PROCEEDINGS OF THE WORKSHOP ON EFFICIENT USE AND MAINTENANCE OF IRRIGATION SYSTEMS AT THE FARM LEVEL IN CHINA

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Part One

REPORT OF THE WORKSHOP

Part One

REPORT OF THE WORKSHOP

I. INTRODUCTION

A. INITIATION OF THE WORKSHOP

1. The Workshop on Efficient Use and Maintenance of Irrigation Systems at the Farm Level in China was the first regional project organized in China by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP).

2. In 1977, following a visit by the Executive Secretary of ESCAP and some of this senior staff, a number of specific proposals for regional projects were submitted to the Government of China for consideration with a view to selecting two for implementation in 1978 using, in part, funds contributed by China to the United Nations Development Programme. Early in 1978, the Government of China informed the Executive Secretary that this Workshop would be one of the two it had selected. Accordingly, a project document was submitted to UNDP, and an agreement between ESCAP and China was drawn up which, among other things, called for the Workshop to be held during the period 24 August to 8 September 1978.

B. OBJECTIVES

3. Virtually all of the developing countries of the region had made large investments in irrigation systems, both large- and small-scale, but the level of efficiency and productivity achieved by farmers had often proved disappointing, and management and maintenance of the delivery and drainage systems at the farm level unsatisfactory.

4. The United Nations Water Conference, held at Mar del Plata, Argentina, in March 1977, in its resolution III, recommended an action programme on irrigated agriculture at the national and international levels. Great importance was attached to the improvement of existing irrigation systems with the objectives, *inter alia*, of raising productivity with minimum cost and delay, improving the efficiency of water use and preventing waste and degradation of water resources.

5. In China, a high percentage of cultivated land had been irrigated and the land was intensively cultivated with a large input of human labour, with emphasis on efficiency in water use. China therefore provided good illustrations of ways in which the objectives of resolution III of the United Nations Water Conference could be achieved.

6. The broad objective of the Workshop, therefore, was to provide information to technical staff of developing countries on institutions, systems and practices used in China in connexion with the operation and maintenance of irrigation systems at the farm level with particular reference to those with potential for transferability to other developing countries of the region.

7. Its immediate objective was to provide an opportunity for technical staff from selected developing countries to observe, study and discuss the approach to those matters in China, to make comparisons with the situation in their own countries, and to reach conclusions and recommendations for consideration in their own countries including the potential and constraints for transferability of Chinese experience to other countries in the region.

C. PREPARATORY WORK

8. With a view to achieving optimum benefits from the Workshop, and having regard to the importance of close links between irrigation engineering and agriculture development, ESCAP requested each participating Government to nominate two participants with the following qualifications: (i) they must be directly involved in the Government's efforts to promote irrigated agriculture; (ii) they must be of sufficient seniority to be in a position to initiate new policies and programmes or modify existing programmes in the light of the Workshop experience; (iii) one member of the team should be an irrigation engineer engaged in supervision or management of irrigation projects; (iv) the second member of the team should have considerable experience in extension services involving the guidance of farmers in the proper utilization of irrigation facilities and application of new technology; and (v) the two members should be at about the same level of seniority to promote co-operation in follow-up action upon their return to their countries.

9. The nominees were also asked to prepare a paper on the subject of operation and maintenance of irrigation systems in their respective countries for discussion and comparative purposes during the Workshop.

10. In addition, ESCAP sent to the nominees a copy of the Food and Agriculture Organization of the United Nations (FAO) publication *Learning from China*, a report on agriculture and the Chinese people's communes prepared by an FAO mission which visited China in 1975. The nominees were requested to study the publication which provided valuable background information on agricultural development in China as well as its organizational aspects.

D. PARTICIPATION

11. There were 16 participants in the Workshop from the following countries: Bangladesh (2), Burma (2), India (2), Malaysia (2), Nepal (2), Philippines (2), Sri Lanka (2), and Thailand (2). Three members of the ESCAP secretariat acted in the capacity of director, technical rapporteur and assistant technical rapporteur of the Workshop.

II. THE WORKSHOP

A. LAND AND WATER RESOURCES

12. China had a total area of 9.6 million km^2 of which 60 per cent was mountains and hills and 20 per cent was grassland. The cultivated area was only about 10 per cent of the total or 1 million km^2. The mean annual precipitation was 630 mm which was unevenly distributed throughout the country, ranging from 100 mm to 200 mm in the north-west to about 1,600 mm in the south-east.

13. Precipitation was also unevenly distributed in time, and on the average a major flood or drought occurred nearly every year during the period 206 B.C. to 1949 when 1,092 heavy floods and 1,056 severe droughts were experienced. There was also a strong seasonal pattern of rainfall over most of the country, 50 per cent to 70 per cent of the annual total occurring in the rainy season, July to September.

14. The total average annual river discharge was 2,700 x 10^9 m^3. There were about 1,500 catchments with an area of over 1,000 km^2. The hydroelectric potential was estimated at 580,000 MW.

15. In general, the land sloped from west to east and all the five major rivers – the Pearl, Yangtze, Yellow, Huaiho and Haiho – drained to the China Sea.

16. Since 1949, there had been a vigorous water conservancy[1] programme based on collective strength and land reform and development.

17. Since 1949, China had engaged in a vigorous water conservancy programme, including the construction of:

(a) 300 large reservoirs (storage capacity more than 100 million m^3);

(b) 1,900 medium-sized reservoirs (capacity between 10 million and 100 million m^3);

(c) 70,000 small reservoirs (capacity between 100,000 and 10 million m^3);

(d) 6,000,000 small ponds (capacity less than 100,000 m^3).

18. During the same period, the capacity of pumped irrigation and drainage stations, including ground-water pumping, increased from 90,000 hp to 55 million hp, and 2 million pumped tube wells for irrigation were installed, there being none before. The area irrigated increased from 16 million to 46.6 milllion hectares during the same period.

19. Flood control had been achieved to a considerable extent on the five large rivers referred to above. Of the 20 million hectares of land which had been subject to floods, waterlogging and drought, 70 per cent had been largely freed from those hazards.

20. Although grain output of 285 x 10^9 kg in 1977 was 1.7 times the production before 1949, largely because of water conservancy works, further increase in production was needed because of the large population. For that reason, the fifth People's Congress held early in 1978 set the total target output for 1985 as 400 x 10^9 kg, and that would require further efforts in water conservancy in order to overcome the effects of floods and droughts.

B. PROJECTS VISITED/ARRANGEMENTS

21. The Workshop participants visited a number of irrigation projects in the Guangxi Zhuang Autonomous Region, around Shanghai, Suzhou and Wuxi, Jiangsu Province and around Beijing. The technical itinerary of the Workshop is given in annex I. Although the technical itinerary was confined to the irrigation projects visited, it must be mentioned that the participants were given the opportunity to visit places of historical and cultural interest which provided them with a background perspective for China's present setting.

22. The participants appreciated very much the excellent arrangements made by the officials assigned to the Work-

1 In this report, the term "water conservancy" refers to water resources projects involving mainly irrigation and drainage but including other purposes, such as flood mitigation, navigation and hydro-power generation, as appropriate.

shop who spared no efforts to make the stay of the participants as comfortable and interesting as possible. They particularly expressed a wish to place on record their heartfelt thanks to the officials and workers they met who are also listed in annex I.

23. The general procedure of the Workshop was a short briefing given by the workers (usually the vice-chairman of the commune and his assistants). After the briefing, the participants broke up into three groups – Agriculture, Irrigation Engineering, and Administration. One or two representatives of the commune were assigned to each group which obtained information on the respective subjects.

24. At the end of the visit to a project, each group held separate discussions and prepared a group report which was submitted to the Workshop director as a basis for preparing the draft Workshop report.

C. INSTITUTIONAL MACHINERY: GENERAL

1. Introduction

25. Much has been written about the evolution of the present administration system in China, and a very brief outline only is given here, in order to facilitate the presentation of somewhat more detailed information on administrative matters related to water conservancy. Reference is made to two publications:

(i) The Constitution of the People's Republic of China, as adopted on 5 March 1978 by the Fifth National People's Congress of the People's Republic of China at its first session;

(ii) *Report from Tungting – A People's Commune on Taihu Lake,* by Wu Chou (distributed to participants in the Workshop).

26. In the context of its socialist basis, the system in China placed special emphasis on two principles – that all people should have appropriate involvement in planning, carrying out and benefiting from the development process, and that responsibility for decision-making should be delegated to the lowest effective level.

27. On the highest level of government was the National People's Congress, Standing Committee and State Council and the smallest unit was the people's commune, which had under its responsibility production brigades and production teams. Between the national level and the communes, in descending order, were provinces, prefectures and counties. There were in addition, at the provincial level, autonomous regions and three municipalities – Beijing, Shanghai and Tianjin – and other subdivisions at lower levels, but the general pattern was as indicated. This structure is illustrated in annex II.

28. As can be seen there was no revolutionary committee (policy-making body) at the prefecture level, the role of the prefecture being essentially to inspect and check work assigned by a province to counties.

2. The commune system

29. The commune played a critical role in the whole system. Distinctive features included:

(a) It was the lowest level at which there a was revolutionary committee;

(b) It was the highest level at which the congress was elected by the voting of all adult (18 and over) citizens, and not by voting of citizens' representatives;

(c) It was the highest level at which the people's organizations developed and managed their enterprises without an associated government departmental structure. (Communes, brigades and teams might, however, have the support of technicians provided by the State if required.)

30. That term, "the State", also had a watershed at the commune level. When, for instance, it was said that a service might be provided by, or payment made to, the State, that referred to institutions at county level or above, where there was a government departmental structure, parallel to the people's organizations which developed and managed programmes appropriate to their level and scope of responsibility.

31. The Workshop was concerned mainly with projects and activities handled at commune or lower level, and some additional information is given on this section of the system.

32. The people's commune commonly comprised 20,000 to 30,000 people in 15 to 25 production brigades, each of which might comprise from 10 to 25 production teams, which in turn had a population commonly ranging between 100 and 300 people. Numbers might, however, be well outside that range.

33. The terms "people's commune" and "production brigades" and "teams" were significant in indicating the relative roles of the bodies referred to. The commune, which often developed and managed industrial enterprises involving resources not conveniently managed at a lower level, might also develop and manage some farming enterprises and had extensive responsibilities in social services, but direct responsibility for use of land was essentially at the production team level, with the brigade

actively involved in co-ordinating and supporting day-to-day operations.

34. The people's commune congress was elected by the votes of all members aged 18 or over and held office for two years. Provision was made for reasonable representation of different age groups and of women.

35. The people's commune congress elected the commune revolutionary committee which elected its own chairman and a number of vice-chairmen who were assigned responsibility for specific areas of activity. (In all cases where the terms chairman and vice-chairmen are used, the post might be held by a woman.) The revolutionary committee carried out functions in the nature of a board of management for the commune with operational responsibilities decentralized as much as possible to the production brigades and teams.

36. The brigade was managed by an administrative committee which held office for one year. It comprised a combination of four members appointed by the commune (secretary, vice-secretary, brigade leader and accountant) and a number, typically five, selected in consultation with the production teams and endorsed by the commune revolutionary committee. These members had responsibilities related to specific areas of activity, i.e. youth, women's affairs, local militia. The names of the four nominees for the key administrative posts in the brigade committee were submitted to the brigade for consideration before a final decision was made.

37. Each production team had a leader who also held office for one year. In consultation with each production team, the brigade compiled a list of names, one for each team, and submitted it to the commune revolutionary committee for approval, after which each team formally elected the designated leader.

38. The following quotations from the two publications referred to previously help to explain the system and its operation.

> "People's congresses and revolutionary committees of the people's communes are organizations of political power at the grass-roots level, and are also leading organs of collective economy ..."[2]
>
> "Deputies to the people's congresses of ... people's communes are directly elected by the voters by secret ballot after democratic consultation ..."[2]
>
> "Local revolutionary committees at various levels, that is, local people's governments, are the executive organs of local people's congresses at the corresponding levels and they are also local organs of state administration ..."[2]

2 Constitution of the People's Republic of China.

"Local revoluntary committees are responsible and accountable to people's congresses at the corresponding levels and to the organs of state administration at the next higher level, and work under the unified leadership of the State Council."[2]

"The people's commune is a social structure that integrates government administration with commune management. It is at once a basic economic organization and a grass-roots unit of state power in China's socialist countryside ..."[3]

"The people's commune exercises state power and organizes its own economic activities related to production, distribution and consumption. People often call this the system of integrating government administration with commune management, or the five-in-one unit administering industry, agriculture, trade, education and military affairs ..."[3]

"The commune helps the brigades and teams to work out their production plans, and supervises and checks up on their implementation. It also lends a hand in improving their administrative and financial work and distribution of income, and spreads advanced experience and methods among them in order to increase production ..."[3]

"With the unified leadership of the commune, trade is more closely geared to agricultural production and other local needs. Basing themselves on the commune's over-all production plan, the trading organizations assess and supply the amounts of chemical fertilizers, insecticides, farm implements and other items needed by the brigades and teams. Also in accordance with the plan, they make prompt purchases of farm and side-line products and arrange proper outlets for them. Their supply and marketing services help considerably to boost production ..."[3]

"The production brigade, functioning under commune leadership, directs its teams in production and administration. The brigade participates in the preparation of the teams' production plans, and guides, examines and supervises their production, income distribution and financial work. It helps them improve management, initiates and runs brigade-wide water conservancy and other farm capital construction projects and, when necessary, organizes joint undertakings between the teams ..."[3]

3 Wu Chou, *Report from Tungting - A People's Commune on Taihu Lake.*

"Ownership at the production team level is basic at the present stage of development. Within the team's area, all land, and all forest and water resources other than those managed by the State, as well as draught animals, farm implements and small farm machinery, belong to the team. Neither the commune nor the production brigade can use them without compensation ..."[3]

"The production team is the basic accounting unit in the commune. In other words, it organizes production and distribution of income, handles its own accounting and is responsible for its own profits or losses."[3]

39. Institutional machinery above commune level was of less direct concern to the Workshop, but it was of some interest that election of members of the county congress started with election of voters by social (mainly occupational) groupings.

40. As indicated above, the words of the Constitution "elected by secret ballot after democratic consultation" summarized a process whereby a consensus was reached on nominees for office before the matter was formalized by voting.

3. Technical support and training services

41. It has been mentioned that there was no government departmental structure below the county level. Communes and lower units were encouraged to develop within their own members the technical competence necessary for the achievement of their development goals. Provision was made, however, for the assignment of specialist cadres (government officers) to a commune by the State when required. Those technicians might work at any level within the commune system.

42. There was also provision for assistance with training. In addition to normal procedures whereby citizens with suitable qualifications might receive higher education, in-service training might be provided at one level for trainees from lower levels. This could include trainees sent by the commune for experience at the provincial level.

43. If a subsidy was being sought for a proposed work, or it affected other communes, the proposal must be submitted to the county for approval, which automatically involved a check on its technical soundness. This service might also be provided on request, even if the proposal affected only the one commune and no subsidy was being requested.

D. INSTITUTIONAL MACHINERY: WATER CONSERVANCY

1. Introduction

44. The arrangements observed and discussed in relation to water conservancy were no doubt similar to those in other areas of activity, but there were some special factors associated with the nature of drainage basins. The basic underlying principles were, as mentioned earlier, involvement and motivation of the masses and maximum effective decentralization. Additionally, in the case of water conservancy, the system appeared to encourage an integrated approach to the management of land and water resources.

45. Except in the case of the Tsing Ping irrigation project, which involved multipurpose development of a river basin, the Workshop was involved with projects and operations carried out within the commune system. However, arrangements in the Tsing Ping irrigation project, a county project, are illustrated in annex III.

2. Initiation of projects

46. It was a reflection of the Chinese approach that projects seemed to be initiated at the lowest level of identified community need and possible remedial action. The effect was that, from the very beginning, projects were closely identified with those who expected not only to benefit from them but also to make an important contribution to their construction. As part of the spirit of local self-reliance, the State was seen as a supplementary resource to be called on only if necessary, rather than as the main provider.

3. Planning, design and construction

47. The planning, design and supervision of construction of work to be carried out by a production team would normally be done by the brigade which also had responsibility for work affecting several teams, or related to brigade interests as a whole. It could, however, seek help from the commune. At each level, plans should be approved by the authority at the next higher level, but once plans were approved at the higher level, responsibility for construction and management was again delegated as far as possible.

48. The concept of multipurpose projects applied at the commune level, and not only for larger projects. In the Yangtze delta area, navigation was often an important component along with irrigation and drainage, and fisheries might also be significant.

49. With regard to over-all planning, it was reported that there were soil maps for all agricultural land, and water was

commonly the limiting factor in the development of agriculture. The policy was to encourage the formulation and implementation of water conservancy plans at all levels. As mentioned above, large inter-provincial projects were the responsibility of the central Government; medium-sized projects were frequently designed by a prefecture, checked and approved by the provincial administration revolutionary committee (with the Water Conservancy Bureau checking technical soundness), with the counties responsible for recruitment for construction.

50. Where there was a need for additional water supplies to make full use of the land in a large or medium-sized project, the water users were requested to adopt all possible water-saving measures, and the local authorities were encouraged to carry out additional smaller water conservation works linked to the main system. In such cases there was a linking of a number of levels of administration in the evolution of the final scheme.

51. In the case of works involving more than one commune, the county would normally construct, operate and maintain those works which could not be related directly to the interests of one commune, and delegated responsibility for the remainder. This is discussed in more detail later in relation to the Tsing Ping irrigation project.

4. Financing

52. As with other aspects, decentralization of financing was the normal approach, and the high degree of success achieved was a very good indicator of local self-reliance. Capital development funds were commonly formed at the production team as well as brigade and commune levels. Thus the production team was commonly the basic accounting unit, as well as being the basic water user in irrigation systems, since there were no individual irrigators except for home gardens. In some cases, such as the Tong Hsin brigade, there was no capital fund at the team level, and it was suggested that that arrangement was coming into favour, since it enabled a more flexible development programme by a larger community.

53. Capital funds were accumulated by setting aside a part, commonly from 7 per cent to 12 per cent, of the income from activities managed by the team, brigade or commune, together with income from side-line activities carried on within the respective unit.

54. Depending on the needs of the unit concerned, a state subsidy might be made available for water conservancy projects. This commonly ranged from 10 per cent to 20 per cent, where the commune or brigade was relatively well off, to 30 per cent to 40 per cent where the need was greater. Higher subsidies were provided in some cases, such as for irrigation and drainage works carried out by the Tong Hsin brigade, where the subsidy amounted to 60 per cent. The subsidy could take a variety of forms, but in principle was aimed at providing those resources which were most difficult to obtain locally. For instance, in the case of the Tong Hsin brigade the subsidy was largely in the form of pumping equipment and construction material. The Wu Chiao commune obtained cement and reinforcing steel at subsidized rates. Where the local work force was inadequate, assistance might be given in obtaining additional labour.

55. Funds for maintenance were raised by charges on water users (production teams). Charges were normally based on the area irrigated, and varied with the intensity of land use. The average was about 15 yuan per hectare[4] per year, ranging from about 9 to 18 yuan depending on the number of crops grown. Funds might also be raised from other water uses such as navigation and fish breeding. Similar charges were levied by the State in relation to state projects or components.

5. Cropping pattern (annual plans)

56. Each year the State compiled over-all production plans with targets for various agricultural commodities. Targets were allocated through provinces, prefectures and counties to communes, which made allocations to brigades and production teams. The allocations were made having regard to conditions such as soil suitabilities for various crops, stage of development, available water, skills and other resources, together with previous production records. Provision was made for negotiation if at any level it was felt that the allocated target was inappropriate.

57. Cropping patterns in individual areas were often subject to an evolutionary process associated with improving levels of soil fertility, and development of improved irrigation and drainage facilities, and that was reflected in the process of fixing annual plans. Thus, as with other issues, the determination of cropping patterns involved a continuing process of communication between the various levels from the central Government to the production team.

6. Water allocation and system operation

58. Good management of water conservancy projects was given the same importance as good construction, the policy being "those who built the project should manage it".

59. Responsibility for day-to-day water allocation and system operation was generally exercised at the same levels as for construction, and this might involve several levels, depending on the size of the project. In nearly all cases,

4 1.69 Yuan = $US 1.00 (approximate estimate, not official, August 1978).

however, the system was based on requirements as assessed by the production team, the water user. The Workshop visited one brigade, however, Lung Chao, in which there were no production teams, and all operations were managed by the brigade itself. The system used was none the less very similar in all cases.

60. Whether or not there were production teams, the area controlled by a brigade was divided into blocks of what might be termed production team size (commonly varying from 10 to 20 ha) and one person was assigned full time to control deliveries to and drainage from the individual plots of land within those blocks. In the common case where there were production teams, the water manager was selected by the team and responsible to the team leader.

61. Depending on the nature of the supply of irrigation water, requests for water were aggregated to give requirements at progressively higher points in the system. Where pumping was involved, one person was assigned full time to each pumping station, by the authority responsible for its performance. This operator was responsible for maintenance as well as operation of the equipment.

62. At the brigade level there might be a vice-leader responsible for water management, or that responsibility might be assigned to one of the brigade members. He was responsible to the brigade leader for those components of the system under the control of the brigade, the objective being to provide water as required to the team, or equivalent areas. Personnel controlled by the brigade water manager might include pump operators and individuals assigned the control part of a distribution system. Similar arrangements applied at the commune level.

63. However, at the Tung Pei Wang commune at Beijing, remote control of 25 wells had been established at brigade level, and three pump operators were now able to handle the work, instead of the normal practice of providing one or two attendants at each well.

64. The case of projects involving more than one commune was illustrated by the Tsing Ping irrigation area referred to earlier, and illustrated in annex III. Over-all responsibility lay with a people's unit, the irrigation area management committee, comprising the chairman of the seven communes and two towns benefiting from the project, together with the chairman of the reservoir project management division referred to below. The committee met weekly to implement resolutions of senior authorities, to formulate and manage irrigation plans, and to popularize recommended irrigation practices.

65. The reservoir project management division was a technical body comprising state personnel and was responsible for management, operation and maintenance of the reservoir, distribution and drainage system down to the level at which responsibility was assigned to the communes. The division had five functional units – Office, Engineering, Irrigation, Multipurpose Activities and Hydroelectricity. Sixteen management stations had been set up within the area as focal points for operation and maintenance of the main, sub-main and distributary channel system. The division (State) assumed direct responsibility for operation and maintenance of the main and sub-main system, the remainder being handled within the commune administration.

66. The distributary canal committees were established on a commune basis, and comprised the water conservancy member of each brigade (generally a vice-leader) and a representative of the division. These committees also met weekly, their functions being to implement resolutions of the area management committee, to develop ways of making more efficient use of water, and to operate, inspect and maintain the distributary canals under their care.

57. In that area the production teams were grouped in their natural villages for operational purposes. Each village had a water management group comprising a representative from each production team. Its functions were to formulate plans in accordance with farm activities, to regulate the water flows, and to save water through the use of good irrigation practices. The members of the group were those directly involved in controlling water use on the land.

68. Requests for water from individual production teams were first considered by the group, and if agreed were considered and co-ordinated by the distributary canal committees, which sought appropriate releases of water through the system.

7. Maintenance of irrigation and drainage systems

69. The general requirement for good management included provision for systematic maintenance. Each area was required to establish a maintenance team and carry out a planned system of maintenance. This was generally done with the same organization as for operation, labour being provided by the affected units in proportion to the benefits received. In addition, intensive maintenance was carried out at the end of irrigation of the second crop.

70. In a number of cases it was noted that one of the reasons given for converting open irrigation and drainage systems to covered systems was the reduction in maintenance requirements.

8. Agricultural research and extension services

71. The degree of decentralization of agricultural research and the methodical integration of research findings were

notable features of practice in China. Experiment stations appeared to be common at the brigade level, and might include rice-seed breeding. Such stations were also established and operated at the commune and higher levels as appropriate. Support for such activities might be provided by the State. For instance, in one case, equipment for sprinkler irrigation trials had been so provided. Technical assistance might also be made available through the assignment of cadres with specialized knowledge.

72. Experience gained at such stations was popularized by various methods, including the holding of demonstrations, the provision of lectures and guidance to production teams and arranging for demonstration plots at suitable scattered locations.

9. Integrated rural development

73. A consistent feature at the places visited was the integrated approach, not only to irrigated agriculture but also to the integration of that development into the total development of the community. This included the timely provision of all requisites for the agricultural programme, orderly marketing, facilities for repair and maintenance of equipment, and, often, for the manufacture of equipment at the commune and brigade levels, roads, town planning and industrial development in relation to rural development and so on.

E. PRACTICES IN WATER CONSERVANCY

74. The systems visited during the Workshop provided the participants the opportunity to observe and study irrigation and drainage practices in southern, south-eastern and northern China.

75. Although water in the Tsing Ping irrigation area was relatively plentiful by normal standards in China, it was still the limiting resource. High water tables were a problem mainly in the natural depressions and lower reaches of the area. In the Yangtze delta, however, land was the limiting resource within the areas visited. Natural drainage of the land was poor, the land surface being generally below high tide level except at Wuxi, and special attention had to be given to both surface and subsurface drainage to overcome the hazards of floods and waterlogging. In all cases irrigation was essential for intensive and reliable crop production because of the strongly seasonal and variable rainfall. The main crops were rice and wheat and, to a lesser extent, cotton.

1. General approach

76. Small projects were considered the mainstay of water conservancy work, with medium and large projects providing the necessary support, particularly for mitigation of floods and droughts. Classification was based on area irrigated, i.e. small size less than 10,000 mou,[5] medium size 10,000 to 30,000 mou and large size more than 30,000 mou. Small projects were encouraged because they optimized use of local materials and other resources and the projects were easy to operate and maintain. Medium and large projects were often needed as well for proper development and use of resources.

77. In carrying out projects, it was essential that local conditions were studied and analysed, requirements determined and appropriate measures adopted with a view to making the best use of available resources.

78. Comprehensive river-basin planning and multipurpose development were adopted whenever possible. This applied particularly to large river basins for which the Ministry of Water Conservency and Electric Power was responsible, but was also evident on quite small projects.

79. Reflecting the importance ascribed to water conservancy, masses of peasants, between 50 and 100 million depending on conditions, were organized to carry out water conservancy works during the slack season, commonly referred to as the winter-spring campaign. Land levelling was the major work, but special teams were also formed for important projects.

80. One of the important objectives of China was to increase and stabilize agricultural production through irrigation. To realize that objective, great attention was paid to the proper use and management of irrigation systems not only in order to make full use of the available water resources but also to ensure the safety of the systems. The Government had therefore instituted a policy of giving equal importance to the proper construction and management of projects. That meant that every structure should be constructed, operated and maintained very well.

81. To carry out the policy, it was essential that complete management organizations be established. Projects built by communes and brigades were managed by the communes and brigades themselves, while projects built by the Government were managed by special bodies organized by the Government. The general rule followed was that whichever authority constructed the system, or any portion thereof, managed it.

82. It was also important that water utilization plans should be drawn up annually or before each irrigation season so that the water could be allocated and supplied in time for irrigation. In the case of systems managed by brigades or communes, water allocation and supply prob-

5 15 mou = 1 hectare.

lems could easily be resolved, as those bodies could make their own decisions. For systems managed by the State, however, it was necessary to have a unified plan which specified how much water should be supplied to each user for a given period of time during the irrigation season. The factors considered in preparing the plan were:

(a) Size of area and kinds of crops grown based on local production plan;

(b) Irrigation and cultivation practices for the crops grown;

(c) Type of soil on which crops were grown;

(d) Available water resources;

(e) Capacity of the conveyance canals.

83. Where water supplies were limited in relation to water demand, certain measures were adopted to conserve water supplies. The water users were requested to save water. They were encouraged to use "self-prepared" water resources such as small tanks and ponds, which they were encouraged to build near irrigation canals like "melons on a long vine". In northern China, many tube wells were drilled so that ground water could be used conjunctively with surface water.

84. In addition to the above measures, land levelling was a basic requirement which was considered particularly important to increase irrigation efficiency.

85. A very important aspect in the efficient use and maintenance of irrigation systems at the farm level was the effective extension (popularization) techniques adopted by China in ensuring that efficient irrigation techniques were applied by the water users. The Workshop observed that those extension techniques frequently made use of slogans which could be remembered easily by the production teams.

86. Among some of the general irrigation practices which were passed down to the water users were the following:

(a) Avoiding "running-water" irrigation – applying irrigation water independently and individually to each plot;

(b) Using shallow water irrigation;

(c) Carrying out watering day and night;

(d) Controlling the ground-water level in the soil.

87. Examples and details of the application of the above were explained to the participants during their visits to project areas.

88. An illustration of the application of the general approach outlined above was seen in the Tsing Ping irrigation area in Pinyang County, Guangxi Province.

89. The importance of the formulation of water utilization plans for the timely mobilization and utilization of inputs was emphasized in the slogan of the "Three Definites" and the "Four Reach to the Field" The "Three Definites" were programmes for irrigating a definite area at a definite time with a definite discharge, while the "Four Reach to the Field" simply meant that water, man, work animals and machines should all reach the field at the same time.

90. In order to optimize the use of the water supply of the system, the "Five Firsts" slogan was adopted which laid down the following basic rules:

(a) First use natural flow of streams and return flow from irrigation areas and then water from ponds and small reservoirs;

(b) First use water from small ponds and reservoirs and then use water from the main reservoir;

(c) First irrigate fields in high lands and then in low areas;

(d) First irrigate large plots and fields and then odd and scattered fields;

(e) First irrigate crops with the greatest need and then those whose needs are not so urgent.

At the same time attention was required to be paid to the following "Four Relationships":

(a) Between irrigation and food control. While it was important to discharge water to prevent flooding, it was also important that as much water as possible should be stored for irrigation;

(b) Between upstream and downstream areas. There should be equitable distribution of water between the two;

(c) Between big discharges and small discharges. In the case of drought, high discharges should be released first so as to reach the tail end of the canal and then smaller discharges maintained. This would minimize water losses and crop damage;

(d) Between power generation and irrigation requirements. Power should be generated only when water was required for irrigation purposes.

2. Distribution and drainage systems

91. Before 1949, the areas visited in the course of the Workshop consisted of irregularly shaped farm lands

drained by meandering water courses. Because of their low elevation, these areas were often subject to floods and waterlogging during wet years but were also subject to drought during dry years. The average annual yield of rice ranged from 100 to 250 kg/mou. After the construction of water conservancy works and arid land consolidation, average annual rice yields increased significantly, the increases ranging from about 400 to 1,000 kg/mou.

92. The distinctive features and practices characterizing the irrigation systems visited during the Workshop were: (a) protection from flooding by the construction of earth embankments around low-lying farm land; (b) careful land preparation through high standards of land levelling and consolidation in regular rectangular blocks of a size to suit local conditions; (c) careful application of irrigation water according to knowledge of crop water requirements gained from local experience and disseminated widely to the members of production teams; (d) provision for irrigation and drainage of plots invididually; (e) control of the ground water table; (f) extensive and intensive use of pumps for irrigation and drainage; (g) provision of access roads; (h) conjunctive use of surface and ground water, including full utilization of supplemental sources of water supplies.

(a) *The Tsing Ping water conservancy works*

93. The general slope in the irrigated area was about 1 in 500 but the individual plots were level. From one plot to another plot there was some difference in level depending on the slope of the land. Where the slope was large, the fields were terraced and the field ditches served as drainage channels for the upper terrances and irrigation channels for the lower reaches.

94. The field ditches were open ditches fed by distributaries which ran parallel to the sub-main canal below the ground surface for some distance. These distributaries also served to collect drainage water from adjacent rice fields and at the same time fed water to field ditches downstream. Where the distributary canals took off from the sub-main canal, simple gated regulators made of rubble masonry were provided. Flow at these bifurcations was measured by staff gauges. The water level in the sub-main canal below the gate regulators was lower than the ground surface, enabling surface drainage water to enter the canal.

95. The plots were irrigated through gaps cut in one corner of the small embankment surrounding the plot, through which water flowed from the field ditches and which could be closed with earth when required.

96. Water could be let into the plots or drained from them by raising or lowering the water level in the field ditches by blocking or unblocking the field ditches below the supply point with earth or small slide gates. Thus, the field ditches could be used for both irrigation and drainage. No measuring devices were used for delivery of water to the individual plots, but it appeared that the experience of the operator enabled efficient water management to be achieved.

97. Drainage water collected from upper fields was used to irrigate downstream areas. One such drainage canal at the Chou Shu people's commune (7.5 km long, 7 m wide, 1.6 m deep with a capacity of 11 m^3/sec) replaced a small and narrow meandering stream. In a number of cases it was noted that lined channels had nearly vertical sides in order to reduce the land area required for a channel with given discharge capacity.

98. In the Kung Tsun production brigade irrigation area, a typical field plot was rectangular, 20 m wide and 50 m long. In general, it was irrigated and drained by the same field ditch but in some cases, depending on the topography, there were separate field and drainage ditches.

99. Field ditches were generally 40 cm wide and 30 cm deep while separate open drainage ditches were generally 60 cm wide and 40 cm deep both being nearly rectangular in cross-section. Field ditches were spaced 100 m apart so that water was applied in opposite directions from each field ditch running between rows of 50 m x 20 m plots. In one area a single outlet at the corner of four plots served all four, with the water flowing away from the outlet in all directions.

100. While plot sizes varied considerably, there seemed to have been a careful planning process to relate plot size and irrigation and drainage systems to the prevailing conditions.

(b) *The Yangtze delta*

101. Except for the Mei Bei production brigade, which was located away from tidal influence, the systems visited in the Yantze delta were in low-lying areas subject to flooding from high tides and heavy rainfall and, in addition, on land at higher levels, losses associated with droughts. The pattern before 1949 had been one crop per year from uneven land which was poorly drained and inadequately watered, with irregular natural watercourses and depressions. Individual blocks were therefore irregular in size and shape.

102. More recently, extensive works had been undertaken with emphasis on the following:

(i) Construction of dykes or embankments to protect low-lying areas from high tides;

(ii) Restructuring the natural channels to provide a regular pattern suitable as a source of irrigation water, as a main drainage system, and as a basis for water transport;

(iii) Control of water levels within the project area by gates and locks and associated pumps;

(iv) Provision of pumps to serve the land to be irrigated, by pumping from the channel systems the head was commonly 2 to 3 m;

(v) Provision of surface and subsurface drainage systems to enable accurate management of surface water supplies and water table, in accordance with the crop requirements;

(vi) Land preparation involving the subdivision of land into rectangular blocks suited to local conditions – commonly 15 to 25 m wide and 80 to 100 m long – and precise levelling of each block;

(vii) Progressive conversion of open supply channels and drains to covered conduits constructed *in situ* using a mixture of subsoil and lime;

(viii) Direct water supply to and drainage from each individual plot for accurate and rapid water control on the land.

103. The increasing use of covered supply and drainage systems was based on improved speed and flexibility in water management, lower operation and maintenance costs, improved access for agricultural equipment and a saving in cultivable land compared with open channel and drain systems. Tractor ("walking tractor") roads were commonly constructed over the covered conduits.

104. Subsurface drains were commonly at a depth of 1 to 1.2 m, and a spacing of 10 to 20 m. At Mei Bei, a spacing of about 7 m was used as the subsoil was clay with a very low permeability.

105. In the systems affected by tides, water quality was suitable for irrigation and, in normal circumstances, water was admitted to the system twice a day by gravity. After heavy rain it was necessary to dispose of the water quickly, and pumps were provided at the frontage with the river system for that purpose.

106. One of the brigades visited had summed up the purpose of the water conservancy works as the "four separates":

(i) To separate the water in the rivers and channels outside the area from the system inside the area;

(ii) To separate the water in the higher areas in the project from the water in the lower areas;

(iii) To provide separate irrigation and drainage;

(iv) To enable separate management of paddy and dry (wheat) fields.

107. The emphasis on flexibility and speed in water control was illustrated in the Wu Chiao people's commune where originally a small number of large irrigation pumping stations, each serving 470 ha, had been built. That had been progressively modified, and there were now 23 pumping stations each serving about 70 ha.

108. In all cases the system was based on the main channel system being used as a drain and irrigation supply and for water transport. Irrigation water was pumped on to the land and returned to the drain by gravity. Water levels on the main channel system were controlled at the desired levels by pumps, gates and locks.

(c) ***Beijing area***

109. In northern China, which was a semi-arid region, 60 million mou of farm land was irrigated mainly through the conjunctive use of ground water and surface water. Where the water table was near the ground surface, the use of ground water and resultant lowering of the water table prevented soil deterioration owing to waterlogging and salinization. In the Beijing area, 4 million mou of farmland was irrigated by both surface and ground water.

110. The Workshop participants visited the Tung Pei Wang commune in the Beijing area where the typical techniques in the conjunctive use of surface and ground water were explained. Of the total area of 33 sq km, the commune first levelled 1,500 ha, consolidated the land into big plots of 15 ha, which in turn were subdivided into smaller plots of 2 mou according to unified plan. Irrigation canals were constructed to convey only surface water from the nearby Ching Mi diversion project and open drainage ditches were excavated. Every 500 m there was a distributary canal serving 2 to 3 ha through field ditches which supplied water to 25 m by 50 m plots.

111. As the surface water was insufficient, 130 wells, 120 to 140 m deep, were drilled to supplement the surface water with ground water. There was a well for every 15 ha. The commune, which grew wheat, corn and rice, received 70 per cent of its irrigation water from ground water and 30 per cent from surface water.

112. The techniques for drilling, testing and developing wells appeared to be similar to conventional practices. Percussion-type drilling equipment was used with drilling mud to keep a 550 mm hole open while installing a 330 mm-diameter steel casing, opposite the aquifers the casing was perforated and wound with wire, and gravel packed. Samples were taken at each aquifer for analyses and a well log was maintained. Pump tests were, however, sent to the First Mechanical Research Institute (a national body) for analysis and determination of appropriate pump capacity and setting. Pumps were generally at 17 hp and could discharge 87 cu m per hour.

113. The annual average total power consumption of each pump (serving 15 ha) was from 600 to 800 kWh. As the cost of electricity was 6 fen per kWh for rural development (compared with 20 fen per unit for industry), the annual cost of pumping came to 2.4 to 3.2 yuan per mou over the area. This water charge varied according to the crop grown and was 2 yuan for rice, 3 yuan for vegetables and 70 to 80 fen for wheat and corn.

3. Maintenance

114. Reference has already been made to the attention given to systematic maintenance of water conservancy works. It was also frequently noted that steps had been taken to modify systems or to use devices and systems which not only operated efficiently but also had low maintenance requirements. The use of covered supply and drainage conduits, and of concrete for gates of all sizes down to farm outlets, were illustrations of this.

4. Irrigated agriculture

115. The term "irrigated agriculture" was particularly appropriate in discussing practices in China since, as mentioned earlier, the whole approach was based on integration of all the components involved in achieving optimum use of land and water resources for crop production. In previous sections reference has been made to those matters which seemed to be of the greatest interest and importance, but it may be convenient to summarize here the factors which seem to be critical.

116. First, however good the available technology and resources might be, it was unlikely that they would be used with full effectiveness unless the people concerned were suitably motivated, and that consideration underlay all others. Secondly, since, for China as a whole, water was the limiting factor in agricultural development preparation of land as a basis for efficient irrigation was treated as a matter of outstanding importance. That involved regular size and shape of individual irrigation plots, and levelling of land within those plots to an exceptioally high standard. For the same reason, there was a continual striving for optimum performance in the systems themselves, and in their operation and maintenance, in irrigation and drainage facilities, in order to produce the highest yields per unit of water provided. As part of the same concern, great attention was paid to soil fertility, with special emphasis on the use of organic fertilizer produced locally, and to the development of plant varieties suited to local conditions through seed-breeding programmes.

117. It was made clear to the Workshop participants that the itinerary had been planned to show some of the areas in which considerable progress had been made in achieving the desired standards of productivity and efficiency, since that was the basis for the Workshop. While further progress was expected in the areas visited, in spite of their relatively advanced state, there were many other parts of China which were currently far behind those which had been visited. South and south-eastern China were relatively well endowed with water, and the same levels of productivity could not be expected on a general basis.

118. In that connexion, reference might be made to some differences in practice associated with water availability. In the Yangtze delta, where water suitable for irrigation was commonly available only a metre or two below the level of the land surface, and could be pumped on to the land at low cost, rainfall which did not fit in with the carefully planned watering programme was drained off as quickly as possible, so that in spite of the substantial rainfall most of the crop water requirements were met by irrigation. In the Tsing Ping irrigation area, however, although most of the area was served by gravity, water was the limiting factor, and use was made of the rainfall as far as possible. The wet season occurred mainly during the growth of the second rice crop, and about 300 mm out of a total of about 500 mm was effective as far as irrigation was concerned.

119. In all areas visited south of the Yangtze, rice was the principal crop, and the precise watering schedules which had been developed seemed to involve, in effect, water availability to the production team almost on demand, although rostering appeared to be practised to some extent. The practices observed in the south involved a capacity in the supply system somewhat higher than might otherwise have been expected. It was understood that in drier areas it was the policy of the Ministry to encourage irrigation on a roster system with a view to reducing not only the capital cost but also losses from seepage and evaporation. In such cases, rostering was based on the layout of the distribution system rather than on existing administrative subdivisions.

120. In spite of differences reflecting local conditions, practices in the areas visited south of the Yangtze were broadly similar, and the general features are summarized in annex IV. It was notable that in all cases detailed information was available on water applications at the various growth stages of rice, reflecting systematic study at experiment stations, followed by effective "popularization" programmes to ensure that the best practices were adopted. The watering sequence for rice was related to plant requirements not only for water, but also for aeration of the root zone, and for appropriate temperatures. Thus the water was allowed to drain from the soil for periods of about a week at certain stages, and, at the early stages of the first crop, depth of water was designed partly for protection from low temperatures.

121. In general, the productivity per unit of water used was very high compared with values commonly encountered in other countries of the region. For instance, total water consumption for a crop of rice was generally below 900 mm, with yields up to 6 tons per hectare.

