PMS Method

Peace (Japan) Medical Services

Irrigation Project Guidelines

Secure Water and Food

JICA
Japan International Cooperation Agency

PREFACE

For a successful reconstruction assistance in Afghanistan, the fundamental issue of how to achieve the reconstruction and restoration of Afghanistan independently and robustly is extremely important. From this point of view, in Afghanistan, where more than 80% of the population lives in rural areas and 60% of the working population is engaged in agriculture and livestock breeding, possibilities and measures for agricultural development cannot be ignored.

Rural areas in Afghanistan are generally self-sufficient, have strong autonomy as social and economic units, based on the spirit of common support, converging on Islam. In order to achieve stability of life and the country, it is essential to strengthen the independence and resilience of rural societies. Since Afghanistan is classified among the arid or semi-arid regions and rainfed agriculture is unstable, the development and effective utilization of water resources and building of sustainable agriculture based on irrigation are the key to reconstruction and restoration of Afghanistan.

However, even after more than 20 years of reconstruction assistance supported by the international community, the lives of people of Afghanistan have not been sufficiently improved, due to the instability and security throughout most of the country.

On the other hand, even under these circumstances, the irrigation project by PMS (Peace [Japan] Medical Services), which was led by Dr. Tetsu Nakamura, has produced remarkable outcomes, resulting in improving the livelihood of local residents in the project area. It can be said that it is an effective model of success in irrigation projects in Afghanistan. PMS produces simple and practical effects of flood control and water utilization, which maximize the use of local resources, and enable the operation and maintenance of facilities to be effectively performed by the local community in the project area. PMS also fostered community ownership, by practicing project activities based on deep understanding and respect for the local community and mutual trust. In difficult social and political situations, much of the success of the irrigation project owes to the charisma and indomitable fighting spirit of Dr. Tetsu Nakamura, which has also earned the trust of local residents. There is no doubt that these community-respecting techniques and processes underpin the success of PMS irrigation projects. These guidelines were created based on the idea that such fruits should be widely disseminated throughout Afghanistan.

JICA began discussions with Dr. Tetsu Nakamura on the preparation of these guidelines since around middle of the year 2018, and the task required conducting some continuous and intensive studies. We planned a closer discussion about the knowledge, experience, and philosophy of Dr. Tetsu Nakamura, regarding the PMS irrigation project, the ingenuity of flood control and water utilization techniques, and the fostering and respect for ownership by the local community, in order to reflect all these values in the guidelines. Unfortunately, on December 4, 2019, Dr. Tetsu Nakamura was shot to death in Jalalabad. However, even with such obstacle, in collaboration with the Peshawar-kai which is an international non-governmental organization to support Dr. Tetsu Nakamura's activities, the PMS, and the Afghan government officials, we are very pleased that the "PMS Method Irrigation Project Guidelines" have been completed timely. We would like to express sincere gratitude to all those involved in creating the guidelines.

We hope, in the future, all stakeholders, including the central government, local governments, local communities and residents, will work hard and cooperate toward the stability and prosperity of the local community by utilizing the guidelines to demonstrate the power of teamwork. This is in line with the approach of Dr. Tetsu Nakamura, who had long been advocating the importance of decision to go through, ingenuity, and continuation in front of Afghan government officials. We sincerely hope that this will be carried on, and that stability of people's lives and security will be realized throughout Afghanistan. We hope that the guidelines will help accomplish it.

February, 2021

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Upon publishing “PMS Method Irrigation Project Guidelines”

On the 4th of December, 2019, Dr. Tetsu Nakamura was gunned down by unknown assailants. Even now, I can hear his voice telling me, "We must continue this project.” Dr. Nakamura, who was a doctor, decided to build irrigation canals because he believed that medical treatment was not enough to keep people alive in Afghanistan and that securing water and food was essential.
He said, "Water does not distinguish between good and bad people," emphasizing reconciliation rather than confrontation. He created irrigation canals in accordance with the conditions of Afghanistan. After 16 years of trial and error, he completed ten weirs around the Kunar River including Marwarid I and II Canals, and finally established the standard design of the PMS intake system. When Dr. Nakamura told us, "My successor is the irrigation canal," he meant, I presume, that if the people of Afghanistan need it, it will be passed on from generation to generation.
The standard design that Dr. Nakamura has arrived at in his "Green Ground Project" is based on the traditional Japanese method inherited from 300 years ago and the method used in Afghanistan. The tradition has been passed on to the present while changing, and has been revived by the people in contact with the nature of Afghanistan. The Afghans practiced these techniques in the field using the materials they had at hand, and developed by themselves in accordance with their own culture. Finally standing at the starting line of the dissemination of the PMS Method Irrigation Project across the country, those who have inherited the idea of Dr. Nakamura in Japan and Afghanistan have completed this “PMS Method Irrigation Project Guidelines” in dialogue with Dr. Nakamura in our minds. This is the result of the collaboration between Japanese and Afghan people. I hope that this Guidelines will support the lives of people suffering from drought in Afghanistan and will be passed on from generation to generation.
Dr. Nakamura has pointed out that critical climate changes such as drought are manifesting in the most vulnerable areas as a result of global warming. This is why he emphasized having deep insight into nature and dealing with it in harmony as the basis of the PMS philosophy. We must have reverence for natural order and avoid construction projects, such as large dams, that attempt to control nature. We make minimal changes to the flow and topography of the river to install a PMS oblique weir, and then take a small amount of water from the weir and return it to the river after it has served for farming in the community. This is the irrigation model that Dr. Nakamura worked out aiming to restore green land and spread the benefits of water widely and equally. Global warming is a natural reaction caused by human economic activities, and it will take a very long time for it to stop. Even in the midst of it, however, we must respect humanity, find the blessings of nature, and seek practical ways to live in peace.
We expect that this Guidelines will be revised in the future with new findings through actual practices in many specific projects. Nevertheless, the unchanging spirit will be inherited in the technology that reconciles with nature. Dr. Nakamura describes it concretely as follows.
(1) To be able to tackle a problem with the simplest device possible.
(2) It should not cost a lot of money.
(3) Any community person with a certain level of knowledge can do the work.
(4) Use materials that are readily available and bring in as few non-local materials as possible.
(5) If damaged, local people should be able to repair it.
(6) You cannot cheat water. Be as honest as water.

I am feeling the revival of Dr. Nakamura's spirit in completion of the Guidelines. Again, I hear his voice saying, "This book is the precious fruit of the cooperation of innumerable people who transcended their positions. On behalf of the 600,000 farmers in Afghanistan, I would like to express my gratitude once again. I extend my inexhaustible gratitude through the culmination of the work described here. (from Foreword to the Japanese version of "The Afghan Green Ground Project") "
I pray that this Guidelines will be utilized across Afghanistan and that peace will come to its people soon.

February, 2021

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PMS Method Irrigation Project Guidelines
Secure Water and Food

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CHAPTER 1

WHAT ARE THE “PMS METHOD IRRIGATION PROJECT GUIDELINES”?

Dr. Tetsu Nakamura and PMS have carried out many irrigation projects in the Lower Kunar river basin of the Nangarhar province in eastern Afghanistan, supplying water to 16,500 ha of irrigated areas as of 2020, supporting the livelihood of 650,000 people, and contributing to the repatriation of refugees and former soldiers, their incorporation into village societies and the improvement of their livelihoods. These PMS method irrigation project guidelines summarize the processes, technologies, experiences / knowledge and lessons learned from the existing PMS irrigation projects. The guidelines target mainly engineers, planners and decision-makers involved in irrigation projects, and present process of dialogue with the beneficiaries, as well as technical information needed for planning, design, construction, maintenance, and irrigated agricultural technology of sustainable irrigation projects, suitable for Afghan conditions and Afghan communities. Their purpose is to contribute to the sustainable development of Afghanistan's communities and irrigated agriculture. As shown in Figure 1, the concept of the PMS Method Irrigation Project Guidelines is to promote sustainable irrigation projects, suitable for Afghanistan, by understanding and practicing the PMS method irrigation project accurately, by developing the method through its actual application and continuous innovation, and by disseminating it.

