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Management of irrigation facilities and water for environmentally sustainable land use

MANAGEMENT OF IRRIGATION FACILITIES AND WATER FOR ENVIRONMENTALLY SUSTAINABLE LAND USE

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ABSTRACT

The aim of this paper is to illustrate the management of water and irrigation facilities for environmentally sustainable land use. The management of irrigation facilities includes the rehabilitation and modernization and maintenance of irrigation and drainage systems while the management of water deals with cultivation planning and operations. The terms connected to these activities need to be redefined incorporating the broader aspects of long-term sustainability of the production system while the process of implementation needs to be essentially multidisciplinary in nature to minimize damages to the environment. This paper, therefore, aims at providing suggestions that guarantee the realization of the objectives of irrigation systems related not only water use but also to environmental soundness.

1. INTRODUCTION

International organizations and lending institutions have focused their attention, since the middle of this century, on the irrigation projects for the production of food and fiber to answer the growing needs of the global population. Consequently, the investments on the agriculture sector have received the highest priority. The suggested scenarios to increase the food production are to increase the extent of global agricultural lands and to intensify production from the existing arable lands. Both these scenarios create environmental implications whereas the disturbances and damages to nature are enormous in the first scenario. However, environmental damages are inevitable in rural and urban developments; hence, the planners and the policymakers should pay special attention to minimize future costs of correcting the damages.

Worldwide experience in irrigation development has clearly shown that the advantages of irrigation can often be counteracted by the risks of environmental degradation. Irrigation systems bring water to new areas and create massive changes in the ecosystem affecting the environment in addition to creating changes in social, economic and technical systems. The projects should generally be tested for their compatibilities with the social, technical, economic and other interacting systems to develop environmentally sound irrigation projects. Experiences gained in new irrigation projects and rehabilitation and modernization projects could be used as the learning process for future projects (Vincent 1990). The World Bank's new policy lays down procedures to ensure that all environmental considerations become routinely and systematically integrated into project design and operation.

(Goodland 1990). It is clear that in some irrigation projects the yields of crop production of existing irrigated land have undergone drastic reduction due to changes in the upper reaches of the system.

This paper intends to discuss the issues related to waterlogging, salinity, and acidity in irrigation systems with special reference to local experiences. The main focus of the paper will be on the planning and implementation of irrigation projects to minimize environmental damages and to suggests strategies to overcome such difficulties using rehabilitation and modernization, maintenance and operation of irrigation works. It also intends to review the adequacy of existing methodologies and procedure for the environmentally sustainable land use.

2. PRESENT STATUS OF ENVIRONMENTAL CONSIDERATION IN IRRIGATION DEVELOPMENT

In contrast to the present concern over environmental issues in irrigation development, in the past it had not been treated adequately. There is no doubt about the environmental degradation due to different types of development programs. This is because most of the projects were planned, designed and implemented by the engineers since most work related to engineering. Once politicians decided on a certain development program they entrusted the framing of the proposals to the administrators and the engineers. In most cases, the development teams comprised only the engineers and administrators. The ultimate beneficiaries were hardly ever involved in or consulted for the preparation of such proposals. In the case of large-scale irrigation projects located inside thick jungles there were no people to be consulted. Such situations compelled them to develop proposals unilaterally and implement them according to their assumptions on socioeconomic and environmental parameters. Even though there were no people living in those areas, the folk in the upstream and downstream areas could have been consulted by the development teams. Unfortunately, this consultation had not taken place resulting in enormous environmental and socioeconomic implications.

The worldwide awareness amongst the general public and the recipients of the project benefits has generated growing interest on the by-products and side effects of development. The responses of the public and the wide gap between the expected and realized benefits have compelled the politicians, planners and the implementors to rethink seriously on these aspects. This cannot be done through single disciplinary design teams and, therefore, it demands multidisciplinary development teams. It is noteworthy that in most of the recent projects not only on irrigation but also in the areas of fishery, tourism, power, etc., serious thought has been given and action taken to appoint special teams of experts to make recommendations on the social and environmental implications.