122. Quick draining of the flat plots was assisted in many cases by field ditches near the perimeter of the plots, and often down the middle, and connected to the drainage outlet. The ditches were commonly about 12 cm wide and 20 cm deep.

123. In those areas also, the growing of three crops per year was common, and that practice was being extended. The most common rotation in the areas visited was wheat-rice-rice, with cotton or barley as alternatives to wheat in some cases. Where the winter crop was not a grain, a green manure was often grown, bird's-foot trefoil being the most common variety encountered, with milk vetch used in one case (Wuxi County).

124. In all cases, special attention had been given to the control of the water table to suit the different requirements of the paddy and the winter crop. Where the water table was controlled by open drains, the depth was varied from about 60 cm for rice to about 1 m to 1.2 m for wheat, by digging out and refilling as required. In that case, the depth of the internal field ditches referred to above was also varied with the crop, being about 18 cm for rice and 50 cm for wheat. Where subsurface drainage had been provided under the plots, the outlets were controlled, and were kept closed when rice was being grown, except when the plots were being drained, and open during the growth of the winter crop.

125. The following summary of rice irrigation practice, which was provided in relation to the Tsing Ping area, illustrates the care that was taken in the matter. The practice was based on studies at the experiment farm since 1966, and was referred to as the nine links in rice cultivation. As shown, they were first presented in very brief form, presumably for easy memorizing, and then elaborated a little.

(i) Soak the field before transplanting;

(ii) When transplanting, use shallow water;

(iii) When growth resumes, use deeper water;

(iv) When tillering, keep soil moist;

(v) After middle cultivation, leave at original moisture;

(vi) When full tillering, expose to the sun;

(vii) At the heading stage, use shallow water;

(viii) When milking, keep moist;

(ix) Expose to the sun for harvest.

(i) Normally the field would be as ploughed, with organic or green manure buried in the soil. The furrows had a spacing of about 20 cm and a depth of about 15 cm. The first soaking involved filling the furrows to about half depth, then allowing them to dry, after which harrowing produced a smooth, level surface. An application of 10 to 15 mm of water was then made, allowed to dry on the surface, and followed by a second harrowing and watering. It was stated that the successive small waterings resulted in better retention of soil fertility and higher soil temperature than a single large watering.

(ii) Transplanting was done with a water depth of 6 to 9 mm, following a third watering as above. Care was taken to ensure planting at the correct spacing and depth. Where mechanical transplanting was done, the care taken in land levelling was an important factor in securing uniform depth of planting. Spacing and the number of plants per "hole" are given in annex IV.

(iii) During the green period which began five to seven days after planting, a depth of 30 to 50 mm should be maintained. This greater depth of water acts as a buffer against undesirably high or low temperatures.

(iv) During tillering, water should be at such a level that the tops of the small ridges in the cultivation were showing. That allowed higher soil temperatures, which increased tillering, and aeration of the soil with improved fertility.

(v) Middle cultivation was carried out about 8 to 12 days after transplanting. Often weeds were buried by working with the feet in the soil and at the same time "stirring" the soil; fertilizer was also applied. The field was then allowed to dry out for two or three days, stimulating further root development. Irrigation was then resumed.

(vi) At full tillering, the field was again allowed to dry out, the length of time being four to seven days, depending on the vigour of the plants. That process increased tillering.

(vii) Water should be applied two to three days before heading, and kept at a shallow depth, 6 to 9 mm, until heading the flowering were completed.

(viii) Conditions at the milking stage were important for yield. At that stage water should be applied every three to four days and allowed to drain quickly, followed by drying until the soil would no longer stick to the feet.

(ix) Little water was required during the ripening stage, but watering should not be stopped too early or there would be premature ripening and an increase in the proportion of empty grains. On the other hand, if watering was carried on too long, there was liable to be an increase in pests and diseases and a delay in maturing, as well as a waste of water.

126. Reference has been made to the emphasis on developing and maintaining soil fertility. Information on practices in the application of fertilizer is also summarized in annex IV. In all areas visited, organic fertilizer was regarded as the basis of soil fertility management. It commonly consisted of a mixture of green manure, straw, pig manure, mud from the bed or banks of rivers/channels and miscellaneous waste material. Applications in the areas visited ranged up to 75,000 kg per ha for each of three crops per year.

127. Management practices for other crops were not obtained in much detail, but some information is also given in annex IV.

128. Only one visit was made in northern China, to the Tung Pei Wang commune near Beijing. Of the total cultivated area of 1,500 ha, 900 ha were used for grain. Two crops per year were grown, the most common combination being wheat and corn with some wheat and paddy. All the cultivated land used for grain had been formed into 50 x 25 m plots with facilities for irrigation of each plot individually, along similar lines to those observed in the south. Water-table control was obtained by the use of deep open drains.

129. Reference has been made to the use of slogans to popularize good practices. The setting of goals or targets by the Government and by people themselves was also common. Maps and charts showing planned development and/or production by 1985 were on display in a number of places visited. In various places a time limit was set for the complete conversion to "Dazhai-type" fields - plots of regular rectangular shape, but with some flexibility in dimensions to suit local conditions, accurately levelled for efficient water management, and with facilities for irrigation and drainage of each plot independently. Reference was also made to the goal of achieving "tonnage fields" - yields of one ton of grain per mou (15 tons per ha) per year. It appeared that goal-setting played a significant role in the continuing improvement of productivity.

F. MAIN FACTORS AND TRANSFERABILITY

130. On the basis of observations and the information gathered, the items listed below, not necessarily in the order of their importance, were considered the main factors which contributed to the effective use and maintenance of irrigation systems at the farm level in China. They are grouped under three main headings:

(a) Administrative and sociological issues;

(b) Engineering and water management;

(c) Agriculture.

131. It was realized that, for various reasons, not all the factors listed below could be adopted by other countries while some could be adopted with varying degrees of difficulty, and over varying periods of time. For purposes of indicating their transferability, the factors were classified into four groups: (1) those which were already being carried out by one or more countries; (2) those which could be carried out without any serious obstacle; (3) those which could be carried out but would require some time for preparations or adjustments; and (4) those which had little prospect of adoption.

132. The numbers in brackets after each factor in the list below correspond to its transferability according to the above classification. In some cases, a factor was classified under more than one category because of its different applicability to different groups of countries, or even in different situations in individual countries.

1. Administrative and sociological issues

133. – Motivation and mobilization of people (see para. 136);

– Development of plots of land of such size and shape as would lead to efficiency in irrigated agriculture (3);

– Integration of irrigation with related agricultural activities, and of irrigated agriculture with all aspects of rural development (1);

– Use of slogans for dissemination of techniques (2);

– Use of goals or targets set by the Government and by the people themselves (1, 3).

2. Engineering and water management

134. – Formation of regular blocks of land (1, 2, 3);

– Land levelling (1, 2);

– Provision of flexible water supply and comprehensive drainage systems to serve individual blocks and to suit different crop requirements (2, 3);

– Conjunctive use of all available water resources by meeans of large and small storages, stream diversions, drainage water and ground water (1, 2);

– Integration of irrigation/drainage systems with:
  (a) Flood protection (1, 2);
  (b) Farm access roads (1);
  (c) Water transport (1);

– Land reclamation through straightening of meandering water courses (2);

- Extensive use of appropriate local materials, techniques and experience (1);
- Use of appropriate designs for simplicity in construction, operation and maintenance (1, 2).

3. Agriculture

135. Use of practices at the farm level based on local experience to increase productivity and optimize water and land use, and, in particular:

- Careful application of irrigation water in accordance with locally determined plant requirements (2, 3);
- Timely use of fertilizers, particularly locally produced organic fertilizers, to build up and maintain soil fertility (1, 2);
- Use of seed suited to local conditions (1, 2);
- Establishment of research stations and demonstration farms in the subject areas, linked with extension services (1, 2).

136. It would be noted that the first factor - motivation and mobilization of people - was not placed in any category because there were a number of elements which contributed to the successful motivation and mobilization of people, each of which could by itself have a different degree of transferability. The elements identified by the participants as being specially important are listed below and have been classified according to their transferability:

(i) Collective ownership of land (4);

(ii) Profit sharing (by work point system) (4);

(iii) Provision of agricultural credit, inputs, storage and marketing facilities (1, 2);

(iv) Decentralization of planning and decision-making (3);

(v) Generation of local capital development funds (3, 4);

(vi) Production target setting through negotiation (4);

(vii) Use of slogans for dissemination of state policy (2);

(viii) Stable prices for agricultural products (3);

(ix) Decentralized demonstration farms and extension services (2);

(x) Education of the public concerning achievements in agricultural production (1, 2);

(xi) Free and frequent flow of public information up and down the organization (3);

(xii) Fairly frequent public selection of leaders, direct at the lowest level, indirect at the higher levels, through a system of negotiation and consensus (1, 2).

137. Although the first two elements listed above, which were considered particularly important, did not seem likely to be applied directly in other countries, it should be noted that there were other ways, already within the experience of some countries, by which most of the benefits associated with those elements might be achieved. Countries might find different ways, through appropriate legal and institutional machinery, to achieve most of the benefits. For instance, various forms of co-operative seemed to offer real prospects of providing the necessary motivation. That type of development called for vigorous programmes for the training of competent leaders, particularly for small rural communities, and it was considered that that warranted the highest priority.

G. CONCLUSIONS AND RECOMMENDATION

138. The conclusions and recommendations of the Workshop are listed below.

1. Conclusions

139. The Workshop had been a very valuable experience which had contributed to the knowledge of the participants in the effective use and management of irrigation systems at the farm level.

140. Most of the technological and agricultural factors identified at the Workshop were transferable to other countries with only modest degrees of difficulty.

141. The principal factor contributing to the success of China in this field was the effective motivation and mobilization of people. That factor comprised a number of elements some of which could, with minor modifications, be applied to other countries without serious difficulty. Although it was recognized that a number of the elements, being closely related to the institutional arrangements in China, could not be adopted by other countries because of differences in social, economic, cultural and political framework, as mentioned in paragraph 137, countries might find different ways, appropriate to their own circumstances, by which most of the desired benefits could be achieved.

2. Recommendation

142. Having regard to the vital importance of the efficient use and management of irrigation and drainage systems at the farm level in increasing the productivity of land and water resources and improving the well-being of the people of the region, it was recommended that the factors in section F be carefully considered and applied to the maximum possible extent, having regard to local circumstances.

Annex I

LOCATIONS VISITED AND OFFICIALS ENCOUNTERED

24.8.1978 *Guangzhou, Guangdong Province*

Ministry of Water Conservancy and Electric Power

Mrs. CHU Yun-pei	Staff member
Mrs. MENG Chih-min	Staff member
Mr. HO Sung-han	Staff member
Mrs. HAN Ching-cheh	Staff member

Foreign Affairs Division, Water Conservancy Bureau, Guangdong Province

Mr. YAO Chang-kuei	Deputy Chief
Mr. TENG Lieh-meng	Staff member
Mr. WU Pen-cheng	Staff member

25.8.1978 *Nanning, Guangxi Zhuang Autonomous Region*

Ministry of Water Conservancy and Electric Power

Mr. LOU Fu-li	Chief, Farmland Irrigation Division

Bureau of Water Conservancy and Electric Power, Guangxi Zhuang Autonomous Region

Mrs. KAN Ku	Director
Mrs. CHEN Miao-ying	Technician

Division of Foreign Office of the Region

Mr. LUO Hsieh-san	Chief
Mr. CHANG Hsueh-ho	Section Head
Mr. HU Chun-feng	Interpreter
Miss PAN Hsueh-ling	Staff member

Bureau of Water Conservancy and Electric Power, Guangxi Province

Mr. CHANG Chuo-liang	Bureau Chief

26.8.1978 *Tsing Ping Reservoir, Pingyang County, Guangxi Zhuang Autonomous Region*

Pingyang County Revolutionary Committee

Mr. YANG Ching-su	Deputy Chairman, Irrigation

Reservoir Management Authority

Mr. MENG Kuei-fu	Director

Reservoir Experiment Station

Mr. WEN Cheu-shou	Technician

27.8.1978 *Tsing Ping Reservoir, Pingyang County, Guangxi Zhuang Autonomous Region*

Kung Tsun Production Brigade, Shing Ping People's Commune

Mr. TENG Chao-chi	Brigade Leader

Chou Shu People's Commune

Mr. MENG Tse-chian	Deputy Chairman, Commune Revolutionary Committee
Mr. WU Chee-chiang	Staff member, Commune Revolutionary Committee

28.8.1978 Travel from Guangxi-Guanzhou-Shanghai

29.8.1978 *Shanghai*

Shanghai Farmland Capital Construction Headquarters

Mr. FAN Chung-yi	Deputy Director
Mr. WANG Cheng-chung	Chief, Planning and Design Division
Mr. MIAO Chin-tang	Water Conservancy Engineer
Mr. LU Pao-cheng	Staff member
Mr. LI Chun-lin	Staff member

Shanghai Agricultural Bureau

Mr. YU Peng-chun	Technician
Mr. YANG Yu-chen	Staff member

Wu Chiao People's Commune, Feng Hsian County

Mr. LIU Huei-lin	Vice-Chairman, Commune Revolutionary Committee
Mr. JI Yong-chun	Head, Commune Irrigation and Drainage Station

30.8.1978 *Shanghai*

Shanghai Industrial Exhibition Centre

Mr. CHANG Chin-ken	Staff member

31.8.1978 *Suzhou Prefecture, Jiangsu Province*

Water Conservancy Bureau, Jiangsu Province

Mr. YUAN Hong-Shen	Staff member

Water Conservancy Bureau, Suzhou Prefecture

Mr. NI Yong-shen	Head
Mr. HSU Hsing-rong	Technician
Mr. CHUANG Kuan-yan	Staff member

Reception Group, Suzhou Prefecture

Mr. YUAN Tsi-on	Staff member

Chung Chao People's Commune, Wuhsian County	
Mr. SHEN Gi-shin	Vice-Chairman, Commune Revolutionary Committee
Mr. CHIENG Chen-tuag	Hydraulic Technician
Mr. SUNG Yu-hsin	Agricultural Technician
Lung Chao Production Brigade	
Mr. LO Kui-yuan	Deputy Leader
Mr. WANG Lung-shu	Water Pump Station Manager and Production Team Leader
1.9.1978 *Kun Shan County, Suzhou Prefecture, Jiangsu Province*	
Chen Pei People's Commune	
Mr. TAO Hsueh-liang	Vice-Chairman
Mr. LI Hsin	Technician, Water Control
Mr. WU Chung Teh	Technician, Agriculture
Tong Hsin Production Brigade, Chen Pei Commune	
Mr. SHEN Wei-chun	Brigade Leader
Mr. CHIN Ting-kun	Brigade Accountant
2.9.1978 *Wuxi County, Suzhou Prefecture, Jiangsu Province*	
Wuxi County Bureau of Water Conservancy and Electric Power	
Mr. CHENG Yu-sheng	Head, Water Control and Agriculture Group
Mr. LU Lin-ken	Technician
Mr. TSU Bo-mieng	Reception Group
Mei Tsun People's Commune	
Mr. KAO Hsu-yie	Vice-Chairman
Mr. CHU Ming-wei	Secretary
Mr. LENG Chung-ying	Agricultural Technician
Mr. SUN Pe-liang	Water Conservancy Technician
Mrs. CHIAN Fung Chuan	Sericulture Technician
Mei Bei Production Brigade	
Mr. CHOU Shen-hsian	Brigade Leader
3.9.1978 (Overnight at Wuxi - depart for Beijing by train at 12.30 hours)	
4.9.1978 *Beijing*	
Ministry of Foreign Affairs	
Mr. PI Chi-lung	Director, Department of International Treaties, Laws and Organizations

Ministry of Water Conservancy and Electric Power	
Mr. LI Po-ning	Vice-Minister
Department of Foreign Affairs, Ministry of Water Conservancy and Electric Power	
Mr. YANG Ting-yuan	Deputy Director
Mr. CHU Ching-teh	Deputy Director
Mrs. TSOU You-lan	Interpreter
5.9.1978 *Hi Tien District, Beijing*	
Tung Pei Wang People's Commune	
Mr. WANG Chen-hong	Vice-Chairman - Education
Mr. LI Yuan-hai	Vice-Chairman - Production
Mr. SOON Ting-yi	Commune Technician
Mr. LIU Huai-shih	Head, Water Conservancy Section
Mr. TENG Tse-fa	Well Sinking Team
Hi Tien District Water Conservancy Bureau	
Mr. DUAN Sao-hua	Technician

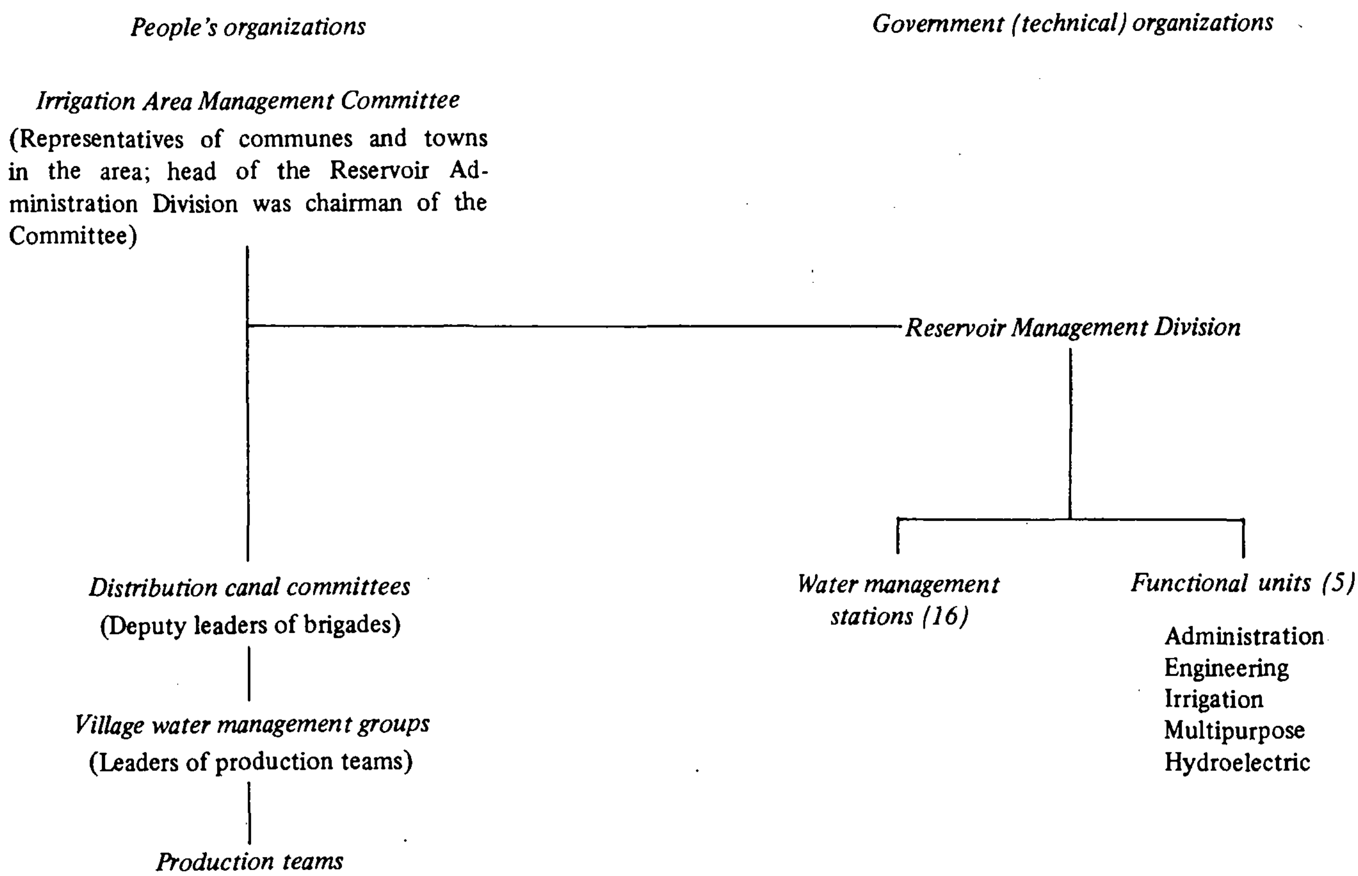
Annex II

INSTITUTIONAL MACHINERY

Level	*People's administration*	*Government unit*
State	National People's Congress, Standing Committee and State Council	Ministry of Water Conservancy and Electric Power (WCEP)
Province (Municipality, Autonomous Region)	People's congress and revolutionary committee	Bureau of WCEP
Prefecture		Bureau of WCEP
County	People's congress and revolutionary committee	Bureau of WCEP
Commune	People's congress and revolutionary committee Commonly, a vice-chairman of revolutionary committee had responsibility for water conservancy, and headed commune group on that subject. A brigade vice-leader might have similar functions at brigade level. One water manager commonly designated by production team.	No unit as such; cadres assigned to work in commune administration

Annex III

ORGANIZATION OF TSING PING AREA



Annex IV

AGRICULTURE

Location	*Common crop rotations*
Tsing Ping area	Rice-rice; some winter "green manure"
Yangtze delta	Rice-rice-wheat (most common) Cotton-wheat, or green manure (once or twice in three years, in rotation with the rice-rice-wheat sequence, in one of the areas visited) Cropping intensity 260 and 275 per cent in two areas visited
Beijing	Corn-wheat (most common) Rice-wheat

Rice-water and fertilizer sequences and applications

Tsing Ping

Water

For watering sequence see paragraph 125. Total application, two crops, formerly 1,200 mm, currently 600-700 mm. Effective rainfall about 300 mm in addition to irrigation. On experiment station, total water use, including effective rainfall, was reduced from about 750 mm in 1967 (first year) to about 640 mm in 1971.

Fertilizer (kg per ha)

A Before cultivation, basic fertilizer (ploughed in): 22,500 kg green manure; 15,000 kg organic fertilizer; 225-375 kg superphosphate; 75-120 kg urea.

B "Mid-cultivation" (8-12 days after transplant): 75 kg urea; 11,000 kg organic manure.

C Twenty days after transplant: 75 kg potash; 375-750 kg lime.

Yangtze delta

	Transplant	*Recovery*	*Tillering*	*Heading or earing*	*Milking*	*Ripening* / *Harvest*	*Total irrigation (mm)*
Shanghai							
Water (mm)	150	45	30		60	150	c. 440 excluding nursery
Fertilizer (kg per ha)	AB	C		D			

A Before ploughing, basic fertilizer;
22,500 kg pig manure;
45,000-75,000 kg organic fertilizer

B After ploughing
375 kg ammonia liquor (17 per cent N)

C One week after transplanting;
225 kg ammonium sulphate

D At beginning of earing;
75 kg ammonium sulphate

	Transplant	Recovery	Tillering	Heading or earing	Milking	Ripening	Harvest	Total irrigation (mm)
Suzhou								
Lung Chao:								
Water applied (mm)	140	60	210	220 (little effective rainfall)			150	750-900 excluding nursery
Tong Hsin:								
Water depth on soil (mm)	150	50	30	Intermittent irrigation until five days before harvest				570-940 plus 110 for nursery

Intermittent irrigation was mainly a seven-day cycle with 40-50 mm depth for five days followed by two days quick draining and drying. Total water varied with temperature and plant variety.

Wuxi:
Fertilizer

For each rice crop:
750,000 kg organic fertilizer ploughed in
150 kg ammonium phosphate during transplant
150 kg ammonium phosphate one week later

For wheat:
Organic fertilizer as above
225 kg ammonium phosphate

Rice transplanting pattern

	Varieties	*Plant space*	*Row space*	*Plants per "hole"*
Tsing Ping	Ordinary	90 mm	150 mm	7-9
	Hybrid	120 mm	210 mm	1
Shanghai	Ordinary	100 mm	130 mm	5 or 6
	Hybrid	60 mm	70 mm	1 or 2
Wuxi	Ordinary	80 mm	150 mm	7

Yields (kg/hectare)

Tsing Ping	*1966*	*1972*	*1977*
Two crops:	7,500	12,000	12,750
Shanghai	*pre-1949*	*1977*	*1978 (est.)*
Grain/year	2,600	13,400	16,000+
Cotton	240	960	1,320

Suzhou	*pre-1949*	*1958*	*1964*	*1970*	*1976*	*1977*
Lung Chao						
Grain/year	3,600	5,700	9,450	15,000	18,150	16,000
Tong Hsin				*1969*		
Grain/year	1,500		6,000	7,500	13,300	11,300

Lower yields in 1977 were associated with very low temperatures.

Beijing

Rice about 5,250 - 6,750 for one crop (600-900 mm irrigation)

Wheat about 4,500 - 5,250 for one crop (90 mm irrigation).

Part Two

REPORTS AND OBSERVATIONS OF PARTICIPANTS

Part Two

REPORTS AND OBSERVATIONS OF PARTICIPANTS

I. PROJECT REPORTS

A. TSING PING IRRIGATION AREA

1. Location, size and engineering features

(a) *Location and size*

The Tsing Ping irrigation area in Ping Yang County of Guangxi Province covered seven communes and two towns. The area was served by one main reservoir and 57 small ponds. The originally designed irrigated area was 120,000 mou (8,000 ha), which was expanded to 169,700 mou (11,313 ha) by the utilization of return flow and the improvement of engineering facilities and irrigation practices.

(b) *Tsing Ping reservoir*

This main reservoir was formed by a homogeneous earth dam about 32 m high and 122 m long and five auxiliary dams. The catchment area was about 76 km^2 with an average annual runoff of 68 million cu m and a minimum flow of 0.55 m^3/s. The gross and effective storage capacities were 76 million cu m and 62 million cu m respectively. There was a saddle spillway with a discharge capacity of 2200 m^3/s. A hydroelectric power plant with three units of total capacity of 760 kW was located at the toe of the dam. The total discharge capacity of the power plant and irrigation sluice was about 15 m^3/s. The main dam was constructed from 1957 to 1959.

(c) *Small ponds and pumping stations*

Subsequently 57 small ponds had been constructed with a total storage capacity of 12.24 million cu m. In addition, 60 small pumping stations with total capacity of 1080 kW and four small hydroelectric powerplants with a total capacity of 1135 kW diverting water from neighbouring streams had been completed.

(d) *Irrigation and drainage system*

A typical so-called Dazhai - type field was a rectangular plot, 20 m wide and 50 m long. Each plot was irrigated by a field ditch as shown in figure I. In some fields, plots were irrigated and drained by the same field ditch. In others, depending on topography, there were separate field ditches and drainage ditches. Field ditches were generally 40 cm wide and 30 cm deep, while drainage ditches were generally 60 cm wide and 40 cm deep. Both were more or less rectangular in cross-section.

Field ditches were spaced 100 m apart. The distributary canals were 200 m apart. They received water from the sub-main canal. In some sub-main canals there were check structures, which diverted water into the distributary canal. In other sub-main canals check structures were not necessary. The control and regulation of water into the distributary canals were assigned to a staff member of the water management station.

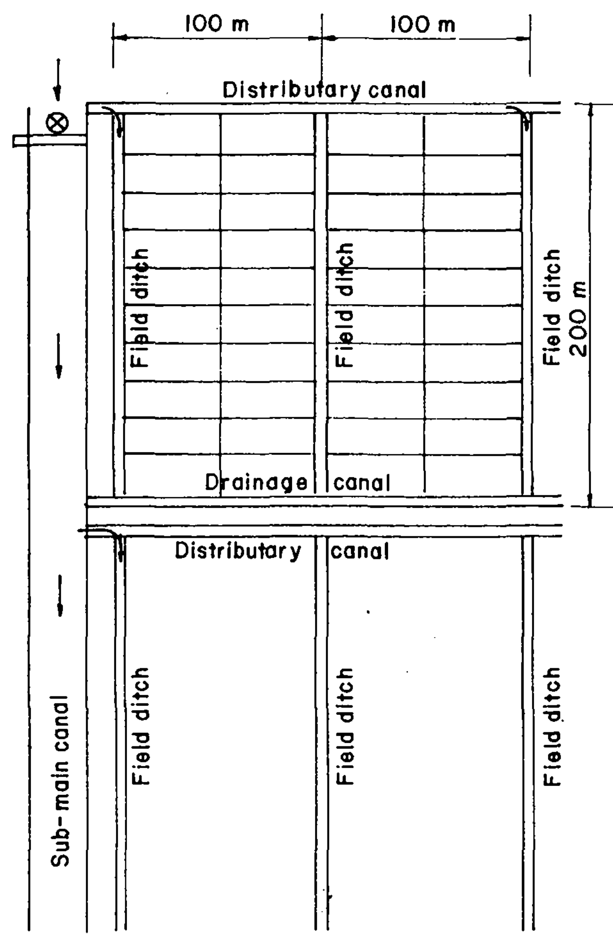


Figure I. Typical layout of field ditches

There was a total of 2,428 field ditches having a total length of 755 km serving the irrigated area. There was a total of 1,163 gates.

(e) *Main drainage channels*

In the Tsing Ping irrigation area, some stretches of natural meandering streams had been modified to become straight drainage channels lined with masonry. They increased the hydraulic efficiency, provided protection to adjacent land from inundation, drainage congestion and erosion, and helped to reclaim land for agriculture from the original serpentine river bed. In addition, they conveyed drainage water to lower land for irrigation. Drainage flow from neighbouring areas was let into the canalized streams through inlets in the masonry side wall at an appropriate level. These inlets prevented retrogression and gully formation which often took place when drainage water flowed over the natural slopes or unlined artificial drains.

One such drainage channel, called the Fight-in-Heaven Canal, was 7.5 km long, 7 m wide and 1.6 m deep with a slope of 1 in 200 and a discharging capacity of 11 m^3/sec. It used to be a very small and narrow channel with 63 bends. The construction, involving 49,000 cu m of earth work, 10,700 cu m of masonry, several bridges and check gates, was completed by the Chou Shu Commune in Ping Yang County in 70 days. The cement was provided by the Government and the labour force of 385,000 man-days by the commune.

(f) *Experiment station*

An agricultural experiment station was attached to the irrigation area. The experimental area was divided into 1.5 mou (1,000 m^2) rectangular plots. Masonry irrigation and drainage channels with internal dimensions of 20 cm and 25 cm were provided. They ran on two sides of the plots. Water was supplied for irrigation through a gap at one corner, and drained out through a gap near another corner into the same channel, by raising or lower the water level in the channel by the simple operation of blocking or unblocking the flow with an earthen plug or a small sliding gate. Thus the same field ditch could be used for irrigation and surface drainage.

2. Irrigation water management

(a) *General*

Over-all responsibility lay with a people's unit, the Irrigation Area Management Committee, comprising the Chairmen of the seven communes and two towns benefiting from the project, together with the Chairman of the Reservoir Project Management Division referred to below. The Committee met weekly to implement resolutions of senior authorities, to formulate and manage irrigation plans, and to popularize recommended irrigation practices.

The Reservoir Project Management Division was a technical body comprising state personnel, and was responsible for management, operation and maintenance of the reservoir, distribution and drainage system down to the level at which responsibility was assigned to the communes. The Division had five functional units – Office, Engineering, Irrigation, Multipurpose Activities and Hydroelectricity. Sixteen management stations had been set up within the area as focal points for operation and maintenance of the main, sub-main and distributary channel system. The Division (State) assumed direct responsibility for operation and maintenance of the main and sub-main system, the remainder being handled within the commune administration.

The distributary canal committees were established on a commune basis, and comprised the water conservancy member of each brigade (generally a deputy leader) and a representative of the Division. These committees also met weekly, their functions being to implement resolutions of the Area Management Committee, to develop ways of making more efficient use of water, and to operate, inspect and maintain the distributary canals under their care (see photographs Nos.1-5).

(b) *Water regulation and control*

As water was a scarce commodity, it was important that it should be economically utilized where possible during all stages of agricultural production. The basic rules for achieving their were called the "Five Firsts" as following:

(1) All uncontrolled water was to be utilized first. That was the water from natural streams;

(2) If that was inadequate, water should be drawn from the 57 ponds and a small reservoir before drawing from the main reservoir;

(3) To irrigate first the fields in the higher reaches before irrigating the lower areas. This presumably indicated that any seepage or infiltration water from the higher areas would find its way to the lower fields which in turn would need much less water;

(4) To irrigate first large tracks of fields before irrigating smaller or scattered areas. This would increase irrigation efficiency;

(5) To irrigate first areas which needed water most. For example, areas where crops were in the heading stage or milk formation stage should get higher priority than areas under vegetation growth.

Experience in the Tsing Ping project had shown that four important relationships should be observed:

(1) The relationship between irrigation and flood control or prevention. While it was important to remove water to prevent flooding, it was also important that as much water as possible should be retained in the area for irrigation purposes during the dry season;

(2) The second relationship was that both the downstream areas and the upstream areas should have an equitable allocation of water. The normal tendency was for areas upstream to get more water at the expense of the lower reaches;

(3) The relationship between big discharges and small discharges especially during droughts. For example, during periods of scarcity of water it was better to release large discharges into the canal system for shorter duration to minimize distribution losses. Once that had been achieved, the discharges could be reduced. This practice, in addition to reducing water losses, would also minimize crop damage with the timely arrival of adequate water;

(4) The relationship between power generation and irrigation requirements. As power was secondary only to irrigation requirements power should only be generated when water was required for irrigation purposes.

(c) *Operation and maintenance of canal systems*

Every year each production team prepared a water allocation request based on the irrigated area and the crop which would be grown. The requests of all production teams were forwarded to the village water management group comprising a representative from each production team. Its functions were to formulate plans in accordance with farm activities, to regulate the water flows and to save water through the use of good irrigation practices. Requests for water from individual production teams were first considered by the Group and, if agreed, were considered and co-ordinated by the distributary canal committees, which sought appropriate releases of water through the system.

The main and sub-main canals were maintained by the State Reservoir Project Management Division, while the distributary canals and field ditches were maintained by the production team.

3. Cultural practices

(a) *Nine linkages*

Since 1966, agricultural technicians in the country had carried out research in cultural practices of paddy on clayey loam soil and after 12 years of research and experiment they reached the following conclusions, i.g. the so-called "nine linkages of cultural practices".

First link. To presaturate the fields before transplanting. This was to increase soil temperature and to regulate soil fertility so as to create the best soil condition for the rice seedlings. In order to achieve this the fields were first ploughed and water allowed to fill only to about half way up the ridges, which were about 15 cm high. Water was then allowed to dry up before harrowing. Following this about 10 – 15 mm of water was applied and the land harrowed and puddled two or three times. About 10 to 15 mm of water was let in before each harrowing. The period of soaking and land preparation was about 7 to 10 days.

If green manure was grown after the second crop it would be necessary to add lime before ploughing. Usually, lime was added twice a year at the rate of 25-50 kg per mou.

Second link. A shallow water layer should be maintained at seedling nursery. Water was first added at a depth of about 6 to 9 mm. Seedings should be planted on the top layer of the soil and not too deep, and in straight lines without leaving any space.

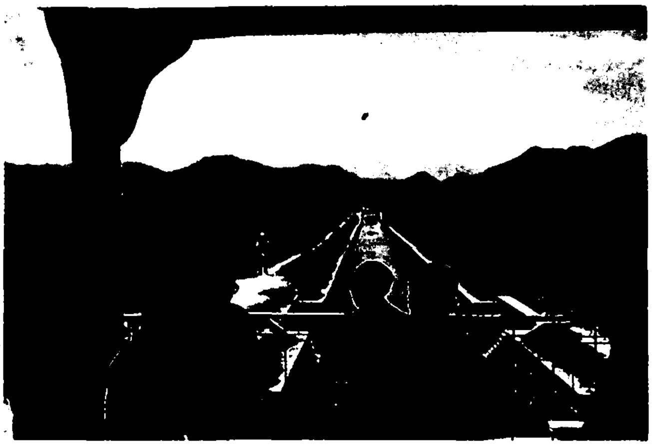
Third link. A deep layer (30 – 50 mm) of water should be maintained after recovery of the seedling, which took place 5 to 7 days after transplanting. This deep layer of water acted as a buffer against very high or low temperatures. In the case of low temperature, water retained heat and kept the soil warm. The reverse was true when the temperature was high.

Fourth link. During the tillering stage, the soil should be kept moist, preferably with no water between rows so that the soil could get more sunshine, better aeration and maintain soil fertility. Higher temperatures also increased tillering.

Fifth link. This activity was called "middle cultivation" and was carried out 8 to 12 days after transplanting. The weeds were buried into the soil with the feet and at the same time the soil was loosened. Irrigation was also stopped for about 3 days. Fertilizer was applied before the soil was loosened and the ridges raised to encourage drying, resulting in strengthening of the roots and root development.

Sixth link. At full tillering stage, the field was exposed to the sun and allowed to dry. This increased tillering. Plants growing vigorously should be exposed to the sun for 7 to 10 days but when there was less vigorous growth they should be exposed for 4 to 5 days followed by irrigation.

Seventh link. A shallow layer of water (6 to 9 mm) should be applied about 2 to 3 days in advance of heading.



Photograph 1. Lined main canal

Photograph 2. Secondary canal

Photograph 3. Division structure in canal system

Photograph 4. Lined tertiary canal

Photograph 5. Brigade canal

This depth should be maintained until heading and flowering were completed.

Eighth link. A milking stage was important for grain bearing. At that stage irrigation should be carried out every 3 to 4 days with "running" water, that is, the land irrigated and drained quickly so that the soil would not stick to the feet. With this practice, grain weight could be increased.

Ninth link. During the ripening stage, the soil did not need water but irrigation should not cease too early. This would result in premature ripening and empty grains. On the other hand if irrigation was stopped too late, it would result in increased peat and disease incidence and delayed maturity.

Where the above practice had been carried out, the annual yield over the preceding 11 years had been more than 500 kg per mou (or 7.5 tons per ha), and over the preceding 5 years the yield had been more than 80 kg per mou. In 1977 the yield was 848 kg per mou.

(b) *Fertilizer application*

During the tour, it was observed that organic manure, both in the solid and liquid form, was being used extensively in fields. It was also noted that green manure legume (bird's-foot trefoil) was planted in fields after the second crop and ploughed back into the field before the following crop. It appeared that chemical fertilizer was only used to supplement rather than as a basic requirement in most cases. The basal fertilizer application per mou consisted of 1,500 kg of green manure, 1,000 kg of organic fertilizer, 15 to 25 kg of superphosphate and 10 to 15 kg of urea. This was followed by the first application of top dressing, about 8 to 12 days after transplanting, which consisted of 5 kg of urea and 750 kg of organic fertilizer (compost). The second top dressing was then applied, comprising 50 kg of potassium, 25 to 50 kg of lime and 750 kg of organic fertilizer (compost) per mou. Deep ploughing was apparently carried out to plough in the green manure so that the decaying process would not be harmful to the newly transplanted seedlings.

(c) *Farm management*

All farm management activities were carried out by the production team as a group wherever possible. Throughout the visit the participants in the Workshop were told that all production brigades were endeavouring to consolidate their fields in accordance with the Dazhai- type field. The following points were brought up:

Land levelling. This was a basic requirement for proper management and cultural practices. Increased yield in almost all areas visited was attributed to proper land levelling so that water levels could be controlled accurately according to the crop requirements and stage of growth.

Manpower mobilization. The system of allocating points according to work done and the teamwork concept ensured mobilization of manpower when and where required.

Agricultural implements and tools. The production teams were able to obtain basic implements and tools wherever required. The underlying principle was self-reliance and the use of simple tools. In the area visited, ploughing was mostly carried out by buffaloes and oxen.

Planting schedules. In the irrigated area, only two crops of rice were grown with an additional crop of green manure after the "late rice". "Early rice" was transplanted from late March to about 5 April and harvested from about mid-July to late July.

The "late rice" was transplanted in early August and harvested in mid-November. Green manure was usually planted after harvesting and ploughed into the ground.

Decisions with regard to planting schedules were first drawn up as a general plan at the county level and, after consultation and discussion both at brigade and production team levels, schedules and quotas were decided upon.

(d) *Benefits from on-farm development and intensive cultural practices*

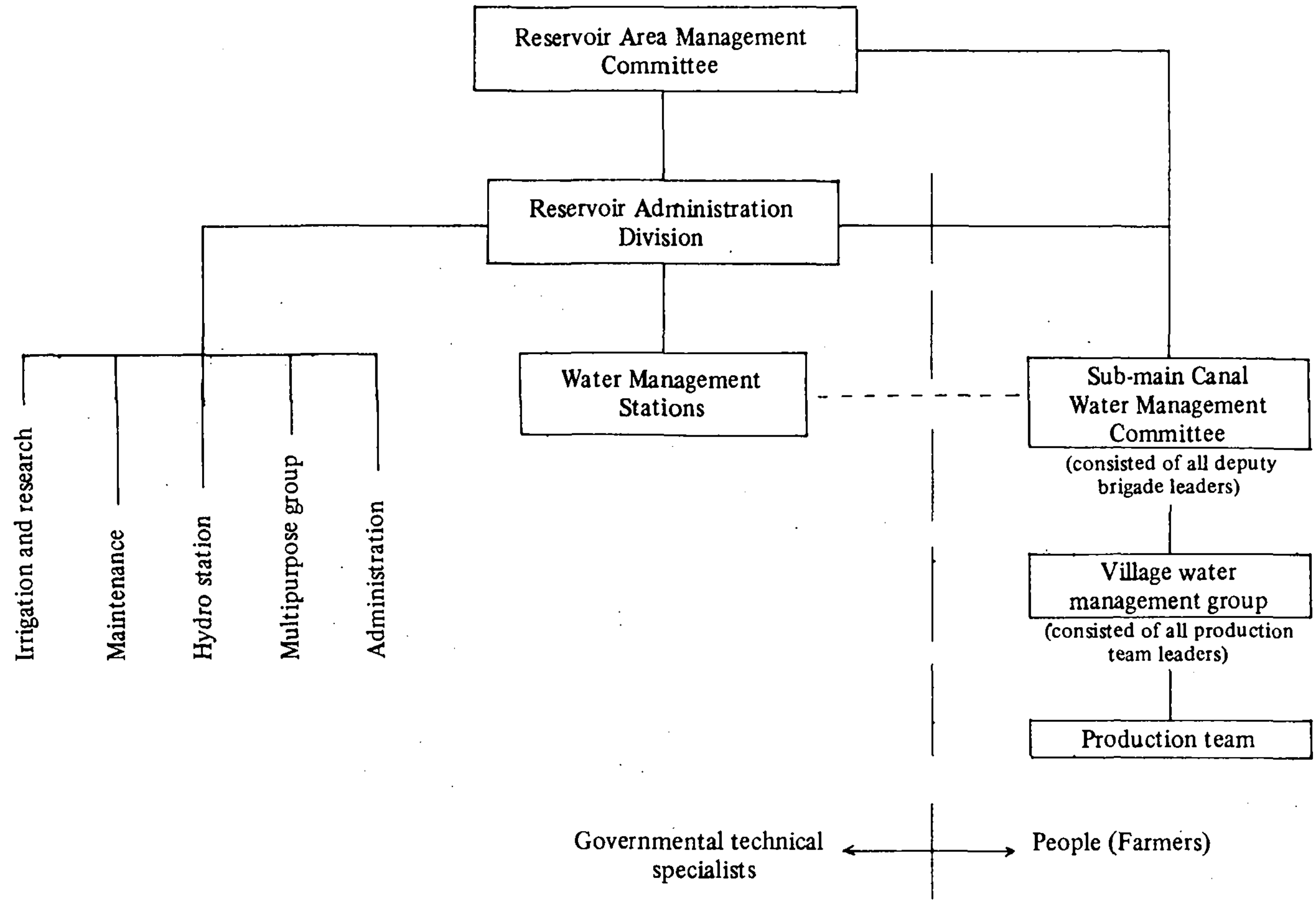
Considerable benefits were reported in all areas visited owing to on-farm development carried out by production brigades and teams. For example, the leader of the Kung Tsun production brigade reported that yields had increased from about 250 kg per mou per year to about 500 kg per mou per year. He attributed the increase to on-farm development in general and to careful and extensive land levelling in particular.