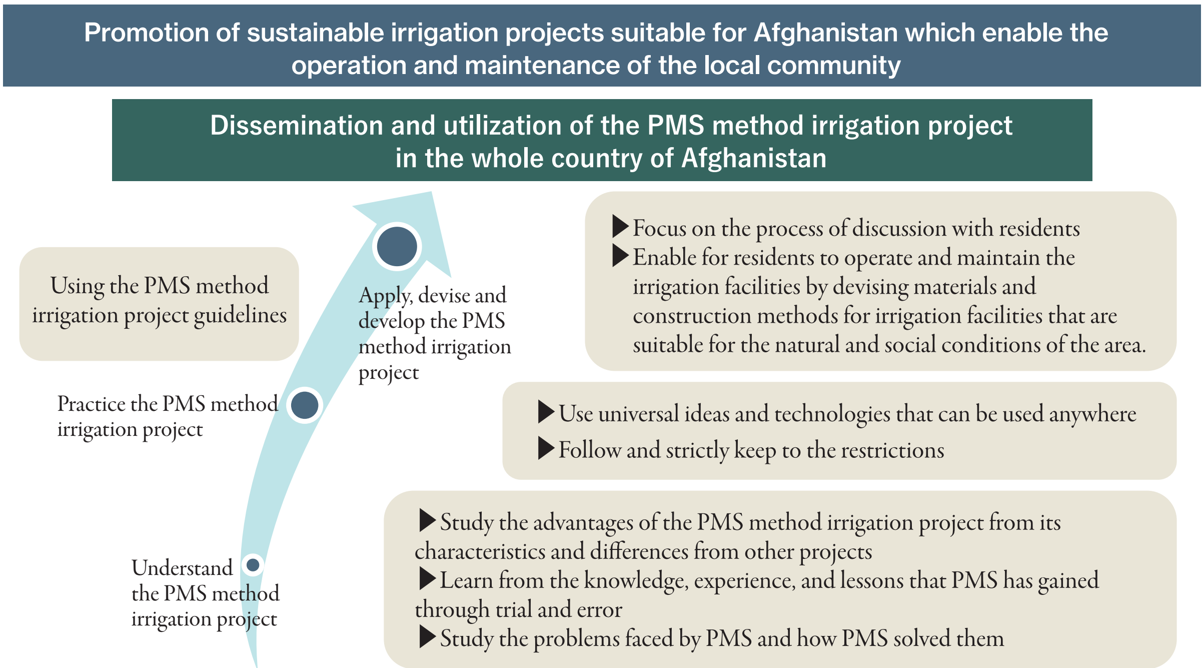


Figure 1 Concept of the Guidelines

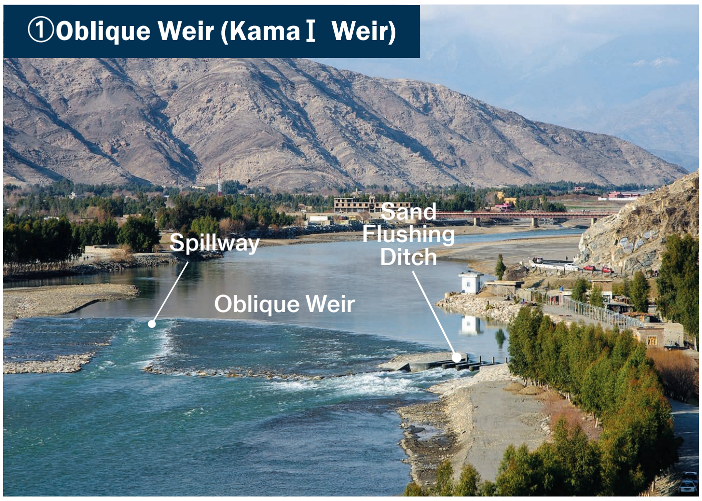
A PMS method irrigation project is an irrigation project in which water is directly drawn from rivers and conducted to farmlands. As shown in Figure 1.3, the PMS method irrigation system is composed of intake weir, sand flushing ditch, intake gate, steep gradient main irrigation canal, sand basin (regulating pond), main irrigation canal, main drainage canal, reservoir, siphon, flood crossing bridge, dike (along the river), and stone spur dikes (within the river flow). The PMS method irrigation project is a simple and practical irrigation project which matches the natural conditions of the region and is based on the operation and maintenance by the community beneficiaries themselves. The project implementation entities/persons respect the local communities and their governance system, and aim to develop the capacity of beneficiary farmers. Beneficiary farmers learn the basic civil engineering techniques of the PMS method irrigation project though the projects, and become able to operate and maintain facilities by themselves.

*1 Also known as sediment trap.
*2 In Afghanistan, the word "levee" is often applied instead of the word "dike", but in this guideline, it will be unified to the word "dike" hereafter.

Figure 2 Functions of PMS Method Irrigation Facilities

Menu of PMS Method Irrigation Facilities

❶Oblique Weir, ❷Sand Flushing Ditch(Movable Weir), Spillway, ❸Double Flush Board Method Intake Gate, ❹Steep Gradient Main Irrigation Canal (Gabion Works, Wicker Works), ❺Sand Basin with Transmission Gate and Drain Gate, ❻Main Drainage Canal, ❼Reservoir, Siphon, Flood Crossing Bridge, ❽Flood Control Facilities(Dike and Stone Spur dike)



Function of Oblique Weir ; By damming the river water and raising the water level on the upstream side, water intake during drought season will be easier. By extending the weir diagonally, the overflow water depth is lowered, the tractive force is reduced, and the weir is less likely to be broken.

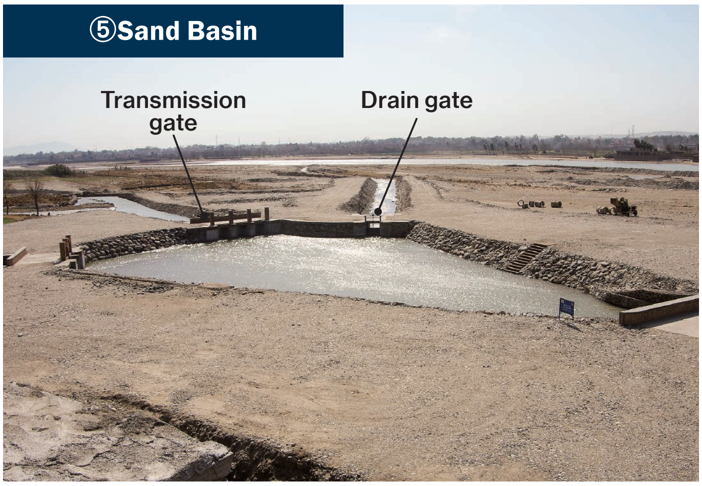
Function of Sand Flushing Ditch ; Sand flushing ditch is installed as part of the intake weir adjacent to the intake gate and prevents the inflow of earth and sand into the intake gate.

Function of Intake Gate ; The intake gate is installed on the riverbank connecting to the boulder oblique weir abutment to draw water into the irrigation canal and adjusts the amount of intake water. Two rows of flush boards are installed in front and rear of the gate pier to create a reservoir. It reduces the water pressure applied to the lower flush board on the river side and prevents the flush board from breaking.

④Steep Gradient Main Irrigation Canal and Main Irrigation Canal

Function of Steep Gradient Main Irrigation Canal and Main Irrigation Canal ; The steep gradient main irrigation canal conveys the sediment contained water drawn from the intake gate to the sand basin without accumulating the sediments in the canal. The main irrigation canal conveys the sediment-free water from the sand basin to the irrigation beneficiary area.

⑤Sand Basin



Function of Sand Basin (Regulating Pond) ; Sedimentation and flushing out of earth and sand contained in the irrigation water. Control of transmission amount of irrigation water.

⑥Main Drainage Canal

Function of Main Drainage Canal ; Excess water other than the required amount of irrigation water will be promptly returned to the river through the main drainage canal to prevent wetland at the irrigation beneficiary areas and to consider downstream water use.

⑦Reservoir etc.

Function of Reservoir etc. ; Protecting the irrigation canal from flash floods and debris flows from the mountain, it secures water retention in dry area and contributes to the growth of vegetation. Where flash floods and debris flows from vallay cross a canal, siphons and flood crossing bridges are provided.

⑧Flood Control Facilities

Function of Flood Control Facilities ; The dike has the function of protecting irrigation beneficiary areas, residential areas, and irrigation canals along the river from floods. The stone spur dike prevents dikes and riverbanks from scouring and also has the function of fixing the alignment of river channel.

HOW SHOULD A PMS METHOD IRRIGATION PROJECT BE LAUNCHED TOGETHER WITH FARMERS?

2.1 Selection of Area Suitable for the PMS Method Irrigation Project

The target area for the PMS method irrigation project is selected according to the flow chart shown in Figure 3 with bestows priority to candidate sites, that the local community strongly desires to operate and maintain facilities. Among the irrigation project candidate sites, listed by the government, based on the requests from the local communities, firstly the areas are selected where there ii a strong demands from the local community, or where the irrigation facilities are broken and irrigated agriculture is thus not possible. Next, secondary priority selection is made regarding natural environmental conditions such as the appropriate land and soil for irrigated agriculture, the availability of irrigation water, and the presence of construction materials in the area. Finally, areas are evaluated based on the perspective of the socio-economic conditions of the community, the local community's willingness to accept the PMS method irrigation project, the farmers' willingness for irrigated agriculture, and the structure of the farmer's organization are confirmed, and the target area is finally determined.