In managing the irrigation facilities there are two main components, namely recurrent maintenance and rehabilitation and modernization (R&M) the latter of which is discrete in nature. These developments are being carried out in existing irrigation projects where an enormous amount of experience and knowledge on the social, economical, and environmental aspects is available for planning. Even though the damages of a permanent nature cannot be reversed or repaired, the recurring degradations such as waterlogging, salinization, and acidification can be arrested or can be kept at acceptable levels. In the past, engineers had not given serious thought to reverse or to minimize environmental damages in the R&M process and these problems have aggravated to such an extent that large areas of cultivable lands are lost. The response to the questionnaire circulated by the International Congress on Irrigation and Drainage (ICID) disclosed that many important aspects such as on-farm and agricultural production and environment have been neglected in R&M projects. Using these responses, a new definition was established to address a wide range of problems and issues.

When water is poorly managed, the efficiency of water use and water productivity of irrigation water become unbearable. In the past few decades, serious thought has been given to the management of water in irrigation so as to improve the effectiveness of irrigation water and to overcome serious environmental damages. Over time, there is a high tendency for the water table to be to built up due to overirrigation. Crops like rice can survive under waterlogged or saturated conditions but its yields are below the potential. Poor water management has made large areas of land uncultivable due to waterlogged and anaerobic conditions in root zones. Also poor drainage of irrigation water can aggravate soil salinity. Therefore, in managing water, due consideration should be given to minimize damages to irrigable lands and crops.

3. DEFINITIONS OF R&M, MAINTENANCE AND OPERATION AND SUITABILITY

This section focuses mainly on the definitions of R&M, maintenance and operations of irrigation projects. It is also intended to review the validity and adequacy of these definitions to address all the needs of the irrigation sector in today's context. In this analysis, it is absolutely necessary to examine the entire agriculture system in a holistic manner with a broader and in-depth vision.

3.1. Rehabilitation and Modernization

Generally, the process of R&M is carried out to address a few of the following aspects in existing irrigation systems: restoration of lost capacity; expansion of the designed command area;overcoming technical deficiencies; reversing environmental changes; adjustment to agricultural changes and adjustment to social changes.

Most of the R&M projects in the past have not completely considered the aspects given above due to lack of knowledge and concern in technical, social, economical and environmental implications. Perhaps, it may be due to inadequate representation of other disciplines by members of the planning and design teams with such disciplines. In most cases, these projects were not only designed and implemented but evaluated by the engineers themselves. Consequently, the performance of irrigation systems has fallen below expectations, creating additional problems related to social, economical and environmental issues, which have threatened the sustainability of the entire agriculture production system. After learning extensive lessons, several definitions were derived by different authors and the definition suggested by Pereira and McCready (1987) can be considered as the most appropriate one to address these problems and issues. "Rehabilitation is the process of renovating an existing project, which has fallen into disrepair, and whose performance is failing to meet its original objectives, in order to meet the original or enhanced technical, social or economic objectives". It is quite appropriate to analyze this definition in the context of the environmental implications. Without going into details of the terms used, it is clear, at a glance, that the environmental considerations are not explicit in this definition. Terms like "original objectives" and "enhanced technical objectives" may mean environmental issues. Table 1 provides information on 33 R&M projects implemented worldwide and indicates the reasons for these projects. This information was collected through a literature review. Accordingly, the issues related to environment were identified in 17 of the 33 projects. This discloses that more than 50% of the projects are affected by environmental implications. Table 2 illustrates the extent of work done to address the items of work identified. Activities like restoration of loss capacity and technical deficiencies were taken care of with scores over 70 points (out of 99) whereas issues such as reversing environmental changes recorded the lowest score of 28 points. As was discussed, this may be due to i) biases of engineering specialists toward physical works and ii) inadequate participation of specialists from other disciplines. Are the implicit references in the definition of R&M sufficient to address or to deal with the environmental implications in today's context? This paper suggests that the emphasis given to the definition in rehabilitation and modernization projects is not at all adequate to deal with such situations and that the definition of R&M should be amended to accommodate this ~~important subject~~ area.