Similarly, the Chairman of the Chou Shu People's Commune quoted an increase from about 100 kg per mou per year to about 400 kg per mou per year. That area had suffered from frequent flooding and waterlogging problems which had been solved by extensive river canalization works followed by on-farm development.

4. Organization, management and finance

(a) *Organization*

The Tsing Ping water conservancy project covered seven communes and two towns. The organization for the management of the project is shown below.



Based on the information provided, it appeared that the organizational structure for management might be divided into two separate sections, namely, the government technical specialists on one side and the people, or farmers, on the other. The close link between the personnel in the Water Management Stations and the Sub-main Canal Water Management Committee consisting of all the deputy brigade leaders was maintained by way of regular weekly meetings. The structure also reflected the production-oriented management structure: the people were responsible for production and the technical specialists employed by the Government provided the support. A case in point was the experimental station, which was located in the project areas and not situated in some far-off research institute.

(b) *Decision-making*

The request for irrigation supply is cited here as an example. All requests for water were channelled through the production team via their team manager who was a member of the village water managemen: group. If supported by that group, the request was channelled upwards to the Sub-main Canal Water Management Committee which would in turn submit the request to the Reservoir Area Management Committee which would consider the requests from all other communes. The deputy director of the Reservoir Administration Division, who was a technical man, presided over the Reservoir Area Management Committee as Chairman, hence providing another link between the people and the technical specialist. After the decision was made, it was channelled to the Sub-main Canal Water Management Committee as well as the Reservoir Administration Division which would in turn instruct the Water Management Stations. From then on, the Water Management Station personnel would be in close liaison with the Sub-main Canal Water Management Committee.

The Reservoir Administration Division, besides having the Water Management Stations under its control, also had other sections providing specific functions, such as irrigation research maintenance, adminstration, multipurpose management and hydroelectric power generation.

Decisions regarding fixing the production quota of various crops and the planting schedule was a two-way process, viz. "top-down" and "bottom-up". In the case of crop production, the State would fix the quota for each county which would then estimate the quota for each commune, and so on down to production team level. The production teams would evaluate their capacity and suggest modifications to the figure and their views were then channelled upwards for revision. If the revised figure was agreed by the county revolutionary committee, the new quota would be made known to all levels down to the production teams. As for planting schedules, they were handled and decided at the brigade level.

(c) *Size of organization*

The size of the management committees depended on the size of the water conservancy works, the number of communes, towns, area of farmland, etc. In the Tsing Ping water conservancy project, the Reservoir Management Committee comprised eight members, the Chairman being the Deputy Director of the Reservoir Administration Division and the other seven members consisting of the vice-chairmen of the seven communes. The number of brigades and production teams again varied from commune to commune and, in the case of Ping Yang County, there were 57 brigades. There were 29 production teams in one brigade and each production team comprised 60 to 100 men. Each production team assigned one man to function as an irrigator and he covered an area of between 100 and 150 mou.

(d) *Financing*

As the Tsing Ping water conservancy project covered seven communes, the cost of major works, such as construction of dams and hydropower stations, were financed by the State. However, construction of the sub-main canals, distributaries, drains, and farm ditches was paid for by the commune and subsidized by the State in kind (for instance, in cement and steel). Water fees were paid to the commune by the production teams for maintenance and future improvement at the rate of 1 yuan per mou (¥15 per hectare).

(e) *Project initiation*

The project was initated by the State in view of its size and nature. Also, the project covered seven communes. However, for project works below the sub-main canal, proposals were initiated by the production team and their proposals (possibly drawn up with the assistance of the technical specialist of the Water Management Stations) were forwarded for approval before construction could commence.

B. WU CHIAO PEOPLE'S COMMUNE

1. Location and engineering features

(a) *Location and problems*

Wu Chiao People's Commune was located in Feng Hsian County near Shanghai. It had 15 production brigades and 174 production teams with a total population of 24,000 and a labour force of 10,000.

The low-lying areas were subject to flooding from high tides and heavy rainfall. Two thirds of the cultivated area was about 3 m above mean sea level, while high tides were 3.5 to 4.0 m above mean sea level. In addition, the area suffered frequent droughts, i.e. inadequate rainfall 9 years out of 10, on the average.

Before 1949, because of poor drainage and inadequate water supply, only one crop had been raised per year. Grain yield had been of the order of 2.6 tons per ha and cotton yield had been about 240 kg per ha. Ordinary farm tools had been used by the farmers because of the scattered nature of the holdings and the small size of the farm. Irrigation had been done by hand or animal power.

(b) *Engineering features*

To control the tidal water and to increase the supply of irrigation water, a water conservancy project was launched in 1964. Various engineering structures and improvements are described below.

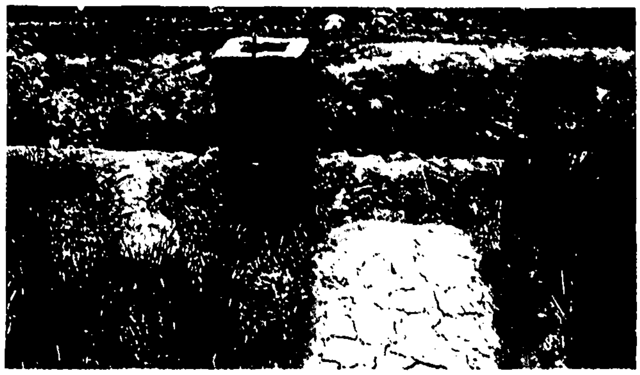
Dikes and locks. Dikes of 3.0 to 3.5 m high were built along the side of main irrigation canals and drains at vulnerable points to stop the tidal flow. Five interlinking locks and 16 gates had been installed. These had helped two production brigades in draining 700 ha of tidally affected area and had facilitated transportation.

Irrigation and drainage system. The entire commune land was divided into blocks which were further divided into plots. Each plot size was 80 m x 25 m. The main irrigation channels were covered semi-circular conduits 1 m wide and 1.5 m high. The branch channels were 60 cm in diameter round cement pipes taking off from the main at a distance of 175 m.

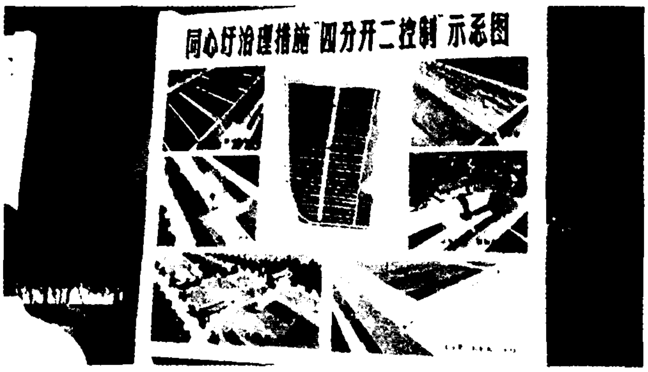
A separate drainage system was provided. Every 250 m there was a 1.2 m deep drain connecting the main drains or rivers. The river courses had been streamlined, and a new river course of 47 km had been made. They mainly served as drainage courses as well as supply canals for irrigation.

Pumps. In the beginning big pumps were installed to irrigate 470-ha plots, but these were not efficient:

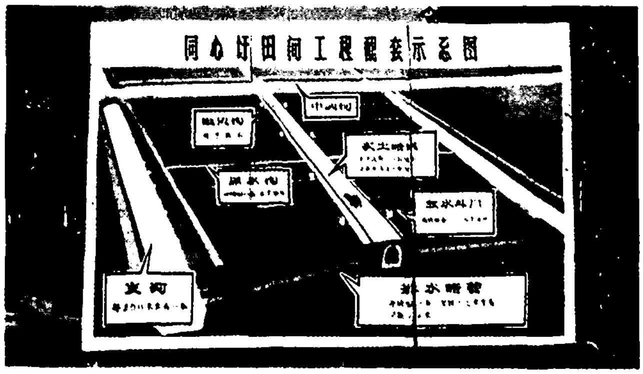
Photograph 6. Covered canal and outlet



Photograph 7. Side view of outlet

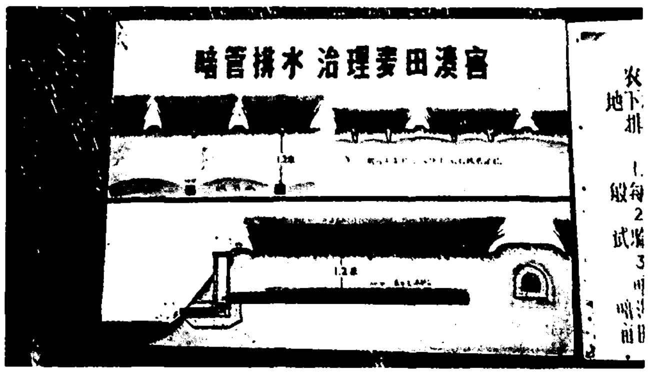


Photograph 8. Drawing slowing irrigation and drainage systems



Photograph 9. Details of deep drains

Photograph 10. Covered drain system



Photograph 11. Schematic deep drains for wheat field

Photograph 12. Samples of drain components

Photograph 13. Drain plug pulling

because of the extreme length of the canals part of the land could not be irrigated. These had now been relocated with small pumps each for 70 ha of farmland. They were easy to manage and met the need for farming activities. In all, there were 23 pumps with a total capacity of 980 kW.

Near the interlinking locks pumps were installed to drain excessive water and also to pump in irrigation water. With these pumps, even if rainfall amounted to 200 mm per day, no waterlogging would take place.

During high tides the outer lock gates were closed. For navigation and to drain the farmland, the interlinking locks were used. The pumps were also used to draw irrigation water from the rivers.

Reducing ground-water level. Ground-water recession had been given high priority. In accordance with the type of topography, soils and levels of the area, different types of ditches and canals had been constructed. In two production brigades, the ground-water level had fallen from 30 cm to 80 cm. Many ground pits had been installed for observation purposes. In another brigade, the ground-water level had been brought down to 180 cm below ground level. This had helped the development of crop roots and thereby increased crop yields (see photographs Nos. 6-13).

2. Irrigation water management (paddy)

(a) For preparation of the field, 80 cu m of water was applied per mou for soaking;

(b) During the transplanting period, a shallow water level was maintained, and 20 cu m per mou of water applied;

(c) During the root recovery period, 25 to 35 cu m per mou of water was applied;

(d) During the tillering period, a shallow water level was maintained and 20 cu m per mou of water applied in order to encourage good development of the root system. Care should be taken to keep the plant "population" at 500,000 per mou;

(e) After tillering, a plant population of only 400,000 to 450,000 should be maintained. During the ear-formation period, 40 cu m of water per mou was applied and the soil kept wet and dry alternately;

(f) After the milk stage, 100 cu m per mou of water was applied;

(g) In case of heavy rain, all the water was drained out and stored in the ditch.

3. Agricultural practices

(a) *Cropping schedule*

For an early paddy crop, seedlings required 30 days, while for late paddy they required 35 to 45 days.

An early paddy crop took about 100 to 120 days to mature from seed to seed. For a good crop the transplanting should be done in 12 days by the beginning of May. For a late paddy crop the transplating might be completed by the end of July or early August. The second crop took 130 to 140 days to mature.

One to two seedlings per hill were required for hybrid varieties and five to six seedlings per hill for ordinary varieties in order to get a good crop.

(b) *Transplanting space*

For hybrid varieties, the distance from plant to plant was 5 cm and the distance between rows 7 cm. For ordinary varieties the distances were 10 cm and 13 cm respectively.

(c) *Fertilizer application*

Basal fertilizer. During the land preparation period, 1,500 kg per mou of organic fertilizer, consisting of pig manure and farmyard manure, was applied. The application of compost (3,000 kg per mou) or night soil (5,000 kg per mou) helped in producing a better crop.

Top dressing. After the first flowering, the application of liquid ammonia at a rate of 25 kg per mou (nitrogen content 17 per cent) had proved very useful.

Additional fertilizers. For a good yield, additional fertilizers were applied during the growing period:

(a) One week after transplanting, 15 kg per mou of ammonium sulphate (containing 20 to 21 per cent nitrogen);

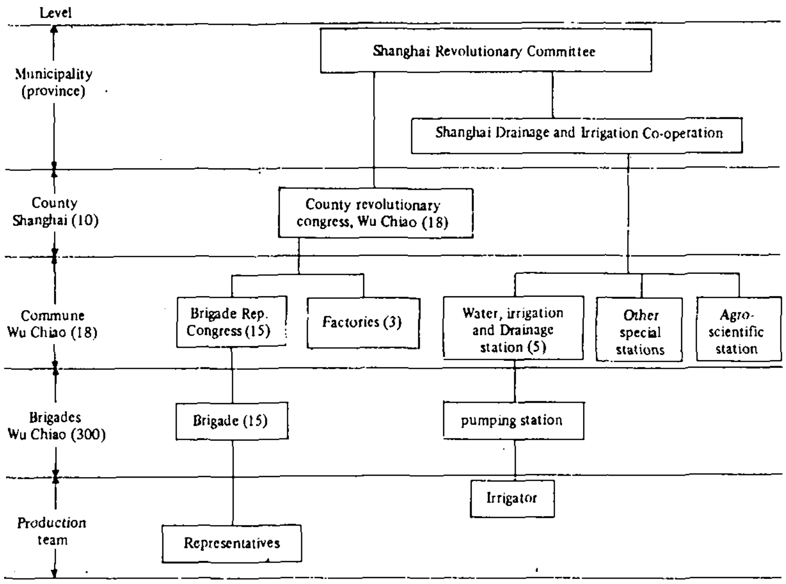
(b) During the ear-bearing period, 5 kg per mou of ammonium sulphate;

(c) In case the above two applications did not improve the crop yield during the flowering period, an additional amount of 1 kg per mou of urea.

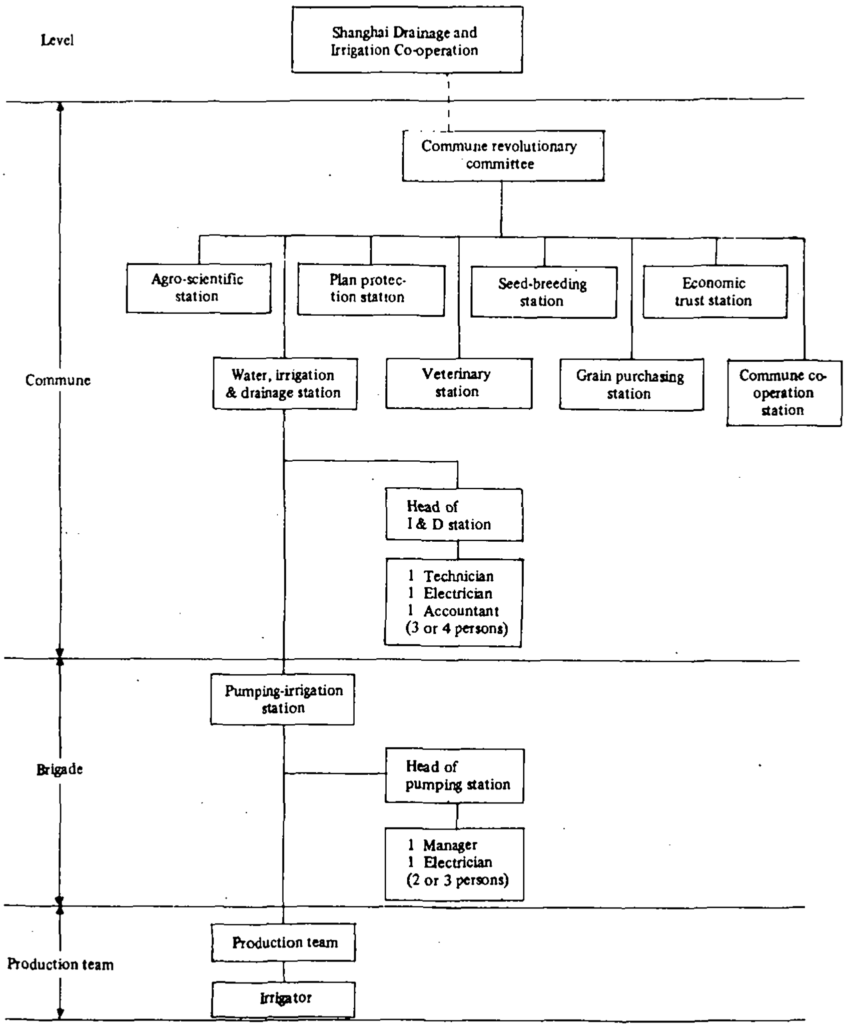
4. Organization, management and finance

(a) *Organization*

The organizational structure of Fung Hsian County was different from that of the Tsing Ping water conservancy project. The organizational chart of Fung Hsian County, with some details of Wu Chiao commune with regard to irrigation in particular, is shown below:



To help the lower hierarchy of the organization, eight specialized stations had been established at the commune level. The **Water, Irrigation and Drainage Station** **had a structure down to the production team level. An organizational chart showing some details is below:**



The people's commune congress was elected by the votes of all members aged 18 or over. Provision was made for reasonable representation of different age groups and of women. Every 60 persons of 18 or above elected a representative to the congress. The people's commune congress elected the commune revolutionary committee, which elected its own chairman and a number of vice-chairmen who were assigned responsibility for specific areas of activity. The revolutionary committee carried out functions in the nature of a board of management for the commune, with operational responsibilities decentralized as much as possible to the production brigades and teams.

The people's commune congress also elected representatives for the county congress. Wo Chiao commune had 18 such members in the county congress, out of which 15 were from brigades and the remainder were from three factories. The county congress elected the county revolutionary committee. There was no quota for each commune to be represented in the county revolutionary committee.

In the revolutionary committees there might be persons from specialized cadres assigned from the upper echelons of the organization. These cadres also acquired their positions through the election process. Although the cadres were on transferable assignment, in practice no transfer was effected unless they were disliked by the local masses or promoted to a higher post.

(b) *Initiation and implementation of the project*

The project was initiated at the grass-roots level. The whole project was planned and designed at the commune level with the help of the cadres assigned from the Shianghai Drainage and Irrigation Co-operation. The project was approved at the county level.

For execution of the project, each brigade was assigned to provide manpower in proportion to the area benefited. The brigade in turn assigned the production teams to supply manpower in proportion to the area benefited by each of the production teams.

(c) *Operation and maintenance*

Each pumping station had two or three persons on the permanent payroll of the brigade to operate and maintain the pumps. The pumps were operated according to the irrigation schedule given by the brigade.

Maintenance of the distributary canal system was arranged at the brigade level by the pump manager. The labour required as worked out by the pump manager was provided by the production teams in proportion to the area benefited.

Maintenance of the individual field ditches was carried out by the respective production team.

(d) *Financing of the project*

Capital investment for the construction of the irrigation system was financed primarily from the accumulated fund of the production teams. The brigade and commune had also financed the project from their respective capital funds, which were built out of their income from subsidiary sources, viz. fish ponds, light industries etc. Wu Chiao commune received contributions for construction of the project from Fung Hsian County in the form of supplies of cement and reinforcement steel rods at subsidized rates.

In connexion with the formation of a capital construction fund at the production team level, it might be noted here that, the production team was the basic accounting unit and obtained income from the sale of farm produce and subsidiary activities. The capital construction fund was assessed at about 10 per cent of its gross income before deductions for the cost of production including the labour provided by its members.

The water charges at Wu Chiao commune were collected by the brigades from the respective production teams as the pumping stations and the distributary canal systems were operated and maintained by the brigades. The current water rate at Wu Chiao was 0.80 yuan per mou (or 12 yuan per hactare.)

C. LUNG CHAO PRODUCTION BRIGADE

1. Location and engineering features

(a) *Location and problems*

The Lung Chao production brigade was situated in Chang Chao County, Suzhou Prefecture, Jiangsu Province. The brigade numbered about 1,440 people and cultivated land amounting to 1,043 mou (or 69.5 ha).

The land, being low lying and close to the estuary of the Yangtze River, suffered floods caused by high tides. Before 1949 there had been more than 180 hills existing in this area. Because of the irregular shape of the land and the high ground-water level, only one crop of paddy or wheat had been ground with an average yield of 240 jin per mou (or 1.8 tons per ha).

(b) *Land consolidation and engineering features*

Land consolidation. In 1964, the State Water Conservancy Bureau started improvement of this area with the people's participation. It involved 538,000 cu m of earthwork and 110,000 man-days of labour. The entire cultivable land was protected by dikes. All hills higher than 2 m were levelled and the low-lying land filled in properly. This task of land-levelling was completed in three winter-spring seasons.

Following the Dazhai type, all land was divided into 80 m x 15 m rectangular plots. All the plots were at the same level and all borders were straight (see photographs Nos. 14 – 17).

Irrigation and drainage system. There were independent irrigation and drainage systems. Five pump houses had been built, two for drainage and three for irrigation. By these separate systems the brigade had overcome the problems of waterlogging, floods and drought as well.

In order to bring down the ground-water level, deep open ditches were constructed between plots. The low ground-water level was required for the third crop of wheat. Since 1969, two crops of rice and one crop of wheat had been raised each year.

Covered canals had been laid for field irrigation: the 10-inch diameter pipe with a capacity of 300 cu m per hour could irrigate about 800 mou. Electric power was used for pumping irrigation water. There were two kinds of canals: one was made of clay and lime (30 per cent) and the other was of concrete pipe. These underground pipes ran the length and breadth of the irrigated plots. The irrigation outlet was a simple precast structure located at the intersection of four plots, and opened or closed with a mortar plug. Each outlet irrigated four plots.

The underground pipe irrigation system had three advantages, as follows:

(i) Good control in releasing water. Late rice needed a lot of water, while wheat needed much less. The system could satisfactorily meet all requirements;

(ii) High irrigation efficiency with low conveyance loss and high speed of flow;

(iii) Low maintainance cost of less land used for the irrigation system. Tractors and other farm machines could easily reach the farmland through farm roads and with standardized size of plots.

2. Irrigation water management (paddy)

A total of 500 to 600 cu m of water per mou (or 7,500 to 9,000 cu m per ha) was applied for each paddy crop. In each crop-growing period the amount of water applied was broken down as follows:

(i) Soaking (land preparation): 80 to 100 cu m per mou;

(ii) Transplanting to rice recovery, which lasted for 8 days: 40 to 45 cu m per mou;

(iii) Tillering for 15 to 20 days: 140 cu m per mou;

(iv) Tillering to ear-bearing for 15 to 20 days: 140 to 150 cu m per mou;

(v) Earing to the rice ripening stage for 30 to 35 days: 100 cu m per mou.

In the plot (measuring 80 m x 15 m), a small channel was formed in between rows in the middle or round the field to allow even distribution of water over the plot after tillering. The following points should be observed:

(i) The proper irrigation should help tillering of the rice crop, preventing defective tillering and allowing the crop to tiller early to attain higher yield;

(ii) During the middle stage of rice growing, the stem should be strong and not thin;

(iii) To attain high yields, the soil should be kept dry and moist alternately at the late growing stage.

3. Agricultural practices

(a) *Crop pattern and planting schedule*

A large percentage of cultivated land produced three crops a year: two crops of rice and one crop of wheat or green manure. In recent years the acreage under early rice had been 900 mou, late rice 1,043 mou and winter wheat 500 mou.

For early rice, the sowing should be done by 25 March and the transplanting by the end of April or early May. The crop was harvested by end of July. For the second rice crop, the sowing should be done by 10 June, transplanting completed by the beginning of August, and harvesting done by the first week in November.

(b) *Green manure*

Bird's-foot trefoil was commonly raised in this area. It was sown in the field at the earing and heading stage of the rice crop. At the end of April it was cut and mixed with pig manure and then allowed to ferment till rice transplanting. A total of 4,000 kg of this organic manure was usually applied per mou of land.

(c) *Crop yield*

Owing to improvement of the irrigation and drainage system and improved cultural practices, the annual yield of crops had continuously increased as shown below.

Year	Average annual yield	
	Jin per mou	Kg per ha
1949	487	3,585
1958	764	5,730
1964	1,266	9,495
1970	2,044	15,330
1976	2,421	18,158

4. Organization, finance and training

(a) *Organization*

The brigade took full responsibility for water conservancy work, including operation. This production brigade had a team of three persons responsible individually for the operation and maintenance of pumps, canals and the water distribution system. The lower unit of the production team did not assume responsibility for operation of the irrigation system.

The country had sent a specialist to undertake the construction and operation of the pump house.

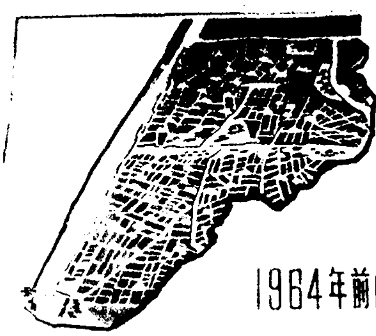
(b) *Finance*

The raising of construction funds was the responsibility of the brigade. The county did not bear responsibility for the capital fund, which fact reflected the self-reliance of the brigade in financing its construction works. It was pointed out that 75 per cent of its income came from industries, and the balance from agriculture.

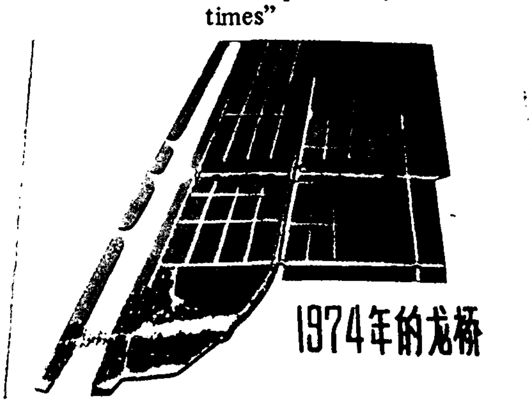
(c) *Training*

An experiment station was operated and administered by the brigade itself. It was conducting experiments on the variation of yields of paddy and cotton with different ground-water levels. It had also undertaken research on the relationship between tillering and the amount of water applied.

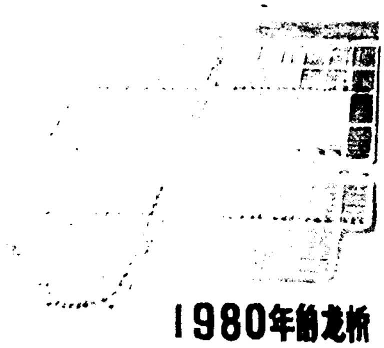
Photograph 14. Commune slogan: "Get up and work hard to carry out the responsibility of modern times"



Photograph 15. Lung Chao production brigade in 1964, before land consolidation



Photograph 16. Lung Chao production brigade in 1974, after land consolidation



Photograph 17. Lung Chao production brigade in 1980, prospective

The lessons learned at the experiment station were conveyed to farmers through lectures and classes in the evenings. The technical information was also disseminated by pamphlets and by radio.

(d) *Mobilization of labour*

It was evident that the success of the scheme undertaken by the Lung Chao production brigade had been brought about by mobilizing the entire labour force. This motivating factor was the basic factor in making the ideal a reality.

D. TONG HSIN PRODUCTION BRIGADE

1. Location, problems and engineering features

(a) *Location and problems*

Tong Hsin production brigade under the Chen Pei commune was located in Kun Shan County, Suzhou Prefecture, Jiangsu Province. In the brigade there were 15 production teams and a population of 1,930 in 510 families. It had a total cultivated land area of 2,800 mou (or 187 ha).

The Chen Pei commune faced frequent natural disasters and a waterlogging problem. As the area was low-lying, the low areas were inundated all the time. The undulating topography made the water unevenly distributed. Before completion of the engineering works, droughts had occurred in nine out of every ten years.

Because of the high ground-water level and the clay-loam soil of the area, the roots of paddy and wheat did not develop well. Only one crop of rice had been raised each year and the yield was only 1.5 tons per ha.

(b) *Engineering features*

The "four separates" principle. From 1958 the construction of engineering works was started in accordance with the following "four separates" principle:

(i) To separate the water of the rivers inside the brigade from the rivers outside;

(ii) To separate the water between high-lying areas and low-lying areas;

(iii) To separate the irrigation system from the drainage system;

(iv) To separate the water supplies for paddy fields and dry fields (wheat).

Dikes and drains. To protect the area from flood, a total length of 11.8 km of dikes had been constructed. Seventeen new river courses with a total length of 3.5 km had been opened up and a lock built to control the water level. The water was stored in river courses for use during the dry season.

Land levelling and irrigation system. The total area of 2,800 mou had been levelled and divided into 100 m x 15 m rectangular plots. The subsurface conduits carried water to the fields. These conduits ran the length and breadth of the irrigated plots, with each outlet irrigating two plots. The irrigation outlet was a simple structure with a thin mortar gate which fitted into slots. Risers had been provided to help in releasing trapped air. Four pumping houses had been built.

The total length of the subsurface irrigation conduits was 13,400 m. The conduits were made of lime and clay.

The breadth of each plot was 15 m, which facilitated the use of a tractor, the spreading of manure, and levelling and drainage.

Drainage system. The drainage system was under the surface. Subsurface drainage and irrigation systems could be operated independently. The system had been designed mainly for the wheat crop, for which the ground-water should be well below the surface. The pipe system was made up of burnt clay units, each with a cross-section of 3" x 3" and a length of 14". The pipe was 1" thick. These units were placed close to touch each other and covered with straw to allow the seepage to pass through the joints. The drainpipe ran the length of each plot at 1.2 m below the surface as shown in figure II.

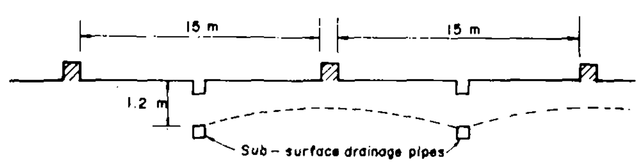


Figure II. Typical layout of sub - surface drainage pipes

Farm roads. Farm roads had been constructed over the subsurface irrigation conduits to a distance of 100 m. Each road was 40 cm higher than the ground and 3.5 m in width.

2. Irrigation water management

The irrigation water requirement for one crop of paddy was estimated at 70 to 80 cu m per mou during the nursery period and 380 to 630 cu m per mou during the period from transplanting to harvest. The following steps should be observed.

(i) Two weeks after sprouting, the field should be irrigated with shallow water of 1 to 2 cm in depth;

(ii) Three weeks after nursery sowing, it should be irrigated with 3 cm of water;

(iii) The water should be kept constant at 3 cm, especially for the early rice crop;

(iv) By the end of April or early May, transplanting started. During the transplanting period, the water depth was kept at 3 to 4 cm;

(v) After transplanting,.5 cm of water was maintained;

(vi) One week after transplanting, the water depth should be reduced to 3 cm. Sunshine raised the field temperature;

(vii) The water depth of 3 cm should be maintained for 25 days. In the process, a plant "population" of 600,000 to 700,000 per mou should be maintained. Weeding of unwanted plants should be done during this period;

(viii) After tillering, the file should be exposed to sunshine in two ways:

a. By opening the water outlet of the subsurface pipe;

b. By draining water through field ditches which were 18 cm deep;

This step lasted for six days before irrigation water was again applied;

(ix) During the grain formation stage, the soil should be exposed to sunshine. The leaves should be straight and new roots given favourable conditions for development. The leaf colour should not change because of over-dryness of the soil;

(x) Six days after draining off the water, the field should be irrigated again;

(xi) The field should/be dried out for another seven days, then irrigated with 5 cm of water for five days;

(xii) Irrigation should stop for one to two days;

(xiii) Seven days' drying and irrigation should be repeated;

(xiv) If it had rained, excess water should be drained;

(xv) At the earing stage, the field should be irrigated and a water depth of 4 to 5 cm maintained for one week;

(xvi) After one week, the field should be irrigated for five days and then dried out;

(xvii) Irrigation should stop five days before harvest.

3. Agricultural practices

(a) *Cropping pattern*

Currently, 75 per cent of the farmland produced three crops a year; the other 25 per cent produced two crops a year. The first two crops were rice and the third was wheat or rape.

For early and late rice crops the space between rows was 13 cm, while the space between plants was 10 cm.

(b) *Planting schedule and crop yields*

In 1964, the annual production from one crop of rice and one crop of weat had been 6 tons per ha. In 1969, it increased to 7.5 tons per ha with two crops a year. In 1976, the annual yield registered at 13.3 tons per ha with two crops of rice and one crop of wheat.

During 1976-1977, the approximate planting schedule and average yield of each crop were as follows:

Crop	*Duration (days)*	*Nursery period*		*Transplant date*	*Harvest date*	*Yield (kg/mou)*
		Days	*Sowing date*			
First rice	100-110	30-40	15/4	15/5	10/7	405
Second rice	120-145	40-45	15/6	25/7	13/10-7/11	270
Wheat	180-200	-	–	15/10	31/5-7/6	262
Total yield						937

(c) *Maintenance of atmospheric temperature*

The brigade had started an experiment in controlling the atmospheric temperature at 32°C by means of a sprinkling operation. As soon as the temperature went above that level, the sprinkler started functioning automatically. It had been observed that by maintaining the temperature at 32°C the formation of defective grain was reduced to 7 per cent. The effects on the yield were still under investigation.

4. Organization, management and finance

(a) *Organization*

The Tong Hsin production brigade had assumed full responsibility for operation and maintenance of the engineering works and facilities. A nine-member brigade revolutionary team played the leading role in the operation of those facilities. Four members of the team (the secretary, vice-secretary, brigade leader and accountant) were nominated by the commune revolutionary committee. The other five members were named by the brigade after thorough discussion among members. The term of the commune revolutionary committee was two years, while the term of the brigade revolutionary team was one year.

The brigade team selected two persons who distributed the irrigation water in the fields according to requirements. The team also slected one operator responsible for operation of the pumps.

As the project covered the area within the brigade, implementation had been initiated by the production brigade itself. The commune had helped the brigade technically to prepare the plan and had approved its implementation.

(b) *Finance and side income*

Sixty per cent of the capital cost of the project, which was the cost of construction materials and equipments, was borne by the State, while the rest was borne by the production brigade. All the labour requirements for construction, operation and maintenance of the project were met by the brigade. The benefits from the increased production went to the members of the production teams of the brigade.

The income of the brigade included the income from agricultural outputs, from brigade industries and from outside occupations of the members. From the total income, production costs, for seeds, fertilizers and electricity, etc. (about 30 per cent) were deducted, also public accumulation funds (about 7 to 12 per cent), public welfare fund for education, health and others (about 1 to 2 per cent) and agricultural tax to the State (3 per cent) – altogether not more than 50 per cent of the total income. The remainder was distributed among the members according to the work points earned in their respective production teams.

While the total value of the industries in the brigade was 200,000 yuan, the annual income was 100,000 yuan. In 1976, the income from agriculture was 640,000 yuan, while the income from side jobs was 85,000 yuan.

E. MEI CHUN PEOPLE'S COMMUNE

1. Location and problems

Mei Chun commune was situated in Wuxi County, Suzhou Prefecture, Jiangsu Province. The total area of Wuxi County was 5,960 sq km. It had 35 people's communes and a total population of about 6 million.

The Mei Chun commune had 21 production brigades and one brigade for fish farming. The area under rice cultivation was 29,000 mou (1,933 ha) and the area under mulberry trees was 4,100 mou (273 ha). The population of the commune was 30,800, of which the labour force amounted to about 16,000. Within the commune there was a dairy farm, a tree nursery and a pig farm. In addition, there was one agricultural experimental farm.

The main problems of the commune before improvement had been zig-zag plots of land, high ground-water level and undulating topography. The average ground elevation was about 6.5 m above sea level. During the rainy season the ground-water level had been less than 1 metre below the ground surface. One rice crop and one wheat crop had been produced per year. The yield of wheat had only been about 300 jin per mou (2.3 tons per ha).

2. Engineering features

(a) *Land consolidation*

The land surface had been levelled for even distribution of water. More than 800 mounds had been levelled and 450 depression areas and ponds filled in with earth. All land had been parcelled into rectangular plots 100 m long and 20 m wide.

(b) *Subsurface irrigation and drainage systems*

Since 1972 all the open canals had been replaced by covered conduits for a total length of 157 km. Similarly, underground drains were built. The layouts of the irrigation and drainage systems at the farm and cross-sections of the covered pipe and sub-main drain are shown in figure III. The irrigation pipes ran between the plots for a distance of

200 m. There were two gated outlets at one spot with an interval of 40 m along the irrigation pipe. Each outlet supplied water to two plots of land. The pipes were made of lime (30 per cent) and soil (70 per cent).

The subsurface drainage pipes were placed 7 m apart 1.2 m below ground level. The inner dimensions of the pipes were 8 cm x 7 cm. The sub-main drains were placed 200 m apart. Their inner dimensions were 13 cm x 13 cm. To facilitate drainage of excess water, the old river courses with a total length of 4,700 m were straightened. After completion of the systems, 95 per cent of the cultivated area could be irrigated and drained separately. Two pumps, each with a capacity of 2 m^3/sec, were used for irrigation. Drainage was by gravity.

(c) *Farm road*

On top of the covered irrigation pipes, a farm road had been constructed for tractor mobility and transportation of products, seeds, fertilizers and other inputs. Single rows of trees had been planted on each side of the road.

3. Agricultural production and subsidiary occupation

(a) *Agricultural production*

Currently, two rice crops and one wheat crop were produced over a large part of the area. A green manure crop was also produced to enrich the fertility of the soil. In 1976, the total yield of the three crops had been of the order of 1,600 jin per mou (12 tons per ha). During the year 1977-1978, the wheat yield was 460 jin per mou and the paddy yield was 700 jin per mou.

(b) *Subsidiary occupation*

In 1977, Mei Chun commune also produced 1,000 tons of cocoon and raised 2,000 pigs. In addition, this commune operated 13 factories. The value of the products and net income increased rapidly after 1971, as shown below.

Year	*Total value of products (1,000 yuan)*	*Net income (1,000 yuan)*
1970	160.2	26.7
1971	1,046.5	483.5
1972	1,467.6	507.7
1973	1,826.6	528.8
1974	2,714.1	782.7
1975	3,023.2	1,020.0
1976	3,829.5	1,119.3
1977	4,253.5	1,134.1

(c) *Schools and hospital*

In the commune there was one middle school and 20 primary schools, with a total enrolment of 6,400 studdents. There was also a hospital, and a doctor visited each production brigade for one day in each week.

4. Organization and management

(a) *Mei Chun commune*

For the commune, the responsibilities of irrigation and drainage management were vested in 11 persons, namely, the head of management, deputy head, accountant, technician in charge of operation, three technicians in charge of design, measurement and maintenance, and four operators of the pumping station and other related installations.

This management team was responsible to the vice-chairman of the commune revolutionary committee. It was noted that all of the 11 members were from the commune, not from the county. However, the county bureau provided leadership and carried out periodic inspection.

(b) *Mei Pei production brigade*

Under the Mei Chun commune, the Mei Pei production brigade covered an area of 1,300 mou of paddy fields and 118 mou of mulberry orchards. The irrigation management team, consisting of one deputy director and four operators, was responsible for the operation and maintenance of the irrigation distribution works in the fields within the brigade, including the junction boxes and distribution valves. Only the field drainage needed daily maintenance and that was done by the respective production teams.

(c) *Project initiation and planning*

Projects were essentially initated at the brigade or commune level, depending on the circumstances. The organization concerned prepared the plan in as detailed a form as possible. With that plan the project proposal was submitted to the county for approval. The county would send technicians to the commune or brigade, as the case might be, to examine the technical suitability and details of the design. In the absence of a detailed design, the county made arrangements to second competent technicians to help the brigade or commune. The cost of such technical support service was borne by the county. Such support might continue during the construction period and even up to the operation and maintenance stage, if necessary.