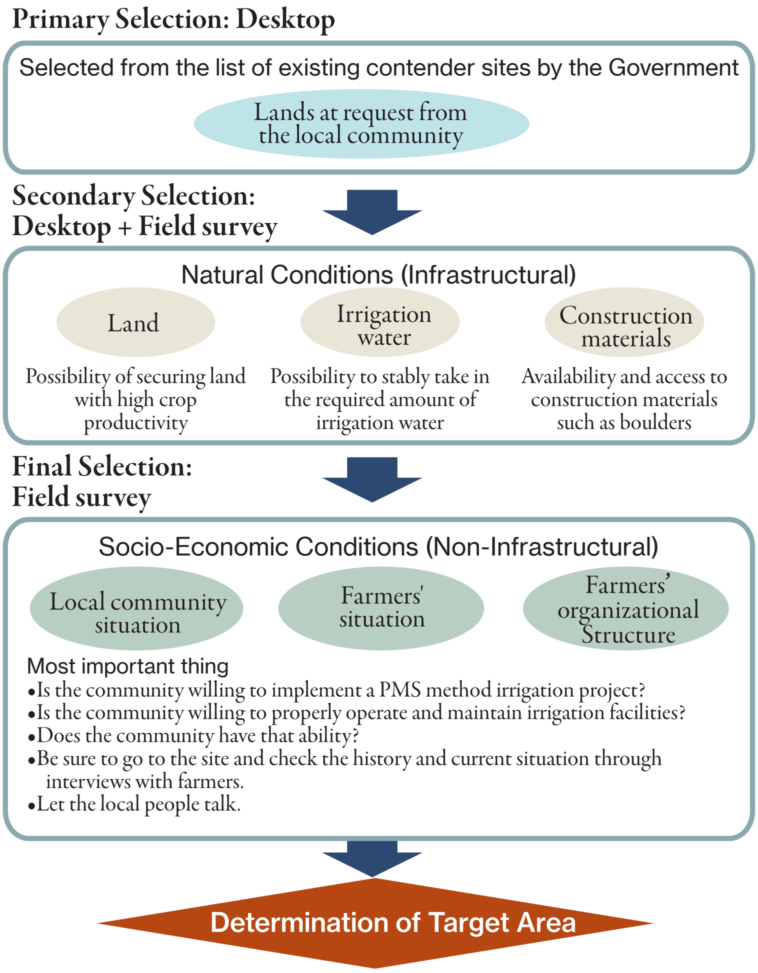
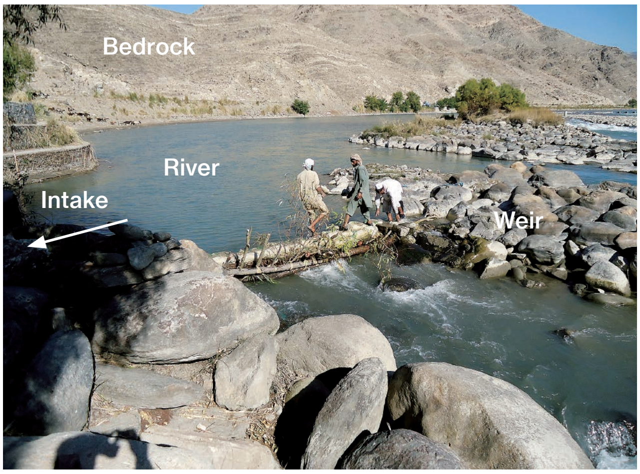


Figure 3 Flow of Target Area Selection of PMS Method Irrigation Project

In the PMS method irrigation project, it is extremely important to select a most suitable site for the intake weir. In principle, the site of the intake weir should be near the old or current intake. However, if there is a problem with water intake, it is best to have a site where the river is moderately wide, the flow is uniform and variations not too extreme, and a channel to convey excess discharges during floods can be secured at the opposite bank. In addition, the site should be with bedrock at the back of the weir and with a stable single sandbar. Finally, it is necessary to consider the impact of the intake weir on the opposite banks, as well as the impact on upstream and downstream river stretches. See Figure 4.

Image of suitable site



Suitable site for PMS method intake weir

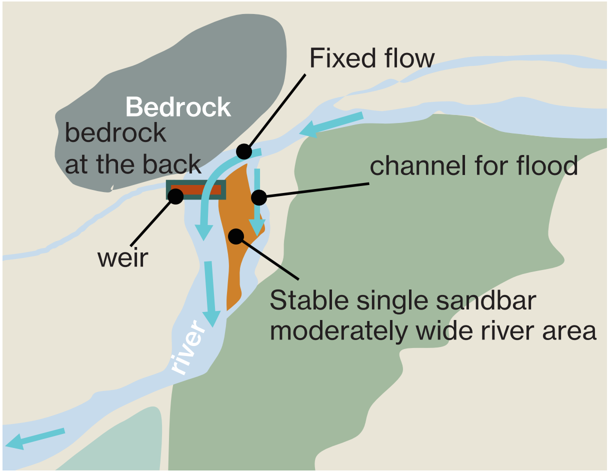


Figure 4 Suitable Site for Oblique Weir with Boulders in PMS Method Irrigation Project

2.2 Formulation of Basic Concept of the PMS Method Irrigation Project through Discussion with Farmers

The PMS method irrigation project is based on the formulation of the basic concept of the project through dialogues and discussions with the local communities. The project implementation entities/persons should understand the true needs of farmers, based on dialogue and consultation, in order to formulate the basic concept of the PMS method irrigation project, which can meet those needs. Specifically, the project implementation entities/persons discuss the contents of Table 1 and the role of the local community, to build consensus and formulate the basic concept.

The contents of the basic concept are: 1) irrigation beneficiary area with balanced water distribution, 2) expected project results, 3) estimated indicative project cost, annual maintenance cost and estimated indicative project implementation and duration period, 4) consensus building on land acquisition and sufficient compensation, 5) study and discussion / coordination related to the impact on the surrounding area, 6) residents' participation in construction projects and in operation/maintenance of irrigation facilities, 7) ensuring security and safety management in the project, 8) construction of water wheels and demonstration farm as ancillary projects.

Table 1 Discussions, Agreements and Allocation of Roles between Project Implementation Entities/ Persons and Local Communities

Contents of Discussions and Agreements	Allocation of Roles	
	Project Implementation Entities / Persons (Central and Local Government, etc.)	**Local Communities** Self-governing body (Community Development Council/*Shura*/*Jirga*) Association (Water Users' Association/ Irrigation Association), etc.
Irrigation beneficiary area, project effects, estimated project cost, maintenance cost, project period	– Outline presentation of irrigation beneficiary areas	– Confirmation and adjustment of irrigation beneficiary areas
	– Presentation of expected project effects	– Confirmation of expected project effects
	– Presentation of estimated project cost and maintenance cost	– Confirmation of estimated project cost and maintenance cost
	– Presentation of project period	– Confirmation of project period
Land acquisition (irrigation facilities: main irrigation canal route, etc.)	– Presentation of necessary land, etc.	– Coordination with each farmer based on laws and local customs
Impact on the surrounding area (risks)	– Presentation of assumed risks	– Risk acceptance decisions and coordination with affected communities
Residents participation in construction projects and operation and maintenance of irrigation facilities	– Request for participation in construction labor by paying wages – Presentation of capacity development program for basic civil engineering techniques – Presentation of capacity development program related to operation and maintenance – Presentation of allocation of roles for operation and maintenance of irrigation facilities between residents and project implementation entities/persons – Presentation of large-scale repair plan and ensuring of budget	– Adjustment of labor supply by farmers, etc. – Confirmation of intention to acquire basic civil engineering techniques – Confirmation of intention to improve operation and maintenance ability – Implementation adjustment / confirmation of operation and maintenance activities after the irrigation facility construction – Formulation of operation and maintenance plans and ensuring securing of budget by residents
Security and safety	– Requests to ensure local security by local communities – Confirmation of safety measures for construction projects	– Adjustment and presentation of security measures – Confirmation of safety measures for construction projects

CHAPTER 3

HOW SHOULD WATER SOURCE RIVERS BE UNDERSTOOD?

Rivers are constantly changing, phenomena such as floods and droughts occur, and river topography fluctuates. Before planning and implementing a PMS method irrigation project, it is first necessary to study the characteristics of the river which will serve as the water source. To construct irrigation facilities which can stably take water from the river during both floods and droughts and to properly operate and maintain them, it is necessary to first know the river conditions during floods and droughts.

The river conditions which should be comprehended in the PMS method irrigation project and the method of grasping them are as summarized in Table 2. Firstly, the existing information is collected, organized, and analysed. Then, interviews and observations are conducted on site, to understand the river conditions. Finally, river surveys for planning and designing the facilities are conducted. In situations where there is not enough data, as in Afghanistan today, field interview surveys and observations are very important. When conducting the observations and surveys, it is important to consider the ways to utilize the obtained information and data, for planning, designing, constructing and maintaining the irrigation projects.

Table 2 River Conditions to be Comprehended and How to Grasp Them

River Conditions to be Comprehended	How to Grasp River Conditions
•**River basin conditions** Flood and drought runoff characteristics and groundwater recharge conditions are analyzed by understanding the topography and visitation, etc. in the river basins. In addition, what kind of water resources are being used, such as the existence of irrigated areas, cities and villages in the river basin, and land use conditions are grasped. •**River channel conditions** Necessary information is obtained for facility planning and designing, such as checking river channel fluctuations (stable streamway, flow direction, riverbed fluctuations) and sandbar fluctuations (stable sandbars, sediment erosion / sedimentation), and grasping sites where water intake is easy. •**River flow conditions (flood and drought conditions)** By grasping water level, velocity, and discharge of the river during floods and droughts, the river flow conditions are clarified. It is analyzed where flooding is likely to occur, where the flood force is likely to concentrate, and how much water can be taken during droughts. It is utilized for facility planning and designing. The sediment transport volume and particle size and water quality are grasped. •**Impact of river structure construction on river flow and channel** The impact on the structures located on the upstream / downstream and left and right banks, river channels and landside areas of the newly constructed river structures in the PMS method irrigation project is analyzed. In particular, the new generation of flood inundation occurrence due to backwater (rise of water level) at the upstream by weir construction are carefully assessed. •**Impact of irrigation water extraction on downstream water use** Investigate the water rights registered with The National Water Affairs Regulation Authority (NWARA) Water Rights Bureau, grasp the current water use situation near the water intake point, and plan new irrigation water intake above the water intake point. Carefully consider whether it will affect water use on the downstream and left and right banks, especially on the downstream side, and coordinate with relevant parties. The water rights registered in the Department of Water Right of NWARA are investigated and the present water use situation near the intake site is grasped. Then, the planned new water intake for irrigation is carefully studied, specially whether it affects the water use on the upstream/downstream and the left/right banks. It is coordinated with the stakeholders.	•**Collection and organization of existing information** The existing information such as satellite images such as Google Maps, existing topographic maps, digital elevation models, geological maps, hydromet information, water rights, and river structures is collected and organized. •**Interview survey among residents** Be sure to go to the site and interview at the site. For local situations and flood conditions, record interview information along with location information (latitude and longitude, etc.) and local photos. In addition, various information is collected and organized. Then, their consistency is confirmed, and the accuracy of interviews is confirmed. •**Observation and measurement of river conditions and their arrangement** Existing information and interviews are often inadequate, and field observations and measurements are especially important for understanding river conditions. In order to grasp the constantly changing river conditions, it is necessary to visit the site on a regular basis and grasp the situation at that time. In particular, it is important for the person in charge of the project to visit and observe the river and flow conditions both during floods and droughts. Results of observations and measurements are organized using photos and sketches. •**River survey and survey study** The cross-sectional survey, the profile survey, and the topographic survey of rivers are performed, and drawings are created. A riverbed material survey is also important for understanding river channel characteristics. Based on these materials, the hydraulic parameters of rivers are examined by non-uniform flow calculation.