3.2. Maintenance

Maintenance is a regular activity which contributes to the regular upkeep of the system to sustain its designed performance. Even though this is the general understanding of the term "maintenance," it should also be sensitive to the performance of the entire production system in the long term. Quite often, the maintenance process deals with the performance of the physical system in the sense of hydraulic behavior. The discussion in this section mainly focuses on the environmental issues that could be taken care of in the regular maintenance process. Some of the aspects considered in R&M relevant to the definition of maintenance are: controlling the loss of capacity; controlling the damages due to technical deficiencies and controlling adverse environmental changes. In addition, the upkeep of facilities with the goals of efficient operation, minimum breakdown and good appearance is the other vital task of maintenance (Yocom 1986).

The most common damage due to poor maintenance in irrigation systems is the risk in the rise of water table to the soil surface and above due to overirrigation. This situation will further get aggravated due to inadequate facilities and inadequate maintenance of drainage networks. The most commonly occurring routine types of maintenance in drainage networks are desilting and removal of bank and aquatic weeds. In practice, the irrigation managers pay special attention to the conveyance system because of the farmer pressure on the supply of water for their crops on a timely, equitable and adequate basis. On the other hand, there is also the pressure exerted by the senior management staff on the system managers to operate the systems at given targets. These pressures compel them to maintain the conveyance system at reasonably acceptable levels and to neglect the drainage systems. In old irrigation systems it is common to see that drainage systems are ineffective in draining the surplus from the irrigable lands because the systems are clogged and blocked. The following damages to the irrigation system can be expected: i) rise of water table above the root zone of the crop which totally damages the crop or which can cause yield reductions; ii) the rise in the water table makes the mechanization impossible causing delays in planting and harvesting; iii) Inadequate and ineffective drainage networks promote the accumulation of salts in irrigated fields due to poor flushing which, in turn, affects the crop yields.

All the issues related to salinization cannot be dealt with completely through maintenance or R&M by themselves because these issues can be brought about by poor quality water, inappropriate operations and also due to incompatibility of water with soils. The salt contents and the concentration of ions in soils play a significant role in the salinization process. Besides those problems, adequate drainage facilities and the regular maintenance of drainage network can definitely control and minimize the loss of irrigated lands due to waterlogging and salinization. Therefore, this paper suggests that the definition of maintenance should be amended to draw the special attention of irrigation managers and policymakers. The proposed amendment to the definition of Pereira and McCready (1987) is as underlined.
"Maintenance is the process of keeping the irrigation, drainage and any other infrastructural facilities in good repair and working order, fulfilling the intentions for which they were originally designed <u>with adequate consideration for minimizing adverse environmental effects</u>". These types of changes are required when the project expectations become broader and also because some side effects of development projects are most often underestimated at the inception of the projects. On the other hand, certain changes in the

environment may have not been seriously felt at that time because of the plentifulness and the availability of natural resources. Today, the pressure for limited resources is very intense because of the growing needs of the ever-increasing population. Therefore, irrigation management should also pay special attention to environmental issues to preserve the already damaged and disturbed nature without allowing it to degrade further.

3.3. Operation

The operation of irrigation systems can be defined as the process of storing, issuance, conveyance and distribution of irrigation water for crop production and the evacuation of excess water from the irrigated lands. The operations in irrigation can cause environmental damages, particularly when the soil properties are marginally suitable for agriculture. In such cases, the quality of water is an important parameter in maintaining the production process sustainable. It is also important to irrigate soils which are susceptible to salinization with adequate quantities of water for leaching. In case of cascade irrigation systems with marginal water quality and the soil properties, the crop establishment of the lower systems should be started first to minimize germination problems due to saline water. In areas where pyrite layers exist (particularly in coastal areas) as a result of improving drainage, the oxidization of pyrite produces sulfuric acids and decreases the pH values of the soil solution. This situation can get further aggravated by inadequately planned operations. Because of the bailing out of water in the lower reaches, drops in the water table in the upper reaches of the system will expose the underlying pyrite layer to oxygen which will activate the acidification process. The adverse effects caused by the construction of drainages in such areas should be controlled by careful operations. Therefore, in drainage projects, the monitoring of the water table related to the depth of the pyrite layer is very important.

4. CAUSE AND EFFECTS OF ENVIRONMENTAL DAMAGES IN SRI LANKA

The effects of environmental damages related to waterlogging, water and soil salinity and acidity in a few irrigation projects will be discussed in this section. There are many more cases of such side effects and by-products of irrigation development in this country and the discussion will be basically focused on the irrigation management aspects in view of minimizing and reversing the environmental changes.

