation officials was highly satisfactory; as the experiment could create case of excellent communication and understanding regarding beneficiaries' demands and irrigation directorates' facilities. Accordingly maintenance efforts could be managed and planned more clearly and effectively. Partial rehabilitation of open channel result in satisfactory hydraulic performance enhancement with reasonably reduced cost. Moreover general recommended guidelines/strategy for developing open channel maintenance are included the paper.

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1- Introduction

Most of the irrigation fields at the tail end of the irrigation system face severe water deficit and also a considerable extent of a general lands is left uncultivated due to water shortage. Reallocation of water for new development area causes additional reduction of water flow into the already stressed agricultural lands at the tail end of irrigation networks. Therefore, the irrigation networks have to be maintained to manage efficient water distribution. The irrigation networks are annually maintained through extensive uncontrolled maintenance practices (de-silting or de-weeding). The improper mechanical maintenance of canals leads to dramatic changes in the cross section geometry, bank collapse and general deterioration (CMRI, 2002).

Moreover, human misbehaviors and misuse of waterways as dumping waste water and farm residuals into waterways are considered as other important causes of open channel efficiency degradation, hydraulic performance and water quality declination. Therefore, farmers' participation is very critical as an assisting factor for solving solution to the problems of poor maintenance of open channels (Cheong, 1971 and Singh, 1992).

Worldwide open channel integrated maintenance is joint efforts between governmental authorities as stakeholders and water user associations as beneficiaries. This paper presents the experience gained from applied project titled "Development of Sustainable Branch Canals Maintenance and Management Program through End Users and Stakeholders Participation". The project was executed by institute of Channel Maintenance Research Institute (CMRI) belongs to National Water Research Center and financed by Science and Technology Development Fund (STDF). The project was initiated as an attempt to increase communication and understanding between irrigation responsible authorities and water user associations to guarantee open channel maintenance quality and sustainability. The principal objective of the project was to situate and examine a comprehensive open waterways maintenance policy that incorporates technical civil works with related social activities. This policy aims to guarantee maintenance process sustainability while in parallel provide social activities for farm organic residuals elimination and conversion into compost and biogas. Consequently, this would reduce farm expenses and enhance life style. Furthermore the project also attempted to identify the issues affecting farmer's participation in maintenance process and aquatic weed management (CMRI and STDF, report 2014).

Within the project activities (STDF project from 2014 up to 2017) was developed for disseminating the participatory concept in channel maintenance practices among water users and stakeholders on four channels in four pilot areas cover up four irrigation directorates in North and Upper Egypt. The major goal of the action plan include participatory plan to join together beneficiaries and irrigation officials in maintenance practices to guarantee excellence and sustainability.

The project activities included: 1- hydraulic activities for carrying out evaluation of existing hydraulic performance of the selected waterways and detecting the worst hydraulic cross sections and provide new design for cross sections dimensions based on regime theories that is matching with environmental circumstances; 2- capacity building for introducing new aspects in manual maintenance and conversion of aquatic weeds and farm residuals into compost and biogas. Moreover the project report include also a general recommendation and guidelines an maintain procedures.

2- Study area description

Four irrigation channels with bed width less than 5 meters were selected within four irrigation directorates (one branch canal in each irrigation directorate). The selected channels were made sure it has active working Branch Canal Water Users Associations (BCWUA), two canals in Upper Egypt and the others in Delta area-North. The canals are; (1) Desonas canal at Al-Behara irrigation directorate, (2) EL-Shiekh Ibrahim canal at Kafr El-Shiekh irrigation directorate, (3) Sayla EL-Gharby canal at AL-Fayoum irrigation directorate, and (4) AL-Sahlyia canal at AL-Menya irrigation directorate.

3- Materials and Method

The project focused on strategy goes into two arrangements to guarantee open channel maintenance quality and sustainability. The project conducted the planed work in close cooperation with stakeholders.

First arrangement gives attention to technical activities, through working with responsible irrigation authorities of open channel maintenance. The work focused on recording hydraulic performance of open channels and cross sections damage assessment. Later, the project redesigned cross sections according to CMRI regime theories (Bakry, 1985 and El-Samman, 1999) and simulated the hydraulic performance of the new cross sections to decide the predictable enhancement in hydraulic flow parameters.

The second arrangement was updating knowledge and skills activities for increasing public awareness regarding open channel maintenance of beneficiaries and stakeholders towards water quality conservation as well as capacity building of rural communities. Throughout this arrangement, the project conducted the followings activities:

A. Surveying social and economical conditions of farming communities involved within the study areas and provided number of awareness meetings and technical training courses.