HOW SHOULD IRRIGATION FACILITIES BE PLANNED AND DESIGNED?

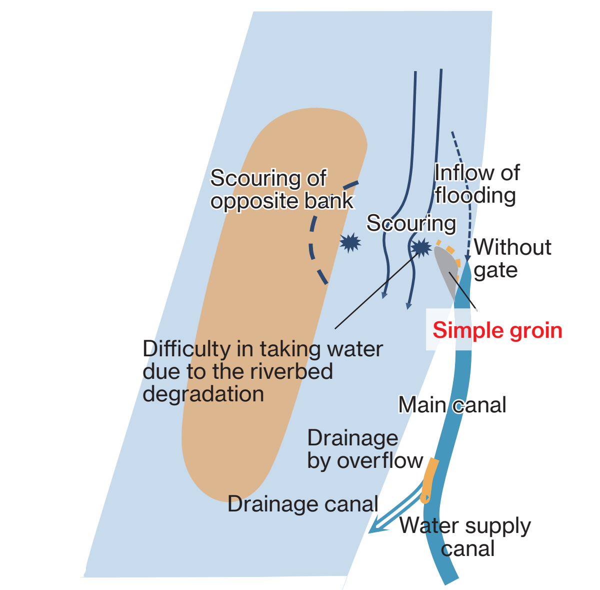
Irrigation facilities need to be planned and designed to ensure a stable supply of irrigation water against floods, droughts, sediment depositions, etc. The PMS method irrigation facilities consist of irrigation facilities and flood control facilities.

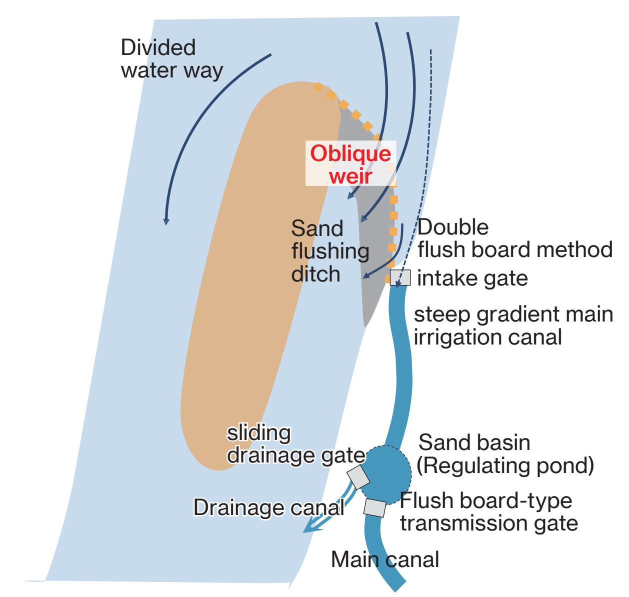
4.1 Basic Concept for Planning and Design of Irrigation Facilities

In Afghanistan, a straight shaped simple barrier has been widely adopted as a water intake structure. However, in this form of a barrier, flood erosion of the riverbed tends to slowly destroy the structure, and because it usually does not have the function of adjusting the water intake amount, it becomes difficult to extract water during the dry season. At the same time, flood flows and sediment inflows cannot be prevented. These were important issues for operation and for maintenance of the facilities. In order to overcome these issues, the PMS method irrigation project introduced a boulder oblique weir and a double flush board method intake gate. In the boulder oblique weir, the entire weir surface from the riverbank to the sandbar is raised to prevent scouring at the edge of the weir. By arranging the weir in a curved shape (in the layout) to extend the overflow line, the unit width flow rate flowing over the weir is reduced. By collecting the water flow in the central downstream section of the oblique weir, the energy of the flood flow is reduced. As a result, the destruction of the weir due to scouring can be reduced or fully prevented and the impact on the riverbank can also be reduced. Furthermore, a sand flushing ditch is provided on the weir to discharge the sediment deposited in front of the intake gate downstream by flushing. At the double flush board method intake gate, closing the flush boards prevents the flood flow from entering the main irrigation canal, and using the double flush board reduces the water pressure, enabling easier manual operation of the flush board. When the water level is low, the flush board is lowered to enable water intake. In addition, the inflow of earth and sand is prevented by extracting the water that overflows,

Table 3 Advantage of Boulder Oblique Weir in the PMS Method Irrigation Project to Conventional Intake Weir

Conventional Intake Weir (Simple groin)	Boulder Oblique Weir in PMS Method Irrigation Project
(diagram 1 below)	(diagram 2 below)





above the flush board. A steep gradient main irrigation canal combined with a sand basin reduces the inflow of sediment into the irrigation distribution canals.

4.2 Layout Planning of Irrigation Facilities

Irrigation facilities should, in principle, ensure the adequate water quantity, with a sufficient water head which would allow gravity flow of the irrigation water from intake site to irrigation area. In the planning of the layout, adequate consensus building with the local community should be achieved by discussing with the residents the availability of land for acquisition and land lease under construction as well as the construction schedule.

1) Existing cultivated land and existing intake points and irrigation canals should be confirmed, and beneficiary areas including new irrigated land should also be confirmed, together with beneficiary farmers. In addition, the candidate site for the new intake point would also be confirmed, as well as the junction point between the new main irrigation canal and the existing irrigation canal (located usually near the utmost upstream part of the beneficiary area).
2) From the new intake candidate site to the junction points, steep gradient main irrigation canals and main irrigation canals are arranged along the shortest distance, and intake points for the distribution canals and the fields, which can secure sufficient hydraulic gradient are selected. Suitable land for intake site is determined by available gradient, river channel curve, bedrock presence, sand bar and other design elements. Sediment-prone areas should be avoided as they can cause difficulties in water intake.
3) The sand basin and the regulating pond should be located near the river at the junction point of the existing irrigation canal and the new main irrigation canal, and a main drainage canal should be provided for the discharge of sediment and excess water.
4) Thhe layout route of the main irrigation canal should be arranged so that the sand basin and the regulating pond at the starting point of each existing irrigation canal are connected. Areas with significant terrain irregularities, sections with rock that are difficult to excavate, and sections with private houses and farmland should be avoided.
5) Reservoirs, siphons and flood crossing bridges should be located where the main irrigation canal crosses small valleys and slopes consist of washes which pass flash floods and flows of debris. Reservoir installation should be avoided in the case that the basins of valleys and slopes are large, and the inflow of flash floods and debris flows is large, or if the water level of the main irrigation canal is at high elevation, because the risk of collapse increases. (See Figure 2)
6) The layout route of the main drainage channel for wetland should be determined in consideration of the layout of the irrigation beneficiary area and the topographical elevation, and should be located in a place where the ground elevation is lower compared to the elevation of surrounding area.

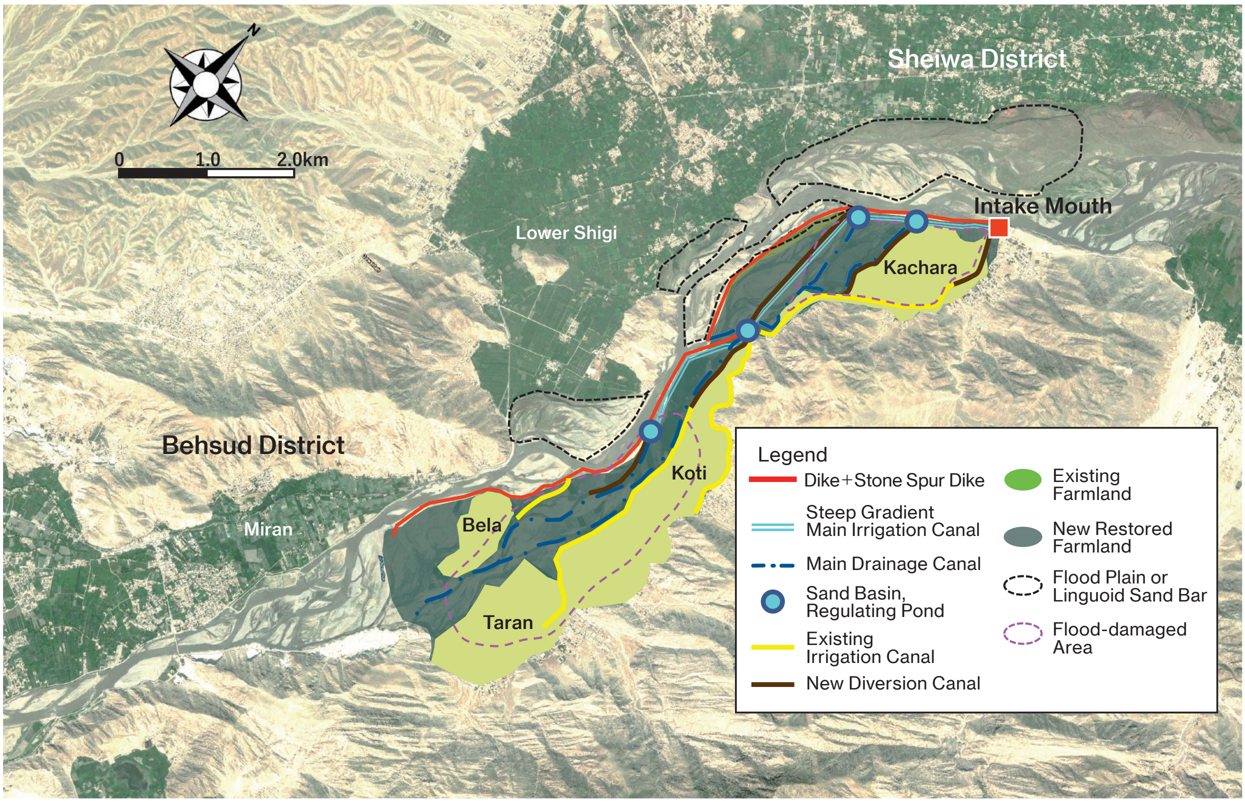


Figure 5 Sample of Layout for PMS Method Irrigation Facilities (Irrigation Facilities and Flood Control Facilities)