4.1. Salinity

The Lunugamvehera Reservoir was constructed (1986) across Kirindi Oya Stream above the existing Ellegala Irrigation System (EIS) which was constructed in 1870 and has been in operation ever since. At that time, EIS was directly fed by a diversion barrage at a lower location from the newly constructed dam.

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Acidity as subject?

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how do you operate drainage then? Is this a design concern?

examples

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The EIS comprises five smaller reservoirs (called tanks) which receive a direct runoff from their own catchments during monsoonal rains. The newly developed area is located above EIS and drainage water from those tracts drains down to this system. In the monitoring of water quality in these tanks and reservoirs the electrical conductivity (EC) and pH values have been collected since 1990. This monitoring was initiated by the Department of Agriculture as a result of farmers' complaints on increasing salinity in irrigation water. Farmers have observed that due to this increased salinity, the germination of the crop was affected and that over a few years their yields had dropped dramatically (from 5 tons/ha to 2-3 tons/ha). At Lunugamvehera Dam site, the quality of water is within the limit of class 1 (below 0.25 mmhos/cm). In the past, the farmers irrigated their lands directly from the river using class 1 water and the present water quality has dropped down to class 2 and even to class 3. Class 2 water can be used for irrigation if the soil properties and the drainage facilities are at satisfactory levels. It is very dangerous to use class 3 water in the long run because it can create very high soil salinity which puts lands out of production. In addition, the dry climatic condition of this area also plays a supporting role in increasing the soil salinity. Please see Figures 1a, 1b, 1c, 2a, 2b and 2c.

The Ec values of Lunugamvehera Reservoir fluctuate around 0.25 mmhos/cm throughout the year. In contrast, the water quality of all other locations is very much poorer than class 1 water. It is hard to believe the extent of degradation within such a short distance as 2 km below the reservoir. This increase in salinity is mainly due to drainage water from the newly developed area which washes down its soluble salts. The most affected sub-system is Weerawila and from January to June the EC values are in class 3 range whose water is severely injurious to plants. Except during April and May, other months are quite dry and, therefore, the EC values can be expected to be higher than at other periods. However, there has been no increasing trend from 1990 to 1992 and the values fluctuate due the climatic conditions. Rainfall and EC values are inversely proportional, i.e., when there is significant rainfall EC values drop down and vice versa. Nevertheless, the water quality has deteriorated in the tanks which receive substantial amounts of drainage water from the newly developed area (Weerawila and Yodawewa).

4.2. Waterlogging

The reduction in yields is not only due to poor quality of irrigation water but to the waterlogged conditions in the fields which increases the salt concentration of the soil solution. The EIS has experienced a reduction in yields to an average of 2-3 tons/ha during the past 7 years. This situation can get worsened due to insufficient drainage facilities. As discussed in the previous section, the water quality is not so favorable for long-term sustainability of land use and, hence, special precautions should be taken to maintain the salt concentration of the soil solution at acceptable levels.

This needs a very effective and efficient drainage system with a supply of irrigation water sufficient for leaching. Since this project is rather a water-short system, it is necessary to depend more on good drainage rather than on leaching. The total area affected by waterlogging in the EIS is around 400 ha out of 4,200 ha but these lands can still be grown with long-term paddy varieties. It is also somewhat difficult to use heavy machinery like tractors for land preparation. Therefore, the land preparation period has been extended to about five weeks causing high water consumptions.

4.3. Acidification

The Nilwala Ganga Flood Protection and Drainage Project is located in the southern part of the country close to the sea outlet. The existing irrigation system was rehabilitated to improve the land productivity and extending existing irrigated area. The area in the Kiralakele sub-system was planned for about 2,000 ha of agricultural land and these tracts are provided with irrigation and drainage facilities. The lower reaches of the project need extensive drainage, particularly during crop establishment and harvesting periods whereas the upper reaches need irrigation while needing to maintain the water table close to the soil surface (around 50 cm below the soil surface) to control acidification. The pyrite layer is at about 50-100 cm below the soil surface and when the water level drops below 50 cm or more the pyrite layer gets contacted with oxygen resulting in oxidation to form sulphurous and sulfuric acids. The reaction increase the acidity in the soil solution to pH values around 2 and very few crops can survive under such conditions. During the land preparation period, the water level in the lower lying areas should be brought to 20 cm below the mean sea level which creates acid-producing conditions in the upper reaches resulting in 80 ha of land becoming uncultivable.

what?

total, per year what?