The commune or brigade, on completion of the design under the instructions of the county's technicians,

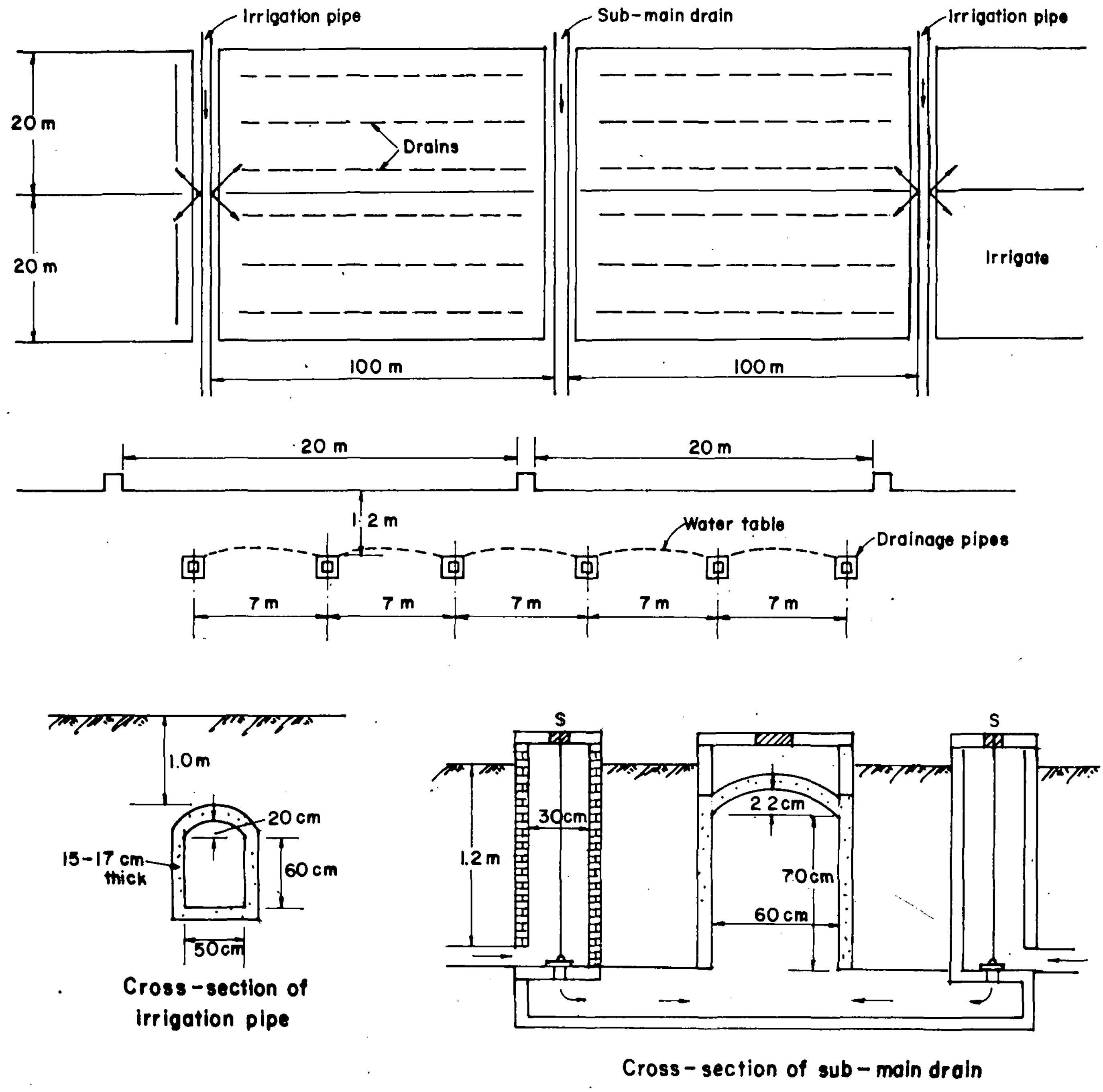


Figure III. Typical layouts of subsurface irrigation and drainage systems would resubmit the project proposal. This review and revision process continued until the project plan was properly prepared and approved by the county. During the construction period, appraisal of the project was carried out regularly by the county.

F. TUNG PEI WANG PEOPLE'S COMMUNE

1. Location, size and engineering features

(a) *Location and size*

Tung Pei Wang people's commune was located in Hi Tien District of Beijing Municipality. It consisted of nine production brigades. The total area was 3,300 ha, of which cultivated land amounted to 1,500 ha. Currently, 900 ha were under grain crops, such as wheat, rice and corn. In addition, vegetables, fruits and fodder were grown in small plots.

The commune had been organized in 1958, with 3,700 farm units and a population of 14,000. It had three towns.

(b) *Engineering features*

Rainfall in the area was scarce and uncertain. In order to raise more crops in a year and to increase yield, irrigation was necessary. To augment the canal water from the upstream reservoir, ground-water had been tapped by 130 pumping stations. The normal output of one pump was 87 cu m per hour. Operation of the pumps was conducted by remote control at the headquarters.

By pumping water from underground, the ground-water level had been drawn down from 7-8 m to 20 m. It had alleviated the waterlogging problem of the area.

The irrigation distribution network consisted of a main canal, a sub-main canal, a distributor and a field ditch. The sub-main canal served an area of 50-60 ha, while the distributor served 2-3 ha. The main canal had a capacity of 1.8 m^3/s.

In the Beijing area, there was a total irrigated area of about 4 million mou (267,000 ha). About 70 per cent of the irrigation water was ground water, while the remaining 30 per cent was surface water.

Before the completion of the engineering works, there had been a waterlogging problem. Therefore, drainage channels had also been constructed to solve this problem.

2. Cropping pattern and application of irrigation water

(a) *Cropping pattern*

Owing to the cold climate, only two crops of wheat and corn or one crop of paddy could be ground in a year. The approximate sowing and harvesting dates of each crop are listed below:

Crop	*Sowing*	*Harvesting*
Wheat	20 September	20 June
Corn	20 June	20 September
Early paddy	early April (transplanting early May)	early October
Late paddy	late May (transplanting 20 June)	late November

(b) *Irrigation water application for paddy crop*

Stage	*Amount or depth of water*
Preparation of field (soaking)	100 cu m per mou
Tillering	5 to 6 cm
Ear bearing	less than 3 cm
Milking	1 to 2 cm

After tillering, a lot of water was applied; before earing, less water. Irrigation was stopped 20 days before harvesting.

(c) *Irrigation water application for wheat and corn*

For the wheat crop, water should be applied six times with a total amount of 50-60 cu m per mou. For corn it should be applied once if there has been no rainfall.

3. Application of manure and fertilizers, and yields

On an average, 5 tons of organic manure, 50 kg of super-phosphate (18-20 per cent P_2O_5) and 50 kg of nitrogeneous fertilizer (17 per cent nitrogen) were applied per mou of land.

As a result of the improvements in irrigation and drainage techniques and improved agricultural practices, crop yields had increased considerably, as shown below.

	Jin/mou	*Ton/ha*
Wheat	600-700	4.5-5.3
Corn	600	4.5
Early paddy	800-900	6.0-6.7
Late paddy	700	5.3

4. Experimental and demonstration farms and others

There was an experimental research farm with an area of 30 mou (2 ha). About 10 per cent of the cultivated area had been used as a demonstration farm. The commune also had a farm mechanization unit for manufacturing farm implements and tools, material supply stations, one hospital and two dispensaries.

II. OBSERVATIONS OF PARTICIPANTS AND RELEVANCE TO DEVELOPING COUNTRIES

Observations	*Relevance to developing countries*
A. ADMINISTRATION, FARMERS' PARTICIPATION AND FINANCING OF CONSTRUCTION WORKS	
1. *Administration and farmers' participation*	
(a) The organizational structure in China was designed and functioned in such a way that the people of the society, starting from production team up to commune/county level, were motivated to initiate and execute water conservancy schemes. This had immense value in achieving the ultimate objective of irrigated agriculture and farm management. The organizations below country level were all "local government" in nature, having maximum statutory decentralized authority necessary to plan and execute their schemes. Those bodies did not take any decision before long-term consultation-dialogue and motivation of the people of the concerned area. As such, the mass also had confidence in the activities of the production team, brigade or commune, as the case might be. This mutual trust eliminated a lot of bottle-necks in administration and simplified the decision-making process.	(a) The organization pattern and decision-making process were quite different in most countries of the ESCAP region. Most of the decisions were taken more or less arbitrarily and the general masses were somewhat imposed upon by the administrative organs of the Government. However, in recent years efforts had been made to encourage people's participation in the decision-making process through intensive co-operative activities. The result was not very encouraging as the responsibility of the co-operative institutions without authority had apparently failed to bring about the desired result, particularly in the irrigation sector. Under the existing institutional framework of the Governments, application was not possible. However, research and field application of new techniques were always being tried to find methods to encourage people's participation in decision-making processes at the village level.
(b) The integration of the activities of both the Ministries of Water Conservancy and Electric Power and agriculture at the commune level was noteworthy.	(b) That philosophy was being planned and adopted in some countries of the region.
(c) It was noted that the system in China provided for decentralization and responsibilities were being clearly delegated at the various levels. In the planning of water conservancy projects, the Government at higher levels only provided the leadership and policy guidelines. This would make the officials at the lower levels feel responsible.	(c) The decentralization approach was certainly very interesting and the views of the Workshop participants would be put forward to their Governments for consideration.
(d) The considerable flow of consultations up and down and the procedure for fixing quotas of grain production were again interesting.	(d) This procedure would make all strata aware of the objectives and policies of the nation. But in different economic systems the quota procedure was inapplicable to other ESCAP countries.
(e) Constant tying-up of the objective of self-reliance and political doctrine would appear to be the central theme for the masses to strive for and this was one of the motivating forces to keep the masses moving and striving together.	(e) The concept of using a central theme to propagate to the masses had been adopted in some countries of the region.

Observations	*Relevance to developing countries*
(f) Group decision and agreement in the selection of leaders at the grass-roots level was noteworthy.	(f) This technique was being applied in some countries of the region.
(g) The integrated planning of supporting services in each commune was noted, such as workshops for repairs of farm machinery, brick-kilns and small factories.	(g) This concept would be useful to most countries of the region.
(h) Collective ownership of land and land reform were the main factors which facilitated the planning, design and construction of on-farm irrigation works with land levelling.	(h) Collective ownership of land in the form practised in China would not be applicable in most countries of the region, but a modified form of land reform could be adopted by enacting suitable land reform laws.
2. *Financing of construction works*	
(a) In China the social system ensured appropriate wages to individual farms through a "work points" award system. The production teams had a built-in system of putting aside 10 per cent of their gross income for construction works for their farmland.	(a) Because of different economic systems, it was impossible to adapt this practice in most developing countries of the region.
B. ENGINEERING AND WATER MANAGEMENT	
1. *Land consolidation*	
(a) Land consolidation work, including land levelling, had been completed in all projects visited. Some plots were 15 m x 100 m large and some 20 m x 100 m, depending on the type of soil.	(a) Land consolidation work had been started in many countries of the region. It should be promoted in all countries for intensive cultivation and to facilitate better management of irrigation water and modern agricultural techniques.
2. *Canal system and main drains*	
(a) A main canal, sub-main canal and distributaries for irrigation systems had been constructed most systematically and in places these had been lined.	(a) This was adaptable in most countries of the region, but the lining of canals might not be economical.
(b) In some reaches, twisting and meandering natural streams had been converted to straight drainage channels lined with masonry, thus reclaiming land from the original stream beds, improving hydraulic efficiency, improving drainage and providing protection against floods and river bank erosion.	(b) Straightening of natural drainage channels involved tremendous cost and should be taken up after economic evaluation. Land acquisition procedures would also create problems and delays.
(c) The irrigation and drainage canal density in all the areas visited was estimated to be over 95 m per ha. This high intensity incorporated into the design facilitated on-farm water management,	(c) Provision of high canal density was currently being undertaken in some countries of the region, but would not reach the stage of the projects visited for economic reasons.

Observations	Relevance to developing countries
encouraged good farm management practices and saved water, e.g. 70 mm of reservoir water used in the Tsing Ping irrigation area, thus enabling an extension of the irrigated area by 40 per cent.	
3. *Farm ditches and drains*	
(a) Irrigation-*cum*-drainage canals were run with the water level well below ground level. This facilitated drainage from adjacent areas, but required numerous check gates to feed irrigation channels at the field level. These irrigation channels ran for considerable lengths and functioned as drainage collectors in the upper reaches. In the lower reaches, they were able to command and irrigate farm land.	(a) In most countries of the region, irrigation canals were constructed with the water level above ground level. The canals were constructed balancing the depth of cutting and filling. Check gates were fewer, though more were being introduced while modernizing the systems. The advantages and disadvantages of the Chinese practice needed to be examined further.
(b) In the delta of the Yangtze River, the ground-water table was very high. To lower the water table, clay-baked pipes were installed 1.2 m below the ground surface at 20 m intervals depending upon the type of soil. In loamy clay soil they were placed only 7 m apart.	(b) Introduction of subsurface drainage systems would have to be considered seriously as the cost would be very high.
(c) A sufficient number of check structures had been constructed in China to lead the water to the farthest fields easily and in accordance with crop requirements.	(c) In most developing countries of the region the number of check structures was usually inadequate to minimize the initial investment.
4. *Use of local materials and simple design of outlet and other structures*	
(a) The use of local materials and techniques in construction was very impressive. The simplicity of the design in facilitating operation and maintenance was again praiseworthy. Ample examples could be found in the design of lock gates, electrical pumping stations, and in lime-earth stabilized soil for subsurface irrigation conduits. Owing to its simplicity, the extensive use of human labour was another case in point.	(a) This was adaptable by improving measurement devices and operating practices.
5. *Water management at the farm level*	
(a) The farmers used water in accordance with crop requirements. In most places, water measurement devices guided farmers and irrigators by using water to the required extent.	(a) This was adaptable by improving measurement devices and operating practices.

Observations	*Relevance to developing countries*
(b) Since the amount of water applied to the plots could be controlled and regulated, an intermittent irrigation method had been adopted in China. As shallow water was maintained a large part of seepage loss could be saved.	(b) This was adaptable with improved facilities at the farm level.
(c) It was noted that extensive use of recycled water was being incorporated into the system. Storage ponds were constructed by digging in low lying areas. Water stored in the ponds was recycled into the irrigation system by pumping.	(c) This technique could be utilized on condition that there was a cheap source of electric power in the rural areas.
(d) Water management in the field was carried out by an irrigator for every 300 mou (20 ha) of farmland. With experience, and facilitated by levelled fields, the irrigator could supply every plot of land evenly and quickly. It was reported that each plot of land could be irrigated in three hours in the Tsing Ping Irrigation areas.	(d) The manpower requirement for water management in China confirmed current thinking on manpower requirements for a good irrigation system in the developing countries of the region.
C. AGRICULTURAL PRACTICE	
1. *Soil management and organic manure*	
(a) It was observed that in all areas visited, as a result of good soil management, marginal soil, such as lateritic soil, could be turned to high production soil. The benefits of the use of green manure and compost were evident. Also, extensive use of lime, to neutralize the acidity formed when using organic manure, had been noted.	(a) Techniques of soil management could be adopted in the developing countries. The use of night soil as a form of fertilizer might not be readily acceptable for some obvious reasons.
2. *Cultural practice*	
(a) The period of land preparation (ploughing and harrowing) ranged from 7 to 11 days in the case of Tsing Ping irrigation area, which was much shorter than in other developing countries of the region.	(a) This operating practice should be adaptable in other countries of the region.
(b) A combination of hand weeding and rotary weeding was practised in China. Manual weeding effectively loosened soil and promoted aeration.	(b) Manual weeding should be advocated.
(c) Rice was planted to a density of 9 million to 10.5 milion plants per ha. By using more organic manure and dense population, the yield had been increased.	(c) In view of the different varieties of rice, the advantages of dense "population" should be further studied.
3. *Use of mechanical equipment and implements*	
(a) In spite of the availability of a large labour force in China, it was noted that extensive farm	(a) In some developing countries of the region, various kinds of farm machinery had been promoted. However,

Observations	*Relevance to developing countries*
mechanization was being carried out and farm machinery being developed. In all the areas visited, farm roads were provided for easy access of farm machinery.	in other countries this had not been adopted owing to unavailability of machinery and poverty of the farmers.
4. *Agricultural experiments*	
(a) It was interesting to note that the agricultural experiments in rice cultivation were carried out and financed by the brigade and commune, rather than the research institutions as in most developing countries of the region.	(a) Currently, the applicability of this practice to the developing countries of the region was doubtful.

III. ANALYSIS OF THE OBSERVATIONS

Important features observed	*Adaptability to participants' countries*[1]			
	(a)	*(b)*	*(c)*	*(d)*
A. ADMINISTRATION, FARMER'S PARTICIPATION AND FINANCING OF CONSTRUCTION WORKS				
1. The organizational struxture in China was designed and functioned in such a way that the people of the society, from production team up to commune and county level, were motivated to initiate and execute water conservancy schemes. The system provided for decentralization and responsibilities were being clearly delegated at the various levels. In the planning of water conservancy projects, the Government provided only the leadership and policy guidelines.				x
2. The integration of the activities of both the Ministries of Water Conservancy and Electrical Power and agriculture at the commune level was noteworthy.		x		
3. The integrated planning of supporting services in each commune was noted, such as workshops for repair of farm machinery, brick-kilns and small factories.	x	x		
4. Group decision and agreement in the selection of leaders at the grass-roots levels was noteworthy.			x	
5. Collective ownership of land and land reform were the main factors which facilitated the planning, design and construction of on-farm irrigation works with land levelling.				x
6. The social system ensured an appropriate wage to the individual farmer through a work point system. Ten per cent of gross income was deducted for the capital construction fund.				x
7. The setting of a production target or quota by the Government and by the people was an important factor for making progress.	x		x	
B. ENGINEERING AND WATER MANAGEMENT				
1. Main canal, sub-main canal, distributaries for irrigation systems had been constructed most systematically with high density and in places had been lined.			x	
2. There was a sufficient number of check structures to lead the water to the farthest fields easily and as per requirement of crops. Intermittent application of water was practised for paddy.		x	x	

1 (a) Those which were already being carried out by one or more countries; (b) Those which could be carried out without any serious obstacles; (c) Those which could be carried out but would require some time for preparations or adjustments; and (d) Those which had little prospect of adoption.

Important features observed	Adaptability to participants' countries			
	(a)	*(b)*	*(c)*	*(d)*
3. Pumping stations had been constructed to lift water for irrigation. The drained water could be recycled into the irrigation system.		x	x	
4. Field plots were all rectangular and of uniform size. Most field plots had been very well levelled.	x	x	x	
5. All outlets were constructed and planned properly for requirement of plots.		x		
6. In the deltaic area, the ground-water level was very high. The underground water table was lowered by installation of baked clay pipes underground at intervals from 7 to 12 m depending on the type of soil. With control of the water table, paddy and upland crops could be raised on the same plot in different seasons. Drainage was a separate system.		x	x	
7. With the integrated reservoir system; ponds and pumping plants to supply irrigation water appeared to be adequate for all seasons.	x	x		
8. In some reaches, meandering streams had been converted to straight drainage channels lined with masonry, thus reclaiming land from the original stream beds, improving hydraulic efficiency, improving drainage and providing protection against floods and river bank erosion.		x	x	
9. Low land was protected from flooding by dikes all round with regulating gates.	x	x		
10. Locally available materials and techniques were used in construction, such as the lime-earth stabilized soil for subsurface conduits.	x			
11. The design of various facilities was kept simple to facilitate operation and maintenance, such as lock gates, electrical pumping station, farm turnout, etc.	x	x		
12. Water management in the field was carried out by an irrigator for every 150-300 mou (10-20 ha) of farmland. Through experience and facilitation of the levelled fields, the irrigator could supply every plot of land evenly and quickly.	x	x		

C. AGRICULTURAL PRACTICES

1. As a result of good soil management, marginal soil like lateritic soil could be turned to high production soil. The benefit of the use of green manure and compost was evident. Also, the extensive use of lime, to neutralize			x	

Important features observed	Adaptability to participants' countries			
	(a)	(b)	(c)	(d)
the acidity formed as a result of the use of organic manure, was noted.				
2. Agricultural experiments were carried out and financed by the brigade or commune.		x	x	
3. Extensive farm mechanization was being carried out and farm machinery being developed. In all the areas visited, farm roads were provided for easy access of farm machinery.	x	x	x	
4. With abundant manpower and scarce land, farmers cultivated land intensively, with three crops a year in some areas.		x	x	
5. Large amounts of organic manure and green manure were applied.			x	x

Part Three

COUNTRY PAPERS SUBMITTED BY PARTICIPANTS

Part Three

COUNTRY PAPERS SUBMITTED BY PARTICIPANTS

A. SMALL-SCALE IRRIGATION SYSTEMS IN BANGLADESH: A STUDY OF PROBLEMS AT THE FARM LEVEL*

1. Introduction

Irrigated agriculture was not a very old feature in Bangladesh. There had been casual and supplementary irrigation through indigenous methods to protect crops in case of droughts. But no organized irrigation on a considerable scale had been practiced prior to the early 1960s. Earlier, the country had been more or less self-sufficient in food supply and irrigation schemes had not been given their due priority in national planning as they were now being given. Only during the early 1950s, when food production started becoming critical and failed to cope with the country's growing population, did everybody started thinking about irrigation.

2. Existing systems

In the course of the last few years, different types of irrigation projects/schemes had been developed in the country. These schemes might be classified into three major groups:

(a) River-water diversion projects,

(b) Low-lift irrigation projects,

(c) Ground-water irrigation projects.

(a) *River water diversion projects*

In this category of irrigation projects, river water was diverted and pumped to obtain head for gravity distribution of water within the project area. Normally these were multipurpose projects where, along with irrigation, flood control and drainage were also ensured by constructing flood embankments surrounding the area and by providing necessary drainage facilities for the excessive monsoon rain water. The Ganges-Kobadak project, designed originally to provide supplemental irrigation to 350,000 acres of land, and the Dacca-Narayangonj-Demra flood control and irrigation project, were of this type. The Dacca-Narayangonj-Damra project was designed to irrigate a total of 14,500 acres of agricultural land, out of which over 10,000 acres were protected from monsoon floods. Other projects of this category were the Chandpur irrigation project, which had just been completed, and the Barisal Muhri and Karnapuli irrigation projects, which were gravity-cum-pump irrigation projects and were still under execution. Considering their magnitude, these projects should be classified as major irrigation projects and kept outside the purview of this paper.

(b) *Low-lift pump irrigation projects*

Under this category of irrigation schemes, small low-lift pumping sets were provided to pump water from different kinds of sources: rivers, canals, depression areas and even ponds. There was no fixed plot of land irrigated by these pumps and normally no permanent irrigation canal existed for providing irrigation water to the farm. Since the average land holding in the country was under two acres and as these were fragmented and could be located in a number of places, even for the smallest low-lift pump a grouping of farmers was necessary to have a reasonable command area for the pump. These were hired out by the Government to a group of farmers, normally a cooperative group, on production of satisfactory evidence that the group was a viable one and would irrigate the land if a pump was allotted. The average size of a low-lift pump was 2 cubic feet per second, driven by a diesel-operated engine which was normally of 15 hp capacity. There were electrical pumping sets also and those were provided to groups which were more or less permanent in nature and which had the electrical facilities.

During the 1977/78 irrigation season, 36,700 pumps were fielded throughout Bangladesh. Out of these, about 1,000 were electrically operated. It was estimated that a maximum of about 55,000 sets of 2 cu ft/sec pumps could be used in the country without affecting navigation and fisheries. That number of pumps would initially serve about 2.2 million acres of land and it was expected that, with improved efficiency of water use, the service area would be increased to a total irrigated area of 2.75 million acres at some later stage.

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Although there was an abundant supply of surface water in Bangladesh, and the whole country was criss-crossed with rivers and canals, there were limitations in lifting water from surface-water sources for irrigation because a minimum flow of water in the river had to be maintained during the dry season in order to prevent saline water intrusion from the Bay of Bengal and also to safeguard against adverse effects on ecology, navigation and fisheries.

(c) *Ground-water irrigation projects*

In view of the limitations to the use of low-lift pumps where surface water was not readily available or its use uneconomical, ground-water development projects were receiving high priority in the country. Ground water for tube-well irrigation was readily available in most areas of the country that would benefit from irrigation. Nearly the entire area of Bangladesh was believed to have underground deep water-bearing aquifers with a depth of 3,000 feet or more. Suitable aquifers for construction of irrigation tube wells were quite deep in most parts of the country, particularly in the north-west and central north areas.

The availability and suitability of ground water for irrigation was dependent on three major factors provided a good aquifer was available at economic depths for installation of irrigation wells, namely:

(i) The proximity of the water table to the surface, influencing the cost of pumping;

(ii) The amount of annual recharge in the basin, determining the quantity of water that could be safely abstracted each year;

(iii) The water quality, indicating its suitability for the crops.

The depth of the water table at most places in the country varied between 0 and 30 feet depending on the location and the season. The average depth of ground water was 12 feet and it reached the surface in most areas after monsoon rains.

Recharge of ground-water supplies was mainly from rainfall and floods which were considered sufficient to support full development of irrigated agriculture for the entire area to which surface-water supplies were not readily available. Studies indicated that ground water was available over an area of about 16 million acres, some of which had already been irrigated with surface water.

As regards water quality, the ground water of the whole country was quite suitable for crop production, except close to the sea where the water was saline.

Depending on the characteristics of the particular area and aquifer conditions, alternative irrigation prospects, farmers' demands, suitability of land for irrigation and other factors, a deep tube well, shallow tube well or hand-pump tube well was sunk.

Deep tube wells. In deep tube-well irrigation projects, a tube well was sunk usually to a depth of between 120 and 300 feet. The diameter of a standard size deep tube well in Bangladesh was 6 in or more. The usual discharge from such a tube well was about 2 cu ft/sec. Since the aquifer conditions of the north-west and the central north were more favourable than in any other areas of the country, the tube wells were mostly concentrated in those areas.

The command area for a deep tube well was usually about 60 acres and required quite a large number of farmers organized into a group. A tube well was usually sunk in an area where a group had been formed beforehand, and the farmers' request to the Government for a deep tube well must indicate willingness to pay a part of the capital cost in the form of rental and the cost of operation and maintenance.

Currently, 11,049 deep tube wells had been installed, of which 7,453 were used to irrigate 338,474 acres of land during 1977/78.

Shallow tube wells. These were smaller and were sunk usually within a depth of 150 feet. These tube wells were usually 3 or 4 in in diameter with a discharge capacity of 0.5 cfs to 0.75 cu ft/sec. Since they were operated by centrifugal pumps, the suction lift of the pump limited the area where the shallow tube-well irrigation could irrigate during the dry season. They were sold to the farmers cash down, or on an instalment basis.

A total of 12,449 shallow tube wells had been installed. On average, each of them irrigated about 8 acres. A total area of 99,600 acres was covered. It was possible to irrigate up to 12 acres of land with one shallow tube well.

Hand-pump tube wells. Unlike other means of irrigation explained above, hand-pump tube wells were manually operated, less expensive, easy to operate and did not involve any grouping of farmers. The price was also within the reach of small farmers. These were 1.5-in diameter wells sunk usually up to 40 to 60 feet where the static water level was very close to the ground surface during the irrigation season. Therefore, they could be owned and operated by small farmers and could irrigate 0.5 acre of land. Since they did not involve any sophisticated technology in installation and operation, a hand-pump tube well could be installed by farmers themselves and put into operation immediately. There were currently about 90,000 such hand-pump tube wells. Projects for the installation of another 300,000 were under execution.

3. Irrigation requirements and development trends

In Bangladesh, about 22.5 million acres of land were now being cultivated for one season or another. There were no significant areas of virgin land to be opened up, so the increased production that was needed to meet the food shortage must come from land that was already being cultivated. Of those 22.5 million acres, about 12.0 million acres were under one crop, 8.4 million acres under three crops and only 1.34 million acres under three crops, giving a total crop acreage of about 33 million acres with an average cropping intensity of about 150 per cent. It was estimated that about 11 million acres could be cultivated for additional crops if irrigation facilities could be provided.

The following table shows the development trends of different irrigation methods for the last 16 years.

It could be seen that the low-lift pump was used over 45 per cent of the total irrigated area. Traditional methods, which contributed quite a considerable percentage to irrigation in Bangladesh, had no further scope for expansion. Under this system, farmers on their own lifted water from nearby rivers, canals, wells and even ponds using baskets and other local indigenous manual methods. This was not an organized irrigation programme.

4. Problems

The irrigation coverage shown in table 1 was far from satisfactory in so far as irrigation efficiency was concerned. At least 3 million acres of land could be irrigated with the existing irrigation facilities. The reasons for low irrigation efficiency in small-scale irrigation projects consisting of low-lift pumps, deep tube wells, shallow tube wells and hand-pump tube wells were as follows.

(a) *Institutional and social problems*

Malfunctioning of the group. The performance of

Table 1. Development of tube wells, shallow wells and low-lift pumps in Bangladesh

Year	*Large-scale irrigation by gravity (thousands of acres)*	*Deep tube wells*		*Shallow tube wells*		*Low-lift pumps*		*Hand pumps*		*Traditional methods (thousands of acres)*
		Number	*Thousands of acres*	*Number*	*Thousands of acres*	*Number*	*Thousands of acres*	*Number*	*Thousands of acres*	
1962/63	–	–	–	–	–	2,024	133.0	–	–	1,000
1963/64	–	–	–	–	–	2,477	156.7	–	–	1,000
1964/65	–	–	–	–	–	2,238	131.1	–	–	1,000
1965/66	21.8	–	–	–	–	3,420	173.5	–	–	1,000
1966/67	46.9	–	–	–	–	3,990	225.5	–	–	1,000
1967/68	104.1	186	4.1	–	–	6,558	316.9	–	–	1,000
1968/69	147.4	386	16.0	–	–	10,852	415.8	–	–	1,000
1969/70	155.5	990	32.1	–	–	17,884	613.0	2,000	–	1,000
1970/71	148.9	997	47.8	–	–	24,481	875.9	8,000	4	1,000
1971/72	63.3	906	29.3	389	–	24,235	883.9	9,000	5	1,000
1972/73	91.2	1,237	66.7	–	–	32,917	1,329.9	15,000	8	1,000
1973/74	97.6	1,583	69.4	998	–	35,343	1,330.8	30,000	15	1,000
1974/75	92.3	2,699	118.0	1,029	–	35,534	1,379.0	40,000	20	1,000
1975/76	111.0	2,648	152.1	2,241	7.6	36,383	1,430.6	50,000	25	1,000
1976/77	112.0	5,983	256.0	6,545	42.0	28,381	1,101.2	60,000	30	1,000
1977/78	138.0	7,453	338.4	12,449	84.0	36,731	1,357.0	90,000	45	1,000
Percentage 1977/78	4.67		11.43		2.84		45.80		1.51	33.75

many irrigation groups using low-lift pumps and deep tube wells was not satisfactory owing to lack of co-ordination among the group members. Group rivalry, power tussles and other social factors, including lack of interest in co-operative practices or malpractice with co-operative facilities, led to malfunctioning of the groups.

Equity problems. The co-operative activities of a deep tube well or low-lift pump group were dominated by comparatively rich or influential farmers. Poor farmers could not afford to purchase shallow tube wells and therefore became receptive to the idea of co-operative groups. Even if they participated individually in the co-operative activities, they were deprived of due benefits.

Lack of co-operation. Successful irrigation required involvement and co-ordination between various agencies responsible for providing inputs and other services. In Bangladesh about a dozen institutions were involved in such activities and sometimes the efforts of all such organizations were not well co-ordinated.

Extension services and social motivation. Knowledge regarding improved agricultural inputs and practices, such as use of high-yielding variety seeds, fertilizer, pesticides and efficient water management, was essential for proper farm management. Extension services at the farm level were not always available for the small and illiterate farmers, who needed them most.

Credit. As most farmers were poor and many were landless, credit facility was one of the prerequisites for efficient operation of irrigated agriculture at the farm level. The availability of credit to poor and landless farmers was extremely limited because of resource constraints and other factors. On the other hand, even if the credit was available, it was sometimes misused, consequently making the farmers appear unworthy of credit for the subsequent period. Although arrangements existed for supervised utilization of credit, because of the innumerable creditors, it was extremely difficult to enforce proper discipline. One of the major reasons for an improper credit system was the absence of proper marketing facilities at the farm level.

(b) *Technical problems*

Type of equipment. Most irrigation equipment was more or less similar in specifications. Therefore, the efficiency in the field of such equipment varied according to conditions. A pump for a constant head operation was not suitable for operation at variable heads. But, in practice, because of the limitations of maintenance facilities, the pump sets were required to be of standard capacity. The farmers' groups who operated the pumps at a different head were therefore deprived of the benefits they could expect from peak efficiency, particularly in respect of fuel cost.

Repair and maintenance schedule. Low-lift pumps were repaired and serviced every year by the Bangladesh Agricultural Development Corporation (BADC), the operating agency of such pumps, and were hired out again during the following irrigation season. All the 37,000 pumps now being operated had to be returned to the field service stations on or before a particular date every year for annual maintenance. As pump repair was dependent on timely return by the farmers' groups, sometimes it was not possible to repair them on schedule, which could result in the non-fielding of some low-lift pumps required by the farmers. Ultimately the farmers' work schedule, as well as the production schedule, was badly affected if pumps were not returned on schedule.

Quality and timeliness of maintenance. Owing to the factors explained in the preceding paragraph, the quality of the repairs was not always up to the acceptable standard and the farmers' groups naturally suffered during the irrigation season when the irrigation equipment broke down, especially when major overhauling was involved.

Field maintenance and supply of spare parts. Most of the engines used for driving pumps were imported. The supply of spare parts was therefore dependent on regular procurement from abroad and that could not always be guaranteed. Even though there was provision for some reserve pumping sets for replacement in such cases, when large-scale dislocation was faced the situation could get out of control. There were cases where a pump group could not be supplied with a replacement pump even in 15-20 days.

Fuel supply. For the operation of about 37,000 diesel-operated low-lift pumps, 10,000 deep tube wells and about 12,000 shallow tube wells, approximately 12.5 million gallons of diesel fuel had to be procured and distributed to the farm level by BADC, the operating agency. All fuel, along with the necessary lubricants, had to be imported. Occasionally there were isolated shortages of fuel affecting the smooth operation of the pumps, caused by a dislocation in the local, regional or national transportation systems.

Inefficient water distribution system. Although all care was taken before selection of a particular scheme for installation, there were cases where pumps or tube wells were wrongly sited because of local inefficiency or for other reasons. The bad site might be either because the level of the land did not allow free flow of water by gravity or because the soil was not suitable for irrigated agriculture. However, whenever possible, lining of the canal or a change in the cropping pattern was recommended to improve the situation.

(c) *Miscellaneous and other related problems*

As an irrigation system was a relatively new feature in Bangladesh, the farmers of the higher reaches are not at all used to irrigated agriculture. However, with the introduction of irrigation during the last few years, the farmers were showing an interest in irrigation. For the systematic development of irrigated agriculture, proper use and maintenance of irrigation equipment was essential at the farm level. Some steps had already been taken in the way of training schemes at the farm level and more were being planned on a larger scale.

During recent years, the price of agricultural inputs had increased while the prices of farm products had not increased to the same extent. That was primarily due to the gradual withdrawal of subsidies by the Government on one side and escalation of the price of farm inputs on the international market on the other side. The situation had affected small-scale irrigation to a great extent.

B. USE AND MAINTENANCE OF THE IRRIGATION SYSTEM AT THE FARM LEVEL IN THE PROJECTS COMPLETED BY THE BANGLADESH WATER DEVELOPMENT BOARD*

1. Introduction

Bangladesh was a generally flat, deltaic country at the confluence of three large rivers - the Brahmaputra, the Ganges and the Meghna - with an area of 55,000 square miles, one third of which was flooded annually. The alluvial plains of the country rose with very low gradient from the Bay of Bengal in the south to the foothills of the Assam hills in the north-east. The climate was tropical with a monsoon season from May to September and a dry season from October to April. Rainfall varied from 50 inches in the west to over 200 inches in the north-east. The average annual rainfall was about 70 inches, 80 per cent of which occurred between June and September and caused widespread flooding, whereas drought or near drought conditions existed for the rest of the year. The monthly mean temperature hardly fell below $60^{o}F$ and the climate was therefore favourable for crop growth throughout the year. The ground-water table over most of the country was high. Approximately 22.5 million acres of land were under cultivation and the average farm size was only 2 acres.

The current population was estimated at about 75 million, but by 1985 it might exceed 110 million at the growth rate of 3 per cent per annum. A large part of the population lived below subsistence level; 90 per cent of the population was rural, 80 per cent of whom were engaged in agriculture. As it was not possible to expand appreciably the cultivated area, intensive use of the existing cultivated land was the main objective for providing jobs and food to the increasing population.

The economy of Bangladesh was traditionally and predominantly agricultural and agricultural output accounted for about 55 per cent of the gross domestic product directly and for an additional 17 per cent indirectly. Over 80 per cent of the foreign exchange earnings of the country were generated from agriculture. The annual consumption of foodgrains was 13 million tons, of which 1.5 to 2 million tons were imported. Agricultural development was therefore essential to the country.

2. Prospects for agricultural development

The country had substantial agricultural resources. The soils were productive and had sustained continuous cropping for centuries. As the climate was suitable for year-round production, two or even more crops could be grown if proper technology was applied, thus effectively multiplying the crop acreage. However, the dry season restricted winter crop production except where soils had exceptionally good water-holding capacity or where irrigation facilities were available. The major objective was to increase the yield of foodgrains from current levels by 2 to 2.5 per cent to a sustained growth rate of 3 per cent per annum so as to reach self-sufficiency in food supply by 1985. The production of the major food-crop rice, along with other agricultural crops, was increasing gradually with the construction of more water control and irrigation projects, use of more inputs and introduction of new high-yielding varieties (HYV). The agricultural input programme had also developed rapidly since 1965; fertilizer consumption had increased by 23 per cent a year. Co-operatives had been set up, using new patterns developed and tested at the Academy for Rural Development at Comilla, to encourage formation of farmer groups and to distribute supervised short-term credit and inputs through co-operatives.

3. Irrigation projects

In the past agriculture was dependent only on the monsoon and hence subservient to its vagaries, but after

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the establishment of what was now the Bangladesh Water Development Board, some major irrigation projects had been taken up, some of which had since been completed. These were the Ganges-Kobadak project, Kushtia unit, the Dacca-Narayangonj-Demra project, the Thakurgaon tube-well project and the low-lift pump irrigation project in the northern districts.

(a) *Ganges–Kobadak project*

The Kushtia unit of the Ganges-Kobadak project was designed to supply water for irrigation to 350,000 acres in Kushtia and Jessore districts. The project had two parts; the first, costing Tk 227.20 million,[1] was completed in 1969/70, and the second was scheduled to be completed by 1980/81 at an estimated cost of Tk 375.0 million. It was mainly a lift-cum-gravity flow irrigation project, the River Ganges being the main source of water. Water from the Ganges was being carried through an intake channel to the pumping plant with an installed capacity of 5,400 cu ft/sec through 3 large (each 1,300 cu ft/sec) and 12 small (each 125 cu ft/sec) pumps. The water pumped into the main canal was supplied to the farmers' fields through a network of canals detailed below:

Main canal	–	120 miles
Secondary canal	–	311 miles
Tertiary canal	–	637 miles
Field channels	–	3,511 in number

Besides the irrigation canals, a network of drainage channels had also been constructed to prevent water-logging and also for reclamation of swamps, etc. The area commanded by the project had been made flood-free by constructing flood protection embankments along the River Ganges and its branches and other spill channels.

With the introduction of HYV rice, which needed more water than the local varieties, the available water could only irrigate about 120,000 acres of the project area during dry months. On the other hand, for supplementary irrigation during the monsoon for the Aman crop (IRRI-20), only about 250,000 acres could be covered under the first and second phases and therefore the entire commanded area could not be irrigated. Water management at the farm level was still to be developed. As the lands were not properly levelled and there were no bunds as boundaries and no field channels, water wastage was considerable. However, attempts were being made to motivate the farmers to build field channels through co-operatives.

Village-based primary co-operative societies had been organized at the primary water-source level, under the *Thana* (police station) co-operative societies called *Thana* Central Co-operative Associations. Distribution and management of water at the farm level was done by the primary co-operative societies. The *Thana* Central Co-operative Association arranged training and provided inputs, namely, seeds, fertilizers, pesticides, credit, etc., under the supervision of the irrigation extension service personnel who guided and supervised activities of the primary societies.

There were five *Thana* Central Co-operative Associations and 588 primary societies in the whole project area.

The responsibilities of the societies were as follows:

(i) Excavation and maintenance of field channels and plot channels with the help of farmers through their own lands;

(ii) Construction of plot boundaries;

(iii) Maintenance and repair of all civil works within the area of a field channel;

(iv) Preparation of an irrigation rotation chart;

(v) Preparation of crop patterns and supervision of production;

(vi) Preparation of an integrated programme for requirements in the way of seeds, fertilizer, pesticides, and ensuring timely distribution of the same to farmers;

(vii) Determination of agricultural credit for farmers and preparation of a seasonal production plan;

(viii) Training of all its members.

The above work was done by the primary co-operative societies with the advice and assistance of the extension and engineering staff of the Bangladesh Water Development Board. The societies worked out their respective programmes before a working season and submitted to the Project Co-ordination Committee, headed by the Deputy Commissioner of the district and comprising heads of different departments in the district as members. The Co-ordination Committee, after approval, sent the programme to the respective societies for implementation. The respective agency made arrangements for supplying seeds, fertilizer, pesticides, etc., in accordance with the approved programme, for distribution to the farmers through the dealers or the co-operative societies.

Problems. Among the problems being faced were unsatisfactory water management; lack of co-operation among farmers; non-levelling of lands, which caused losses of irrigation water; unwillingness of the farmers to dig plot channels; absence of border ridges in plots; high seepage loss; inadequate drainage; and silting of the intake canal.

1 Taka per US dollar (period average):

1971	*1972*	*1973*	*1974*	*1975*	*1976*	*1977*	*1978*
7.761	7.595	7.742	8.113	12.019	15.347	15.375	15.016

Table 2 shows the commanded area, crop area and irrigated area of HYV rice from 1965/66 to 1977/78 of the Ganges-Kobadak project (first phase).