4.3 Priorities to be Considered in Designing Irrigation Facilities

The priorities to be considered when designing and examining the specifications of each irrigation facility are as follows.

- The height of the boulder oblique weir should not be excessively huge and should be within about 2 m height in order to ensure the stability of the weir body against the river flow during floods. In addition, embedment depth of at least 1 m should be secured under the riverbed.
- The boulder oblique weir should have a gentle slope as much as possible to prevent erosion caused by flood flows. The weir should be designed so that the overflow water over the weir collects in the center of the curved crest of the weir through the apron. The radius of curvature is set so that the center point of the curved arc does not deviate from the plane range of the boulder oblique weir.
- Since the part where the wing of the boulder oblique weir attaches to the sandbar and the foundation are likely to be weak points structurally, the weir wing should be sufficiently embedded in the sandbar, and the sandbar should be reinforced with boulders and cobble stones.
- The steep gradient main irrigation canal should be designed to carry the required amount of irrigation water and to prevent sediment deposition. If the longitudinal gradient is too gentle, the flow velocity will decrease, sediment deposition will increase, the cross-sectional area of the main irrigation canal will become larger, and the land occupancy range will become wider. Adversely, if it is too steep, the flow velocity will increase, the stability of the revetment is impaired, and the peeling of the canal bed lining is promoted. Therefore, a well-balanced longitudinal design should be made in consideration of the above trade-offs.
- The sand basin should secure a capacity large enough to capture the suspended sediment contained in the extracted irrigation water. From the maintenance viewpoint, it is advantageous that the depth of the

sand basin is not too large, but if it is too shallow, the required area of sand basin would become larger. Therefore, the design should take into consideration both restrictions related to land acquisition and ease of maintenance.

- The main drainage canal should have a cross sectional area sufficient to discharge design drainage amounts, but the width of the drainage canal should not be excessively large, to minimize the requisition of the agricultural land.
- While designing the wings of the intake weir and the embedment depth of the foundation in the ground, the height of the intake weir, the boulder diameter, the cross-sectional area of the main irrigation and drainage channel, etc., specifications should be set with a safe margin to stabilize the structure, secure the amount of water intake during extreme drought, and secure the cross sectional area is sufficient during floods.

CHAPTER 5

HOW SHOULD FLOOD CONTROL FACILITIES BE PLANNED AND DESIGNED?

Flood control facilities in the PMS method irrigation project are constructed by combining embankments along the river and stone spur dikes within river flow.

5.1 Basic Concept of Flood Control Facility Planning and Design

Firstly, the areas which are likely to be eroded or submerged by flood water are identified. Dikes should be provided in the flood risk area to prevent inundation.

A protruding stone spur dike should be provided in the area sensitive to erosion risk, to direct the flood flow away from the riverbank toward the center of the river and to exert a hydraulic jump effect minimizing sediment accumulation. However, when designing the dike, it is necessary to give due consideration to the land use on the inland side of the dike. It is quite possible that an unexpected flood may occur and the dike breaks, so the sophistication of land use in the hinterland (inland) of the dike should be strictly avoided. From this point of view, dikes should be provided only in absolutely necessary cases. Within the inland areas where floods have occurred in the past, land use restrictions should be imposed, based on the assumption that floods may inundate more than planned, and people should never be allowed to live in these areas. The layout plan should give due consideration to social and environmental impacts, such as land acquisition necessary for dikes and the impact on the opposite river shore caused by changes of flow direction, induced by installation of spur dikes.

5.2 Layout Planning of Flood Control Facilities

As shown in Figure 5, the layout planning of flood control facilities such as dikes and stone spur dikes should consider the layout of irrigation facilities, the conditions of the inland area to be protected, and the flood conditions. In particular:

- By conducting a field survey with reference to satellite images and land use maps, areas where flood inundation and erosion are likely to occur need to be identified, and irrigation facilities, farmlands and houses to be protected from floods need to be confirmed.
- The dike should be provided along the river in the flood prone area, where the ground elevation is lower than the design flood water level of the river. Dike construction on both sides of the river should be strictly

avoided. When a dike is planned on one riverbank, existence of a flood retarding area should be confirmed on the opposite bank. If it is unavoidable to construct dikes on both banks, they should not be continuous, but intermittent dikes such as open levee, and should have the function of letting the river flow escape to the inland area, in the event of a large-scale flood.

- On the outside of the curved part of the river channel, the flood flow velocity becomes high and collides with the riverbank, so scouring and erosion are likely to occur and there is a risk of dike deterioration and break. A stone spur dike should then be provided, in these sections, to direct the flood currents away from the bank. In a general, the stone spur dike should be provided for the purpose of controlling the direction of flood flow and fixing the ridges and sandbars.

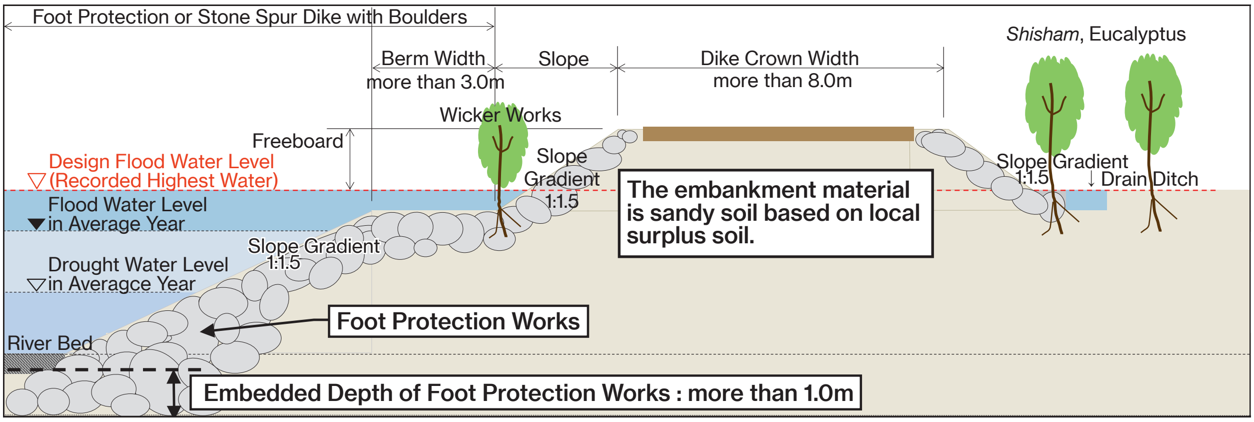


Figure 6 Standard Cross Section of Dike for the PMS Method Irrigation Project

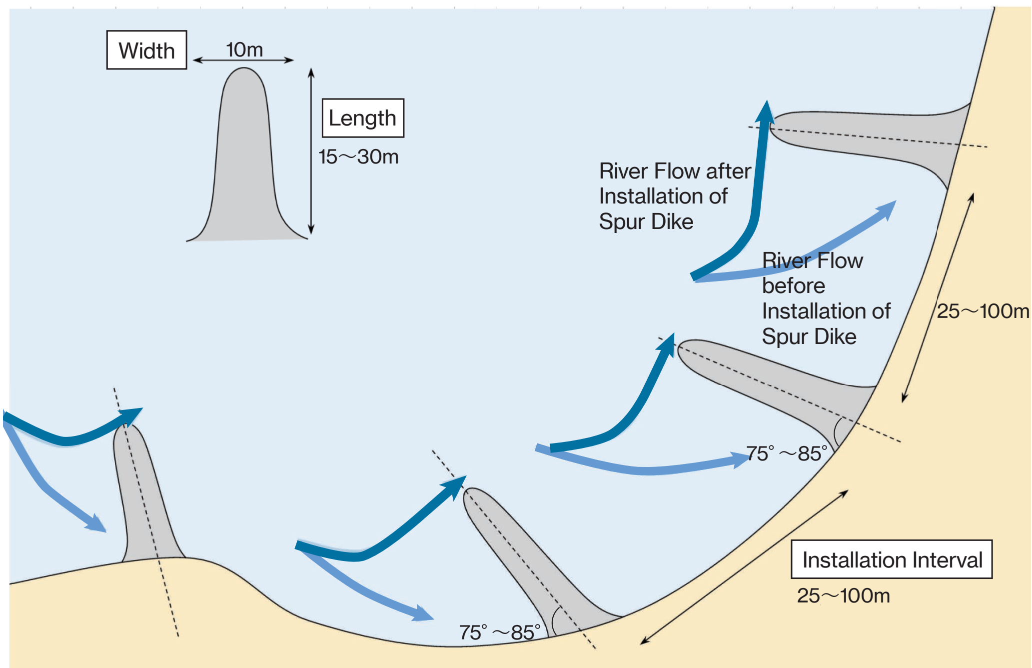


Figure 7 Example of Plane Arrangement for Upward Stone Spur Dike

5.3 Priorities to be Considered when Designing Flood Control Facilities

The priorities to be considered during designing and addressing each flood control facility are as follows.