B. Introducing new ideas for practically eliminating water pollutants such as farming organic residuals and animal's manure from sources instead of dumping these pollutants into the waterways.

C. Providing number of farmers with biogas production units for introducing the concept of biogas production under the project supervision.

4- Results of and Discussion

4-1 Technical activities

For evaluation of hydraulic performance and rehabilitation assessments of open channels under the study, the project accomplished several procedures for investigation, measurements, calculations and analysis. The following statements describe procedures and findings:-

A. Survey the longitudinal and cross sections of the selected open channels for earthen levels and dimensions; and also hydraulic measurements such as, current velocities, hydraulic radius, water levels. Also discharges and roughness coefficients were estimated.

B. Evaluate the existing hydraulic performance as priority and subsequently evaluate the deterioration and broad surroundings of longitudinal and cross sections; these evaluations were accomplished throughout analysis of the collected and measured data with utilization of hydraulic mathematical computer model Sobek_2D.

C. Plot longitudinal section of each channel under conditions of actual and design situations; design dimensions were provided by irrigation administrations of pilot areas. Throughout comparison of hydraulic gradient lines as well as bed and bank levels for both situations for each channel; significant variations in hydraulic performance were observed among surveyed sections of each channel. Also throughout the hydraulic evaluation, the worst hydraulic performance reaches of each channel were determined and officially reported and put forward to irrigation sector in Egyptian Ministry Water Resources and Irrigation (MWRI) for insistent rehabilitation requests.

D. Redesign the rehabilitated cross sections to satisfy the irrigation demands by using the available data from survey and applying regime theories to be compatible with local natural and environmental conditions. The redesign procedures followed the regime theory recognized by Channel Maintenance

Research Institute (CMRI), (Bakry, 1985) which is as follow:

$Y = -3.909 + 4.384\ (nQ/\sqrt{S})^{0.063.}$

$A = -0.244 + 1.846\ (nQ/\sqrt{S})^{0.761}$

Conditions

Discharge $Q > 5m^3$ /sec

Sandy / Sandy loam soil

Where:

Q = discharge m^3/sec

A = area of water section m^2

S = water surface slope cm/km

n = roughness coefficient

E. For simulation and hydraulic assessment of the studied canals, the project utilized SOBEK_2D mathematical model to simulate the hydraulic impact of cross sections dimensions change; and also evaluate the improvement percentages in the hydraulic performance and conveyance efficiency as new modified sections and new construction materials are introduced. SOBEK mathematical model is a powerful 1D and 2D instrument developed by WL Delft Hydraulics institute, Netherlands.

F. The hydraulic longitudinal section of each channel was plotted, based on calculated hydraulic parameters, and compared with actual and design situations. The comparison demonstrated remarkable enhancement in hydraulic parameters and performance. Technical report on the required cross sections dimensions and amount of earthen works were delivered to the responsible authorities.

G. Comparison between design velocities and actual measured and calculated velocities respectively before and after rehabilitation for the entire length of each canal showed significant improvement in velocities; for Desonas canal; actual measured velocities improved by around 57.7%, for EL-Shiekh Ibrahim canal; actual measured velocities improved by around 69.8%, for Sayla EL-Gharby canal, actual measured velocities improved by around 69.8%; and for AL-Sahlyia canal; actual measured velocities improved by around 79%.

H. Through simulation it could be made detecting and introducing the minimum necessary adjustments in cross sections dimensions, in case of full channel rehabilitation, to minimize the rehabilitation costs whereas sustaining hydraulic efficiency at satisfactory level. Also through the simulation, the worst reaches of each canal are assigned and insistent recommendations for partial rehabilitation were reported.

I. Irrigation sector in Egypt In coordination with the project implemented application of partial rehabilitation process on Desonas canal. The project made the redesign and provides cross and longitudinal sections new dimensions. Analysis of Desonas canal and its surveyed earthen dimensions and hydraulic parameters revealed that worst hydraulic sections are placed in the following four reaches: (1) from inlet to Km (0.250), (2) from Km (0.800) to Km (1.600), (3) from Km (2.620) to Km (2.925) and (4) from Km (3.275) to Km (3.650).

J. To evaluate the current hydraulic efficiency of the canal under the study cross section, survey of earthen dimensions and hydraulic parameters measurements have been carried out for the selected canal before and after rehabilitation. The average hydraulic radius of Desonas canal after rehabilitation works is 0.77 m whereas hydraulic radius before rehabilitation was 0.56 m; the average increase in hydraulic radius after rehabilitation works is about 37.5%. The discharges at the intake before and after rehabilitation are 0.48 and 1.0 m^3/s respectively. Also at the downstream reach of the canal; the discharge is improved by 16% of its actual discharge before rehabilitation.