Table 2. Commanded area, total crop area and HYV rice area of the Ganges-Kobadak Project (first phase) (in acres)

Year	*Commanded area*	*Total crop area*	*Total irrigated HYV rice area*
1965/66	120,000	191,400	–
1966/67	120,000	194,786	–
1967/68	120,000	199,863	4,250
1968/69	120,000	213,550	1,227
1969/70	120,000	223,313	1,742
1970/71	120,000	221,450	12,300
1971/72	120,000	193,206	17,070
1972/73	120,000	185,820	10,636
1973/74	120,000	189,976	31,700
1974/75	120,000	194,397	36,441
1975/76	120,000	189,499	42,703
1976/77	120,000	216,824	45,801
1977/78	120,000	266,340	56,378

(b) *Dacca-Narayangonj-Demra project*

A pilot project near the metropolitan city of Dacca was a flood control, drainage and water management project completed by the Board in 1969 at a cost of Tk 23.30 million. The project area was divided into two parts, known as area I and area II, having a net cultivable area of 10,100 acres and 4,900 acres respectively. Area I was fully protected from floods and was supplied with irrigation water round the year. Area II was not protected from floods and became submerged to a depth of between 5 and 15 feet during the monsoon. A pumping plant with four electrically driven axial flow pumps, with a capacity of 128 cu ft/sec per unit, pumped water into the project area from the River Lakhya for irrigation during the dry months and pumped water out for drainage during the monsoon. Roads and railway embankments around the area served as flood protection dykes approximately 19.5 miles in length.

The irrigation system comprised a 7-mile long main canal, 9 lateral canals with a total length of 19 miles and 13 sublateral canals totalling 5 miles in length, 9 direct turnouts and 159 outlets. There were 125 miles of field channels and 144 miles of plot channels. The drainage system consisted of both improved natural channels and newly excavated ones. The total length of the drainage channels in areas I and II was 21 miles and 5.2 miles respectively. The drainage channel in area I passed out excess rain water to the pumping plant from where it was pumped out to the River Lakhya or to the main canal. The drainage water from area II flowed by gravity into the natural drains.

So far, about 12,000 acres had been brought under irrigation in areas I and II taken together, 80 per cent of which were covered by HYV crops. A cropping intensity of 202 per cent had been attained, compared to the pre-project crop intensity of 97.8 per cent. The ultimate target was 270 per cent.

Problems. Though the main canal could hold water that could be drawn by pumps up to the full capacity of 512 cu ft/sec, the distribution system was designed for 250 cu ft/sec only. As the area of HYV rice in the project area increased, the water supply had become inadequate and only 70 per cent of the area could currently be irrigated. Steps were therefore being taken to increase the capacity of the distribution system so that the whole project area could be brought under irrigation for HYV cultivation.

During excessive rainfall, a considerable amount of land in area I went under water to a depth of 3 to 5 feet, damaging the standing crops. The silted-up drainage channels were therefore being re-excavated.

The canal embankments had settled in places, with the result that the crest level had sunk below the designed water level. Owing to the lower water level, considerable land remained unirrigated. Steps were being taken to strengthen the canal embankment and raise its crest level.

All outlets did not have gates, and even where gates had been supplied they disappeared owing to non-co-operation among farmers. An adequate number of checks and fall-boards were needed to raise water for irrigating higher land. Arrangements were being made to improve the situation.

Co-ordinating bodies. Water management and distribution of irrigation water in the project area was being done through the following committees:

(i) .Outlet committee: 150 (number of outlets, 190);

(ii) Canal committee: 9;

(iii) Central canal committee: 1;

(iv) Primary co-operative societies: 59.

Functions of the co-ordinating committees. The function of the outlet committee was to excavate, remodel and maintain the field channels through the farmers and develop the area under its command. The function of the canal committee was to develop the area under its command by adhering to the approved cropping pattern and to draw up and follow the rotational irrigation programme. The function of the central canal committee was to help attain full development of the project area with the co-operation of the project authorities and the members of the canal committee.

The functions of the primary co-operative societies were to obtain short-term and medium-term loans from the loan-giving agencies to purchase agricultural inputs and implements, and to encourage saving among their members.

Rotational irrigation water distribution. Outlet committees acted as leaders of the area under their command for efficient water use. The local farmers of an outlet elected representatives, called model farmers, who were responsible for distribution of water and crop development. Requests for water were made by the Board's extension agent, according to which water was supplied to the plots. The model farmer maintained close co-ordination with governmental departments under the guidance of the extension agents. He attended training classes organized by the extension personnel and learned about the látest techniques in applied irrigation and agronomy. The model farmer in turn taught the farmers under his command. A small amount of money was paid as honorarium to the model farmers.

Table 3 shows the commanded area, crop area and irrigated HYV rice area of the project from 1965/66 to 1977/78.

Table 3. Commanded area, total crop area and HYV rice area of the Dacca-Narayangonj-Demra project (in acres)

Year	*Commanded area*	*Total crop area*	*Total irrigated HYV rice area*
1965/66	14,732	16,082	–
1966/67	14,732	16,319	–
1967/68	14,732	20,370	410
1968/69	14,732	29,200	4,479
1969/70	14,732	27,644	8,830
1970/71	14,732	27,725	11,355
1971/72	14,732	28,110	14,568
1972/73	14,732	26,240	14,641
1973/74	14,732	24,029	10,494
1974/75	14,732	26,676	27,296
1975/76	14,732	24,438	14,705
1976/77	14,732	24,659	13,672
1977/78	14,732	26,889	13,625

(c) *Thakurgaon tube-well project*

A total of 380 electrically driven deep tube wells, each with an average capacity of 2.5-3 cu ft/sec and an average depth of 300 feet, had been installed in Thakurgaon in the district of Dinajpur with a loan from the Federal Republic of Germany to provide irrigation facilities to 68,800 acres. The project was completed in 1969 at a cost of Tk 98.80 million. An average length of 2,000 feet of lined canal had been provided to each tube well through which water was carried to the fields.

Farmers' primary co-operative societies had been organized for which a training programme and agricultural inputs were arranged by the *Thana* Central Co-operative Association under the guidance and supervision of the irrigation extension service personnel of the Board. Distribution and management of water at the farm level were carried out by these co-operative societies in accordance with the project. The area irrigated by the tube wells was fast decreasing, i.e. from 61,733 acres in 1969/70 to 10,100 acres in 1977/78, because of various factors but particularly damage during the independence war of 1971. Currently, 66 tube wells were completely out of order.

Problems. Water management and control at the field level were not yet fully developed. There was also a lack of extension and other promotional activities. The tube wells were also out of order often and the spare parts for electrical and mechanical equipment were not always available. There were occasional power failures and shortages of power also. Remedial measures were being taken to improve the situation.

Table 4 shows the commanded area, crop area, and number of tube wells in the Thakurgaon project from 1965/66 to 1977/78.

(d) *Low-lift pump irrigation scheme*

The project was initiated in the districts of Rajshahi, Rangpur, Dinajpur and Bogra by the Board in 1962/63; 594 pumps, each of 2 cu ft/sec capacity were installed in 94 stations scattered all over the area. The main purpose of the scheme was to withdraw the perennial river flow at a low cost through pumps, lined canals and field channels. The distribution of irrigation water in each of the pump stations was done by outlet committees under the charge of the canal committees. The extension personnel, jointly with the chairman and secretaries of the canal committees, prepared a water rotation programme, according to which the limited supply of irrigation water was distributed among farmers in parcels and not all at one time. The water rotation programme depended on the moisture retention capacity of the soils, varieties of crops to be grown, etc. Since rice was the main crop and the soil was

Table 4. Commanded area, total crop area and number of tube wells working in the Thakurgaon tube well project

Year	*Commanded area (acres)*	*Total cropped area (acres)*	*Total HYV rice irrigated (acres)*	*Total HYV wheat irrigated (acres)*	*Number of tube wells installed*	*Number of tube wells working*
1965/66	68,800	–	–	–	292	114
1966/67	68,800	93,967	–	–	312	312
1967/68	68,800	90,107	2,140	604	362	343
1968/69	68,800	117,149	6,789	2,407	362	362
1969/70	68,800	136,637	12,506	2,561	377	366
1970/71	68,800	144,354	33,175	4,903	377	315
1971/72	68,800	90,507	14,451	659	377	45
1972/73	68,800	98,451	11,876	2,538	377	255
1973/74	68,800	120,045	19,155	3,277	377	318
1974/75	68,800	10,400	11,451	–	377	231
1975/76	68,800	118,657	2,155	11,771	377	241
1976/77	68,800	111,434	11,178	5,910	377	293
1977/78	68,800	149,515	22,941	17,683	377	299

mostly medium to heavy textured, 6-10 days' rotation was generally adopted. The farmers of each outlet were entitled to receive irrigation water according to the water rotation roster. The timely and proper use of water depended, therefore, mainly on co-operation among the farmers.

Implementation of the scheme had not been very satisfactory, for various reasons. Although theoretically a 2-cu ft/sec pump should be able to irrigate over 100 acres of Boro paddy, the records indicated that the maximum area irrigated by each pump was only 38.5 acres.

Low operation hours of pumps, inefficient distribution system, lack of co-operation among farmers and co-ordination between various agencies, and want of spare parts and proper repair facilities for pumps, were some of the factors responsible for such poor performance of the scheme.

Table 5 shows the total commanded area, crop area irrigated and number of pumps in the low-lift pump irrigation scheme.

4. Conclusions

On analysis of the methods of use and maintenance of irrigation systems at the farm level and the problems in the above completed projects, it appeared that the factors responsible for under-utilization of facilities of the projects might be summarized as follows:

(a) Non-levelling of lands, absence of high border ridges on plots and plot channels;

(b) Insufficient number of checks, regulating structures, gates and measuring devices at the farm level;

(c) Inadequate drainage facilities in the project area;

(d) Insufficient spare parts and inadequate maintenance facilities of equipment and machineries;

(e) Agriculture through artificial irrigation being new to most of the farmers, there was a lack of interest and unwillingness to adopt irrigated agriculture;

(f) Non-existence of proper co-operation among farmers in the use of irrigation water;

(g) Inadequate water management at the farm level;

(h) Lack of training of farmers in applying correct quantities of water for different crops and at different stages of growth and also in the frequency of irrigation needed for each;

(i) Adoption of flood irrigation in lieu of furrow irrigation;

(j) Lack of consolidation of holdings to economic and uniform size;

(k) Improper maintenance of project works.

Action had already been taken by the executing agencies of the projects to solve these problems but a lot more had to be done for the full development of these irrigation projects.

Table 5. Commanded area, total crop area, and total number of pumps working in the low-lift pump irrigation scheme

Year	*Commanded area (acres)*	*Total crop area (acres)*	*Total HYV rice area irrigated (acres)*	*Total number of pumps installed*	*Total number of pumps working*
1965/66	39,900	72,555	–	407	149
1966/67	39,900	80,264	–	458	156
1967/68	39,900	78,229	911	538	258
1968/69	39,900	70,577	1,644	594	214
1969/70	39,900	84,531	2,952	668	214
1970/71	39,900	78,415	5,481	668	213
1971/72	39,900	50,600	968	668	30
1972/73	39,900	67,279	3,178	668	157
1973/74	39,900	81,422	3,469	668	161
1974/75	39,900	81,174	3,471	668	137
1975/76	39,900	65,675	2,884	668	145
1976/77	39,900	75,593	3,526	668	158
1977/78	40,800	97,077,	5,163	668	119

C. PROPOSED MEASURES FOR IMPROVEMENT OF THE PANLAUNG IRRIGATION PROJECT IN BURMA*

1. Introduction

Agriculture, including crops, livestock, fisheries and forestry, dominated the economy of Burma as it provided 40 per cent of the gross domestic product, 70 per cent of employment and 90 per cent of export earnings. In addition, much of manufacturing, transportation and trade involved the processing, handling and distribution of agricultural commodities. Rice was the major crop, accounting for 65 per cent of the cultivated area and half the export earnings from the agricultural sector.

The predominant agricultural area was the central belt formed by the Chindwin, Irrawaddy and Sittang valleys and the Irrawaddy delta. Forest covered nearly 75 per cent of the land area and contained the richest timber stands in Asia. Livestock was spread throughout the country, basically for draught purposes, and fishing was an important activity for many families. The Burmese economy had suffered severely from war damage and agricultural production did not recover pre-war levels until the mid-1960s. The Government had, until 1974, attached a low priority to agricultural development in the preceding decade, only 11 per cent of its total capital expenditure being devoted to that sector, with the trend declining during that period both relatively and absolutely. The adverse weather conditions of some years finally precipitated the complete overhaul of the economic plan which had emphasized mining and industry. The Government had now given high priority to agricultural investment to raise production.

For that purpose a considerable amount of investment was being made in the agricultural sector, with the emphasis on the development of irrigation projects and water management works.

Nyaunggyat multipurpose dam and irrigation project was one of the water management projects to be implemented with a loan from the World Bank, and which involved the proposed improvement works for the existing Panlaung irrigation system.

2. Project area

(a) *Location*

The project area was located between latitudes 20°N and 22°N and longitudes 96°E and 97°E. It was situated

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in the dry zone of central Burma. It covered part of Kyaukse, Myittha, Tada-U and Windwin townships of Mandalay Division. Mandalay, the second largest city in the country, was situated at about 50 miles from the centre of the area.

The irrigable area covered the present Panlaung irrigation tract of 86,913 acres and about 115,000 acres of currently rain-fed land in the Samon River valley which was adjacent to the Panlaung irrigation area.

(b) *Climate*

The climate in the project area was tropical. Monsoon rains usually started in the middle of May and lasted till October. The heaviest rains occurred during September and October. The rainfall was not evenly distributed. The average annual rainfall did not exceed 32 inches (813 mm).

The mean monthly temperatures in the project area are shown below:

Months	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*
Degress in Fahrenheit	71.4	77.0	85.8	91.2	87.8	87.1	86.9

Aug.	*Sept.*	*Oct.*	*Nov.*	*Dec.*
84.9	84.0	82.0	77.5	71.6

Extreme minimum temperatures were observed during December (descending to 44.6^{o}F) and maximum temperatures occurred during the month of April (reaching 109.9^{o}F).

The average relative humidity during the winter varied between 50 per cent and 60 per cent. It was around 40 per cent in March and April. In the monsoon season it rose as high as 84 per cent.

The maximum wind velocity in May, blowing in a south-south-east direction, was 40 miles per hour.

The maximum monthly evaporation in the area occurred in the month of April, reaching 14 inches (356 mm)

(c) *Existing irrigation and drainage works*

The Panlaung irrigation system was currently composed of four diversion works, namely, Kinda weir, Nathlwe weir, Kyime weir and Htongyi weir, with their integrated canal networks irrigating 39,858 acres, 13,545 acres, 30,341 acres and 3,169 acres respectively, making a total irrigated area of 86,913 acres.

As the irrigation water could be supplied in accordance with river flows and not in accordance with crop water requirements, and since the two frequently did not synchronize, the yield of crops in the area was low.

The following table shows the average monthly run-off of the Panlaung River:

Month :	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*
Mean monthly : inflow, thou- : sand acre-feet :	44.9	35.6	37.0	30.5	48.6	91.9

July	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Total*
111.2	200.7	225.1	216.0	104.8	59.1	12,05.4

Irrigation supply was distributed by a network of lateral canals and farmer-built distribution systems. The main canal, laterals and other structures needed rehabilitation. Additional structures would be needed to provide better water control, especially for dry-season crops. There was a limited number of lateral drainage channels of large capacity that crossed the area, with the result that drainage conditions were poor during the wet season. All-weather access roads in the project area were also lacking; the transport of agricultural produce and inputs was, therefore very difficult during the monsoon season.

The field irrigation and drainage system in the area was inadequate for modern agricultural practices. There were not enough farm ditches, with the result that many farm units had to receive irrigation water from adjacent fields, making it difficult to grow crops other than paddy. Field-to-field irrigation caused considerable wastage of water and an unequal distribution, resulting in shortages when water was scarce. In that way, many fields received too little water or no water at all and the water arrived too late at the lower end of the fields. Inadequacy of the drainage system caused flooding, resulting in poor water management and, consequently, low yields.

Poor accessibility to the fields owing to lack of farm roads caused delay in transportation of agricultural products and inputs, poor water management and poor crop attendance by farmers.

Uneven topography made for excessive water requirements for paddy cultivation and uneven distribution of water within the plot, resulting in low yields.

Land fragmentation, caused by subdivision of individual holdings through inheritance, and also by construction of public works such as irrigation and drainage channels, roads, railway lines, etc., divided the fields into under-sized plots and irregular shapes, which had an adverse effect on the efficiency of farm operations.

(d) *Soils*

Six types of soil were predomiment in the project area: light brown soils, light brown diluvial soils, meadow cinnamon soils, red-brown savanna soils, dark compact savanna soils and meadow soils.

Light brown soils were found on the slightly high plain level. The texture was light and the structure crumby. Yellow and reddish plots were found in the soils, which indicated the presence of iron compound. The soil reaction was neutral. The humus content was low.

Light brown diluvial soils occupied the higher and lower slopes near the dry forest. The texture was light and sometimes even sandy horizons were seen. The soils in the upper horizons were nutty; the lower horizons possessed a crumby structure. The humus content was low and the soil reaction slightly alkaline.

Meadow cinnamon soils had developed on recent creek deposits. The texture was heavy to medium loam. The humus content was 4.62 per cent. Carbonates were found in the lower horizon. The soil reaction was weakly alkaline. The upper horizon was cloddy. The clay content was over 50 per cent.

The red-brown savanna soils were characterized by a light texture. The upper portion was mostly structureless, porosity space being big and aeration good. The water-holding capacity was low. The content of humus was low, ranging from 0.34 to 1.23 per cent.

The dark compact savanna soils were on the flat alluvial plain. The structure was cloddy and the texture heavy. In the dry season cracks appeared and in the rainy season soils were sticky and adhesive. Heavy texture and large quantities of clay minerals (Montmorillionite) were responsible for the soils swelling. The soil reaction was alkaline.

The meadow soil developed mainly in river creeks and depressions. Typical meadow soil was brownish grey in colour, cloddy in structure and the texture was heavy loam. The soil was characterized by alkaline reaction.

(e) *Agricultural production and cropping patterns*

As the project area was situated in the dry zone of central Burma, prevailing high temperatures and favourable soil conditions favoured cultivation of many crops in the area throughout the year. However, current crop yields were generally low, because irrigation water supplies from the diversion weirs had to depend on the streamflows and generally could not meet the water requirements. Hence, only 70 per cent of the total irrigable area was irrigated. Since the streamflow in winter was low, extensive double cropping was not possible. The present second crop covered about 51.0 per cent of the total area.

With the water supply assured through the construction of the Nyaunggyat dam project and intensive cultivation using high-yielding varieties, fertilizers and improved agro-techniques, a cropping intensity of about 200 per cent was envisaged with sustaining high yields.

(f) *Labour availability and farm size*

The Mandalay Division was administered through 25 townships. Total population in the project area was over 190,000 with a growth rate of 2.8 per cent per annum.

Current labour availability in the project area was sufficient for peak labour requirements for harvesting of monsoon crops and for land preparation for the second crop in October and November.

There were two main types of land in the project area, based mainly on the availability of irrigation, though some paddy grown close to rivers was in rain-fed condition. The other main class of land was known as *ya*, which implied rain-fed conditions and was often at slightly higher levels than the paddy land. Settlement was denser on paddy lands and consequently paddy farms were smaller than *ya* farms. The average paddy farm size was 8 acres and the average *ya* farm 10 acres. Nearly 40 per cent of the paddy farms and 28 per cent of the *ya* farms were 4 acres or less in size. Seventy per cent of the paddy and *ya* farms were below the average size. The average size of a farm plot was 0.6 acre in the existing area (mostly paddy farms) and 1.35 acres in the currently non-irrigated area (mostly *ya* farms).

(g) *Communications*

The main highway from Rangoon to Mandalay passed through the project area. Kume was on this highway. Myittha was on a road that branched off from this highway and went west to Myingyan. A road from Kyaukse to Tada-U skirted the northern boundary of the project. An unpaved road along canal banks connected Kinda to the main highway. Another such road connected Kinda to the main highway. Yet another further north connected the Lungyaw farm to the main highway. Unpaved roads to most villages could not be used after heavy showers as they were not on embankments.

(h) *Land tenure*

All land belonged to the State. Cultivators were regarded as tenants of the Government since the enactment of the Tenancy Act of 1964. They could not transfer land to anyone else and their heirs could not possess the land as a matter of right. When a farmer died, the village land committee might distribute the land to another cultivator if he left behind only minor sons, or if his sons were in non-farming occupations. They might even take away all or part of a farmer's land (under Section 38 of the Land Nationalization Act of 1953) for failing to grow a prescribed crop.

Land ownership in this context meant only the right of usufruct. The pattern of ownership was highly skewed in the project area, as in all of Burma. In the existing area, 40 per cent of the farms were less than 4 acres in size, but their total area was only 11 per cent of the farm land. On the other hand, farms over 10 acres in size comprised 20 per cent of the number of all farms but contained 48 per cent of the farmland. In the *ya* land, distribution was slightly more skewded.

3. Proposed irrigation development

(a) *Engineering structures*

The works proposed on the Nyaunggyat multipurpose dam and irrigation project were the construction of a storage dam located 9 miles upstream from the Kinda diversion weir, which would regulate the runoff of the Panlaung River, the rehabilitation of existing irrigation systems, and the construction of new systems on currently non-irrigated land in the extension area.

The total net irrigable area of 201,500 acres was subdivided as follows:

Rehabilitation of the existing Panlaung system	86,913 acres
Construction of a new system for the extension area in the Samong River valley	114,587 acres

The following were some of the salient features of the storage dam:

Catchment area	850 sq mi
Dam height	250 ft
Dam length	2,000 ft
Type of dam	Zoned roll-filled dam
Installed capacity	40 MW
Firm power	26 MW
Annual output	
Total	175 million kWh
Firm	65 million kWh

No canal linings were proposed for the irrigation canals of the existing and new systems. Soils in the existing area were mainly clayey loams (90 per cent) and sandy loams (10 per cent). The proportion was 60 per cent and 40 per cent in the extension area.

(b) *Rehabilitation of the existing area*

The proposed works included desilting of canals, repair and replacement of canal structures, construction of farm ditches within the irrigation blocks, drainage improvement, flood protection and road improvement. They were aimed at improving the current irrigation structures by remedying existing short-comings and deficiencies.

In the past, desilting works had not been sufficient to keep the maximum capacity of the canals up to its design value of 1 cu ft/sec for 47 acres (1.5 l/s/ha). The full capacity of the canals would be needed because a more intensive crop pattern was proposed. Peak monthly demands occurred in April and August with maximum crop water requirements of 8-9 inches.

Replacement of the outlets to the irrigation blocks by new gated outlets was proposed as the main measure for improving water control. Additionally, measuring flumes would be installed at the head of distributaries and check structures would be equipped with stoplogs for better control of the head at offtakes.

The existing natural drainage network would be improved by deepening and upgrading existing canals and the construction of supplementary drains. The capacity of the drainage system would be 1 cu ft/sec per 25 acres (2.8 l/s/ha), which would be enough to evacuate the one-day rainstorm of 1 in 10 years' occurrence. The minimum depth of the drains would be 5 feet.

The existing access to the irrigated area would be improved by providing a main road 16 feet wide, and gravel surfaced roads on a 22-feet wide and 2-feet high embankment which would be superimposed as much as possible on the existing road networks of the municipalities. Service roads along the main canals would be widened to 16 feet, and along other canals to 8 feet wide.

Flood protection embankments would provide protection against the Panlaung flooding between the Nathlwe weir and the Htongyi confluence with the river. The Panlaung River discharge downstream of Kume would be reduced by increasing the flow diverted into the Pauk Chaung flood channel, which, in turn, drained into the Samon River. The Pauk Chaung channel should also be contained within flood embankments as well as the Samon River downstream of the Pauk Chaung. In the case of the latter, the embankment would protect low-lying areas on both sides of it. The Pauk Chaung escape weir capacity would be increased by replacing the existing weir, which had a high-level fixed crest, with a new structure with radial gates. The low-lying crest of the new structure would provide better evacuation of the Panlaung bed load which caused silting up of the Panlaung and the canal offtakes (sama, Mezebintha canals) downstream from the escape weir.

Drain outlets into the embanked sections of the rivers would be provided with outlet structures equipped with automatic no-return flow gates. Flood embankments had a crest width of 10 feet, 1.5 to 1 per cent slopes and were located at a distance of at least 170 feet from the river bank.

Within the irrigation blocks, distribution of water would be improved by tripling the length of the water courses. As was presently the case, the water courses would be used alternatively for irrigation and drainage. The average distance between two ditches would be 400 feet. The bed level of the water courses would be 3-4 feet below ground level, in order to keep ground water low, and could eventually be increased to 5 feet in badly drained areas. Check structures in the water courses would be provided, consisting of earth dams equipped with 12-inch concrete pipes to drain the water courses at the bottom.

(c) *New extension area*

The irrigation system was designed to have the same capacity as that of the rehabilitation works in the existing areas, with 1 cu ft/sec supplying about 47 acres.

The distributaries would be laid out along the slope and would be equipped with drop structures where the slope of the terrain exceeded permissible longitudinal canal slopes. Minors would be laid out across the slopes and spaced about 3,300 feet apart. Outlets would serve irrigation blocks of 100 acres. Cross regulators would be provided at the takeoff of distributaries and minors.

Drains would be relatively small as the width of the area did not exceed 5 miles. As in the existing area, they were designed to evacuate a one-day rainstorm of once in 10 years' occurrence (5.05 inches). Ground water was sufficiently deep in most of the area not to create any problems for the moment. Secondary drains would be laid out parallel to the distributaries along the slope. Drop structures would not be provided. Some bed erosion would be accepted. Slopes of the smallest canals were not to exceed 0.4 per cent. Tertiary drains were located immediately above minors and would drain into the secondary ones. An interceptor drain would catch runoff from the area above the diversion canal and evacuate it to natural drains.

The main road network consisted of one main road running along the proposed main canal for the extension area which would be connected with the existing Rangoon – Mandalay highways and some additional links. Service roads ran along the distributaries and access tracks between the minors and the tertiary drains. Access to the irrigation blocks would be provided by a concrete culvert (24 inches) across the tertiary drains.

Flood protection embankments would be constructed along the Samon River starting from the Pauk Chaung confluence down to the Panlaung confluence. Drain outlets with no-return gates would be provided where drains crossed the embankment.

Proposed land development works comprised clearing, land shaping, bunding and construction of water courses. Land clearing, shaping and smoothing would be required for the whole area. For land shaping purposes, the area was subdivided into land with general slopes (1:2,000 scale map) of less than 0.25 per cent (60 per cent), 0.25 to 0.50 per cent (27 per cent) and 0.5 to 1 per cent (13 per cent), with a proposed water-course grid of 330 feet spacing, alternately, an irrigation ditch and a drainage ditch both running along the slope. The proposed dimensions for the basins varied between 130 feet x 330 feet (1 acre) for less than a 0.25 per cent slope and regular relief to 65 feet x 165 feet (1/4 acre) for a 0.5 to 1 per cent slope and irregular relief.

4. Difficulties in the development of the project

Though there were not expected to be any difficulties in solving the engineering problems, it was envisaged that some difficulties would be encountered with regard to the following problems.

(a) *Land consolidation and reparcellation works*

In land consolidation works, about 5 per cent of the presently cultivated lands would be lost owing to the construction of irrigation, drainage and road networks. Some exchange of lands among farmers would also have to be made in land reparcellation work so that individual holdings of land would fall into a rearranged unit block.

It was hard to convince the farmers that the advantages to be gained through land consolidation and reparcellation works were far greater than the cost of the very small percentage of land they were going to lose.

It had therefore been decided to start the land consolidation and reparcellation works in the extension area where there would be less objection to it. But for the existing service areas, like the Panlaung irrigated tract, it was planned to start with a pilot area covering about 3,000 to 4,000 acres of land, just to demonstrate to the farmers the works involved in the land consolidation and reparcellation and the advantages that would facilitate them in their farming operations.

(b) *Persuading farmers to change their farming practices*

It would be very difficult to persuade the farmers in the project area to switch from their old traditional farming practices to modern agricultural techniques. The introduction of new improved seeds, usage of heavy dosages of chemical fertilizers and pesticides, and weeding, required more labour and higher farming costs, which were the factors hindering the farmers from readily switching farming practices. It had been planned, therefore, to set up some demonstration farms in the project area and also increase the extension services to educate the farmers.

5. Conclusion

Implementation of the Nyaunggyat multipurpose dam and irrigation project would only improve the physical conditions for increasing the agricultural production.

It was foreseen that full benefits from the project would not be realized unless the technically improved facilities were put to use properly and measures to raise the farmer's capability for increasing agricultural production and their incentives to do so were undertaken.

It had been decided, therefore, to undertake measures such as improving the irrigation and agricultural organizations and management, training irrigation personnel, guiding the farmers in irrigation techniques, developing institutional support to the farmers in credit supply, marketing, processing, storage and supply of agricultural inputs, and to carry out research on crops, irrigation and cultivation practices simultaneously.

D. USE AND MAINTENANCE OF IRRIGATION SYSTEMS IN INDIA*

1. Introduction

A developing economy demanded full exploitation of its resources in order to provide an economic base for balanced growth in other sections. With few exceptions, the dominant resources requirement was water. Agriculture was the mainstay of India's economy and water was one of the very basic inputs for agricultural production which needed to be stepped up continuously to meet the ever-increasing requirement of food and fibre for the country's large population. In large countries such as India, water supplies were ill-distributed in space and time. Because of the ever-increasing requirement for water for intensive/extensive cultivation and industrialization, the gap between the demand and supply was likely to increase to unexpected levels sooner rather than later.

In order to achieve the accelerated pace of development, provision of additional irrigation facilities had been an important feature of the over-all national economic development programme. The country's irrigation potential had increased from 22.6 million hectares in 1950/51 to over 53.8 million hectares in 1977/78. Table 6 indicates the additions of irrigation potential from major, medium and minor irrigation works in the various plans.

Table 6. Additional irrigation potential in the various plans (in million ha)

Period	*Total cumulative potential irrigated area*		*Cumulative total potential at the end of the period*
	Major and Medium	*Minor*	
Pre-plan (1950–1951)	9.7	12.9	22.6
I Plan (1951–1956)	12.2	14.1	26.3
II Plan (1956–1961)	14.3	14.8	29.1
III Plan (1961–1966)	16.5	17.0	33.5
Annual plans (1966–1969)	18.1	19.0	37.1
V Plan (1974–1975)	21.5	24.3	45.8
1975–1976	22.5	25.2	47.7
1976–1977	23.5	26.2	49.7
1977–1978 (tentative)	25.0	28.8	53.8

* By N.L. Shankaran, Director (Irrigation), and Pritam Singh, Member (Floods), Central Water Commission, Ministry of Agriculture and Irrigation, New Delhi.

The irrigation projects in the country were classified under three categories, i.e. major, medium and minor projects. Whereas earlier the classification had been based on the cost of the project, now it was on the basis of culturable command area (CCA). According to the latest classification of irrigation projects, projects having CCA up to 2,000 ha, up to 10,000 ha and more than 10,000 ha were categorized as minor, medium and major projects respectively.

Out of the increased potential from 1950-1951 to 1977-1978 of 31.1 million ha, 15.3 million ha and 15.9 million ha had been contributed by major/medium and minor projects respectively. The major/medium schemes involves large financial outlays and took comparatively longer "gestation" periods than minor projects. However, the coverage by individual major/medium schemes was much wider than the minor schemes. These projects called for involvement of larger sections of the rural community and provision of infrastructural facilities for development of irrigation. This potential, created at huge cost to the national economy (in terms of money as well as labour), had to be utilized efficiently in order to achieve the expected benefits. Therefore, it was necessary that all-out efforts be made to ensure the proper use and maintenance of irrigation systems.

However, in view of the limited availability of water resources, the irrigation potential could not be infinitely increased to meet the increasing demands. Thus, it would be of interest to review the available resources of water of India before discussing the use and maintenance of irrigation systems in detail.

India had good rainfall and its rivers contributed 5 to 6 per cent of the total surface-water flow of the world. However, nearly two thirds of India was either arid or semi-arid. The Ganga and Brahmaputra were the two big river systems of India. The Ganga accounted for nearly 493,360 million m^3 of waters. The Brahmaputra accounted for 555,030 million m^3 of water. The third largest river system was the Indus, of which about 49,336 million m^3 of water were available for use in India; the balance went to Pakistan. In India, although the over-all quantity of water was sufficient, it was unequally distributed with erratic rainfall patterns. Assessment of the country's utilizable water potential was still an exercise. However, in 1976 the National Commission on Agriculture assessed that out of 180 million ha m available, within the present technological development, only 35 million ha m and 70 million ha m of average annual water resources would be utilizable from the ground water and surface water respectively by the year 2025. Out of that, 28 million ha m would be for uses other than irrigation. Against that, taking the various factors into account, the ultimate irrigation potential for purposes of broad assessment had been taken as 110 million ha. This would be 52 per cent of the sown area of 210 million ha in the year 2025. Thus, in order to cover the whole sown area of 210 million ha with irrigation facilities, it was extremely important that irrigation systems were made use of in the most efficient manner.

Broadly speaking, the concept of good use and maintenance of irrigation systems could be categorized as follows:

(a) Minimizing losses at storage and diversion structures and in the canal system (from head works up to the field outlet);

(b) Maximizing the use of water in the farmers' fields;

(c) Economic and administrative measures to improve over-all efficiency;

(d) Other measures:

(i) Command area development authorities;

(ii) Institutional arrangements for credit to farmers;

(iii) Modernization of existing irrigation projects;

(iv) Miscellaneous.

2. Minimizing losses at storage and diversion structures and in the canal system

(a) *Reservoir losses*

In a storage irrigation scheme there was considerable evaporation loss from the reservoir. The loss from unit water surface area varied from place to place and month to month. The loss in the month of May and June was generally two to five times more than in the winter months of December and January. The annual evaporation varied from a maximum of 300 cm (120") in parts of Rajasthan to a minimum of 50 cm (20") in parts of Assam and Jammu and Kashmir. It was a well recognized fact that for a given quantity of impounded water the loss would be higher if stored in a shallow reservoir than in a deep one. The manner in which the storage reservoir was operated also had a bearing on evaporation loss. The smaller the quantity of water in the reservoir during this period, the lower the evaporation loss from the reduced water surface. In view of the heavy evaporation losses during the hot season, the economics of the mode of reservoir operations should be carefully examined. It had been suggested that nurseries for paddy etc., if raised in compact blocks, preferably in the head reaches of minors on a commercial scale, either by the Government or by co-operative societies, could ensure economy in the use of water for the nurseries, as only the portions of channels serving those need be run. From the agricultural experiments recently conducted in the country, it had now been confirmed that it was not necessary for nurseries to be close to the fields where paddy was required to be transplanted, because rice seedlings could stand a couple of days of transport and handling without injury. Thus, utilization of the stored water to the maximum extent before the onset of the hot season favoured reduced evaporation loss and helped in achieving a degree of economy in the use of stored waters.

(b) *Diversion works*

Absence of mechanical arrangements for lift crest shutters, of the type that fell back in position immediately after the floods had receded, had been a problem on the existing weirs. Better efficiency in the use of available waters could be achieved by installing either mechanically or electrically operated gates on diversion structures.

(c) *Canal and distribution system*

Generally two types of losses, conveyance losses and operation losses, as detailed below, occurred in a canal system.

Conveyance losses. A considerable amount of water was lost through evaporation and seepage in the canal system from the head of the canal up to the outlet where the waters were diverted to the farmers' water courses. The losses occurred because of seepage in the canal, evaporation and evapotranspiration of weeds present either in the flowing water or on the canal banks. The commonly accepted figure for such losses in alluvial soils of north India was approximately 45 per cent of the discharge at the canal head. This included 17 per cent in the main canal and branches, 8 per cent in distributaries and 20 per cent in water courses. However, the general practice was to adopt these losses at 8 cu ft/sec per million sq ft of the wetted perimeter of the canal. In order to reduce such losses, the measures adopted were lining of vulnerable reaches, rostering or separate channels, growing similar crops under one outlet, adequate provision of canal regulators and proper maintenance of the irrigation system by provision of sufficient funds and adequate time during which canals were closed for maintenance.

Most of the outlets feeding the waters to fields were generally not gated. These uncontrolled outlets were not only a source of wastage of irrigation waters but also tended to create problems like waterlogging, soil salinity, etc. It had now been conceded that it was uneconomic to install ungated outlets since the benefits accruing from the waters conserved by gated outlets outweighed the additional cost of providing gates. In many operating projects, because of insufficient allocation of funds for maintenance of canal systems and continuous running of the canals without sufficient closure periods, there was deterioration in the over-all efficiency of the canal systems. It had now been accepted that by not allocating suitable funds, much costlier repairs had to be undertaken at a later stage. In view of the importance of keeping canal systems in efficient working order, an amount of Rs 50 per ha[1] of gross irrigated area had been recommended for the expenses of operation. Secondly, unless a complete shutdown each year of the canal for maintenance and repairs was insisted upon, there could be no assurance that operation and maintenance and repairs would be accomplished as needed to ensure full realization of benefits. Thus, proper operation and maintenance on a continuous basis was a necessity if the system was to yield, without interruption, the full anticipated benefits.

Operational losses. Operational losses in the canal occurred owing to deliveries to turnouts and escapes and also when the demand for water was abruptly decreased before the flow in the irrigation canal was reduced. In order effectively to check these losses, efficient communication facilities, such as a wireless system, approach roads, etc., had been proposed so that controlled flows let into the canals and distribution system would be made more responsive to changing conditions of demand in the command area. Secondly, much of the losses occurred during the night because many farmers had not got used to the idea of irrigation at night. This was particularly so in cases where irrigation water delivery systems were not kept in proper shape. Whenever there were some breaks or cuts in the system during the night, these were not discovered and repaired early with the result that substantial increases in operational losses occurred. In that connexion, farmers were being educated through various agricultural extension programmes so that they would go for night irrigation which indirectly would also reduce canal breaches occurring at night and allow for quicker repairs of those that did occur.

3. Maximizing the use of water in the farmers' fields

Whereas management of water delivery right from the planning of water resources projects to construction and operation of storage and water conveyance structures was purely the work of the engineer's organization, the on-farm management was agro-technical in nature. The objectives of irrigation management were optimum crop yields, maximum water use efficiency and minimum damage to the soil. It consisted in managing the application and use

1 Rupees 8.193 = $US 1.00 (1978 period average).

of water, not in isolation but in its environmental complex, chiefly water-soil-plant-atmosphere complex.

(a) *Selection of crop pattern*

Cropping patterns in the country had been adopted, in the past, on *ad hoc* recommendations. However, now it was realized that a suitable cropping pattern and crop calendar based on agro-climatic conditions prevailing in the command area were basic prerequisites to achieving efficient use of irrigation water in the fields. The different soil and land classifications in the command area had to be considered with regard to:

(i) Behaviour of soil in the changed water regimes brought about by the introduction of irrigation;

(ii) Delineation of land suitable for irrigation;

(iii) Suitability of the soil for a particular crop proposed, etc.

(b) *Depth and frequency of irrigation*

Crop growth and water input relationship was almost a linear one up to a certain point. To realize optimum crop yields, the irrigation should take place while the soil water potential was still high enough so that the soil could supply water to meet the regular atmospheric plant demands without placing the plant under a stress that would reduce the yield or quality of the harvested crops. Frequent application of more irrigation water than was required, instead of benefiting the crop and its yield, resulted in wasteful use of water. Inadequate depths could not cover the entire root zone and might also not be able to keep the soil salts below harmful levels. That could be avoided by determining the moisture retention property of the soils, the actual moisture available in the soil (by lysimeter, etc.) and the effective depth of the soil profile for a particular crop.

(c) *Distribution of irrigation supplies*

It had been observed that water requirements of crops varied with their stage of growth. The term "critical stage" was commonly used to define the stage of growth when plants were most sensitive to shortage of water. Each crop had certain stages at which, if there was shortage of moisture in the soil, yields and quality were adversely affected. It was therefore now being considered that, in order to extend the benefits of the created potential in an efficient way and to larger segments of the society, the irrigation supplies might be distributed so that crops did not face shortage of soil moisture at their critical stage of development.

(d) *Crop and soil management practices*

Water use efficiency (crop yields/evapotranspiration of crop area) was influenced by crop and soil management practices. Water use efficiency was not closely dependent on the water available, if the supply was within evapotranspiration limits, even though the crop yields depended upon the adequacy of the water supply. The storage of more water in the soil profile increased the water use efficiency of grain crop grown under conditions of limited water supply. Similarly, letting an irrigated crop like wheat or maize run out of water at the critical stage of its growth might cut into yields and thereby water use efficiency without lowering appreciably the total seasonal evapotranspiration. It was therefore, considered essential that crop water requirements be worked out properly and provisional arrangements made to supply the same so that irrigation waters would be found adequate when they were required.

(e) *Minimizing field losses*

It had been assessed that about 17 per cent of the discharge at canal head was lost in the field. This loss occurred owing to adoption of faulty irrigation methods, permeability properties of the soil, improper land shaping, grading and levelling, etc. Measures such as construction of a suitable number of field channels and proper land shaping were therefore recommended for adoption. Generally, it had been the experience that construction of field channels (carrying waters from water courses to the individual fields) always posed a problem in effectively making use of the irrigation waters. Planning Commission (union Government) directives only stipulated that construction of field channels had to be done by farmers, and survey, alignment and supervision of the construction had to be done by the governmental authorities. Farmers themselves did not generally have the financial resources or the interest to construct these field channels. In order to meet the situation, it had now been suggested that the field channels might be constructed by the state authorities or project authorities and the cost thereof recovered from the farmers. However, that had to be done within the existing irrigation codes and acts of the state governments.