- The dike alignment should be parallel to a smooth radius of curvature along the shape of the river alignment to prevent the formation of water streams which cause erosion. Along the dike embankment on the river side, revetment works and foot protection works should be provided, ensuring sufficient embedment depth, to prevent the embankment from breaking due to the erosion at the foot area. The height of the dike embankment should include a freeboard over the design flood water level.
- The length of the stone spur dike should be set appropriately with a norm of about 10% or less of the river channel width after the dike embankment is provided. If the stone spur dike is extended to have more than necessary length, to keep river alignment away from the riverbank, it may promote excessive scouring on the opposite side bank. Therefore, length of the spur should be sufficient but not exorbitant.
- The stone spur dike needs to be continuously monitored for possible damages and erosion as well as sand deposition in the area surrounding it.is the spur should be designed such as to facilitate maintenance, i.e. by use of gabions large boulders. In addition, since it is necessary to replenish boulders periodically, it is necessary to stockpile boulders in places along the riverbank.

CHAPTER 6

HOW SHOULD PMS METHOD IRRIGATION FACILITIES BE CONSTRUCTED?

6.1 Implementation System and Implementation Process of PMS Method Irrigation Project

It is expected that the Afghan government will become the project implementation entity/person using donors or the government's own funds, and will implement and disseminate the PMS method irrigation project under the project implementation system shown in Figure 8. The project implementation entity/person, together with the "PMS Method Irrigation Project Advisory Team", formulates the basic concept in consultation with the local community. Then, together with the Consultant who undertakes the consultant contract, in collaboration with the beneficiary farmers, facility planning and design, project implementation planning and construction supervision are carried out. During the facility planning process, it is necessary to discuss with the residents, to attain information about matters, such as confirming the availability of land for acquisition and settling the agreement on the contents of the planning and design. The construction company which undertakes the construction contract employs neighboring residents to carry out the construction work. The project implementation system will be maintained even after the construction is completed, and the operation and maintenance of irrigation facilities by the water users' association (WUA) or irrigation association (IA) will be supported for a certain period of time by the Contractor. As for the project cost, indirect costs for maintaining the corporate activities of consultants and construction companies and related expenses are expected, in addition to the direct construction costs, and contingency costs need always to be secured to prepare for unforeseen circumstances during construction and during the support period thereafter.

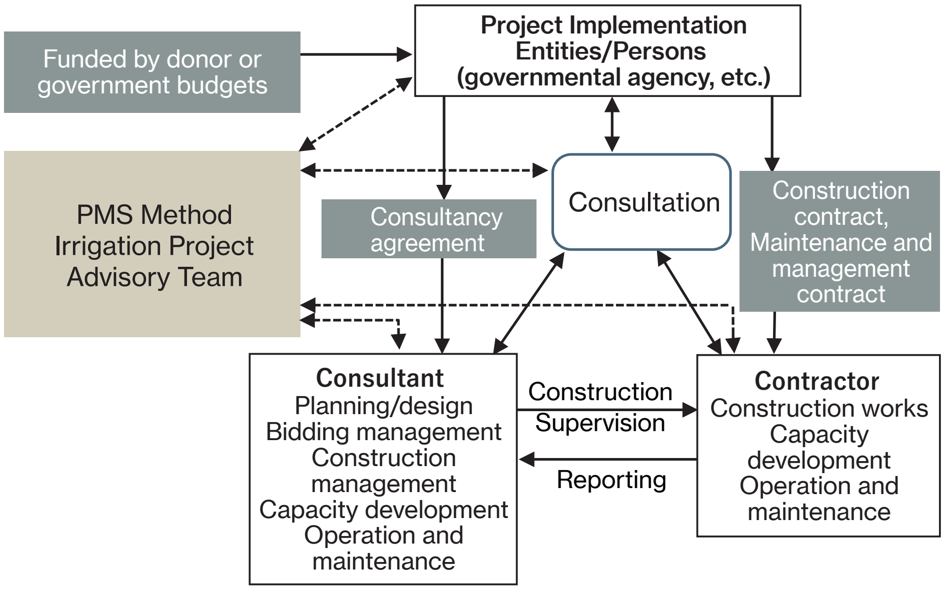


Figure 8 Example of Establishing a Future Project Implementation System
(when a government agency is the executing entity)

6.2 Construction Supervision for PMS Method Irrigation Facilities

Construction supervision includes establishment of construction implementation system, procurement of materials and equipment necessary for construction, securing of labor force and training of personnel, security and safety measures during construction, process control, quality control, cost control, etc. It is expected to complete in about two years. When it is a small-scale intake weir or intake gate irrigation project, the construction work of the PMS method irrigation facility should be completed within one year, if possible, aiming for early operation. If the construction period is multiple years for a relatively large-scale construction, temporary intake for water should be provided, and water extracted from the river so that the supply of irrigation water would not be interrupted, even during the construction period.

The priorities to keep in mind in construction supervision and construction work are as follows.

- Construction Schedule: Since the intake weir is a structure located in the riverbed, it should be constructed during the drought season. Since the construction of the intake gate and sand flushing ditch involves placement of concrete, a temporary coffer dam should be constructed, and the construction should be conducted under dry condition. Construction in the inland areas such as the main irrigation canal and sand basin can be carried out all year round.
- Construction Implementation System: The organizational structure, group formation and number of people in the construction work are planned, and the efficient placement of workers is planned in consideration of the flood season and drought season.
- Procurement of Construction Materials and Equipment: The method of procuring construction materials and heavy machinery required for the construction of the facility is also planned. In the case of procuring boulders, the required transportation volume within the construction period should be anticipated, the "daily transportation volume" of the dump truck is established, and the loading capacity is monitored at the site. Also, it is necessary to keep a stockpile of boulders near the construction site to prepare for emergencies. Here, in areas where there are no large boulders, some considerations such as using cobble stones as a filling

material for pilings of gabions shall be required.

- Quality Control Plan: A method of ensuring the quality of each type of work and ensuring the construction as designed (supervision of completed form) is planned. Particularly careful and attentive work is required for those parts becoming invisible after works. These include structural foundations, wings of intake weirs penetrating sandbar (natural ground) and backfilling portions of revetment.
- Security and Safety Measures: Security measures should be coordinated and planned in collaboration with local residents' associations and neighboring chieftains, and safety management education should be provided during construction. For those who may suffer disadvantages by the construction works, the purpose and contents of the project shall be carefully explained in advance, consensus building shall be made, and sufficient compensation shall be provided.
- Training / Education plan: On-the-job training and education of human resources related to the construction will be planned in anticipation that the local residents, who participate in the construction work would become core members of the maintenance group for the irrigation facilities after the construction is completed.
- A ground-breaking ceremony shall be held when the works get underway and a completion ceremony on completion of construction. With the participation of the provincial governor and irrigation department staffs in these ceremonies, revealing the event schedule will enhance the morale of workers toward the works as well as boosting expectations for sense of community unity and ownership

CHAPTER 7

HOW SHOULD OPERATION AND MAINTENANCE OF PMS METHOD IRRIGATION FACILITIES BE IMPLEMENTED?

The continuous operation and maintenance after construction is extremely important in the PMS method irrigation project. Normal facility operation includes operation of flush boards on structures such as intake weirs, and facility maintenance includes daily inspections, canal cleaning and dredging. After floods, irrigation facilities should be carefully inspected and all possible damages repaired. Water distribution should be reviewed in the event of unexpected drought, and distribution facilities should be restored accordingly. In other words, after the construction of irrigation facilities, the residents themselves must operate and maintain the irrigation facilities. It is important to contribute and cooperate to improve and continue sustainable and beneficial irrigated agriculture according to the local situation, after the PMS irrigation facilities are constructed. By maintaining fair and proper water distribution and through continuous inspection and improving of the irrigation facilities, if any damage or malfunction is detected, the systems can fully and sustainably perform their designed functions. In particular, regular sediment dredging in the irrigation canal is important to secure the required amount of irrigation water.

From this perspective, based on the current situation of water governance in the local community, the project implementation entities/persons or the government and the local community discuss and agree on their respective roles and responsibilities in the operation and maintenance of irrigation facilities which are clarified. Table 4 shows the basic roles and responsibilities of each organization for each necessary operation / maintenance works. In principle, the normal operation and maintenance of irrigation facilities is carried out by the beneficiary farmers, and efforts are made to maintain the functions of sustainable facilities. The project implementation entities/persons or the government is required to respect the will of the local community and beneficiary farmers, and to continue to be involved by ensuring a budget for large-scale repairs and restorations. The typical destruction patterns and countermeasures for the existing PMS irrigation facilities so far are as follows.