5. MANAGEMENT OF IRRIGATION FACILITIES AND WATER FOR SUSTAINABLE LAND USE

This section suggests the strategies to be followed in the management of water and irrigation facilities to reverse some environmental changes and also to minimize and prevent further degradation of the entire agricultural production system. As discussed in the sections above, the processes of R&M, maintenance and operation can be used in this task.

5.1. Rehabilitation and Modernization

In the past, in most R&M projects sufficient attention had not been paid to the cause for the degradation of the production system and the R&M project were more of a civil engineering nature to solve the conveyance and distribution problems. By looking at some problems given in this paper it is made clear that it is not only an engineering affair. The yield reductions and the land becoming uncultivable in a profitable manner are not mainly due to inadequacies, untimeliness, and inequitable supply of water but also due to inappropriate drainage and water table management. From Table 2 it is apparent that more emphasis was given to activities to make the physical irrigation supply system functional and it is experienced that after a few years of rehabilitation the systems fall back to the original dilapidated conditions due to inadequate considerations to operational and institutional rehabilitations or reorientations. The following activities should be carried out during the R&M projects: i) The design team of the project should include an environmental specialist and an environmental impact assessment should be carried out before the start of the initial planning; ii) The objectives of the project should be clearly defined after conducting a diagnostic analysis and prefeasibility studies. Once these studies are completed, the issues, problems and constraints for the realization of the project objectives can be clearly identified; iii) The project activities can be designed based on the diagnosis so as to solve the problems and to overcome the constraints; iv) Finally, the monitoring and evaluation of the designed activities should be done during implementation and after completion to make corrections, if any.

The most recently implemented rehabilitation projects have special considerations to improve the drainage networks. In the Irrigation Systems Management Project which was implemented in three districts of this country, large sums of money have been set apart for rehabilitation of drainage systems. However, in implementation, the priority given to these aspects was not sufficient and this work was carried out during the final year. This paper suggests that the improvement to drainage work too should be started side by side since it is an equally important aspect in irrigation management. Similarly, in the rehabilitation of EIS under ADB assistance very high priority has been given to improvement of drainage canals. The farmers of this system were fully aware of this situation and requested the irrigation agency to start drainage work before the canal system rehabilitation. Therefore, the designing and planning of the drainage work also started simultaneously with the irrigation system work. Unfortunately, due to the very short notice given by the donor to complete the work, the diagnosis phase of the project was not carried out. However, IIMI which was carrying out research in the project could provide information and data on the need of rehabilitation. On the other hand, the project designs were done by the very same staff who operates the system.

5.2. Maintenance

Proper maintenance of irrigation and drainage systems can result in the postponement of the recurrence of rehabilitation at closer intervals. In general, maintenance can control the changes due to waterlogging and salinity. When water can be bailed out efficiently from the irrigation system, the building up of the water table can be controlled. By keeping the water table substantially below the soil surface, the agricultural operations and supply of oxygen to the plant growth become efficient. Similarly, soil salinity can be maintained at desired levels by flushing out the salt transported by saline water. These flushing out operations and maintaining the water table at desired levels can be done only through a hydraulically efficient drainage system. Therefore, seasonal maintenance such as desilting and removal of bank and submerged weeds is essential. Most of the irrigation systems are affected by the loss of capacity of drainage canals due to weeds and silt deposits. The loss of capacity due to weeds in canals results in the reduction of cross sectional area and increase in roughness coefficient. The reduction in capacity ranges from 30% to 60% depending on the weed types. Silt deposition and weed growth have complementary effects in loss of capacity with silt providing a good base for weed growth and weeds increasing the sedimentation due to flow retardation. For the efficient discharge of surplus water, it is necessary to have a sufficient hydraulic gradient. Desilting and removal of weeds in the conveyance section increase the hydraulic gradient and lower the roughness coefficient. Therefore, these two activities in maintenance contribute not only to control further degradation of the production system but to improve crop yields. This paper recommends the removal of weeds once a year and desilting at least once in three years to sustain the performance of irrigation systems.