(f) *Drainage*

Drainage of command areas was essential in order to achieve optimum production. Proper drainage not only increased crop yields by providing aeration space to the pores of the soils but provided better cropping systems and resulted in better utilization of soil and water resources. Field drains, trunk drains and main drains were a necessity in any efficiently managed command area of an irrigation project.

Other equally important methods of maximizing the use of waters in the fields included adoption of a proper crop growing season, selection of a suitable irrigation method, plant species adaptation, tillage, planting pattern, application of fertilizers, and weed, pest and insect control measures.

4. Economic and administrative measures to improve over-all efficiency

(a) *The Economic approach*

The economic approach was based on the idea of attacking the problem of efficient water use through water pricing. By employing an adequate price policy it would be possible to discourage wasteful use of water by the farmers.

There was growing thinking in government circles that the current system of charging water rates to cultivators on a crop area basis did not provide much incentive for economy in the use of water. Knowing that a fixed rate was to be charged irrespective of the quantity of water consumed, farmers indulged in excessive irrigation which proved harmful to their crops and land and resulted in wasteful use of irrigation water. However, the adoption of water charges on a quantity basis would involve selling water to an individual consumer by means of an accurate measurement of the quantity supplied.

(b) *Administrative approach*

This approach was based on an effective administrative control system supported by proper legislation with a view to effecting far-reaching iimprovements in the water supply and distribution system. It included making available the basic inputs of irrigated agriculture, such as seeds, fertilizers, pesticides, water, at a reasonable price and pricing of agricultural produces at fixed floor prices.

Generally the dam or the diversion structure in an irrigation project was completed earlier than the entire canal system. Farmers whose lands were located in the head reaches of the canal system then tried to make use of the available waters in adopting high water-consuming crops and irrigation techniques which used irrigation waters extravagantly. Subsequently, when the entire canal system was completed and the waters had to be equally distributed over the entire command area, those farmers resisted any curtailing of their supplies. Just by curtailing the unauthorized use of irrigation waters in the head reaches in earlier years of operation, the potential could be extended to the tail reaches more effectively.

Some activities such as construction and maintenance of water courses, field channels, field drains, land shaping etc., helped in reducing the gap between the potential created and utilized and thus improved the efficiency of the irrigation system. Farmers were now actively invited to form associations such as water users' associations and drainage district associations, which helped promote public participation in the efficient operation and maintenance of irrigation projects. By involving the farmers, a sense of contributing to the over-all efficiency of water use was created in them and they themselves felt responsible for its proper use.

5. Other measures

According to the provisions of the Constitution of India, development of water resources was essentially a State matter and, therefore, the responsibility for investigation, formulation, implementation and operation of irrigation projects was vested mainly in the respective state governments. The central Government could be entrusted with the regulation and development of inter-state rivers and river valleys only to the extent to which such regulation and development under the control of the union was declared by Parliament by law, to be expedient in the public interest. The powers of control and regulation exercised by the central Government were thus mostly advisory in nature.

Many steps had now been undertaken to increase the efficient use of irrigation systems in the country. Some of these measures are described below.

(a) *Command area development authorities*

With the large step-up in the creation of irrigation potential, steps had also been taken to utilize the created potential. The most important of these was the establishment of command area development authorities for a number of irrigation projects in the country. These authorities were entrusted with the responsibilities of constructing field channels and field drains, land levelling and land shaping, assistance to farmers in getting necessary inputs of seeds, fertilizers and pesticides, etc. They had, under special circumstances, also been assisting the farmers in getting the requisite credit from banks and other financial institutions. Currently, 51 command area development authorities were operating in the command areas of the major irrigation projects in the country.

(b) *Institutional arrangements for credit to farmers*

The engineering works of irrigation projects had to be financed from government resources and, except for water courses,[2] executed, operated and maintained therefrom. Field channels and on-farm development works were to be executed by the beneficiaries themselves and, along with water courses, maintained at their own cost. In India,

2 A water course is a channel feeding a block of 40 ha (100 acres) of the command area from the canal system.

where land holdings were generally small, a single outlet served the lands of scores of farmers and on-farm development works presented difficulties. In addition, the farmers, being poor, were not able to generate financial resources in order to purchase improved varieties of seeds, agricultural implements, fertilizers, etc. Financial institutions and co-operative societies were being set up in the rural areas in order to help the farmers to obtain loans at reasonable rates of interest. These loans were repayable once the crop had been harvested. However, in some of the States, it has been seen that processing of the loan application of a farmer was cumbersome as he might not have a clear title to the land or the land might not be registered in his name in the land revenue records. Steps to improve and update the land revenue records were therefore contemplated.

(c) *Modernization of existing irrigation projects*

One of the most urgent and immediate tasks in the operation of irrigation projects was to modernize existing old schemes; particularly those built in the last century and the earlier part of the present century. These systems were very old and their usefulness was limited by structural handicaps like outmoded headworks, absence of silt-excluding devices, absence of sufficient numbers of regulators, and wear and tear on the canal. Modern agriculture, particularly after the introduction of new hybrid and high-yielding varieties, demanded more exacting irrigation supplies. Unless the systems were modernized with better regulation and control facilities, it would not be possible to provide irrigation supplies for optimum results. State governments had therefore been obliged to make a complete review of these old projects expeditiously and prepare a systematic programme for their modernization in a phased manner. Some of the works for which modernization had been undertaken were: (i) the Okhla and Tajewala weirs on the River Yamuna, the Jobra weir on the Mahanadi River (these weirs were being replaced by barrages); (ii) old canal systems such as Bewar Branch, Farukhabad Branch, Mat Branch of the Lower Ganga Canal, Upper Ganga Canal, Sarda canals and Trebeni canals.

(d) *Miscellaneous*

Another aspect that had been receiving the attention of the Government was the efficient use of available irrigation supplies and proper operation of the irrigation systems. The First Conference of State Ministers of Irrigation, held in July 1975, recommended that operational programmes for supply of water in command areas of major irrigation projects be formulated and reviewed periodically by the State authorities with the assistance of a central team. Thus, a central team comprising irrigation engineers, an agronomist, ground-water and water-management specialists had been constituted by the Union Department of Irrigation. State governments had also been requested to set up similar teams with similar composition for the purpose. The central team, in consultation with the State teams, provided necessary help to the State or project authorities in regard to water conservation and utilization and drawing up of operational programmes of the irrigation projects. The team had inspected many projects in the country and given its recommendations in so far as the engineering, agronomical, administrative and legislative aspects were concerned.

One of the major steps recently taken by the Union Department of Irrigation was to set up a strong central monitoring organization in the Central Water Commission (under the Department of Irrigation). Three chief engineers with supporting staff had been appointed to visit various projects under construction, review progress made and advise the State governments with regard to timely and corrective action so as to achieve the anticipated targets. As part of monitoring and modernization, one of the important aspects had been the phasing of construction in such a way that the canal systems were constructed block by block and distributary by distributary, so that as and when waters were made available they were put to use immediately.

A central co-ordinating committee had also been established, under the chairmanship of the Secretary of the Department of Irrigation, with senior officers of the concerned departments or ministries, to review the progress periodically and take necessary action to assist the project authorities.

E. WATER MANAGEMENT AT THE FARM LEVEL IN INDIA*

1. Introduction

Water was the elixir of life and its use was vital to modern civilization. Population put the emphasis in food production on the development of water resources and their better management. Irrigation was not a single, self-contained activity, but included soil physics, soil chemistry, agricultural chemistry and plant chemistry, agrimeteorology, plant physiology, soil engineering, crop husbandry and economics. The farmer was not the least

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but most important in the whole management. The management of irrigation water for successful irrigated agriculture required development of information through research, dissemination and creation of an enlightened farmer's attitude. To have a clear-cut idea of management of irrigation water, a knowledge of climatic conditions of the different parts in the country was necessary.

(a) *Diversity of climate and weather*

The extent of the diversity of weather and climate in India was perhaps greater than in other areas of similar size in the world. Assam in the east and Rajasthan in the west presented extremes of wetness and dryness. The average annual rainfall in the Thar Desert was less than 15 cm, whereas at Cherrapunji in the east it was more than 1,000 cm. There were variations from year to year in weather conditions, region-wise and country-wise. Some parts of the country were subject to those variations to a greater extent and with greater frequency than others.

(b) *Distribution of rainfall*

The average annual rainfall in the Indian plains had been estimated to be 105 cm. Its distribution varied widely from one part of the country to another: very heavy rainfall of over 400 cm over the southern slopes of the Khasi-Hills, the Brahmaputra Valley and the Western Ghats, heavy rainfall amounting to over 200 cm over the whole of Assam and the western coast of the peninsula, and low rainfall of less than 40 cm over western Rajasthan, with a portion receiving less than 20 cm. Nearly one third of the country received less than 75 cm of rain.

Meteorological subdivision	*Normal annual rainfall (cm)*
Punjab, Delhi, Haryana	63
Rajasthan (eastern)	70
Rajasthan (western)	31
Saurashtra and Kutch	48
Royalseema	68
Interior Karnataka (northern)	68

Broad area-wise distribution of rainfall

Rainfall (cm)	*Area (percentage)*
0 - 75	30
75 - 125	42
125 - 200	20
Above 200	8

(c) *South-west monsoon (June to September)*

Every part of India outside Assam and the adjacent States faced the probability of a drought at least once in five years, and some regions, such as Gujarat, Rajasthan, Royalseema and Telengana were liable to drought once in about three years. The aberrations were maximum in the areas of low rainfall, but where monsoonal rainfall is above 100 cm the frequency of abnormal monsoon was comparatively small. Prolonged breaks in the monsoon were caused when the normal trough of low pressure in the south-west monsoon season, which extended from Rajasthan to Orissa, shifted towards the Himalayas and persisted there for several days.

(d) *North-east monsoon (October to December)*

This was of land origin, orginating from the Siberian high pressure system. The rainfall from the north-east monsoon was less dependable than that from the south-west monsoon. The precipitation in northern India in winter was associated with the passage of western disturbances which varied from year to year.

(c) *Irrigation in India*

Out of a total geographical area of 328.78 million ha in India, an area of 304.34 million ha was reported to be under various land utilization. The net area sown was 142.24 million ha, and the total cropped area was 171.16 million ha (1975-1976). As a result of efforts put in till the end of 1977-1978, irrigation potential created was of the order of 52.3 million ha from various sources. The net irrigated area and gross irrigated area at the end of 1975-1976 had been of the order of 34.45 million ha and 42.94 million ha respectively. During the 1978-1983 Five Year Plan period, it was proposed to create an additional potential of 17 million ha (8 million ha from major and medium and 9 million ha from minor irrigation). The total irrigation potential would be about 30 per cent of the gross sown area of about 173 million ha at the end of 1977-1978.

2. Command area developement

An Irrigation Commission report in March 1972 observed that a series of co-ordinated measures were called for to optimize benefits from irrigated agriculture. Emphasis was laid on scientific crop-planning, consolidation of holdings, land shaping and land levelling, supply of inputs at the appropriate time, gearing up of agricultural research and extension activities. Attention was also drawn to the need for construction of roads, markets, and storage and other infrastructural facilities in the command areas. For the integrated development of command areas, the

Commission suggested establishing a special administrative agency.

In August 1972, a committee of ministers was set up to look into the reasons for under-utilization of created irrigation potential and suggest remedial measures. The committee visited several projects and analysed the problems and recommended the following measures to ensure full utilization of created irrigation potential:

(i) Provision of irrigation facilities, extending right up to the field;

(ii) Land levelling, shaping and preparation prior to creation of irrigation potential;

(iii) Conjunctive use of ground and surface water;

(iv) Provision of inputs such as improved seeds, fertilizers, insecticides and pesticides;

(v) Provision of infrastructural facilities such as farm implements, marketing, processing, communication and storage;

(vi) Education, demonstration, training and extension facilities for cultivators;

(vii) Credit facilities.

The committee felt the need for a broad-based area development authority for every major project with a command extending over 100,000 ha, to be responsible for comprehensive development of the command area.

In May 1973, the Planning Commission requested the States to look into inefficient utilization of created irrigation potential by the major and medium irrigation projects and laid emphasis on an integrated and well co-ordinated approach to irrigated agriculture for optimum production. The Commission drew attention to the need for field channels and drainage in the command areas of irrigation projects. This was followed by communication of the Union Ministry of Agriculture to the State governments, and a series of discussions were held with the State governments on the following points:

(i) Instead of taking up various developmental programmes in isolation, there was clear need for adopting an area development approach, emphasis being given, of course, to schemes aimed at improved water utilization in each command through the improvement of water delivery and drainage systems and the execution of land-levelling and land-shaping works;

(ii) The programme of integrated development in the command areas should deal with modernization and efficient operation of the irrigation system, development of main drainage, development of field channels and field drainage systems within the farmer's block, land shaping, exploitation of ground water, fixing and enforcing of a suitable cropping schedule, preparing a plan of input, supply of credit, seeds, fertilizers, tractors and sprayer services, arranging the inputs and services, planning and arranging necessary marketing and processing facilities and the communication system for maximum benefits to the farmers, preparing individual programmes of action for small farmers, marginal farmers and agricultural labourers, and building implementation into the master plan;

(iii) A unified organization with a direct line of command could exist in so far as departments of irrigation, agriculture, soil conservation and co-operation were concerned;

(iv) There should be a land development corporation or a farmer's service society to meet the requirements of funds for various on-farm works. Such a corporation or society should have an investment programme with its own funds as well as funds obtained from various financing institutions;

(v) Proper arrangements should exist for execution of on-farm works on behalf of the beneficiaries.

The Government approved the Central Sector Scheme for Command Area Development Programmes in December 1974. The National Commission on Agriculture (1976) had made known the various aspects of command area development programmes and laid great stress on development of land in the command area in an integrated manner comprising:

(i) Laying out of plots and common facilities such as water courses, field channels, drains and farm roads;

(ii) Consolidation of farmers' scattered plots into one or two operational holdings;

(iii) Construction of water courses and field channels;

(iv) Construction of field drains where necessary, linking them with connecting drains;

(v) Provision of farm roads;

(vi) Land formation to suitable slopes.

The Commission suggested that land formation was equally important in the commands of minor irrigation projects. The Commission recommended that every attempt should be made to carry out the work in the field for the maximum number of days in a year even by giving sustenance loans to farmers for missing a crop in the process of land formation operation.

So far, command area work for scientific land and water management was being carried out in India in 16 States spread over 121 revenue districts.

(a) *Land formation*

As mentioned earlier, the rainfall had a wide variability on the Indian subcontinent so the technique of land forming varied from place to place depending upon land configuration and the thickness and nature of the soil. The broad purpose was to create optimum environments for equalizing moisture distribution first in the seedbed and then in the crop-root zone for uniform plant growth. This might be accomplished by land levelling, by forming terraces or by making furrows, or by a combination of all three. Where the available irrigation supplies were relatively scarce, as in most arid and semi-arid areas, one of the important objectives of land forming was also the resulting economy in water use, enabling larger areas to be provided with irrigation supplies and reducing the cost of drainage operation.

(b) *Providing field channels and water control and regulatory structures*

The construction of field channels[1] was the responsibility of beneficiary cultivators who tried to bring irrigation water without field channels (i.e. field to field) from the outlet head and used much more than the required amount of water. The water control and regulatory structures in the field could prevent the execessive use of water at the head reach and improve availability at the tail end. Several types of lining material had been tried in different irrigation commands and been found suitable under different conditions.

The lined field channel, including division box, drops, road crossing and cross drainage structures, saved 50 per cent of irrigation water wasted at the outlet, reduced seepage loss occurring in elevated sections of earthen channels, distributed irrigation water evenly and efficiently, reduced drainage problems, created additional irrigation potential up to 45 per cent in the *rabi* season and 20 to 30 per cent during the *kharif* season, reduced annual maintenance cost and increased production.

3. Summary

Efficient water management at the farm level needed more attention than dry land farming. New techniques to solve the problems present in the irrigation command area were coming up and the command authority was working towards improving future scope for optimum agricultural production.

Training of farmers and technicians at the farm level had provided adequate confidence to the people engaged in the command area development work through the active co-ordination of irrigation, agriculture, and co-operative organization. More employment for the local farmers was being generated through multiple cropping, and farmers were more confident they would obtain the yield they had planned for through efficient water management practices.

F. ON-FARM WATER MANAGEMENT IN MALAYSIA: CURRENT PROBLEMS AND EFFORTS*

1. Introduction

Irrigation in Malaysia had been provided up to the present time for paddy fields only. It was believed that rice had been grown for at least 2,000 years in Malaysia, and early cultivators depended either on rainfall alone or on water diverted into paddy fields by constructing rudimentry structures, such as brushwood dams across streams. It was interesting to note that some canal systems had been in existence even before the British administration of Malaysia. The most noted canal was the Wan Mat Saman Canal in Kedah, which was completed in 1888 and was still in existence. Irrigation development *per se* only began to take place at the turn of the century, mainly because of the need to be less dependent on other countries for rice - the staple diet of the nation.

In the late 1950s a serious shortage of rice was experienced. The Government at that time became aware of the need to meet the possible recurrence of such situations by the development of potential rice areas in the country and by the intensification of rice cultivation where possible.

With the introduction of double cropping of rice, and the need to increase rice production to self-sufficiency level as well the advent of the high-yielding varieties (HYVs), there was a growing awareness of the need for proper water management and control at the farm level, not only to achieve a favourable water regime for the cul-

1 A water course is a channel built at government expense to convey water from an outlet to, for example, a 40-ha block. A field channel is a channel built by cultivators beyond the water course to serve the various fields within the block.

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tivation of rice but also to optimize the rapidly diminishing water resources in the country. This might be regarded as the logical outcome of the irrigation development that had taken place in the country recently.

2. Early irrigation systems

In the traditional mode of cultivation, the planting of paddy had been so timed that the growing period coincided with the monsoon season and the harvesting period with the dry season. Moreover, the paddy varieties planted then were photo-period sensitive and thus the yield had been influenced by the rainy season. Farmers had only been able to carry out subsistence farming with this method of traditional wet rice cultivation.

Traditional methods of rice cultivation were highly susceptible to the vagaries of nature and partial or total crop failure often resulted when the anticipated monsoon rains failed to come. It was therefore recognized that in order to forestall crop failures and ensure production, an effective form of water control was necessary.

After 1932, with the formation of the Drainage and Irrigation Department, the area provided with irrigation and drainage facilities in the country increased steadily. Water control in those areas in the majority of cases was effected through the drainage and irrigation facilities.

The majority of the irrigation schemes were constructed to enable one crop of paddy to be cultivated in a year. The crop was planted during the rainy season and the schemes were designed to supplement the rainfall and ensure provision of a reliable water supply throughout the growing season.

Owing to varying conditions of topography, soil, rainfall and water, different methods of irrigation systems were developed over the years. Broadly, the distribution of irrigation water over cultivated land could be classified into three categories, namely, controlled drainage, supplemental irrigation and inland riverine schemes.

(a) *Controlled drainage schemes*

In this type of system, irrigation depended on the conservation of direct rainfall. If there was inadequate stream-flow for a paddy area, or if it was considered uneconomical to construct long conveyance canal systems to deliver water to the area for the cultivation of a single crop of paddy, a system of drains was alternatively constructed and equipped with drainage controls, as shown in figure IV. When water was required, the weir-type drainage control gates would be shut down and water levels in the drains allowed to rise above ground level and inundate the adjacent paddy fields to a required depth. Any excess water was

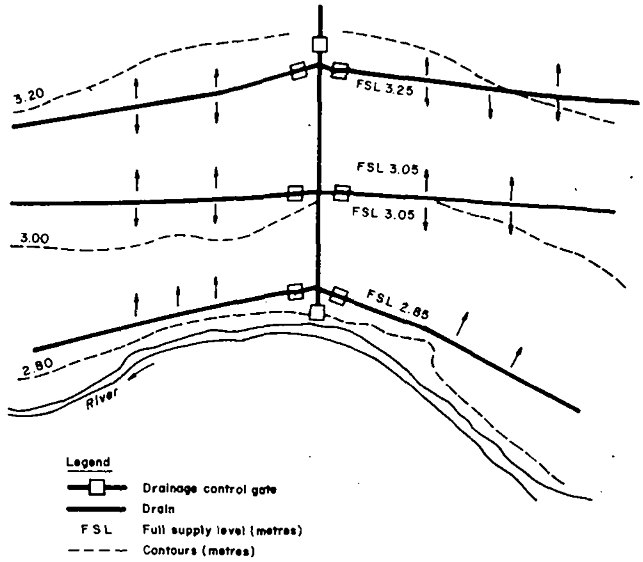

Figure IV. Controlled drainage scheme

allowed to spill over the drainage control gates, thus allowing reasonable control over the water in the inundated area.

(b) *Supplemental irrigation schemes*

Most irrigation schemes existing along the coastal areas came under this category. In these schemes, water was generally available from a diversion dam or pump for a single crop of paddy which was planted during the wet season. This water was required to be maintained at a predetermined depth in the fields and, in order to do so, some degree of controlled drainage was also used. This prevented excessive loss of irrigation water and enabled drainage to take place to the desired levels prior to the harvesting period. A typical system is shown in figure V.

(c) *Riverine irrigation schemes*

Further inland and away from the coastal belt, small pockets of paddy fields were irrigated by irrigation systems similar to those described previously; however, the conveyance canal ran along contours and was located on both sides of the valley. There was usually no drainage system provided and any excess water found its way to the river at outlets downstream of the scheme. A typical scheme of this type is shown in figure VI.

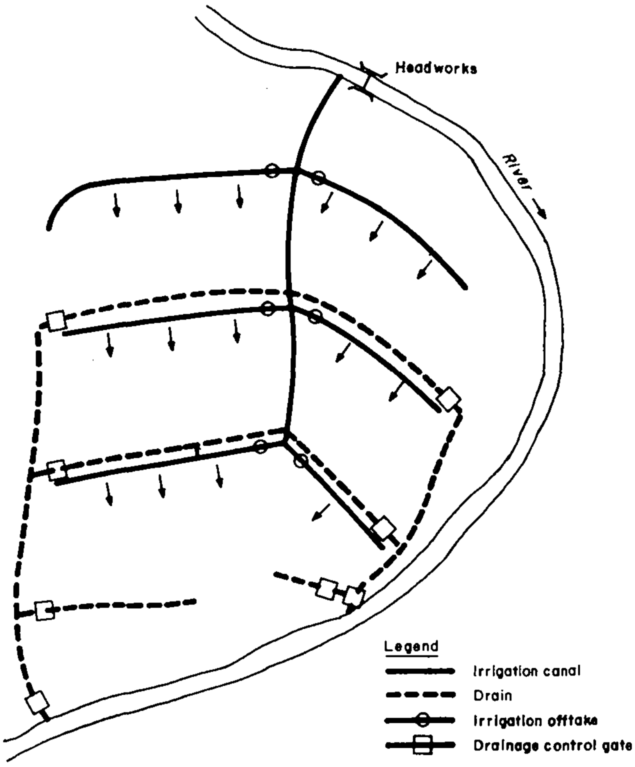

Figure V. Typical supplemental irrigation system

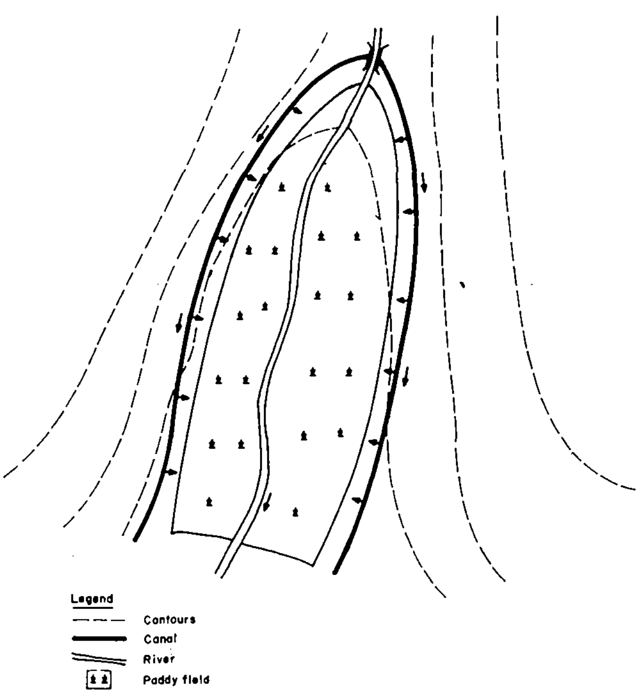

Figure VI. Typical riverine irrigation scheme

3. Rice production and the role of water management

The total land area in Peninsular Malaysia currently under rice cultivation was about 1,000,000 acres (404,700 hectares). This represented some 12 per cent of total arable land in the country. Since the early 1930s, sustained efforts had been made in the systematic provision of irrigation facilities in order to increase rice production.

The social and economic development envisaged in the provision of those facilities would benefit the livelihood of the rural farmers, thus contributing towards poverty redressal in a section of the Malaysian economy which was generally regarded as being among the most economically depressed. The development was further expected to make a significant contribution towards the national goal of self-sufficiency in rice production.

In the past 15 years massive investment had been made in irrigation projects. In addition to heavy expenditure on irrigation works, the introduction of the short-term, high-yielding varieties of paddy, together with increasing application of farm inputs (such as fertilizers and insecticides), had contributed towards the recent remarkable increase in rice production. In spite of this increase, the national average yield was far below the potential of the high-yield varieties.

A key factor for increasing current yield levels lay in improvement of the standards of management and control of water at the farm level. In view of the sensitivity of the high-yielding varieties to adverse physical conditions such as drought and flooded conditions, in order to have the high yields, they demanded timely water application and better water control, improved cultural practices and adequate agricultural inputs.

4. Problems encountered in water management at the farm level

As elaborated previously, most irrigation schemes in Malaysia had one independent system to supply the irrigation water to the fields and another independent drainage system to drain off excess rainfall, as shown in figure VII.

As was typical of irrigation systems in the country, the main canals functioned only as conveyance systems, whereas the secondary canals had the dual role of conveyance and distribution. Water in the secondary canal was usually maintained at about 30 cm above ground level and water was let into the adjacent fields through a number of unregulated offtake pipes. The spacing of secondary canals or distributaries varied with topographical conditions. The distance between a distributary and a drain in a relatively flat paddy area varied from about 0.5 km to 2.5 km.

Each distributary in such an area usually supplied water to about 200-500 ha.

(a) *Inadequate distribution systems*

There may be as many as 10 to 15 farm lots owned by different farmers in the area between a distributary and a drain. Water from the distributary supplied through the unregulated offtake pipes passed from field to field, each field being demarcated by field ridges or bunds which played the role of water conservator as well as forming a boundary between individual holdings. Figure VII shows the passage of water from a typical distributary across farm lots. In such a system, water was supplied continuously to all parts of the field at the same time and the field offtake pipes were requried to deliver the high water requirement during the pre-saturation period at the beginning of the irrigation season. After pre-saturation, the supply was regulated at a rate just sufficient to make good any losses. Distribution of water in the fields was left entirely to the farmers and often was not carried out in an organized manner.

The topography of the area within an irrigation block could often be undulating, so that the depth of water in a field varied. Thus, high areas might receive very little or no irrigation water and depend mainly on rainfall, and under such circumstances the field ridges were well placed to conserve water. With regard to water control, little difficulty was experienced in supplying water to low fields, but for higher fields there might be difficulty in maintaining the required depth of standing water. This could lead to low fields being waterlogged and sometimes flooded to a greater depth of water than was required in order to supply the higher areas. The consequences of this were excessive water use, delayed irrigation supply to higher fields and waterlogged conditions persisting in lower areas. The prevalence of such adverse conditions would lead to low yields.

When the irrigation supply was commenced during the off-season (dry season), the water took a long time to saturate the farthest fields, with the time lag being as long as 30 days in some projects. Consequently this led to a lag in cultivation activities within an irrigation block, the fields nearest the distributary being ready for harvest and therefore requiring no water while those farthest away from the distributary were being irrigated for the still-growing crop. A conflict in water use was thus created between farmers in a block.

Another instance of conflict of water use arose from this method of continuous irrigation which caused the formation of the "cascading wedge". Thus when water moved across a field from the distributary to the drain end of the block, there existed a head loss across every field bund opening. Where the crossfall or gradient across the field was

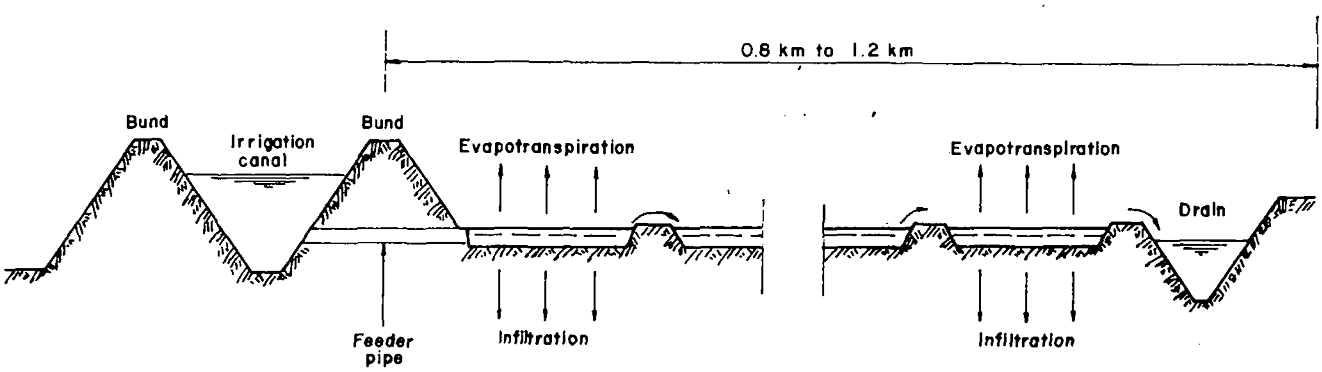

Figure VII. Flow of water over farm lots relatively steep, downstream water levels might not affect the upstream water level; however, where the gradient was relatively flat, downstream levels influenced upstream water levels, creating a wedge of water which was deeper near the distributary end and shallow towards the drain end of the irrigation block. This wedge might drown newly prepared nursery beds which were near to the distributaries and, to avoid this situation from arising, farmers often illegally sealed the offtake pipes, thereby preventing the irrigation water from flowing into the other farmers' fields downstream of the distributaries.

(b) *Uneven topography*

Generally, although most of the irrigated paddy areas in Malaysia were on flat ground, they were not sufficiently flat for water to flow properly from higher to lower areas, towards the drain. High ground, surrounded by depressions, hindered proper water control and distribution. This led to irrigation shortages in the shadow area of settlements or in areas of high ground. The size of the irrigation blocks and the numerous small-holding farmers cultivating them made land-levelling work too expensive. Uneven topography therefore led to excessive water losses and lack of water control which had adverse effects on yields and production.

(c) *Infield drainage problems*

Just as inadequate distribution systems caused water control and management problems, lack of drainage facilities resulted in flood conditions. Pockets of low-lying areas often became permanently waterlogged in the absence of field drains. In such ill-drained areas, the harvesting of crops in standing water resulted in poor farm practices, leading to losses of grain, high moisture content and rapid deterioration of the havested grain.

Poor drainage conditions also made mechanical harvesting difficult. Studies had shown that repeated tractor ploughing of rice fields under prolonged saturated conditions resulted in the progressive weakening of the soil bearing capacity to such an extent that continued mechanization of farm activities became impossible.

5. Efforts to improve on-farm water management

With the introduction of double cropping, the main effort in irrigation development was directed at ensuring an adequate water supply for the second crop (dry season crop). During this season, the rainfall was much less and river discharges were correspondingly lower. This greater need for water had in recent years led to the construction of storage reservoirs and large pumping stations involving major engineering works. In the control drainage schemes, the rudimentary facilities were upgraded to modern systems through the construction of conveyance and distribution canals. In other areas, where drainage and irrigation facilities were already provided to supplement rainfall for the single cropping of paddy, the existing reticulation systems were improved and enlarged as well as provided with additional facilities to irrigate both the dry season and wet season crops.

The double cropping developments and the extensive use of high-yielding varieties gave rise to an urgent need to overcome the problems of poor water control and management if the expected high yields and increased farmer incomes were to be realized.

(a) *Development of on-farm facilities*

Proper water management at the farm level could only be practised by providing adequate irrigation and drainage facilities for effective water distribution and control. Current efforts at irrigation development in Malaysia had therefore been directed towards the provision of on-farm facilities in existing irrigation schemes. In all instances, terminal irrigation facilities in the form of tertiary and quaternary canals and drains with proper checks and control devices had been and were being constructed. Farms roads and other access facilities had also been constructed to provide the necessary transport facilities for the farmers.

With the introduction of on-farm facilities, cropping intensities had also greatly increased, from about 165 per cent to about 195 per cent, computed on both space and time frames. The gradual lag in cropping schedules from the planned cropping schedules owing to poor water delivery and drainage systems could cause many areas to miss the cultivation of one crop in about four to five years in double cropped areas. On the other hand, with the timely delivery of water and supported by the necessary organizational structure, the occurrence of such cultivation failures might be prevented.

(b) *Comparison of infrastructure densities*

A comparison of the densities of existing infrastructures in some parts of the Muda irrigation project to that of developed countries such as Japan, in metres per hectare, is shown below:

Infrastructure	*Some areas in the Muda project*	*Japan*	*Asian Development Bank recommendation*
	(metres per hectare)		
Irrigation canal density	10	80 - 120	50 - 80
Drain density	9	80 - 120	50 - 80
Farm road density	8	80 - 120	50 - 80

Studies had shown that provision of a higher density of canals and drains was a requisite for optimum water and farm management practices.

Experience in Malaysia had shown that the provision of on-farm facilities required only a relatively modest increase in financial investment and that investment in turn brought attractive returns to the farmers in terms of additional yields and net income.

As mentioned earlier, improved on-farm water management had been brought about by the construction of tertiary and quaternary canals fed from secondary canals. Where existing paddy fields had been parcelled out in regular rectangular shapes, on-farm development was easily achieved. Where the farm lots were very irregular in shape and size, as was generally the case in Malaysia, on-farm development became more difficult. In the absence of land consolidation, the establishment of a layout of irrigation drainage and farm road network would have to take into account the existing arrangement of farm lots (to be impartial in the acquisition of the land and minimize social discontent) and the topographical features within the blocks to avoid large-scale land levelling.

The Drainage and Irrigation Division of the Ministry of Agriculture was currently using various materials and methods of construction of tertiary and quaternary systems. While some canals constructed by the cut and fill method were generally less expensive to construct, others required more land, which became progressively more valuable, and at the same time these canals were more expensive to maintain. Canals constructed with imported earth could be designed in hydraulic sections and constructed as "floating canals". Glass-reinforced polyester (GRP) structural flumes or conduits had recently gained in popularity owing to increased speed of construction and the minimal amount of land used. The selection of the proper type of material to be used for the construction of the canal system was based on economic, technical and social factors.

(c) *Size of terminal units*

After implementation of the tertiary and quaternary systems in a paddy area, the irrigation blocks were divided into service areas, irrigated by independent tertiary canals. These service areas were further divided into smaller contiguous and manageable units to which water could be supplied from a single irrigation turnout serving a small group of farm lots. For example, in the Muda irrigation project, it was proposed to establish such service areas to encompass some 80 ha to 200 ha. These irrigation service areas were further divided into four or more irrigation service units, each unit having an area of some 20 to 25 ha.

Being small, contiguous and independent, these units were made more amenable for the practise of better water control and management. The size of the units was convenient also to facilitate the organization of farmers in each irrigation service area into work groups to carry out farm activities that required group action.

(d) *Measuring devices in irrigation systems*

A requisite for proper water control and management was the installation of measuring devices in offtakes and other structures to facilitate control and regulation of the irrigation supply to the fields according to requirements. The incorporation of such measuring devices formed an integral part of on-farm facilities in all new projects implemented in the country.

(e) *Training facilities in water management*

The provision of additional facilities to enable more efficient water distribution and control would not by itself benefit an irrigation project unless the facilities were utilized and the functions understood by farmers, extension workers and irrigation staff responsible for the operation of the scheme. Moreover, the full utilization of the irrigation project facilities required integrated and co-ordinated action between engineering agencies and those responsible for agricultural development.

In order that the total benefits of the on-farm development work be realized by the users, a national water management centre was currently being established in the Kemubu scheme area. This centre would undertake the training of engineers, agriculturalists, technicians and rural leaders. The centre was equipped with full training facilities, including several pilot farms and one demonstration farm. The training programmes would be supported by suitable studies which would be conducted at the training centre and would include:

(a) Water management for rice and other crops;

(b) Water management techniques, including irrigation systems operation and management and related agricultural practices, including farm mechanization;

(c) A practical improvement programme for various existing irrigation and drainage systems in the region;

The centre was being established under a joint technical co-operation programme with the Government of Japan.

6. Conclusion

Malaysia had seen defects in irrigation systems in the past and if left unremedied these defects would extend their effects over time. It thus became essential to improve irrigation system in order to increase food production in the country to cope with the increase in population and to curb heavy dependence on imports.

Land suitable for rice cultivation was getting scarce in Malaysia owing to topographical and soil conditions, but at the same time the development of additional land cost more and took a long time. Hence, the solution lay in increasing yield, which was best brought about by the practice of proper water control and optimum farm management.

G. OPERATION AND MAINTENANCE OF INFORMATION PROJECTS IN NEPAL*

1. Introduction

(a) *Agriculture as the backbone of the national economy*

The predominance of the agricultural sector in the national economy could be seen by the fact that it was the major source of livelihood of 94 per cent of the population (12.6 million) and accounted for about two thirds of the gross domestic product and 80 per cent of export earnings.

Cultivated land in the country amounted to 1.98 million ha, which was only 14 per cent of the total land area, of which about 38 per cent was in the hilly and mountainous regions and about 62 per cent in the Terai plains. On the other hand, 62 per cent of population resided in the Terai plain belt.

With regard to land distribution, 75 per cent of the households had holdings of less than 1 ha and accounted for about 25 per cent of the cultivated area. Conversely, a mere 8 per cent of households owned holdings in excess of 3 ha and accounted for about 39 per cent of the cultivated area. *Per capita* land holding had declined from 0.20 ha in 1961 to 0.17 ha in 1971 and 0.16 ha in 1975 because of the expanding population.

Owing to topographic limitations, the cultivated area could not be increased and the only alternative, in order to feed the increasing population as well as to continue export earnings, was to increase agricultural production per hectare. In that context, the role played by irrigation was significant.

(b) *Importance of irrigation in agriculture*

Irrigation was the basic factor in agricultural production. Other inputs, such as improved seeds and fertilizers, could have effects only with the adequate supply of water. It had been found that with the simple application of regulated water, production increased considerably. Thus, irrigation facilities played a great role in boosting the economy of Nepal.

2. Water resources and irrigation development

(a) *Water Resources*

Surface water was a variable resource both in time and quantity. This was especially true for Nepal, where a south-west monsoon of four months' duration was followed by an eight-month dry period. River discharges varied widely during the year, being high during the monsoon and low in the dry season. The major river basins were the Karnali in the far western part of the country, the Narayani (Gandaki) in the central region and the Koshi in the eastern part of the country. These three major rivers drained 135,000 sq km of the country. There were other, medium-sized rivers and innumerable small streams criss-crossing the country. The average annual rainfall in the catchment systems of the three major rivers was 900 mm, 2,000 mm and 1,790 mm respectively. The annual rainfall of Nepal was 1,516 mm, i.e. about 61 inches. The average annual runoff coefficient within Nepal was about 78 per cent and about 169 x 10^9 cu m of water were annually drained from the river basins, which worked out to about 5,360 cu m per second of average flow. The hydrological data of the three major rivers were as follows:

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River	Drainage area (km^2)	Max. discharge (m^3/sec)	Min. discharge (m^3/sec)
Karnali (at Chisapani)	42,890	10,190	214
Gandaki (at Tribeni)	38,800	20,000	230
Sapt Kosi (at Chatra)	59,500	23,000	300

Nepal had ground-water basins, mostly in the Terai belt in the south. The thickness of alluvium of this belt was from 125 to 150 feet. It consisted of porous and impervious strata making the Terai belt one of the major ground-water reservoirs. The heavy annual precipitation provided a good recharge to these aquifers. Therefore, if properly developed, it could prove to be an inexhaustible resource. Up to the present, ground water had not been extensively developed in Terai. Some areas had shown promising results and pockets of artesian belts had been found where tube-well irrigation projects were being implemented.

(b) *Irrigation development*

The temperature and amount of sunshine were quite favourable for growing different crops throughout the year in most parts of the country. Also, the average rainfall in most areas was sufficient to meet the total moisture requirements of most monsoon crops, such as rice and maize. However, there was moisture deficiency for winter crops. And the distribution of rainfall was very erratic and uneven throughout the growing season, with intermittent drought from two to four weeks. In some rain shadow areas in the hills and mountains, the annual rainfall was inadequate for growing rice, the staple food. In the hills and in Terai irrigation was therefore required for cultivation and to grow a second or winter crop.

The total irrigable area in Nepal had been estimated at about 1 million ha, which was nearly half of the total cultivated area. Though abundant water resources were available, a meagre 14,700 ha of land had been irrigated with facilities from government-built projects before 1951. In 1951 the Irrigation Department was created under the Ministry of Food, Agriculture and Irrigation. The irrigated area had increased to 144,000 ha by the end of 1977. A further 64,051 ha had been targeted to be brought under irrigation by the end of the current fifth five-year plan (1976-1980). It was also estimated that some 140,000 ha of land were being irrigated from the irrigation channels built by the farmers' groups themselves. All added together, the irrigated area by the end of the fifth five-year plan would be 17.5 per cent of the total cultivated area.

The main constraints for not achieving the targets of the plan were insufficient data for planning and design, and lack of skilled technicians.

The development of irrigation schemes by the Government was started with the launching of Nepal's first five-year plan in 1957. During that plan period (1957-1962), several medium and small schemes were undertaken in Kathmandu, Pokhara Valley, as well as in the Terai plain. A total of 11,725 ha of land were brought under irrigation during the period. During the subsequent three-year plan (1962-1965), some 6,670 ha of land were brought under irrigation.