- Washout of Sandbar at Intake Weir Abutment：Repair of joint of the weir and sandbar protection by boulders and cobblestones;
- Scouring at the Downstream Part of Intake Weir and at the End of Sand Flushing Ditch：Repair of the main body of the weir by placing boulders;

Table 4 Roles and Responsibilities of Stakeholders in the Operation and Maintenance of Irrigation Facilities

Operation and Maintenance Work	WUA or IA by Beneficiary Farmers	*Mirab* (water manager)	Project implementation entities/persons or Government
Operation of Irrigation Facilities - Intake Gate Operation and Water Distribution (Water Users' Expense)			
Water Allocation Plan	• Formulation	-	• Support
Intake gate operation and equitable water distribution	• Pay *mirabs* • Proper on-farm water management (Chapter 8)	• Intake gate operation and proper water distribution	• Uunderstanding the operational situation
Measuring and monitoring water level and intake amount		• Measuring the water level and intake amount • Monitoring proper water distribution	
Response to extreme situations	• Consensus building on water distribution rules during drought • Proper on-farm water management (Chapter 8)	• Implementing water distribution rules during drought • Response to floods	• Joint discussion on water distribution rules during drought • Response to floods
Maintenance of Irrigation Facilities (Water Users' Expense)			
Maintenance Plan	• Formulation	-	• Support
(Irrigation facilities) • Daily maintenance and regular simple repairs	• Implementation of repair work • Regular cleaning (participation in *Hashar*)	• Inspection/ Observation • Daily cleaning • Regular cleaning (participation in *Hashar*)	• Understanding the situation of maintenance activities • Observation • Regular survey
(River channels) • Understanding rivers and sandbars situation			
Large-Scale Repair of Irrigation Facilities (Project implementation entities/persons' or Government's Expense)			
(Irrigation facilities) • Repair of gabion at joint of the weir • Repair of the weir and downstream erosion • Repair of dike and revetment works	• Labor Participation in repair work		• Ensuring of budget • Inspection/ Observation • Understanding of field situation • Implementing large-scale repairs, restorations, and river construction • Implementing as a new PMS method irrigation project if restoration is required
(River channels) • Sandbar protection • River bank protection • Excavation and dredging for ensuring division of river channel			

Note: *Shura* and RBC arbitrate mainly to resolve water disputes. *Shura* is customary arbitration, while RBC is arbitration based on the water law. *Shura* convenes *Hashar*.

- Erosion of Riverbank around the Weir：Repair of revetment works, river bank protection, and repair of the main body of the dike by constructing spur dikes or adding stones to the existing spur dikes;
- Damages to Water Intake Due to Changes in Mainstream of Rivers and Changes in River Channels such as Sediment Deposition：Excavation and dredging of the river and the sandbar for guiding the mainstream and for maintaining the sandbar, and ensuring division of river channel;
- Destruction and Sediment Deposition at Main Irrigation Canal Due to Flash Floods and Debris Flows：Repair of revetment works, dredging of inflowing sediment by emergency response team, and extension or installation of a flood passing bridge of the main irrigation canal, etc.

CHAPTER 8

HOW SHOULD AGRICULTURE AND IRRIGATION TECHNOLOGY BE IMPROVED?

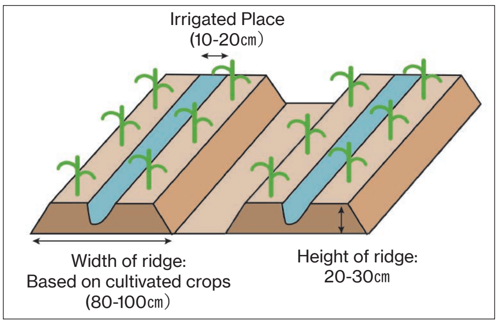
While the technology for constructing irrigation facilities that convey water to irrigated areas which require water is very important, we must not forget the importance of irrigated agricultural technology for the efficient use of water to produce crops. In the existing PMS irrigation project area, various issues have been found to impact irrigated agricultural technology, and they have been improved one by one. Among these, sustainable technologies related to irrigated agricultural technology are introduced. In the future, similar problems may occur in irrigation projects in each region where PMS system projects are implemented, and it is necessary to utilize the technologies shown here to improve the problems at an early stage and improve productivity.

8.1 Establishment of Demonstration Farm for Technical and Agricultural Extension

For agricultural workers who have little experience in crop cultivation, a demonstration farm is established for the purpose of efficient disseminating of cultivation technologies in irrigated agriculture, and the outputs of the PMS method irrigation project are ensured.

8.2 Irrigation Technology (Appropriate On-Farm Water Management)

Proper water use in irrigated fields is an important issue to prevent waterlogged damages and improve crop productivity. If proper water use is known, fair water distribution based on it is possible, and it contributes to water saving. Figure 9 shows the method of irrigation on ridges, with a drainage ditch in between two irrigation furrows, which is one of the appropriate water management methods in the irrigated field.



This irrigation method has a high water saving effect because it irrigates only near the crop roots. In addition, since only the top of the ridge is irrigated, the roots can grow healthily due to the improved drainage conditions.

Figure 9 New Method of Irrigation on Ridges in the Existing PMS Irrigation Project That is Effective (irrigation methods that make wide ridges and supply water to the center of ridges)

8.3 Cultivation Technology

The effective technologies which solve the problems of cultivation and enable sustainable crop farming are compiled. In particular, crop rotation, shading culture, alley cropping, sowing technology, nursery production, etc. are effective cultivation technologies which have been demonstrated in the PMS demonstration farms and can be carried out using local materials.

Photo 1 Shading Culture

Photo 2 Alley Cropping

8.4 Soil Improvement Technology

The soils in Afghanistan are characterized as sandy and with high pH in general. Such soils have problems, such as occurrence of nutrient deficiency like phosphoric acid and low water / nutrient retention in cultivating crops, which is very difficult to manage. The countermeasures for maintaining crop productivity of farmland are soil improvement technology, soil analysis for appropriate soil management, and improving soil fertility with leguminous crops cultivation, etc.

Photo 3 Soil Fertility is Improved by Applying Nitrogen to the Soil by Mixed Cropping of Maze and Beans.

*? Low pH values (<5.5) indicate acidic soils, while high pH (>8) indicate alkaline soils. Soils with pH in between are best for crop or pasture production..

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Abbreviations

ADB	:	Asian Development Bank
ADCP	:	Acoustic Doppler Current Profiler
AGCHO	:	Afghan Geodesy and Cartography Head Office
AGS	:	Afghanistan Geological Survey
AMD	:	Afghanistan Meteorological Department
CAD	:	Computer-Aided Design
CDC	:	Community Development Council
DAIL	:	District Agriculture, Irrigation and Livestock Offices
DDA	:	District Development Council
DGEH	:	Department of Geo-Engineering and Hydrogeology
EC	:	Electric Conductivity
EC	:	European Commission
FAO	:	Food and Agriculture Organization of the United Nations
GPS	:	Global Positioning System
HYMEP	:	Project for Capacity Enhancement on Hydro-Meteorological Information Management
IA	:	Irrigation Associations
IRDP	:	Irrigation Restoration and Development Project
IRRI	:	International Rice Research Institute
JICA	:	Japan International Cooperation Agency
MAIL	:	Ministry of Agriculture, Irrigation and Livestock
MRRD	:	Ministry of Rural Rehabilitation and Development
NGO	:	Non-Governmental Organizations
NSP	:	National Solidarity Program
NWARA	:	National Water Affairs Regulation Authority
OJT	:	On-the-Job Training
PDCA	:	Plan, Do, Check, Action
pH	:	Power of Hydrogen
PIM	:	Participatory Irrigation Management
PMS	:	Peace (Japan) Medical Services
PRRDD	:	Provincial Regional Rehabilitation and Development
RBA	:	River Basin Agency
RBC	:	River Basin Council
SRBC	:	Sub River Basin Council
USGS	:	United States Geological Survey
WB	:	World Bank
WUA	:	Water Users' Associations

Measurement Units

Length		Time	
mm	millimeter (s)	s, sec	second (s)
cm	centimeter (s)	min	minute (s)
m	meter (s)	h, her	hour (s)
km	kilometer (s)	d, day	day (s)
		y, yr	year (s)
Area		**Volume**	
mm^2	square millimeter (s)	cm^3	cubic centimeter (s)
cm^2	square centimeter (s)	m^3	cubic meter (s)
m^2	square meter (s)	l, ltr	liter (s)
km^2	square kilometer (s)	MCM	million cubic meter (s)
ha	hectare (s)		
jerib	1jerib =0.2ha		
Weight		**Speed/Velocity**	
mg	milligram		
g, gr	gram (s)	cm/s	centimeter per second
kg	kilogram (s)	m/s	meter per second
ton	ton (s)	km/h	kilometer per hour

Currency Equivalents

(Exchange Rate)

US$1.00 = AFN 77.02 (JICA rate as of February 2021)

US$1.00 = JPY 103.90 (JICA rate as of February 2021)

AFN 1= JPY 1.35 (JICA rate as of February 2021)

(Land Area)

1 jerib=0.2ha

1 jerib = 2,000m^2

1 ha=10,000m^2

CHAPTER

1

WHAT ARE THE "PMS METHOD IRRIGATION PROJECT GUIDELINES"?

1.1 Background

Rural communities in Afghanistan are suffering from the scarcity of water, which in turn results in hunger. They are exhausted, due to the recurring wars and natural disasters which continued for over 40 years. Farmlands have become dry, and people in the local communities are unable to resume their traditional lives. Furthermore, in irrigated agriculture, due to the lengthening of drought trends, changes in snowmelt patterns, frequent flood damages as the result of climate changes in the recent years, and the inadequate operation and maintenance of irrigation facilities, the traditional watering methods have become ineffective. This was particularly evident during the worst drought[4)] in about 40 years which peaked in the year 2000, causing tremendous damages all over Afghanistan. Approximately 12 million people, or about half of the population, were affected by the drought and approximately 5 million people suffered from starvation. This drought tendency has continued to present days.