5.6. Operations

In the preparation of operation plans the normal irrigation requirement includes only the consumptive use of the plant, on- farm losses, distribution and conveyance losses. Since water is a scarce resource, in most irrigation systems the water requirement for washing out the accumulated salts is generally not provided. Irrigation managers expect the flushing to be done using rain water. Unfortunately, the projects situated in the dry zone do not receive sufficient rain for flushing out and, therefore, it is absolutely necessary to provide leaching in irrigation scheduling.

In case of cascade or upstream and downstream type of irrigation systems where poor quality water is used, the downstream sections of the project should establish their crops with certain time lags with the upstream sections. This is done to minimize germination problems due to saline water. Once the crop is strong enough to tolerate a certain concentration of salt then it can be irrigated with lower quality water. This paper recommends a time lag of at least two weeks between the upstream and downstream sections in water reuse systems. Due consideration should be given to the water table fluctuation in the operation of irrigation systems when the irrigated or drained land is susceptible to acidification and waterlogging. As explained in the previous section, certain soil profiles are very sensitive to the water table fluctuations. When there are pyrite layers care should be taken not to expose the acid-producing layers to oxygen. Therefore, it is necessary to keep the layers submerged as far as possible. Hence, in drainage projects, the evacuation of water should be done while maintaining certain water levels in the upper reaches of the system.

6. Conclusions

If the system managers pay special attention to managing water and irrigation facilities the environmental changes and damages can be greatly minimized. These damages continue to occur and ultimately put large areas of land out of production due to the insensitivity of irrigation managers on this subject area. Therefore, it is vital to make them aware of the causes and effects of irrigation development and frame policies at the national level to sustain environmental soundness. The normal activities such as R&M, maintenance and operation can be used carefully to minimize and reverse environmental changes.