During the third five-year plan (1965-1970), major stress was laid on the implementation of minor irrigation schemes, several of which were in Terai. The idea behind minor schemes as a crash programme was to build irrigation facilities quickly at a reasonably cheap investment cost but with quick returns. A separate Minor Irrigation Department was created in 1967 but it was amalgamated with the Irrigation Department by the end of 1971 in order to develop small schemes side by side with major and medium projects under one department. The contribution from these projects during this plan period was 37,835 ha.

According to topographical conditions and geographical distribution of arable land, planning aimed at developing major and medium irrigation projects in the Terai plain while small schemes were taken up in the valleys and hilly regions. Similarly, tube-well irrigation schemes were being developed in the Terai plain for year-round intensive cultivation which was not possible with surface-water schemes owing either to scanty supplies of water in the river or to non-existence of surface-water resources. The Irrigation Department was planning irrigation schemes under this strategy.

During the fourth five-year plan (1970-1975) allocation was made for the creation of irrigation facilities for a total area of 183,000 ha, but up to the end of that period only 52,463 ha could be provided with irrigation water. The details of the accomplishment of irrigation projects for all plan periods are summarized below:

Project	Planned area (ha)	Actual irrigated area (ha)
1. Irrigated area prior to 1956		
Chandra canal (Saptari)	10,000	13,000
Judha canal (Rautahat)	1,000	810
Jagadishpur reservoir (Taulihawa)	600	400
Pardi dam (Pokhara)	490	320
Subtotal		14,530

Project	Planned area (ha)	Actual irrigated area (ha)
2. Irrigation projects completed during first five-year plan (1957-1962)		
Tika Bhairab (Lalitpur)	1,620	400
Mahadw Khola (Bhaktapur)	940	275
Jhaj (Rautahat)	4,300	2,900
Sirsian Dudhaura (Bara)	1,350	1,500
Tilawe (Persa)	4,300	4,300
Phewatal (Kaski)	320	320
Vijaypur (Kaski)	1,890	325
Gokarna (Kathmandu)	400	375
Other small schemes (Kathmandu)	2,160	1,330
Subtotal		11,725
3. Irrigated projects completed during second three-year plan (1962-1965)		
Hardinath (Dhanusa)	1,940	2,000
Dundwa (Banke)	1,940	1,250
Manusmara (Rautahat) Phase I	2,000	2,700
Kathku (Lalitpur)	810	360
Godavari (Lalitpur)	810	100
Bosan (Kathmandu)	960	260
Subtotal		6,670
4. Irrigation projects completed during third five-year plan (1965-1970)		
Khageri (Chitwan)	6,000	400
Tokha (Kathmandu)	390	200
Pasupati (Kathmandu)	100	75
Sangepatyani (Tanhu)	500	300
Sisaghat (Lamjung)	200	40
Minor irrigation projects	36,820	36,820
Subtotal		37,835
5. Irrigation projects completed during fourth five-year plan (1970-1975)		
Dedhgaon *tar* (Nawalparasi)	350	240
Pathraiya (Kailali)	2,000	2,133
Chaurjahri *tar* (Rukum)	400	600
Chatra canal (Sunsari-Morang)	67,000	30,000
Gandak East canal (Bara, Parsa, Rauthat)	31,400	11,700
Chepetar (Gorkha)	100	60
Babai (Kapilvastu)	400	400
Pushaha (Nawalparasi)	300	300
Mahakali (Kankai)	5,000	3,000
Chakhu (Khola, Bhaktapur)	100	100
Pipaltar (Dhading)	60	60
Gajuri *tar* (Dhading)	100	100
Pithua (Chitwan)	170	170
Tube wells (Sirha, Sarlahi, Bara, Parsa, Rupandehi)	2,000	1,600
Minor irrigation schemes	2,000	2,000
Subtotal		52,463

Project	Planned area (ha)	Area completed by 1977 (ha)
6. Targets of fifth five-year plan (1975-1980) and work completed by end of 1977		
Kankai (Jhapa)	8,000	1,340
Tika Bhairab No. 2 (Lalitpur)	230	230
Gowang (Sindhuli)	100	45
Bishambhara (Bhaktapur)	200	200
Battar lift irrigation (Nuwakot)	560	424
Kamla (Dhanusa – Sirha)	25,000	3,000
Hande *tar* (Lamjung)	270	270
Ramgha *tar* (Lamjung)	220	220
Genyandi *tar* (Parbat)	100	100
Banganga (Kapilvastu)	6,000	4,500
Projects of agricultural year public channels renovation	3,400	3,400
Public channels renovation	2,000	1,200
Tube well projects (Kailali, Kanchanpur)	600	400
Narayani Anchal (irrigation additional) Bara, Parsa	–	5,000
Chitwan irrigation project (Chitwan)	(12,400)	–
Lumbini tube wells (Rupandehi)	7,000	500
Manusmara, second phase (Sarlahi)	3,000	–
Western Kosi canal in addition to Chandra canal	(11,000)	–
Khutiya (Kailali)	5,000	–
Marchawar lift irrigation (Rupandehi)	(10,000)	–
Pokhara water conservancy Project (Kaski)	1,200	–
Subtotal	83,880	20,829

3. Irrigation projects under construction

The earlier irrigation projects were generally designed for supplementary irrigation of rice crops through diversion works on rivers. But now attention was being paid to implementation of projects which would provide year-round irrigation. In recent years, financial assistance had been obtained as soft loans from the Asian Development Bank (ADB) and the International Bank for Reconstruction and Development (IBRD) for some such projects. Consultants were generally employed for feasibility studies and supervision of construction. Such projects included the following:

(i) Kankai irrigation project (Jhapa) in eastern Nepal would provide year-round irrigation for 5,000 ha;

(ii) Chitwan irrigation project in inner Terai would irrigate 12,400 ha. This was mainly a lift irrigation scheme;

(iii) The World Bank and the Government jointly had undertaken the Narayani intensive irrigation project in Bara Parsa and Rautahat districts of central Nepal for year-round irrigation of 31,400 ha;

(iv) The World Bank had been assisting the Lumbini ground-water project (Rupandehi) in western Nepal which would irrigate for multicropping over an area of 7,000 ha. There would be 63 deep tube wells of 3 to 4 cu ft/sec capacity;

(v) The World Bank had recently agreed to assist in the improvement of Chatra irrigation project (Sunsari-Morang). This was also an intensive agriculture scheme for a 67,000 ha area.

Besides the above projects, there were several other major projects under construction with government resources, viz., Kamla irrigation project (Dhanusa-Sirha), 25,000 ha; Banganga irrigation project (Kapilvastu), 5,000 ha; Khutiya irrigation project (Dhangarhi), 5,000 ha. And several small schemes in the valleys and *tars* of hilly regions were under construction or under study. In the current year, a United Nations Capital Development Fund grant had been made available for the Marchawar lift irrigation scheme of Rupandehi (10,000 ha). Similarly, a major project in the hills, the Pokhara water conservancy project, was being implemented, with the assistance of the Government of China, which would irrigate 1,200 ha of land besides producing 100 kW of hydropower.

Obviously, owing to the rugged nature of the country, the possibility of constructing medium- or even small-scale irrigation schemes in the hills was very limited. The inner and outer Terai, with more favourable topography and large areas of suitable soil, were most favourable for irrigation extension. In these extension projects, four major items were stressed for the development of successful irrigation schemes:

(i) Improved design and planning for major works, including desilting works, water-measuring devices for proper flow control, and better design of the main canal to meet peak water requirements and to reduce seepage;

(ii) Inclusion of tertiary canals and on-farm development with drainage infrastructure, a communication network, etc., in the plans for year-round irrigation;

(iii) Improved operation and maintenance of the system;

(iv) Guidance and training for the farmers in year-round irrigation farming through the establishment of farmers' irrigation associations.

Great efforts were therefore needed at present in the rehabilitation of existing schemes for year-round irrigation, as well as undertaking the construction of new schemes.

4. Maintenance and operation of irrigation projects

(a) *Need for proper operation and maintenance*

A successful irrigation project depended not only on good planning, design and construction but also on proper operation and maintenance after construction. Without a suitable operation schedule, the project could not be expected to produce maximum benefits, and good maintenance was the key factor in allowing the project to run smoothly and last long.

In Nepal, it had been observed that a project of low construction cost usually demanded high maintenance and operation costs. This had happened in the case of early projects with an investment cost of NRs 3,000 per ha.[1] The unit cost of ADB and IBRD projects had been high, at NRs 15,000 to 16,000 per ha. With higher standards of construction, the operating costs would come down.

(b) *Co-ordination between agriculture and irrigation*

It had now been recognized that the full impact of irrigation development on food production could not be realized unless a co-ordinated programme of agriculture, irrigation, co-operatives and extention services at the farm level was launched. Agricultural extension and research services were provided by the Agriculture Department. Under agricultural research, there were 18 stations throughout the country working mainly on the selection of seeds, their multiplication, and optimum use of fertilizer. Most of the research was conducted under irrigated conditions. Studies had been carried out on cropping patterns, variety tests, fertilizer requirements and consumption of water by the main crops, i.e. paddy and wheat. Many research stations, for instance, Parwanipur, Janakpur and Bhairwa, were also carrying out experiments on the same lines. Field

1 NRs 12.083 = $US 1.00 (1978 period average).

extension services were provided in 51 districts, of which 28 were intensive agriculture development districts. The programme was directed at the district level by the District Agriculture Development Offices (DADO). At the farm level, junior technicians and assistants carried out extension work to the farmers on improved cultural practices, suitable cropping patterns and use of fertilizers. DADO also helped the farmers to apply for credit from suitable loan-giving agencies, such as the Agricultural Development Bank.

(c) *Organization for operation and maintenance*

At present irrigation projects in Nepal were mainly maintained and operated by a government agency, i.e. the Irrigation Department, through maintenance divisions and subdivisions. However, like some countries of the region, such as Japan, the Republic of Korea, Sri Lanka and the Philippines, operation of some irrigation systems was being tried by water-users' associations. As an experiment, these water-users' associations were being formed for the operation and maintenance of systems at the farm level while the maintenance of major parts of the project was still undertaken by the Irrigation Department. A detailed description of such organizations and their functions will be described later in this chapter. These organizations were essential, not only to make the farmers feel that schemes and projects were their poperty but also for their participation in modern agricultural practices so as to reach food production goals. In the past, irrigation projects had been provided with only main works such as diversion structures, main and secondary canal systems, and they had been maintained by the Irrigation Department. Tertiary canal systems, field channels and terminal structures required to lead water into farms had been the responsibility of the farmers. The farmers did not have any organization to deal with the distribution of water to individual fields. They would not provide all of these facilities on their own and irrigation could not achieve the expected results. It had now been ensured that on-farm development works were included in all the projects. Also, wherever possible, such works were now being incorporated in all old projects although such works would raise the cost of the whole project.

For the construction of medium and small irrigation schemes as well as for operation and maintenance of completed projects, the Irrigation Department had created four Regional Directorates since 1972. This had made it easier to execute and supervise project works by timely checking and close attention by the Directorates. For example, after completion a medium project was operated and maintaned by a subdivision having one assistant engineer, two or three overseers and a few gate and turnout operators with a gang of *dhalpas*. The *dhalpas* looked after the general repair of the main and secondary canals. Recording of actually irrigated areas was done by one or two *amins* (land surveyors) also in the subdivision who prepared records of irrigated lands under each crop with the help of cadastral maps. A subdivision covered an area from 3,000 to 6,000 ha. Whereas for a small project commanding 150-500 ha only, an operation and maintenance unit was established headed by an Overseer (junior engineer), a division comprising several subdivisions was headed by a Divisional Engineer who was an administrative head as well as being responsible for preparing the budget for operation and maintenance of all projects under the division. He was responsible to a Regional Directorate.

(d) *Operation and maintenance of Narayani zone irrigation development project*

Narayani zone irrigation development project had two irrigation components (surface and ground water), which are described below.

Surface irrigation system. Nepal eastern canal, which was one of the main distributaries of the Gandak main canal, had an irrigation command area of 28,700 ha in the Bara and Parsa districts of the project. The whole command area of the canal was divided into 12 blocks, each block consisting of an area of 1,900 to 2,500 ha. Remodelling of the NEC main canal, construction of branch, secondary and tertiary canals, and a drainage system in each block, improvement of the main canal road, branch channel roads and other approach roads and other improvements were included.

Ground-water irrigation system. The total irrigation command area under the ground-water system was 2,750 ha. The ground-water irrigation scheme included fixing up transmission lines, installing submersible pumps, construction of distribution and drainage systems, and construction of pump houses for 14 old tube wells and installation of 14 new tube wells with all the above improvements.

Along with improvement of the irrigation system, agricultural development activities both for the total irrigation command area of 31,430 ha and the non-irrigated area of the whole of Bara and Parsa districts was carried out under the project. The project had a well organized agriculture extension structure down to each village *Panchayat* level. The training and visit system of extension emphasized regular training of field staff to upgrade their technical ability and dissemination of improved agriculture technology among farmers through regular scheduled visits by extension workers to the contact farmers.

Description of on-farm facilities. From each secondary canal several tertiary canals carried water to the farms. Each tertiary canal, which covered 15-40 ha of farm land, had several division box turnouts each covering 5-12 ha in area. The irrigation water was released to the fields through these division boxes. The project was constructed as far down as the tertiaries and division boxes. After the division boxes, the construction of field channels for efficient distribution of water in the fields was done by the farmers themselves under the water-users' association. The project provided technical help to the farmers in constructing field channels and helped them to start and run smoothly a water-users' association for each tertiary.

Distribution of water in each block. The farmers whose fields fell under the command of a tertiary canal formed a group called a water-users' team. The farmers whose fields fell under the command area of a division box in the tertiary formed a subgroup and elected a "subleader" of the division box.

All subleaders formed an executive body of the association for the tertiary. The subleaders of the tertiary elected a leader from among themselves who acted as the main leader for the tertiary. Construction of the field channels from division boxes by individual farmers was organized by the subleader of the division box under the leadership of the main leader. The routine release of water through division boxes in a tertiary was controlled by the main leader, while distribution of water after the division box was controlled by the subleader for the box. Generally, the subleader considered the degree of urgency for water in individual fields when deciding distribution. Under the project, a leader for each secondary canal had to be elected to regulate the routine release of water for the tertiaries.

For each tube-well area a water-users' association was formed. All the farmers whose fields fell within the command area of the tube well were included in the water-users' team. The whole command area of the tube well was divided into between three and six blocks according to the number of division boxes in the main distribution channel. All farmers whose land fell within the command of a division box formed a subgroup and elected a subleader. All the subleaders formed an executive committee for the association. They elected a main leader from among themselves for operation of the tube well. Construction of field channels after the division box was organized by the subgroup leader of the block with the help of project technical staff as necessary. For each tube well, a monthly water distribution schedule was prepared by the Agriculture Officer in charge of the tube well based on the recommended cropping pattern in different blocks. The water to each block was distributed according to this schedule under the close supervision of the main leader and the Agriculture Officer. In the block, the distribution of water in individual fields was decided by the subgroup leader of the block.

5. Problems encountered in proper operation and maintenance

(a) *System built by the farmers*

Dams built by farmers in the hills were easily washed away. But they were easily rebuilt. A permanent structure of masonry would be too costly for farmers. The entrance and channel became silted up. It was now realized that construction of regulator gates at the entrance was advantageous. If properly operated, e.g. closed during peak floods, they would reduce maintenance work. However, the fine silt deposited in the fields was advantageous in increasing fertility.

A considerable number of main canals passed through permeable soil and lost much water. Such sections needed lining with rip-rap, or medium-sized stones with cement mortar, or tamped clay.

Higher-lying lands were generally very permeable and the people there had chosen to grow rice which needed large volumes of water. In such fields, alternative crops which consumed less water should be grown.

The dry season flow of streams was not properly used and was generally wasted. On low-lying basins a fodder crop should be grown after the wheat harvest. This required training in irrigation practices and agricultural extension services which at present lacked sufficient field workers.

(b) *Government-operated projects*

For proper water management, land had to be graded to lead water into field channels and drain ditches. Where the land involved was not extensive, levelling could be done manually. Mechanized levelling could also be tried where farms were accessible by road. But in most cases that was not possible as the farms were in the centre of many fields and away from road. One of the biggest problems in Nepal in efficient water management was the fragmentary nature of holdings and different shapes of plot. The layout of field channels to the central part of several farmers' fields was a problem and a source of dispute. Thus, a land consolidation programme had become essential. Though it called for legislative measures, the programme could be of great help to the small farmers of Nepal by consolidating holdings and setting them in compact blocks of viable size. Thus the net cultivated area would also increase.

Simple supply of irrigation water to the farmers did not mean much. It was necessary for the farmers to know when to use it and how much to use in conjunction with other inputs. The farmers at present had a tendency to over-irrigate their crops in the absence of proper water management. On the one hand that deprived the downstream farmers of their right to water and, on the other hand, crop yield was low because of over-irrigation and lack of drainage facilities. Therefore, water management at the farm level was the main theme of all irrigation projects now being implemented.

Petty quarrels were very common in the distribution of water to fields in critical periods when every farmer wanted to irrigate his field first. The transfer of water from field to field by digging channels through the fields was not allowed. People's participation was therefore necessary in the operation. If farmers could involve themselves in operating the projects by means of farmers' associations, such problems would be automatically eliminated. Also, their sense of responsibility would be gradually wakened in all spheres of work associated with the project. This ideology had been developed in the Narayani irrigation development project as explained earlier.

In the Narayani project, there had been an initial lack of full participation by farmers in constructing field channels and their maintenance. The project staff had had to watch the leaders continuously to get the work done. However, after observing the improvement where such construction had already been done and was functioning, the farmers were now better acquainted with the system and thus had started to participate.

Because of uneven topography and lack of land development, some structures such as culverts and falls were needed in the field channels to lead water efficiently to the individual fields. The farmers had been reluctant to pay the cost of materials for the construction.

6. Recommendations

For efficient use of existing farm irrigation schemes improvements should be carried out by the Government, such as provision of head regulators and arrangements to minimize seepage losses and land slides.

Agriculture inputs and extension services should be made available where irrigation projects had been completed. Special attention should be given to the need of the farmers for credit. Completion of irrigation projects should be intimated to the Agriculture Department for follow-up action.

Fragmented land holdings should be consolidated, at least in irrigated areas, by legislative means to make on-farm development and efficient water management feasible.

On-farm development works and land levelling should be carried out in all future irrigation projects with a view to intensive cultivation.

H. FARM-LEVEL WATER MANAGEMENT DEVELOPMENT PROGRAMME IN THE PHILIPPINES*

1. Introduction

The Philippines was principally an agricultural country composed of 7,107 islands. Its total land area was about 30 million hectares, some 8.9 million hectares of which were potential areas for cultivation. About 3 million hectares were potential areas for irrigation development. Currently, the total irrigated area was about 1.2 million hectares.

In September 1974, Presidential Decree No. 552 was promulgated providing a more vigorous thrust to the implementation and attainment of the objectives of the Philippines' irrigation programme. The National Irrigation Administration (NIA) five-year irrigation development programme which was an integral part of its long-term plan (Irrigation Development Plan up to the Year 2,000) called for an average increase of irrigated area of 135,000 hectares annually for the subsequent five years.

To realize such a programme, the Decree provided NIA with broader powers and objectives "to investigate and study all available and possible water resources in the Philippines, primarily for irrigation, hydraulic power development and/or other use as flood control, drainage and reforestation in co-ordination with other agencies/ institutions either public or private".

One vital objective of the National Irrigation Administration under its current Irrigation Development Programme was oriented towards the sustained implementation of a water management programme at the farm level. This was triggered by the fact that substantial portions of the irrigable area covered by existing systems were not effectively served despite the availability of water supply.

Among the problems identified were:

(a) Excessive conveyance and distribution losses;

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(b) Excessive farm water wastes and losses in the paddy field;

(c) Inadequate terminal irrigation facilities for effective water control, equitable water distribution and proper water use at the farm level;

(d) Improper utilization of irrigation water by the farmer end-users;

(e) Inefficiency in the operation and maintenance of the irrigation system itself owing to non-co-operation of some irrigation water-users;

(f) Inadequate canal capacities to serve intended service areas owing to silted canals and poor maintenance.

This paper aims to present information on previous, current and future plans on water management development programmes in the Philippines with the end in view of sharing with other participants in the ESCAP Workshop some ideas and experiences.

2. Historical account of the water management programme

The above-mentioned situational problems were given serious consideration which led to the birth of the NIA-Asian Development Bank (ADB) joint water management project, with the principal purpose of improving operation and management in selected irrigation systems. ADB provided the financial and technical assistance with the Philippine Government providing local counterparts. The project was launched in July 1968 and was terminated in August 1970.

Water management in this project was defined as the "integrated processes of diversion, conveyance, regulation, measurement, distribution and application of the right amount of water at the proper time and removal of excess water from the farms to promote increased production in conjunction with improved cultural practices".

The main staging areas of operation were the pilot projects in the Angat River irrigation system area in Bulacan and the Penaranda River irrigation system at Gapan, Nueva Ecija.

Eight additional pilot irrigation projects, strategically located throughout the Philippines, were selected for the purpose of gradually introducing innovations in water management practices. These included improvement of the existing methods relative to effective irrigation water utilization, equitable distribution schemes, timely use of adequately tested production inputs, and improved farm management and cultural practices.

To attain project objectives, the total involvement and co-operation of the farmers was solicited. Irrigators' groups/associations were organized initially and the necessary training for the members and officers given.

In-service training programmes on water management for NIA technical personnel from the project areas and other irrigation systems were also conducted. Field training and demonstration services to farmers in the project systems were intensified and given more emphasis.

A water management manual was developed to serve as guide to field implementors. To promote awareness of the project's scope and objectives, so as to enlist farmer's co-operation, preparation and distribution of printed matter was also undertaken. One of these was the *Ang Magpapatubig* (The Irrigator).

Agricultural extension services to intensify crop production were employed in an integrated approach.

Major contributing factors attributed to the rather slow progress of the work during the initial stage of implementation were as follows:

(a) Insufficient available information and data on hydrology, climatology, soils, agronomic and agro-economic data in the different localities under consideration;

(b) Acquisition of necessary rights-of-way for the construction of farm ditches was difficult and a tedious process because of the resistance of some landowners and farmers;

(c) Construction work could be undertaken only after harvest;

(d) The negative reactions and attitudes of farmers to accepting modern irrigation and agricultural practices in lieu of their centuries-old methods, beliefs and traditions;

(e) Shortage of trained technical manpower in irrigation water management, both in the supervisory and farm-level groups;

(f) Lack of information, materials and water management guides.

3. Current programme on farm-level water management

(a) *Water management pilot project in national irrigation systems*

NIA, fully aware of the importance of water management in improving the system's efficiency and performance, had made bold and determined efforts to implement a water management programme on a wider scale by selecting

43 national irrigation systems as water management pilot areas. Three of these were currently covered by the NIA Office of Special Projects. These pilot areas served as the testing grounds for all water management practices in every regional irrigation office.

The necessary service roads and terminal irrigation facilities, such as main turnouts (MTO) with measuring devices; main farm ditches; supplementary turnouts (STO), also with measuring devices; drainage ditches and other similar structures, were constructed effectively to implement improved water management practices. The average area covered per MTO was 32.95 hectares while the average service area per STO was 10.03 ha (see table 7).

Water distribution being practiced in various water management pilot areas was either by rotation or by simultaneous method. In the simultaneous method, irrigation water was conveyed through a main farm ditch (MFD) and distributed simultaneously in the service area through supplementary farm ditches (SFDs). In the rotational method, irrigation water was conveyed through the MFD and distributed by rotation in the different SFDs.

(b) *Special project method of water distribution and farm-level facilities*

One of the first big projects to utilize some of the experiences of the NIA-ADB water management project was the Upper Pampanga River project in Nueva Ecija.

Currently, almost all of the NIA special projects completed and under construction were designed taking into consideration the rotational irrigation method. The scheme involved the application of the daily water requirement to a small area termed a rotation unit within a pre-set time dimension of about 24 hours. Other rotation units received irrigation water in succession similarly according to the set schedule.

Basically, the method necessitated the division of the whole project area into rotation areas and further subdivision into rotation units. Normally, there was a maximum of five rotation units per rotation area of about 8 to 12 hectares per unit. Each rotation area serviced by about 800 to 1,000 metres of main farm ditch was provided with either one double- or single-gated turnout. Each rotation unit was served by a supplementary farm ditch of about 500 to 700 metres long which branched out from the main farm ditch. The head of each supplementary farm ditch was provided with a division box and a check structure.

Farm ditches were located and constructed as far as possible to follow existing lot boundaries. Every rotation area was adequately intercepted by a drainage ditch which was connected to a collector drain to a major waterway (see table 8 for statistical data on density of irrigation facilities in the Upper Pampanga River project).

Water delivery to the main turnout was controlled by the water tenders.

(c) *Formation and development of irrigators' groups/associations*

The success of any developmental undertaking such as the management project in the Philippines would depend on the active support and total involvement of the irrigation water-users themselves. A group's adoption of efficient irrigation water use along with application of the latest farming techniques, as well as awareness of joint responsibilities to overcome agricultural problems would greatly promote increased production and raise living standards. Irrigators' groups served as an effective vehicle for re-educating and training farmers in improved techniques of farm management. They could also act as a catalyst in modifying the behaviour patterns of farmers concerning water use.

The organization and development of irrigators' organizations in all NIA water management pilot areas as well as the NIA Office of Special Projects was one important concomitant activity currently being given attention. The organizational process involved the conduct of pre-organizational education/training programmes for prospective member-water-users of different rotational areas at the MTO level. Some topics included in the programme were: project objectives, schemes of irrigation water delivery and distribution, the importance of irrigators' groups/associations, function and objectives, organizational structures and procedures, method of operation, and duties and responsibilities of members of irrigators' groups. The next phase was the actual formation of irrigators' groups at main turnout level followed by the organization of continuing education and training programmes for the members as a way of strengthening their organizations.

Organized and responsible irrigators' groups were effective partners of irrigation development. Their principal functions were the equitable distribution and proper utilization of irrigation water below the turnout among their members and the maintenance of the farm ditches serving their farms.

Currently there were 533 irrigators' groups with a total membership of 18,357, covering a total land area of 16,900 hectares in 40 NIA national irrigation systems with water management pilot areas (see table 9). In the entire NIA Office of Special Projects, a June 1978 report showed that 5,444 compact farm associations/irrigators' groups and 19 project development compact farms had been organized involving some 105,935 and 1,361 farmer water-users respectively (see table 10).

4. Concomitant activities supportive of current farm-level water management programme

(a) *Research to acquire needed data and information useful for the implementation of improved water management project*

NIA-NSDB water management improvement project. This was an applied research undertaking currently being carried out in different NIA regional research stations emphasizing the maximization of water use and rainfall in accordance with improved cultural practices to promote increased production. Various studies have included: (i) determination of water requiremnts of improved varieties of rice in four regional NIA sites; (ii) grain yield responses of improved rice varieties to different rates of irrigation application; (iii) methods of rice irrigation; (iv) determination of effective rainfall and water-use efficiency; and (v) determination of conveyance and distribution losses. This research was supported by the National Science Development Board.

PCARR-NIA water management improvement project. This project had been recently terminated. Studies completed were: (i) soil moisture stress studies in the field: (ii) growth and yield response of high-yielding varieties of rice to different rates of irrigation; (iii) determination of conveyance and distribution losses; (iv) determination of effective rainfall and water-use efficiency. The funding agency was the Philippine Council for Agricultural Resources Research.

Currently, research work was also being pursued by the NIA Office of Special Projects through its various agriculture divisions. The activities involved not only water management research but also other aspects of agricultural development, such as farmers' assistance and training, agro-economic studies, agricultural progress monitoring, training of operation and maintenance personnel, and cropping pattern development. The characterization of water management parameters involved the determination of crop water requirements, soil percolation rates, conveyance and distribution losses, residual soil moisture, farm irrigation efficiency through water balance studies, collection of hydrometeorological data, river and canal rating, water quality analyses, soil moisture stress study, and sedimentation studies.

(b) *System-wide water management in NIA systems*

As a support move to the implementation of water management practices, chiefs of all national irrigation systems were enjoined to install measuring devices (direct reading staff gauges) and one standard non-recording rain gauge for every water master's division covered by their respective irrigation systems.

(c) *Training and manpower development*

Various water management training programmes had been conducted and were being carried out on a contінous basis in different NIA regional training centres. The main thrust of the programmes was to equip farm-level irrigation authorities with the necessary knowledge of and skills in improved water management practices, in consonance with approved farming practices, human resources development, system operation and maintenance, irrigation extension principles and techniques, etc. Among the participants were irrigation superintendents, farm organization specialists, water masters, gatekeepers, ditch tenders and farmer-leaders.

A comprehensive training programme was also being carried out in the NIA Office of Special Projects with the objective of providing irrigation personnel, in addition to adequate knowledge and skills, with the necessary motivation in planning, implementation and evaluation of water management practices.

The water management technologists were provided with more extensive training, having been the mid-level managers in the organization in charge of the operation and maintenance of the irrigation system.

Training programmes were also planned for personnel under the water management technologists, for instance, water tenders, gatekeepers and hydrometeorological observers. In addition, personnel above the technologist level also underwent training; these included supervising water management technologists, zone engineers and irrigation superintendents.

The training programme for all irrigation personnel embraced the following major aspects: irrigated crop production, irrigation water management, and human resources management, including establishment and development of farmers' organizations.

5. Summary of Problems Encountered in Programme Implementation

(a) The service ability of constructed terminal irrigation facilities and structures. As observed some of the complaints entertained by the irrigation field personnel were of the defects and deficiencies in the construction of such facilities;

(b) Some members of irrigators' groups complained that the pre-determined quantity of water being allowed into the farms was not sufficient to satisfy their crop requirements;

(c) In extreme cases, destruction of some terminal facilities by the water-users occurred;

(d) Illegal checking or diversion of irrigation water persisted. Water-users obtained irrigation water directly from the main farm ditch, which should not be the case. They were supposed to receive water from the supplementary farm ditches serving their farms;

(e) Non-maintenance of the farm ditches in some areas by the water-users. These facilities were maintained only when needed;

(f) Problems of water distribution when water-users were not well organized;

(g) During the pre-construction period, problems in negotiating rights-of-way were encountered;

(h) Inequitable distribution of water, resulting in conflicts among farmers themselves and sometimes with NIA personnel;

(i) Non-conformity with the water delivery schedule of the system in spite of advanced information disseminated to the water-users;

(j) Non-involvement of farmer water-users in the planning stage prior to the construction of the terminal irrigation facilities;

(k) Excessive use of irrigation water;

(l) Some farmers allowed their work animals to wallow in conveyance facilities, resulting in destruction;

(m) Poor maintenance of paddy fields by some water-users resulting in excessive water waste;

(n) Farmers still used water for weed, pest and disease control, which was inpractical;

(o) Diversion of water directly from the main and lateral canals;

(p) In most cases, water-users upstream of the canals or farm ditches were hesitant to join the irrigators' groups because of their easier access to irrigation water. On the other hand, farmers in the downstream portion were more willing and co-operative in forming groups and practicing proper water management;

(q) Though research work was currently being conducted on various water management aspects, actual application of the resulting data (though considered conclusive) by farmers was difficult;

(r) Severe effects of siltation in a few pilot areas;

(s) Lack of necessary incentives to motivate or encourage water-users to establish and strengthen an association;

(t) Still inadequate education and training for irrigators' groups and association members and officers, as well as other irrigation water-users;

(u) Violation of irrigation laws by some water-users.

6. Recapitulation of observations and recommendations

(a) Operational and serviceable terminal irrigation facilities were motivating factors helpful in promoting proper water management and in forming irrigators' groups and associations;

(b) Maximum efforts should be exerted to form active and responsible irrigators' groups that might effectively handle equitable water distribution and farm ditch maintenance activities in their area;

(c) Continuing education and training programmes for irrigation users with strong emphasis on proper water management, proper maintenance of terminal irrigation facilities and structures, effective management of irrigators groups' associations activities, etc. must be a sustained activity;

(d) Sustained follow-up, guidance and supervision of irrigation users with regard to water distribution activities and farm ditch maintenance should be carried out at the initial stages of implementation by the irrigation authorities;

(e) Maximum co-ordination of the activities of NIA field implementors and field technicians of other agencies should be maintained at all times, particularly in the context of the training programmes for irrigation group members;

(f) Mobility of farm-level irrigation authorities (irrigators' association workers) should be given immediate attention considering the extent of their area of coverage. Currently, only two irrigators' association workers were covering the entire pilot area in each region;

(g) A functional manpower development programme must be developed and given to farm-level irrigation authorities on a sustained basis to further improve their work competency and efficiency;

(h) Cropping pattern development and setting of irrigation water delivery schedules should be planned and prepared ahead by the chief of the system in consultation with his farm level field men (water masters, ditch tenders) and irrigators' group leaders and, preferably, with the field personnel of other government agencies engaged in production;

(i) Provision of necessary incentives to irrigators' group members and officers as a way of motivating them to strengthen their organizations to ensure successful implementation of the water management project. One form of incentive was the provision of legal assistance to the group leaders/members in cases where criminal acts associated with programme implementation occurred;

(j) Delegation of part or all operation, maintenance and management activities of a particular national irrigation system or a portion thereof to a duly organized and active irrigators' association (in accordance with Presidential Decree No. 552) might be considered a very encouraging incentive. The necessary training should be undertaken prior to delegation or transfer. In the current situation, however, this might not be immediately realized;

(k) Still another form of incentive was the transfer of ownership of a portion of an existing national irrigation system to the responsible irrigation association with corresponding repayment of its construction cost as conceived in the 1975 policy guidelines of NIA;

(l) The giving of discounts to farmer water-users who pay their irrigation charges on or before the due dates might also be considered a form of incentive. Just recently, NIA had provided for a 10 per cent discount for such farmers;

(m) Providing employment preference to irrigation group members and officers during the construction period was yet another form of incentive. This was one source of their additional income;

(n) What might sometimes be overlooked by the farmers was the important incentive in the form of education and training on matters relative to water management, irrigation extension strategies, operation and maintenance, management, etc. There was a universal saying that "knowledge is power";

(o) The new NIA regulations (Memorandum Circular No. 9, series 1977) which replaced the former water code (Presidential Decree No. 1067) should be strictly enforced. Violators of certain irrigation laws were to be penalized (by a fine and/or imprisonment) according to the new regulartions. Violations included destruction of hydraulic works or structures; illegal taking or diversion of water in an open canal, aquaduct or reservoir; and unauthorized obstruction of an irrigation canal;

(p) Closer co-ordination between field-level authorities should be maintained at all times. Half-hearted concern or support of some field personnel to the programme should not persist. They should be made fully aware that the programme was not just the concern of one agency; it was a national programme;

(q) NIA field implementors should also attend to the problems, needs and interests of irrigation water-users outside the pilot areas. It was intended ultimately to expand the pilot area system if found successful, and it would be better and proper to have a head-start;

(r) A somewhat "jealous" attitude on the part of some farmers outside the pilot area had been observed. However, they responded favourably by appealing to those already covered by the pilot area to exert all possible efforts to make a success of the first pilot projects. The farmers were eager for the expansion of such projects;

(s) Strong emphasis must be placed on the importance of maintaining the essence of co-operation among irrigation users, particularly with regard to self-help projects. Farmer water-users should not be "spoon-fed";

(t) Particular emphasis should also be given to maintaining strict discipline among water-users, particularly in the proper distribution of irrigation water and maintenance of farm ditches. It was believed that this universal factor encompassed all other success factors in any development undertaking;

(u) In any undertaking the human factor was admittedly the hardest to handle. NIA farm-level workers had therefore been advised to exercise patience and flexibility, as well as an active zeal in pushing through the programme;

(v) There must be a way to show appreciation to irrigation groups whose members were carrying out maintenance and water distribution activities as desired. One way might be to provide some sort of rebate in the payment of their total irrigation charges. Accrued rebates might serve as a good source of association funds;

(w) Planning from below might be considered effective strategy to ensure proper project/programme implementation and development. A particular example was in the planning phase involving the construction of terminal irrigation facilities. Affected water-users should be consulted and involved. Though that might take longer, the result was expected to be productive;

(x) Further strengthening of the research component of water management, in terms of providing the necessary financial and manpower support, must be a sustained activity.

7. Conclusion

The National Irrigation Administration intended to expand further the water management project area to include other existing national irrigation systems. The current water management pilot areas had served as the testing grounds for all NIA water management activities.

To date, it could be said that the practice of appropriate water management techniques was still new in some of the Philippine irrigation systems. The problems expected to be encountered were numerous. Some of them had already been identified and new ones were continually being encountered as the project activities progressed. Generally, at the farm level, it had been observed that the most critical problem area concerned irrigation water-users. Effecting a change in the habits of water-users to achieve judicious management and utilization of water could not be accomplished overnight. It required much hard work, patience and flexibility on the part of the irrigation authorities. Full acceptance by the water-users and their active involvement was deemed indispensable to the project's success.

Technical and other administrative problems of project implementation might be considered secondary. What was required was a comprehensive approach to water management by considering all important and relevant factors and constraints in the formulation of solutions to the problems encountered.

Table 7. Some statistical data on water management pilot projects in the Philippines

System	*Service area (ha)*	*Number of main turnouts*	*Ha per main turnout*	*Number of supplementary turnouts*	*Ha per supplementary turnout*
Region I: Urdaneta Pangasinan					
1. Laoag-Vintar	457	24	19.04	36	12.69
2. Tagudin	373	9	41.44	33	11.30
3. Amburayan	449	13	34.53	40	11.22
4. Masalip	380	18	21.11	42	9.05
5. Agno	467	10	46.70	47	9.94
6. San Fabian	426	9	47.33	40	10.65
7. Dipalo	432	9	48.00	38	11.36
8. Totonoguen	368	18	20.44	38	9.68
Subtotal	3,352	110		314	
Region II: Cauayan Isabela					
1. Apayao-Abulog	376	10	37.60	38	9.89
2. Tumawini	300	15	20.00	25	12.00
3. Baggao	430	16	26.87	44	9.77
Subtotal	1,106	41		107	
Region III: Quezon City (temporary)					
1. Porac-Gumain	396	8	49.50	37	10.70
2. Colo	475	7	67.85	33	14.39
3. Sto. Tomas	537	14	38.35	47	11.43
4. Nayom	404	14	28.85	41	9.85
Subtotal	1,812	43		158	
Region IV: Pila, Laguna					
1. Cavite Friar Lands	320	18	17.77	32	10.00
2. Palico	394	18	21.88	37	10.65
3. Dumacaa	419	16	26.18	46	9.11
Subtotal	1,133	52		115	
Region V: Naga City					
1. Daet-Talisay	437	11	39.72	53	8.25
2. Cagaycay	501	12	41.75	39	12.85
3. Hibiga	372	10	37.20	23	
4. Bulan	457	12	38.08	36	12.69
Subtotal	1,767	45		151	
Region VI: Iloilo City					
1. Aklan	458	12	38.16	59	7.76
2. Mambusao	480	8	60.00	47	10.21
3. Sibalom-San Jose	417	14	29.78	49	8.51
4. Bago	517	11	47.00	37	13.97
Subtotal	1,872	45		192	

Table 7. Some statistical data on water management pilot projects in the Philippines *(Continued)*

System	*Service area (ha)*	*Number of main turnouts*	*Ha per main turnout*	*Number of supplementary turnouts*	*Ha per supplementary turnout*
Region VII: Tacloban City			no pilot area		
Regional VIII: Tacloban City					
1. Binahaan	550	14	39.28	53	10.38
2. Mainit	500	18	27.77	65	7.69
3. Bao	561	14	40.07	58	9.67
4. Bito	500	14	35.71	40	12.50
5. Hindang-Hilongos	483	14	34.50	61	7.92
Subtotal	2,594	74		277	
Region IX: Zamboanga City					
1. Labangan	462	16	28.87	56	8.25
2. Salug (incl. ext.)	463	13	35.61	44	10.52
Subtotal	925	19	64.48	100	18.77
Region X: Cagayan de Oro City			no pilot area		
Region XI: Davao City					
1. Lupon	424	22	19.27	48	8.83
2. Padada	428	12	35.66	43	9.95
3. Banga	360	11	32.72	51	7.06
4. Cantilan	584	15	38.93	64	9.12
Subtotal	1,796	60		206	
Region XII: Cotabato City					
1. Libungan	480	15	32.00	50	9.60
2. Kabacan	454	11	41.27	46	9.86
3. Malasila	304	9	33.77	37	8.21
Subtotal	1,238	35		133	
Total	17,595	534	32.95[a]	1,753	10.03[b]

a Average area (ha) per MTO.
b Average area (ha) per STO.