4-2 Participatory activities

Dolisca *et al.,* 2006 mentioned that the experiment gained from conducting several workshops, seminars, and the awareness program showed that the farmer participation in canal management programs could be enhanced by providing information about benefits from the canal management as increasing annual income, improving education, strengthening organizational memberships, and increasing the involvement of women in the canal management process. Therefore upgrading skills programs were designed to focus on the following issues: 1) raise the awareness for key stakeholders regarding issues of canal maintenance, water quality and aquatic weeds control; 2) introduce the technology of converting the aquatic weeds to composite and biogas energy.

4-2-1 Workshops

Workshops were held to focus and explain number of issues related to canal maintenance process and water quality preservation. The total number of workshops was 14 workshops attended by 354 individuals representing farmers and irrigation officials. The topics and schemes of workshops were selected based on the discussions with irrigation officials and members of water user associations. Topics covered during workshops included the following:-

- Theoretical courses in open channel maintenance and explain how to save water.
- Courses on preserving water sources free of pollution and explain the bounce back public health influences.
- Theoretical training courses on converting aquatic weeds into compost and biogas as well as bio fertilizer.

- Address collaboration between governmental authorities and water user associations to set up lawful position for water user associations.
- Address launching awareness campaigns and educational programs to enhance human common behaviors.

4-2-2 Training program

The project hold four conventions with irrigation officials and water user associations of the selected canals at WUA headquarters to discuss the general training requirements of water users to keep the canal efficiently functioning and pollution free. Damianos and Giannakopoulos (2002) suggest that education/training of the farmers; the farm's economic size, participation by neighbors or relatives; age and basic education can influence farmer participation in the agro-environmental schemes in Greece. So that the project offered three practical training programs as following:.

A- Manual maintenance program.

The project manufactured twelve groups of improved manual maintenance tools. Each group of tools comprised of four items (fork, knife, cutter and axe). The proposed manual maintenance program for canals comprised of several steps to hopefully achieve the required maintenance quality and eliminate hydraulic performance problems. The maintenance program steps were:-

1- Preparation of the required maintenance plan and work schedule in cooperation with water users along the canal to get their convincement and approval.

2- Producing the required number of modified hand tools and distributes the manufactured tools over participated groups of farmers.

3- Follow-up and evaluation of manual maintenance works to achieve high quality.

The project implemented 23 training courses attended by 639 individuals representing farmers and irrigation officials. The tools were placed at irrigation directorates to be distributed over farmers' maintenance groups (five farmers per each group) for continuation of manual maintenance process regularly over the entire cultivation year under supervision of the irrigation directorates.

B- Compost production

The project conducted 4 training courses for farmers and stakeholders on conversion of farm residuals and aquatic weeds into composite and attended by 212 individuals representing farmers and irrigation officials. The teamwork of the project introduced the theoretical concept on how to produce compost out of farm residuals and aquatic weeds. Moreover, issues relevant to compost production process were thoroughly discussed. These issues were:

- What is compost?
- What materials could be used in compost?
- The benefits of compost for cultivation.
- Factors affecting the success of compost production.
- Problems and solutions.

The project also conducted practical training on producing compost for WUA members in attendance of official engineers of water orientation and irrigation administration.

C- Biogas production

The methodology of converting farm organic residuals and aquatic weeds into biogas was introduced to farmers and the irrigation officials during 5 training courses attended by 232 individuals representing farmers and irrigation officials. Sufficient theoretical introduction on what is biogas, how to produce it using bio farm residuals and aquatic weed were presented. The project in cooperation with water orientation administration and WUA selected two locations for applying the idea of biogas production from organic farm residuals and aquatic weeds. The project provided the selected locations with two biogas production units (digester), one unit for each location, with unit capacity of 7.5 m^3. The project teamwork provided practical training for water user association members and irrigation officials on how to prepare the mixture of organic residuals and animal manure and how to follow up the production process. The productivity of biogas was measured to be approximately 2.5 m^3 per day with daily feeding with the bio mixture. These results are agree the result that mentioned by Almoustapha (2008) which indicate that biogas production during hot and cool seasons, 0.52 m^3 and 0.29 m^3 respectively of biogas per m^3 of digester per day. And disagree with the result of the author EREC (2003); this difference may be due to different conditions and different digestion materials used. Also, bio fertilizer was used for agricultural fertilization for wheat crop; and land productivity was compared with land productivity using chemical fertilization (wheat crop). Productivities were similar for both fertilization methods, but bio fertilization method witnessed preference in production quality.