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TABLE 1. REHABILITATION ~~NEEDS~~ GOALS IN PROJECTS

No.	NAME OF THE PROJECT	COUNTRY	REF.	A1	A2	A3	A4	A5	A6	TOT	PERCENT
	SOUTH ASIA										
1.	TANK IRRI.MODERNI.PROJECT	SRILANKA	FOWLER89	1	0	1	0	1	1	4	66.67
2.	GALOYA WATER MANAGE.PROJECT	SRILANKA	FOWLER89	1	1	1	1	1	1	6	100.00
3.	PERIYAR-VAGAI REHA.&BETT.PRO.	INDIA	FOWLER89	1	1	1	0	1	1	5	83.33
4.	UTTAR PRADESH	INDIA	O36R57	1	0	1	1	1	1	5	83.33
	Sub total			4	2	4	2	4	4	20	83.33
	SOUTH EAST ASIA										
5.	HONG WAI PIONEER AGRI.PROJ.	THAILAND	FOWLER89	1	1	1	1	1	1	6	100.00
6.	NORTH-EAST IRRIGATION SYS.	THAILAND	O40R1	1	0	1	0	0	0	2	33.33
7.	WEST TARUM REHAB.& BETTER.	THAILAND	FOWLER90	1	1	1	1	1	1	6	100.00
8.	EAST JAVA IRRIGATION PROJ.	INDONESIA	O40R8	1	0	1	1	0	1	4	66.67
9.	FIVE YEAR DEVELOP.PLAN	INDONESIA	O40R25	1	1	1	0	1	1	5	83.33
10.	PAPAR-PETERONGAN IRRIGA. SYS.	INDONESIA	O40R27	1	0	1	0	1	1	4	66.67
	Sub total			6	3	6	3	4	5	27	75.00
	MIDDLE EAST										
11.	MUJIB&SOUTHERN GHORS IRRI.PRO.	JORDAN	O40R11	1	1	1	0	0	1	4	66.67
12.	GREATER MUSSAYIB PROJECT	IRAQ	O40R27	1	0	1	1	0	0	3	50.00
13.	TOKAT PROJECT	TURKEY	O36R1	1	1	1	1	1	1	6	100.00
	Sub total			3	2	3	2	1	2	13	72.22
	AFRICA										
14.	EL-HAMMAM IRRIGATION SYSTEM	EGYPT	O40R5	1	0	1	1	0	0	3	50.00
15.	MIDDLE DRAA PROJECT	MOROCCO	O40R6	1	1	1	0	1	1	5	83.33
16.	BENI AMIR PERIMETER	MOROCCO	O36R58	1	1	1	1	1	1	6	100.00
17.	EDOZHIGI IRRIGATION SYSTEM	NIGERIA	O40R41	1	0	1	1	1	1	5	83.33
18.	OFFICE OF NIGER	MALI	O40R63	1	0	1	1	1	1	5	83.33
	Sub total			5	2	5	4	4	4	24	80.00
	EUROPE										
19.	ATINA/VILLA LATINA	ITALY	O40R12	1	1	1	0	0	0	3	50.00
20.	COLLECTIVE IRRIGATION SYSTEM	ITALY	O36R16	1	0	1	0	0	0	2	33.33
21.	SYRDARYA AND AMUDARYA PROJECT	USSR	O40R30	1	1	1	1	0	1	5	83.33
22.	TARASCON AREA	FRANCE	O40R57	1	0	1	1	0	0	3	50.00
23.	SOUTHERN FRANCE CANAL	FRANCE	O40R66	1	0	1	0	0	1	3	50.00
24.	WEST PYRENESS	FRANCE	O40R62	1	0	1	0	1	1	4	66.67
25.	DOURNE&FOREZ CANALS	FRANCE	O36R19	1	1	1	0	1	0	4	66.67
26.	PRODIM	PORTUGAL	O40R73	1	1	1	1	1	1	6	100.00
	sub total			8	4	8	3	3	4	30	62.50
	OTHERS										
27.	COCHELLA VALLEY	USA	O40R91	1	0	1	0	0	0	2	33.33
28.	RENMARK IRRIGATION SYSTEM	AUSTRALIA	O36R22	1	0	1	0	1	1	4	66.67
29.	GOULBURN IRRIGATION SYSTEM	AUSTRALIA	O36R23	1	0	1	0	0	0	2	33.33
30.	SOUTHERN VICTORIA	AUSTRALIA	O36R30	1	0	1	0	1	1	4	66.67
31.	IRRIGATION SYSTEM IN ALBERTA	CANADA	O36R53	1	1	1	1	1	1	6	100.00
32.	MODERNIZATION OF PADDY FIELD	JAPAN	O40R16	1	0	1	1	0	1	4	66.67
33.	MIYAT IRRIGATION DISTRICT	JAPAN	O36R41	1	1	1	1	0	0	4	66.67
	Sub total			7	2	7	3	3	4	26	61.90
	TOTAL			33	15	33	17	18	23	140	70.71

NOTE

1. A1: Restoration of lost capacity
2. A2: Expansion of comand area
3. A3: Overcoming technical deficiencies
4. A4: Adjustment to environmental changes
5. A5: Adjustment to agricultural changes
6. A6: Adjustment to social changes