Table 8. Statistical data on density of irrigation facilities in the Upper Pampang river project

Irrigation systems	*New irrigable area (ha)*	*Canal density (ha per km)*	*Canal structure* Existing (units)	*Canal structure* Existing but modified (units)	*Canal structure* New or additional (units)	*Density (ha per unit)*	*Turnouts (ha per unit)*	*Farm main ditch (m per ha)*	*Supplementary farm ditches (m per ha)*
New irrigation systems									
1. PBRIS extension	14,933	93.23	100	29	270	37.43	52.95	12.62	46.59
2. Platero area	608	98.24	–	–	15	40.53	38.00	14.97	33.91
3. Aliaga area	5,388	88.95	16	2	171	28.51	43.10	12.00	33.29
4. Rizal-Munic area	2,638	91.24	–	–	84	31.41	45.48	10.83	25.94
5. Sto. Domingo area	11,585	76.56	–	–	409	28.33	34.58	21.64	37.10
Rehabilitated existing irrigation systems									
1. PRIS area	13,266	70.97	247	–	286	24.89	38.34	10.60	42.31
2. TRIS area	11,718	68.56	20	37	75	21.11	37.80	19.89	39.78
3. LTRIS area	2,720	63.37	88	–	40	2.25	37.26	14.99	37.49
4. Vaca area	2,511	71.91	61	–	29	27.90	52.31	17.24	40.71
5. Murcon area	4,629	55.15	34	69	116	21.14	37.63	18.15	42.13
6. PBRIS area	10,371	56,83	91	102	250	23.41	33.56	16.08	44.04
7. San Agustin ext. area	844	64.10	–	36	10	18.35	40.19	17.81	37.25
8. Pamaldan Cinco-Cinco area	1,258	75.89	–	–	41	30.68	37.00	9.73	31.61
Average		75.00	82.13	45.83	138.15	27.30	40.63	15.12	37.86

Table 9. Status report on irrigators' groups in water management pilot areas as at June 1978

Region	*System*	*Number of irrigators' groups organized and/or revitalized*	*Total membership*	*Area covered (ha)*
I. Urdaneta, Pangasinan	1. Agno	10	648	526.39
	2. Amburayan	13	2,162	448.86
	3. Dipalo	9	201	388.15
	4. Laoag-Vintar	27	1,305	452.07
	5. Masalip	18	1,003	385.94
	6. San Fabian	8	641	427.22
	7. Tagudin	12	1,040	405.18
	8. Totonoguen	18	307	345.87
	Subtotal	115	7,307	3,379.68
II. Cauayan, Isabela	1. Abulog	10	256	360.00
	2. Baggao	15	681	392.46
	3. Tumaini	28	238	371.84
	Subtotal	53	1,175	1,124.90
III. Quezon City	1. Colo	10	262	4,436.86
	2. Nayom	14	286	385.06
	3. Porac-Gumain	8	330	384.80
	4. Sto. Tomas	9	431	640.21
	Subtotal	41	1,309	1,846.93
IV. Pila, Laguna	1. Cavite	14	134	281.32
	2. Dumacaa	15	470	895.00
	3. Palico	10	400	769.89
	Subtotal	39	1,004	1,946.21
V. Naga City	1. Bulan	12	381	384.59
	2. Cagaycay	3	31	34.28
	3. Daet-Talisay	11	299	331.67
	4. Hibiga	13	328	287.05
	Subtotal	39	1,039	1,037.59
VI. Iloilo City	1. Aklan	12	437	480.57
	2. Bago	8	276	442.20
	3. Mambusao	12	173	351.12
	4. Sibalom-San Jose	11	497	411.66
	Subtotal	43	1,383	1,685.55
VII. Tacloban City		no pilot area		
VIII. Tacloban City	1. Bao	21	472	557.35
	2. Binahaan	9	189	266.12
	3. Bito	18	412	529.32
	4. Hindang-Hilongos	20	549	323.83
	5. Mainit	18	281	576.40
	Subtotal	86	1,903	2,253.02
IX. Zamboanga City	1. Labangan	16	235	462.00
	2. Salug	11	241	334.05
	Subtotal	27	476	796.05
X. Cagayan de Oro City		no pilot area		
XI. Davao City	1. Banga	11	360	434.92
	2. Cantilan	11	498	377.00
	3. Lupon	21	433	431.00
	4. Padada	12	333	390.39
	Subtotal	55	1,624	1,633.31
XII. Cotabato City	1. Kabacan	11	348	430.59
	2. Libungan	15	409	427.04
	3. Malasila	9	380	339.90
	Subtotal	35	1,137	1,197.53
	Total	533	18,357	16,900.77

Table 10. Accomplishments in the organization of farmer irrigators' groups, compact farm associations and project development compact farms in special projects as at June 1978

Project	*Area, ha*	*CFA/FIG*			*Farmers involved*			*PDCF*			*Farmers involved*		
		Target	*Organized*	*Percentage*	*Target*	*Actual*	*Percentage*	*Target*	*Organized*	*Percentage*	*Target*	*Actual*	*Percentage*
ADSIP	8,754	178	2	1.12	2,500	52	2.08	2	2	100	60	57	95
AMIADP	35,330	1,016	1,016	100.00	22,617	22,617	100.00	3	3	100	90	90	100
AFIP	25,300	860	228	26.50	16,874	2,833	16.78	–	–	–		–	–
CLGIP	12,000	240	30	11.66	12,000	1,455	12.12	2	2	100	566	765	+35
CRIP	19,700	530	54	10.18	9,396	885	9.40	3	3	100	200	200	100
DNIP – I	11,540	295	51	17.28	2,570	602	23.40	3	3	100	90	72	80
DNIP – II	15,080	301	1	.33	5,026	32	0.63	3	1	33	30	32	+6
JRMP	24,700	497	33	6.63	12,350	612	4.95	–					
LCIADP	4,425	129	38	29.45	2,300	425	18.47	–					
LDBDP – IC	14,815	299	89	29.76	8,208	3,421	29.49	3	4	+33	45	145	+222
MRMP	76,197	1,855	1,203	64.85	37,133	25,091	67.57						
PRDP	14,759	305	70	22.96	9,404	1,474	15.67						
PRIP	13,000	300	9	3.00	4,000	212	5.30						
TISIP	25,920	718	348	48.47	15,473	11,524	74.40	–					
TRIP	14,500	300	–		7,000	–		–					
UPRIIS	79,058	2,380	2,272	95.46	44,610	35,700	80.02	–					
Total	393,078	10,203	5,444		211,461	105,935		19	18		1,081	1,361	

Note: Some projects had organized compact farms but had not reported the fact and others had overshot their target in the numbers of farmers involved, as indicated by the plus sign in their percentage accomplishment.

I. PROBLEMS ENCOUNTERED IN EFFORTS TO IMPROVE THE PERFORMANCE OF IRRIGATION PROJECTS IN SRI LANKA*

1. Introduction

The Republic of Sri Lanka was a tropical island in the Indian Ocean with an estimated current population of 13.5 million, 80 per cent of which was rural. Of the total land area of 16.2 million acres (25,300 sq miles), about 5 million acres were used for agriculture, 9.3 million acres were under forests and the remaining 1.9 million acres were under water bodies, urban areas or under other uses. About half of the forest land was potentially suitable for agricultural development.

The country's climate was characterized by nearly constant temperatures but with large variations in rainfall. Based on precipitation, the country could be divided into two district zones. The wet zone (average annual rainfall over 75 inches) situated in the south-west quadrant and covering about 30 per cent of the land area, and the dry zone (average annual rainfall, 35-75 inches) covering the remainder of the island. The wet zone supported more than three quarters of the total population and accounted for about 70 per cent of the cultivated land. The dominant climatic features were the north-east monsoon from November to February and the south-west monsoon from May to September. Depressional and conventional rains occurred during the inter-monsoonal periods and were likely to occur in any part of the country.

Cultivation in the wet zone was mostly under rainfed conditions, while in the dry zone the rainfall was often poorly distributed and highly erratic and therefore supplementary irrigation was necessary for successful cultivation. Almost all recent expansion in irrigation and the great majority of the total irrigated area of the country was in the dry zone.

Irrigation in Sri Lanka dated back to 600 B.C. when an extensive network of irrigation tanks had been developed by the ancient kings, who had recognized the potential for irrigated agriculture in the dry zone. There was historic evidence that appropriate institutional and legal systems had also been established for ensuring their proper operation and maintenance as well as careful use of irrigation water. This was clearly indicated in the Kondavattuwan stone pillar inscription found in the Gal Oya Valley attributed to King Dappula IV (924-935 A.D.) which read:

> "For an offence connected with the flooding of the fields a fine of 2 Akas shall be levied. For an offence connected with ploughing a fine of a Kalanda shall be levied. For an offence of having ploughed late a fine of 5 Kalandas shall be levied."

These magnificient works gradually fell into disrepair and neglect when Sri Lanka became a colony of successive foreign powers. In 1900, a separate government department, the Irrigation Department was established in order to expedite the execution of irrigation works and had since been engaged in restoring ancient irrigation systems and construction of new schemes.

It now also undertook the following functions:

(a) Preparation of master plans of development for the different river basins for the optimum utilization of land and water resources;

(b) Project formulation and detailed designs of major irrigation, hydropower, flood control and reclamation projects;

(c) Provision of consultancy services in the field of water resources development to other government departments, corporations and other institutions;

(d) Construction of major irrigation projects for the conservation, diversion and distribution of water for the cultivation of irrigable lands;

(e) Construction of lift irrigation projects, for the cultivation of subsidiary food crops;

(f) Construction of flood protection, drainage and salt water expulsion projects;

(g) Applied research in hydraulics, hydrology, soil mechanics and land use as applied to water resources development projects.

2. Economic situation

The economy in Sri Lanka was predominantly agricultural and therefore water resources development had been primarily for agriculture. Agriculture contributed about 35 per cent of the gross domestic product. The bulk of agricultural production was represented by the four principal agricultural crops: paddy, tea, rubber and coconuts.

Paddy was grown for domestic consumption and was supplemented by imports. About 40 per cent of the coconut output was exported. Tea, rubber and coconuts together accounted for about 75 per cent

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of the country's export earnings. The proceeds of their sale abroad paid for the import of foodstuffs, other consumer goods, and equipment for agricultural and industrial development. The economy of the island thus depended upon the production of four commodities and export of three of them.

3. Paddy production

The reconditioned and the new irrigation systems together irrigated about 925,000 acres (374,000 ha) and efforts were continuing at a pace to expand that acreage. Major irrigated crops in the island were paddy, sugar, onions and chillies. Paddy was the most widely irrigated crop, cultivated in two seasons of the year (the *Maha* and *Yala* varieties).

Maha was started with the north-east monsoon in October or November, and the second paddy crop, *yala,* sown in April or March, was subject to the availability of water in the tanks. The yields were generally as low as 0.9 ton per acre and 0.8 ton per acre for *maha* and *yala* respectively. The lower *yala* yield was primarily due to the water shortages experienced during the latter part of the cropping season.

Farmers generally perferred broadcasting to transplanting despite the latter's potential for higher yields. Fertilizers were subsidized for paddy and other subsidiary crops did not enjoy that benefit. Nevertheless, present fertilizer use on paddy was about 30 per cent of the recommended dosage of 1.5 cwt of urea and 2 cwt of basic paddy mixture per acre.

It had been estimated that the Sri Lanka's rice requirements would be about 2.2 million metric tons by the year 2000. The productivity of most existing paddy lands could be increased by at least another 30 per cent, for the potential was there. If current average production per acre of 45 bushels could be increased to 60 or 70, then total paddy production would rise to 1.25 to 1.5 million bushels, which would be equal to the total production of rice and the imports of rice and flour for the year 1976.

4. Ground water

In the recent past the Irrigation Department had started investigations of the feasibility of exploitation of the island's ground-water resources for irrigation purposes. Ground-water exploration had been mainly confined to the sedimentary Miocene limestone deposits which formed a deep narrow belt along the north-western and northern coasts of the island.

In Mannar District over the past two years about 100 wells had been sunk in private paddy lands. Unfortunately, however, frequent complaints were received from farmers regarding depressed yields or crop damage caused by increased salinity and or alkalinity in paddy fields irrigated regularly with ground water.

In the Jaffna peninsula, which was at the northern extremity of the island, an area of about 1,100 sq km lay under Miocene limestone. Extensive use of ground water for irrigation had been practised over a long time in this part of the island. Further in Puttalam and Mannar districts about 1,500 acres had been provided with irrigation facilities using ground water. Thus the total area using ground water for irrigation was about 84,000 acres.

Rainfall recharge of aquifers, depletion of part of the recharged water as flow into the sea, quantity of water extracted, intrusion of sea water and variations in salinity were some aspects of the problems under study in those areas. Water levels in wells, salinity and electrical conductivity of water samples were observed fortnightly.

5. Lift irrigation schemes

There were four major lift irrigation schemes on the island covering about 8,000 acres, and they were associated with major surface irrigation schemes. These were mainly for subsidiary food crops such as chillies, pulses and onions.

The irrigable areas were strung along the main gravity canals; the pump units were diesel operated. All canals were lined with concrete and PVC pipes had been used for the construction of rising mains. The problems encountered in these schemes could be summarized as follows:

(a) Frequent breakdown of pumps and shortage of spares. It had been recommended that all pumps be electrified as soon as possible;

(b) Over-use of water;

(c) Lack of know-how in cultivation of cash crops;

(d) Use of water for domestic purposes;

(e) Failure to realize the value of water, supplied free of charge, but at tremendous initial capital cost of the State;

(f) Lack of interest and co-operation on the part of the farmers.

6. Mahaweli development project

Sri Lanka was endowed with a system of rivers, sufficient rainfall, land resources and a climate suitable for year-round crop production. A large number of reservoir sites suitable to store the runoff were available for use in the respective basins or for transbasin diversion purposes. All possible reservoir sites had been selected and many of them investigated. The limitations of embarking on these projects had so far been mainly the capital that could be allocated to this sector.

The most promising of all these was the Mahaweli development project. The Mahaweli Basin covered some 4,030 sq miles of the country's 25,000 sq miles and was estimated to discharge 6.6 million acre-feet (ac-ft) of water annually. Rising in the hill country at elevations of over 6,000 ft above sea level, it also had a significant hydropower potential.

A UNDP/FAO team, in collaboration with specialists from Sri Lanka, had prepared a master plan for the development of the water resources of the Mahaweli Basin and adjacent areas during the period 1965-1968. The plan proposed to utilize 4.7 million ac-ft of the flow for agricultural development in an area of 900,000 acres lying in the dry zone of the island. Of those 900,000, roughly 250,000 were currently irrigated, but deficient in water supplies, and 650,000 acres would be new lands, some of them being under rainfed cropping. The plan also envisaged the installation of hydro-power plants with a total capacity of over 500 mW for the production of some 2,600 million kWh of energy annually.

The plan included the construction of several large dams on the main river and its major tributaries as well as on streams flowing through the areas selected for agricultural development.

The creation of reservoir storages on the Mahaweli and its tributaries would also provide for a substantial measure of flood control. The activities connected with the plan covered some 40 per cent of the land area of the island.

The estimated total cost of the scheme was SRs 6,700 million in 1968;[1] and the implementation period was originally to be 30 years. The present Government had launched an ambitious programme (Mahaweli Accelerated Programme) to complete the balance of the project in six years, with the help of massive foreign aid.

Implementation of the programme on an accelerated basis had been entrusted to the following organisations: the Central Engineering Consultancy Bureau, the Irrigation Department, the Mahaweli Development Board, and the River Valleys Development Board.

Under this project, the development of an area of 900,000 acres in the dry zone, for multiple cropping had been planned with the available 900,000 ac-ft in the projected area, and the diverted 4.7 million ac-ft from Mahaweli Ganga, making a total of 5.7 million ac-ft of water. The duty of water assumed for the development, averaged 8.5 ac-ft/ac per year. This duty of water could only be achieved by adopting strict water management policies.

7. Tank modernization project

The dry zone had some 180 major tank irrigation schemes, serving a total cultivated area of about 400,000 acres. Deterioration of the irrigation systems, poor water management and inadequate agricultural supporting services were the prime constraints limiting agricultural production in these schemes.

The tank modernization project, covering the five tank schemes of Padaviya, Mahakanadarawa, Mahawillachchiya, Pavatkulam and Vavunikulam in the north central dry zone, with an aggregate irrigable command of 31,500 acres, had been launched by the Government as a package programme for modernizing the irrigation, agricultural extension and supporting services, with a view to making the agricultural effort under the five schemes viable.

It had been ascertained that the techniques to be adopted under the project would more than double the current income of the farmers settled under the schemes. The importance of this project lay in the fact that it was a prototype project to draw out ultimately the full potential of all land under major irrigation schemes.

The corner-stone of the project was efficient water management, based on the rotational issue of irrigation water, and the optimum use of rain water to enable double cropping on the entirety of the irrigable area under the tanks. The total cost of the project, including farm machinery, was SRs 225 million ($US 27 million in 1976 prices).[1]

The project would directly benefit some 10,000 small farm families, cultivating about 3 acres each. Construction work was being carried out by the Irrigation Department at Mahakanadarawa and Mahawillachchiya.

The main works involved in modernization of the irrigation distribution systems were:

(a) Desilting and enlarging the entire conveyance system;

(b) Repairing, enlarging and surfacing with gravel, the embankments used as farm roads;

(c) Excavating drains to improve drainage;

(d) Lining of canals where necessary. Experiments were being carried out at Mahawillachchiya to select the best kind of lining to be adopted;

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1 SRs per $US 1.00 (period average):

1968	*1976*	*1978*
5.952	8.459	15.608

(e) Repairing and modifying the existing structures in the irrigation system to enable controlled releases for each farm on a seven-day rotation schedule;

(f) Installation of regulators to increase water control;

(g) Installation of Parshall flumes to measure release from tanks and water flows at various points of the system;

(h) Provision of offices, workshops, stores, housing to be used in connexion with expanded operation and maintenance of the project.

The project proposals provided for the supply of 150 four-wheel and 450 two-wheel tractors with necessary attachments and equipment for land preparation. One of the reasons for the planting season currently being long-drawn-out and causing excessive wastage of water was the non-availability of tractors as and when required.

Various institutional and supporting legislative systems had come into operation during the past 35 to 40 years, designed to handle various problems associated with the control and use of water, land tenure, land use and effective local participation of users, etc.

The Irrigation Department had been assigned full control over the operation and maintenance of irrigation systems by Irrigation Ordinance No. 45 of 1917 which was repealed by Ordinance No. 32 of 1946. The Irrigation Ordinance of 1946, amended in 1951, prescribed the use and operation of irrigation water and distribution systems, including responsibility for operation and maintenance, how water was to be distributed and how operation and maintenance costs were to be covered from payment of rates by farmers. The Irrigation Department was responsible for drafting and providing them with regulations for the protection of the irrigation works and conservation of water.

The date of commencement of cultivation operations, extent of land to be taken up for cultivation during a given cultivation season, etc. were to be decided beforehand at a meeting of the cultivators on the basis of the recommendations made and limitations set by the representatives of the Irrigation Department.

After the Paddy Land Act was enacted in 1958 the Irrigation Ordinance was suitably amended in 1968 to include provision for Cultivation Committees set up under the former legislation, which were given wider powers to regulate all irrigated cultivations, stipulate maintenance responsibilities, impose irrigation rates, etc.

The recently dissolved Agricultural Productivity Committees were entrusted with the important task of integrating and co-ordinating the various services pertaining to agricultural development. Nevertheless, the general experience had been that the administration of water distribution and maintenance of the systems continued to be far from satisfactory.

The Agricultural Department had its share in providing extension services, agricultural research work and providing improved seed paddy, etc.

8. Farmers' organizations

The success of farm water management and increased production depended mainly on the efficiency of farmers' associations and their co-ordination, because the responsibility of water management at the terminal level was shared by those associations. Legislation under the Irrigation Orginance, the Paddy Lands Act and the recent Agricultural Productivity Law provided for water management. Almost all farmers' associations in irrigation schemes did not emerge spontaneously but were creations of the State.

The now defunct Agricultural Productivity Committees were the most powerful of those associations. Members of those committees were from within the farmers' committees. Their field was wider and the activities extended beyond farm-level management.

Earlier the responsibility of agricultural development had been diffused over a series of administrative units and ministries responsible for specific aspects but not for the whole process. The various institutions involved were the Department of Agrarian Services, the Paddy Marketing Board, the Department of Agriculture and the Co-operative Department. Owing to fragmentation of responsibility, co-ordinantion was difficult. In order to overcome this problem the Agriculture Productivity Committees were formed to function as the co-ordinating agency of the integrated programme of agricultural development. The main function of the Committees had been to maximize utilization and productivity of lands.

The members of the Committees (APCC) were appointed by the Minister of Agriculture and Lands. At the village level, APCCs were assisted by Cultivation Committees (CC) whose members were also appointed by the same Minister. Both APCC and CC were assisted by the Administrative, Engineering and Agricultural Officers in technical matters. These committees were responsible for ensuring that the agricultural lands were used to the maximum benefit of the country. Towards this end they had far-reaching powers in prescribing the cropping patterns to be followed in their areas, as well as in the allocation of inputs such as credit, fertilizers, tractors and irrigation water.

9. Water management for augmenting food production

Water was no longer unlimited. It had become an expensive commodity and, like other commodities, it was scarce for irrigation needs.

This change had been brought about not so much by the increasing demand for irrigation on account of extensive new lands brought under irrigation, but by the lack of judicious use. Time was when there had been an abundance of water for the areas of land under irrigation, and the need for its conservation and judicious use not yet felt.

Today, the mouths to feed numbered in the millions. This compelling need had opened up additional acres in thousands to irrigation, but had not however prompted a study of water use with the same amount of interest. The age-old water-use practices had been taken for granted, for all practical purposes: in respect of transmission, distribution and methods of irrigation practiced. These systems and practices needed to be vastly improved upon. Equally important was the matter of tapping ground water on the resources side and the use of machinery on the practices side.

It was quite obvious that large investments alone on irrigation projects would not solve the problem of scarcity of food, and it was only recently that world-wide concern had been expressed about the large amounts of water wasted in irrigation schemes. Such waste led to decreases in the acreage under cultivation, waterlogging, spreading of malaria, and soil erosion, etc. It had been identified that with the use of existing resources, production of rice could be increased remarkably with efficient water management alone. With that in view, the Water Management Branch had been established in the Irrigation Department headquarters.

Starting from scratch, with no previous experience in this field, the Water Management Branch had acquired a substantial amount of experience within a short period of operation from the pilot studies it carried out in several selected schemes.

The conclusions from the above studies had revealed the following:

(a) The necessity of establishing water management units in each of the major schemes, an engineer to be the manager, assisted by selected staff trained in this field;

(b) Adequate regulating and controlling structures must be provided;

(c) Main and distributary canals must be rated and gauge posts installed to facilitate controlling issues;

(d) Rotational issues should be introduced as a matter of principle;

(e) Cultivation programmes should be drawn up to incorporate efficient and effective use of rainfall;

(f) The need for maintenance of records (acreages, issues, tank levels, yields, duties, etc. for each season);

(g) Sufficient funds must be provided by the Department for the operation and maintenance of channel systems;

(h) Demonstrations of water management and improved agricultural practices at farm level by extension services would be effective in the way of propaganda and motivation;

(i) Communication between farmers and management staff to promote confidence among them was essential.

As it was a new field of study, efficient water management could be achieved only when the officers engaged in this work had a good knowledge of application of irrigation methods, timing, farm layout, design of irrigation systems and so forth, in such ways and means to make the best use of water available for agricultural productivity. Thus a training course in water management was organized at the Rajangana scheme to enable all engineers and technical officers in the Irrigation Department, Mahaweli Development Board and the River Valley Development Board, to gain good knowledge of it, with the long-term objective of establishing good water management practices to achieve self-sufficiency in rice.

As efficient water management was gradually progressing in the country, the Water Management Branch now played a consultancy role to other institutions dealing with irrigation, such as the Mahaweli Development Board, the River Valley Development Board and the Central Engineering Consultancy Bureau.

An irrigation and water management pilot project was currently being carried out with United Kingdom aid. This was being conducted at the Kaudulla scheme, situated in the dry zone in the north central province.

The tank had supported no irrigation in recent times, until rehabilitation work had began in 1958. This work had been done in two stages; stage I, of 4,752 acres was completed in 1963 and stage II, of 5,935 acres, received its first issues of water in 1976. The present total command was thus 10,687 acres lying to the east of the tank. To the north-east, between stage II and the command of Kantalai tank, there were approximately 10,000 acres of commanded land, that would form stage III of the development at an indefinite date. A potential stage IV of 21,000 acres also existed.

The principal supply to the tank came from the south through a natural channel of the Aggalawan Oya which was fed by the Minneriya tank. Water from the Mahaweli Ganga had become available to the Minneriya tank in 1976 for the first time. This created quite a new situation for the cultivators at Kaudulla as they should now have a reliable supply of water for the *maha* season and would expect at least a partial supply for the *yala* season. The extent to which that could be achieved, and in addition the viability of developing stages III and IV, must depend to a large extent on success in management of the water now becoming available.

The initial objective of the study at Kaudulla would be to describe quantitatively what happened at this scheme. This meant assessing the main elements of the water budget, namely:

Inputs	:	Direct rainfall Inflow from catchment Releases from storage at Minneriya
Outputs	:	Crop consumption Seepage from tank Seepage from channels Seepage from fields Evaporation Surface runoff
System storages	:	Above surface Unsaturated zone Below water table

The study would attempt to quantify the variations in each of those components both in space and in time so that areas and periods of particularly high consumption might be identified and reasons therefore sought. It was hoped that that would provide solutions to the basic problems of irrigation development in these areas and the findings benefit not only the existing scheme but also the newly developed areas under the Mahaweli project.

The Water Management Branch kept records of water issues of eight major tanks and the table below gives the respective tank duties.

Duty of water for paddy

Scheme	*Maha 1975/76 ft.*	*Yala 1976 ft.*	*Maha 1976/77 ft.*	*Yala 1977 ft.*	*Maha 1977/78 ft.*
Rajangana		5.54		5.60	8.16
Hakwatuna Oya	3.25				
Kaudulla			3.68	5.12	2.99
Wahalkada			2.92	5.60	3.35
Vavunikulam	4.01	4.39	4.59	7.25	
M.I.K.				4.72	
Pimburettewa					4.15
Nagadeepa					3.99

Competitive cultivation among groups of farmers was carried out at the Rajangana scheme, where all the canals were earthen. Canals were rated and gauge posts installed at important points in the channel system in order to quantify the water used by each group. The average conveyance efficiency as calculated from the returns of the above study was about 55 per cent. A similar study at the Wahalkada scheme, where only the field and distributary channels were lined with concrete, revealed a conveyance efficiency of 70 per cent.

The water issue schedules for schemes were prepared based on tables 11 and 12, which relate field water requirements (FWR) with the different stages of growth of paddy plants.

Table 11. Water duty for land preparation (single 36-hour water issue)

Water issue	*FWR (inches)*	*Duty (acres per cu ft/sec)*	*cu ft/sec per acre*
First issue			
Soaking and preliminary tillage	5	7.2	.149
Second issue			
Puddling and levelling	2	18	.056

Source: *Jalarrudhi* (Journal) of the Irrigation Department, December 1976.

Duration of land preparation should be limited to two weeks and water issue of a total of 7 inches should be made during this period as follows:

(a) Initial issue of 5 inches in 36 hours for soaking and preliminary tillage;

(b) Second issue of 2 inches in 36 hours after four or five days for puddling operations.

Table 12. Different growth stages for three common variations of paddy

Growth stage	*Variety*	*Period after sowing (days)*	*Plant characteristics*
Initial stage	4½ months	0-30	Planting and early tillering
	3½ "	0-20	
	3 "	0-20	
Crop development stage	4½ "	30-70	Active tillering
	3½ "	20-50	
	3 "	20-45	
Mild stage	4½ "	70-115	Flowering and heading
	3½ "	50-80	
	3 "	45-75	
Last stage	4½ "	115-135	Maturing
	3½ "	80-100	
	3 "	75-90	

Source: *Jalarrudhi* (journal) of the Irrigation Department, December 1976.

Table 13 gives the field water requirements for different stages of growth and the respective duties for a seven-day rotational issue of water and 36-hour irrigation.

Table 13. Water duty for paddy irrigation

Growth Stage	*Field water requirement (in)*		*Duty (acres per cu ft/sec)*		*Duty (cu ft/sec per acre)*	
	Yala	*Maha*	*Yala*	*Maha*	*Yala*	*Maha*
Initial stage	2.80	2.34	12.86	15.38	.077	.065
Crop development stage	3.10	2.49	11.59	14.46	.086	.069
Mid stage	3.18	2.57	11.32	14.00	.088	.071
Last stage	2.65	2.18	13.58	16.51	.074	.061

Source: *Jalarrudhi* (journal) of the Irrigation Department, December 1976.

If all the farms under each field channel were to be irrigated in 36 hours, it was essential that the field channel should have sufficient capacity to carry the discharge according to the duty given in table 13. If the field channel capacity was small or, conversely, if the irrigable area was larger, the duration of irrigation had to be adjusted accordingly.

A variety of causes leading to wastage of irrigation water and a number of problems encountered in the efforts to improve the performance of irrigation projects are listed below:

(a) Initial delay in cultivation owing to non-availability of draught power, implements, seed and credit facilities, etc. Only a few farmers started work according to schedule and in the mean time water went to waste through drainage;

(b) Not making use of effective rainfall. Irrigation water was basically meant to supplement rainfall for the *maha* cultivation. If the farmer delayed and missed the rainfall, large doses of irrigation water were required to mature the crop in the dry months, thus reducing considerably the amount that could be used for *yala* cultivation. At present on an average, only 30 per cent of the acreage was cultivated in *yala* in major schemes and that in minor schemes was considerably less than 30 per cent.

(c) Delay in sowing by farmers in certain areas was due to their preoccupation with *chena* cultivation. It was only after they completed their *chena* cultivation that they shifted to the irrigation schemes. This was specially common in settlement schemes, where the settler was selected from villages adjacent to the scheme. Settlers' interests were divided between *chena* cultivation, *purana* village and the paddy lots in the settlement schemes;

(d) In some irrigation schemes the farmers waited till the reservoirs were full and sufficient water for the *maha* crops was guaranteed. In most areas reservoirs filled only towards December. As a result, farmers lost the benefit of early rains;

(e) The variety of seeds to be sown as determined by the cultivation meeting was not adhered to and farmers used long-term varieties;

(f) Farmers demanded too much water in the mistaken belief that standing water was essential to get a good yield;

(g) Considerable amounts of water were wasted by the farmer using flowing or standing water as a substitute for weed killer or labour-intensive manual weeding;

(h) Illicit tapping of water by illegal cultivators and encroachers;

(i) Paddy was being cultivated in well-drained soils in some schemes, leading to excessive consumption of water. For example, at Uda Walawe scheme, duties as high as 16 ac-ft/ac had been observed;

(j) Conveyance losses amounted to about 50 per cent. Lining of canals, in places of excessive seepage, must be considered. This also favoured rotational issues as water could be conveyed to fields quicker than by unlined canals;

(k) Bad maintenance of the irrigation distribution systems mainly because of shortage of funds.

The following important factors were found to affect the distribution and use of water:

(a) The irrigation systems designed in the past had not been geared to successful rotational irrigation practice. Control structures were found necessary in order to isolate sections and to ensure equitable distribution. In most schemes the gate control devices did not permit satisfactory adjustments for water issues. It was recommended that they be replaced by screw-type spindles which enabled fine control;

(b) Under local conditions where the farm sizes were comparatively small, it was not possible to assess the quantity of water used by each farmer. Further, to maintain and operate such a system would be too combersome and costly;

(c) Farmer education and active participation of farmers was the most important factor in successful water management. Most Sri Lankan farmers were ignorant of improved agricultural practices, water requirements, improved varieties of seeds and use of fertilizers, etc. Also they did not value the irrigation water, supplied free by the State, and there was no incentive for curtailing waste or limiting its use;

(d) Cultivation meetings should be held well before the cultivation dates, so that sufficient time was available for the cultivators and the extension service officials to attend to detailed programming of cultivation activities;

(e) Permanent fencing of the fields should be done by the farmers collectively, with assistance from the State wherever necessary. Delay in fencing of certain individual sections tended to put back the cultivation calender.

(f) The crop insurance scheme had to be revised so as to take into account the payment of adequate compensation for loss of crops. This would encourage the farmer to commence cultivation with the initial rains, thereby making the best use of the direct rainfall for crop growth.

10. Remedial measures to improve water management

The following remedial measures would help considerably to reduce wastage of water and step up production of rice:

(a) The foremost essential requirement should be a farmer education programme on improved agricultural practices at the national level. This could be implemented by extension services through demonstration plots, lectures, literature and films, etc.;

(b) There was an urgent need to ensure active farmer participation and involvement in water management. For this purpose the Cultivation Committees and Agricultural Productivity Committees had been established earlier but did not perform a satisfactory role. It was proposed that for each field channel serving about 50 acres, the farmers, by general consensus, elect a group leader among themselves. The group leader so elected would also be the contact farmer under the "Training and visit system" of the agricultural extension services. For an irrigation scheme, there should be farmer representatives (one each for about 500-1,000 acres) who, along with the Irrigation Engineer, the Agricultural Extension Officer, the Agrarian Service Officer and the Co-operative Officer, would form the Management Committee.

The group leaders of each field channel area would elect among themselves a representative for an area of 500-1,000 acres depending on the size of the scheme and the persons so elected would be the farmers' representatives on the Management Committee. The Management Committee would meet frequently and take all decisions in regard to water management and cropping patterns in any scheme.

It was intended that, with active farmer participation by the above procedure, the usual problems of damage to control structures, cutting of channel bunds, illicit tapping of water, etc. could be avoided;

(c) A "water distributor" had to be appointed for every 500 acres by the Government to issue water to the field channels and to supervise the activities of the group leaders. He had to have had some education to enable him to maintain records of water issues.

A Maintenance Overseer was recommended for every 2,500 acres. He would be responsible for maintenance as well as operations of the system in the designated area. A technical assistant should be assigned to take responsibility for all operations and maintenance work over about 5,000 acres;

(d) In most irrigation schemes there were large areas of encrochments which were cultivated by illicitly tapping water. These encroachments should be surveyed and, where the water availability situation in the scheme permitted, should be taken on to the specification register for regular issue of water and an adequate irrigation distribution system provided. All other encroachers should be barred from tapping water from channels;

(e) It was widely recognized that slow legal procedures and the small penalties imposed, if any, sometimes years after the event, for illicit tapping of water, damage to structures, etc., had a bad effect on staff morale and did little to deter cultivators from stealing water. Therefore legislation should be suitably amended to impose prompt and severe penalties for such acts;

(f) The State should try to import sufficient numbers of tractors to ease the current acute shortage which was the main reason for extended land preparation periods;

(g) The authorities should strictly adhere to the cultivation calendar fixed at the proprietors' meeting. Extension of water issues beyond the originally fixed date should not normally be allowed and such extension, when allowed, should be subject to heavy penalties as a deterrent;

(h) In all schemes, whether there was a water shortage or not, rotational issue of water should be adopted as a matter of routine. This rotational issue would have to go down to the smallest of field channels and to enable this to be done control gates should be provided with screw-type spindles. Various control structures and pipe outlets had to be maintained at satisfactory levels. For this purpose, adequate funds should be made available for maintenance to the Irrigation Department;

(i) Rapid soil surveys should be carried out, especially in schemes where there was heavy consumption of water, and the cropping pattern changed to other crops in soil types where the percolation rate was high;

(j) To make cultivation of other crops attractive on permeable soils which were at present cultivating paddy, it would be necessary to review the costs of inputs for such crops and fix a realistic price for production from such crops;

(k) Cultivators should be informed of the permitted quantities of water and use of water in excess of that quantity should be subject to penal rates. To facilitate this, the State should seek means of charging for water on a quantative basis for a group. This introduced an incentive to use less water and would cultivate among farmers the habit of co-ordination as a group, which was essential in implementing successful water management.

J. MULTIPLE CROPPING ON RICE FARMS IN PETCHABURI, THAILAND*

1. Background

Thailand, a constitutional monarchy, was located in south-east Asia, its total area was 514,000 sq km and it had a population of approximately 45 million.

Thailand might be divided into four regions: the central plain, the continental highlands of the north and north-west, the plateau in the north-east, and the peninsula in the south. The principal agricultural area was the central valley, which extended 480 km from north to south and was 160 to 240 km wide. In this region the population was at its densest. The north-east region was dry with poor soils. In the small south-east area and the peninsular region, the rainfall was relatively high and the vegetation tropical. The average annual rainfall of the country was about 1,400 mm.

The population in Thailand included some 30 ethnic groups. The Thai group was the largest and comprised 80 per cent of the total population. The Thais generally were Buddhists. Education was compulsory for children between ages 8 and 15.

Over 50 per cent of the country was covered by forest, but there were about 12 million hectares of arable land of which about 11 million hectares were cultivated. Agriculture was the main source of livelihood. Rice was the most important crop, using two thirds of the total cultivated area. The land was operated in family-size units. About 90 per cent of the land was cultivated by the owners. Although farming was done with primitive implements, Thailand was one of the world's leading exporters of rice. In recent years, cassava and corn had become important export crops. Rubber was also an important export crop. Sugar cane, tobacco and kapok were produced mainly for domestic use. Cocoa, peanuts, soybeans and others were produced both for export and domestic use. Jute was grown for local use to make bags for rice, etc. Coconuts, sesame and mungbeans were among other important crops. There were over 12 million head of cattle and considerable amounts of beef and pork were exported.

Efforts were being made to diversify the economy of Thailand by supporting the development of industries. The average income was $US670 per farm household.

2. Phetchaburi demonstration farm project

The project was situated south of Canal No. 2 of the Phetchaburi Canal, east of the Phetchaburi-Hua Hin Highway, and a few kilometres north of the Phetchaburi Farm of the Royal Irrigation Department.

It was composed of an area of about 44 rai (or 7 hectares) of which about 10 rai were being used office buildings and living quarters.

The purpose of the project was to experiment and demonstrate the culture of rice and other crops in the area of the Phetchaburi irrigation project.

* By Narong Poolsilapa, Chief, Phetchaburi Demonstration Farm Project, Phetchaburi.

3. Cropping pattern

Intensive cropping systems on good soils can help farmers in the project area and other rice-producing areas to grow many other crops in addition to rice.

Studies on intensive cropping systems with rice, soybeans, mungbeans and a fairly wide range of vegetables had been conducted in the area for about 10 years and extended to farmers. There were 17 cropping patterns as follows: soybeans - rice; cucumbers - rice; string beans - rice; cabbages - rice; chinese cabbage - rice; balsam pears - rice; mungbeans - sesame - rice; mungbeans - cucumbers - rice; mungbeans - sweet corn - rice; mungbeans - mungbeans - rice; mungbeans - string beans - rice; soybeans - sesame - rice; cucumbers - sweet corn - rice; cucumbers - cucumbers - rice; cucumbers - Chinese cabbage - rice; wax gourds - cucumbers - rice; string beans - cucumbers - rice.

4. Cost and return per rai
(in baht)[a]

Pattern	*Return*	*Cost*	*Net cash income per rai*
1. Soybeans - rice			2,207.04
Soybeans	1,417.70	277.72	1,131.98
Rice	1,179.29	112.23	1,067.06
2. Cucumbers - rice			2,458.59
Cucumbers	1,603.74	133.65	1,470.09
Rice	1,068.69	80.19	988.50
3. String beans - rice			8,270.77
String beans	10,338.65	3,634.13	6,704.52
Rice	1,630.90	64.65	1,566.25
4. Cabbages - rice			11,610.65
Cabbages	11,932.67	1,593.77	10,338.90
Rice	1,355.61	83.86	1,271.75
5. Chinese cabbage-rice			2,749.81
Chinese cabbage	2,377.32	873.30	1,504.02
Rice	1,326.98	81.19	1,245.75
6. Balsam pears - rice			9,070.10
Balsam pears	9,152.00	1,131.95	8,020.05
Rice	1,152.15	102.10	1,050.05
7. Mungbeans - sesame - rice			2,230.76
Mungbeans	957.87	137.79	820.08
Sesame	455.02	66.93	388.09
Rice	1,219.87	155.73	1,064.14
8. Mungbeans - cucumbers - rice			4,410.67
Mungbeans	1,225.92	201.36	1,024.50
Cucumbers	2,690.36	368.39	2,321.97
Rice	1,219.87	155.73	1,064.14
9. Mungbeans - sweet corn - rice			2,491.78
Mungbeans	1,137.94	190.34	947.60
Sweet corn	768.00	175.71	592.29
Rice	1,060.67	108.78	951.89
10. Mungbeans - mungbeans - rice			3,631.66
Mungbeans	1,802.08	410.42	1,391.66
Mungbeans	499.51	43.90	455.61
Rice	1,896.59	112.20	1,784.39
11. Mungbeans - string beans - rice			4,386.75
Mungbeans	1,677.92	137.63	1,540.29
String beans	2,307.23	504.60	1,802.63
Rice	1,120.20	76.37	1,043.83
12. Soybeans - sesame - rice			2,853.98
Soybeans	1,577.08	323.05	1,254.03
Sesame	527.78	58.90	468.88
Rice	1,297.07	166.00	1,131.07
13. Cucumbers - sweet corn - rice			2,891.08
Cucumbers	1,178.59	157.14	1,021.45
Sweet corn	691.36	56.79	634.57
Rice	1,311.43	76.37	1,235.06
14. Cucumbers - cucumbers - rice			5,843.37
Cucumbers	3,356.48	231.60	3,124.88
Cucumbers	1,737.91	22.42	1,715.49
Rice	1,078.00	75.00	1,003.00
15. Cucumbers - Chinese cabbage - rice			9,347.13
Cucumbers	5,440.00	955.00	4,485.00
Chinese cabbage	5,360.00	1,085.87	4,274.13
Rice	638.00	50.00	588.00
16. Wax gourds - cucumbers - rice			5,713.20
Wax gourds	3,155.09	281.94	2,873.15
Cucumbers	1,737.91	22.42	1,715.49
Rice	1,208.65	84.00	1,124.56

a Baht 20.336 = $US 1.00 (1978 period average).

Pattern	*Return*	*Cost*	*Net cash income per rai*
17. String beans - cucumbers - rice			5,797.32
String beans	3,470.00	391.17	3,078.83
Cucumbers	1,737.91	22.42	1,715.49
Rice	1,078.00	75.00	1,003.00

Unit prices were as follows:

Paddy rice	25-30	baht per 10 kg.
Mungbeans (first)	140-160	baht per 16 kg.
Mungbeans (second)	70-80	baht per 16 kg.
Soybeans	1-2.50	baht per kg.
Cucumbers (first)	2-3	baht per kg.
Cucumbers (second)	1	baht per kg.
Sesame	10	baht per kg.
Sweet corn	0.50-1.00	baht per ear
Balsam pears	3-4	baht per fruit
Wax gourds	1-2	baht per kg.
Cabbages	5-7	baht per kg.
String beans	3-5	baht per kg.
Chinese cabbage	3-5	baht per kg.

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