The result agree with the author's Azizi and Zamani (2008); Ben-Ayed (2002) who found that factors affecting participation in rural development programs were: (1) economic factors (expectation of profit from a new occupation); (2) project related factors (variety of activities, revolving funds, provision of consultants, continual support and follow-up); (3) relationships between people and development workers (positive perception of development workers and gaining of trust, their friendly characteristics, and frequent visits by development workers); (4) social factors (persuasion by a friend or neighbor, good relationships with other people, and friendship with project workers). The importance of farmer participation in system management has been also emphasized in previous studies (World Bank, 2003, Sherif *et. al.* 2010,).

5- Guidelines for maintenance program

Throughout the study and from observations during the project; guidelines for maintenance programs were developed for increasing the effectiveness of waterways. These guidelines are highlighted as following:

a. Performing routine mechanical aquatic weed control around two times a year, April and August, before summer and winter cultivation seasons to get irrigation waters delivered sufficiently to the agricultural lands through effective entire canal length.

b. Intensify manual weed control for the entire canal length on monthly basis for floating and ditch bank aquatic weeds types to avoid any water flow problems.

c. Organizing and executing continuous training programs to introduce farmers to participation in manual maintenance of canals through using modified removal hand tools and also provide them with the required numbers of such tools.

d. Arranging and executing awareness programs on the dangerous of dumping farm residuals and domestic waste into waterways. Such as health hazards has impact on waterways efficiency and water quality that harm agricultural products and soil in terms of quality and productivity.

e. Preparation of training courses for farmers on elimination of farm residuals safely and how to use it for producing organic fertilizers (compost) for their lands instead of chemical fertilizers and saving costs. That definitely would contribute in raising their products profitability.

f. Preparation of training courses for farmers on elimination of aquatic weeds and organic farm residuals in safe way through using simply constructed biogas production units to produce biogas as a new alternative energy source. And also bio-fertilizers that could be used to enrich soil fertility and decrease farm costs.

g. Cooperate with Ministry of Environment Affaire for providing integrated investment program for recycling rice straw through collection and compaction into blocks or rolls to be used in some other purposes such as animal feeding or conversional industries for paper production and others. Also irrigation responsible authorities could have number of rice straw compactors available for rent by water users associations. That can represent fund raising source for sponsoring social local service projects such as, garbage collection, sewage systems and others. Such services would help guarantee elimination of water pollutants from sources.

The result of this paper agrees with the same evaluation of the author Slama (2003) that summarized the benefits and returns of applying the participatory of canal management as follows:

· reducing the financial and the institutional burdens on the government.

· promoting economic use of water and the associated increase in productivity by giving users the opportunity to: (i) appreciate the scarcity of water and cost of delivering water to the farm gate, and (ii) develop a sense of ownership and responsibility over the irrigation system.

6- Conclusion and general recommendations

According to the discussions between the project teamwork and analysis of the collected data as well as diagnoses of observations made throughout the study, several general recommendations can be emphasized as following:-

a. Partial canal rehabilitation made remarkable enhancement in canal hydraulic performance while saving appreciable sum of money. That allows dividing the annual budget allocated for maintenance over larger number of canals. It is also recommended to keep observing and searching for most hydraulically worst sections and plan for partial rehabilitation of such sections.

b. Farmers attended the workshops and training programs showed appreciated interest in getting knowledge regarding various aspects of developing waterways performance. The educational level of the new generation of farmers was observable and played a significant roll in their eagerness to learn and develop their lands productivity. Also women in the studied areas were firmly standing beside their family members and contribute in farming process and livestock; they even in some areas are taking care of collecting and removing garbage to public dumping places with motorcycles equipped with wheel collecting boxes.

c. Manual maintenance and compost production got a very good echo among farmers, as they recognized the direct compensations of conserving their canals water quality on their crops quality and how local production of composite could make them good money save as well as improve their public health.

d. It is very advisable to continuously training farmers to keep their knowledge up to the required level to be able for making the change of their faming style on the right time and transfer the gained knowledge to the future generations.

e. Throughout the project activities there is an urgent call to provide the studied area with sanitary services and sewage networks. Missing of such services jeopardize public health of residents with unlimited hazard and push them to use waterways as an alternative for dumping wastewaters.

f. There is also a necessity to situate official efforts to assist farmers recycling farm residuals and rice straws following cultivation seasons instead of burning and polluting the environment or deposit residuals into waterways causing severe flow obstructions.

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