POINTS SYSTEM

1 - YES

0 - NO

TABLE 2. IMPLIMENTATION OF REHABILITATION

No.	NAME OF THE PROJECT	COUNTRY	REF.	A1	A2	A3	A4	A5	A6	TOTAL	No.Item	Average
	SOUTH ASIA											
1.	TANK IRRI.MODER.PROJ.	SRILANKA	FOWLER89	3	0	3	0	2	1	9	4	2.25
2.	GALOYA WATER MANAG.PROJ.	SRILANKA	FOWLER89	1	2	3	1	2	2	11	6	1.83
3.	PERIYAR VAGAI REHA.&BETT.PROJ.	INDIA	FOWLER89	3	3	3	0	2	1	12	5	2.40
4.	UTTAR PRADESH	INDIA	Q36R57	2	0	3	2	2	1	10	5	2.00
	Sub total			9	5	12	3	8	5	42	20	2.10
	EAST ASIA											
5.	HONG WAI PIONEER AGRI.PROJ.	THAILAND	FOWLER89	3	3	2	0	2	2	12	5	2.40
6.	NORTH-EAST IRRIGATION SYS.	THAILAND	Q40R1	1	0	3	0	0	0	4	2	2.00
7.	WEST TARUM REHAB.& BETTER.	THAILAND	FOWLER89	1	3	3	0	3	3	13	5	2.60
8.	EAST JAVA IRRIGATION PROJ.	INDONESIA	Q40R9	2	0	3	0	0	0	5	2	2.50
9.	FIVE YEAR DEVELOP.PLAN	INDONESIA	Q40R35	2	2	2	0	1	1	8	5	1.60
10.	PAPAR-PETERONGAN IRRIGA. SYS.	INDONESIA	Q40R37	1	0	2	0	3	1	7	4	1.75
	Sub total			10	8	15	0	9	7	49	23	2.13
	MIDDLE EAST											
11.	MUJIB&SOUTHERN GHORS IRRI.PRO.	JORDAN	Q40R11	3	3	2	0	0	2	10	4	2.50
12.	GREATER MUSSAYIB PROJECT	IRAQ	Q40R27	3	0	3	3	0	0	9	3	3.00
13.	TOKAT PROJECT	TURKEY	Q36R1	2	3	2	2	2	1	12	6	2.00
	Sub total			8	6	7	5	2	3	31	13	2.38
	AFRICA											
14.	EL-HAMMAM IRRIGATION SYSTEM	EGYPT	Q40R5	2	0	2	2	0	0	6	3	2.00
15.	MIDDLE DRAA PROJECT	MOROCCO	Q40R8	0	2	2	1	1	0	6	4	1.50
16.	BENI AMIR PERIMETER	MOROCCO	Q36R58	2	2	2	2	2	2	12	6	2.00
17.	EDOZHIGI IRRIGATION SYSTEM	NIGERIA	Q40R41	2	0	3	2	2	2	11	5	2.20
18.	OFFICE OF NIGER	MALI	Q40R63	2	0	3	2	2	2	11	5	2.20
	Sub total			8	4	12	9	7	6	46	23	2.00
	EUROPE											
19.	ATINA/VILLA LATINA	ITALY	Q40R12	2	1	2	0	0	0	5	3	1.67
20.	COLLECTIVE IRRIGATION SYSTEM	ITALY	Q36R16	3	0	3	0	0	0	6	2	3.00
21.	SYRDARYA AND AMUDARYA PROJECT	USSR	Q40R30	2	1	3	2	0	3	11	5	2.20
22.	TARASCON AREA	FRANCE	Q40R57	3	0	2	2	0	0	7	3	2.33
23.	SOUTHERN FRANCE CANAL	FRANCE	Q40R66	2	0	3	0	0	2	7	3	2.33
24.	WEST PYRENESS	FRANCE	Q40R62	3	0	2	0	1	1	7	4	1.75
25.	BOURNE&FOREZ CANALS	FRANCE	Q36R19	3	2	2	0	1	0	8	4	2.00
26.	PROITM	PORTUGAL	Q40R73	2	1	3	1	1	3	11	6	1.83
	Sub total			20	5	20	5	3	9	62	30	2.07
	OTHERS											
27	COCHELLA VALLEY	USA	Q40R91	3	0	3	0	0	0	6	2	3.00
28	RENMARK IRRIGATION SYSTEM	AUSTRALIA	Q36R22	3	0	2	0	2	1	8	4	2.00
29	GOULBURN IRRIGATION SYSTEM	AUSTRALIA	Q36R23	2	0	3	0	0	0	5	2	2.50
30	SOUTHERN VICTORIA	AUSTRALIA	Q36R38	2	0	2	0	2	2	8	4	2.00
31	IRRIGATION SYSTEM IN ALBERTA	CANADA	Q36R53	3	2	3	2	1	1	12	6	2.00
32	MODERNIZATION OF PADDY FIELD	JAPAN	Q40R19	1	0	2	2	0	1	6	4	1.50
33	MIYAT IRRIGATION DISTRICT	JAPAN	Q36R41	3	2	3	2	0	0	10	4	2.50
	Sub total			17	4	18	6	5	5	55	26	2.12
	TOTAL			72	32	84	28	34	35	285	135	2.11

NOTE

1. A1: Restoration of lost capacity
2. A2: Expansion of command area
3. A3: Overcoming technical deficiencies
4. A4: Adjust.envim.changes
5. A5: Adjust.agri.changes
6. A6: Adjust.social changes

POINTS SYSTEM

3 - Thoroughly done
2 - Moderately done
1 - Minimally done
0 Not done