In response to the situation, the Peace (Japan) Medical Services (hereinafter referred to as the "PMS"), an international non - government organization (NGO), launched the "Green Ground Project" in 2002 in Afghanistan, and started construction of irrigation canals in 2003. By 2020, the irrigation of 16,500 ha in Behsud, Sheiwa, and Kama districts in the Nangarhar province was underway, and the PMS planned to support the livelihood of 650,000 people, aiming to achieve effective irrigation by supporting the development of irrigation facilities in all three districts. The first project, the Marwarid Irrigation Project, started in 2003 and was completed in 2010, with the irrigation of 3,000 hectares of farmland including section of the Gamberi Desert, to support the livelihood of farming communities. It is also estimated that some 150,000 refugees have returned to the area. From 2010 to 2012, an irrigation facility was constructed on the Kabul River to supply irrigation water to 60 - 70% of the cultivated land around the Kabul River in the Behsud district of the Nangarhar province. In the watershed of the Kunar River, which has more rapid and frequent floods compared to Kabul River, irrigation facilities were constructed in the Kama district during 2008 - 2012, Kashkot in the Sheiwa district during 2012-2014, and Miran in the Behsud district during 2014 - 2016 period. Stable agriculture has been achieved by supplying sufficient irrigation water to the lower Kunar River and the Behsud district along the left bank of Kabul River. Based on their experience with implementing irrigation projects (including trial experimental plots for about 20 years), PMS has succeeded in developing a model of the "PMS Method Irrigation Project", which include integrated irrigation and flood control facilities starting with intake weirs and gates, through main irrigation canals, regulating ponds, up to drainage canals.

These PMS activities and irrigation projects have received peace awards, such as the Ramon Magsaysay Award (Peace and International Understanding) in 2003 and the Outstanding Civil Engineering Achievement Award from the Japan Society of Civil Engineers in 2018. Dr. Tetsu Nakamura, who had led the existing PMS irrigation project, was awarded Honorary Citizenship of Afghanistan, the Ghazi Mir Masjedi Khan High State Medal, and he also received an Islam Commendation from the Ulama (religious leader) of the Nangarhar province in Afghanistan.

Data Collection Survey on Agriculture and Rural Development in Afghanistan, conducted by JICA from 2017[5)], and a previous study[6)] list the following results of evaluation of the technology and achievements of the existing PMS irrigation project:

1) Clarification of technical relevance of irrigation facilities;
2) Positive impact on local socio-economy by sufficient supply of irrigation water; and
3) Positive economic and social impact by the irrigation project process and improvement of awareness and

capacity for operation and maintenance, in cooperation with the local communities.
Furthermore, the existing PMS irrigation project has achieved comprehensive results, such as the repatriation of refugees and former soldiers, their incorporation into village societies and contribution to peace-building by improving their livelihood.
During 2016, the Afghan government prepared the National Comprehensive Agriculture Development Priority Program 2016 - 2020, aiming to take up food production increase as an important measure towards achieving food security. The plan aims to reach a total irrigation area of 3.1 million hectares of pre-war level by 2025 through rehabilitation of irrigated areas and development of new areas. The breakdown is 900,000 hectares of rehabilitation of irrigated lands and 120,000 hectares of new irrigated lands.
Finally, the existing PMS irrigation project, which has mainly been deployed in the Kunar river basin, is worth disseminating throughout the country as an irrigation project suitable for the Afghan climate and local communities, that supports the reconstruction of the Country.
Therefore, based on experience and lessons learned from the existing PMS irrigation project, and reflecting the philosophy and will of Dr. Tetsu Nakamura, the "PMS Method Irrigation Project Guidelines" (hereinafter referred to as the "Guidelines") have been created, to help disseminate the PMS method irrigation project all over Afghanistan.

1.2 Purpose of the Guidelines

The "PMS Method Irrigation Project Guidelines" mainly target engineers, planners and decision-makers involved in irrigation projects. It aims to contribute to sustainable development of irrigated agriculture for Afghanistan's communities by presenting the philosophy of Dr. Tetsu Nakamura, process of dialogue with the beneficiaries, and technical information needed for planning, design, construction, maintenance, and irrigated agricultural technology of sustainable irrigation projects, suitable for Afghan conditions and Afghan communities.
In order to achieve this purpose, the Guidelines state that the basic policy is to respect the independent development of local communities, their ownership of the project and to enable them to operate and maintain sustainable irrigation facilities for a period of 100 years, and the optimal form and the most suitable irrigation technology for Afghan conditions. With the Guidelines, it is hoped that the local and central government officials and technical staff, as well as people in the local communities, decision-makers and those involved in aid, will rekindle with the "initiative, ingenuity and commitment to go through" for the recovery and rehabilitation of Afghanistan, which was Dr. Tetsu Nakamura key objective.

1.3 Concept and Contents of the Guidelines

As shown in Figure 1.1, the concept of the PMS Method Irrigation Project Guidelines is to place importance on the need of local communities, and to promote sustainable irrigation projects suitable for Afghanistan, by understanding and practicing the PMS method irrigation project properly, by developing the method through its actual application and continuous innovation, and by disseminating the PMS method irrigation project across the entire country of Afghanistan.

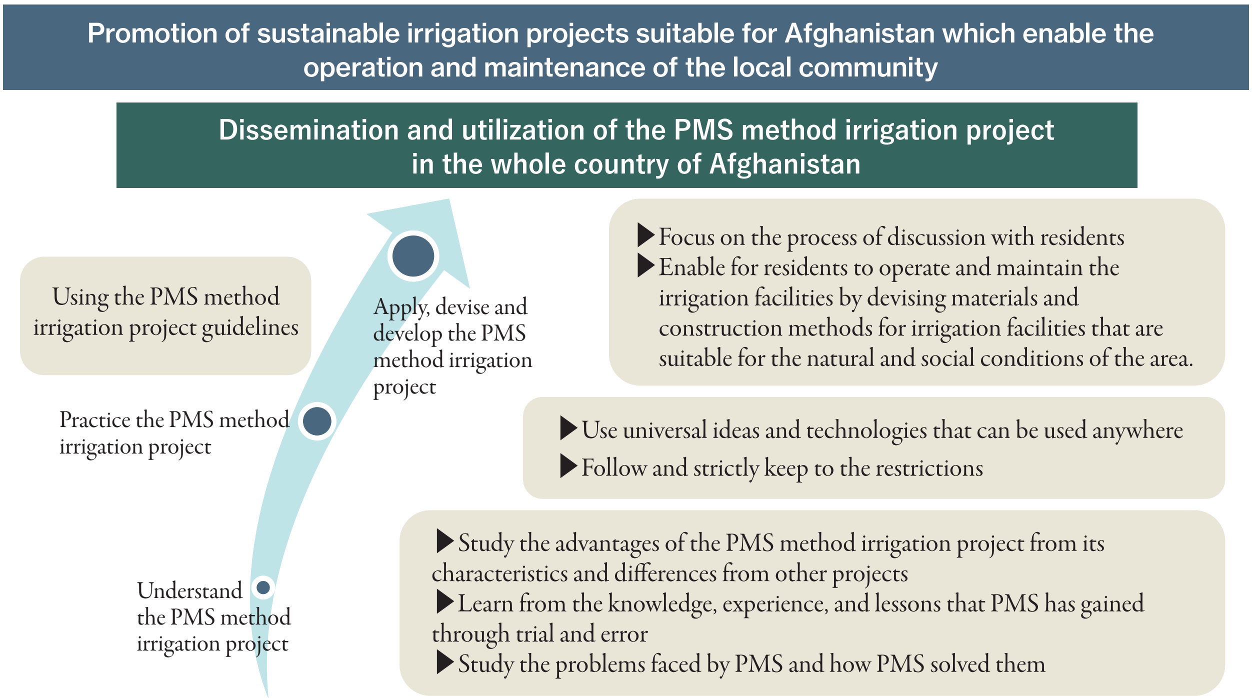


Figure 1.1 Concept of the Guidelines[2)]

The Guidelines summarize the experience, knowledge and lessons learned from the existing PMS irrigation project in the Lower Kunar river basin of the Nangarhar province in eastern Afghanistan. The existing PMS irrigation project is based on local technology, adapted to the characteristics of the Kunar River and its basin. However, the process of collaboration with the stakeholders, the ideas and techniques in planning / designing and construction / maintenance of irrigation facilities can be applied universally in Afghanistan. The application of the PMS method to other areas where natural conditions and river conditions are different is also possible. The Guidelines show both the universal specifications of the PMS method irrigation system structures which are not affected by natural and river conditions, as well as the specifications based on the local rivers and natural characteristics. It also lists the points to take note of, including some restrictions to strictly keep to. In other words, the Guidelines summarize the contents necessary for the local communities to follow, such as:

- to obtain the knowledge to properly carry out the PMS method irrigation projects in various areas,
- to actually discuss the method with the residents,
- to plan and design irrigation and flood control facilities, and
- to construct, manage and maintain the facilities by themselves.

The Guidelines mainly describe the distinctive technology of the PMS method irrigation project which plans, constructs and maintains with participation of the local communities. For the technical contents required for general planning, design, construction, maintenance of irrigation projects and public involvement, refer to the existing policies / guidelines and manuals. The Guidelines provide a list of reference documents, and briefly introduce some of them.

Furthermore, through continuous observation, feedback, and analysis in the areas to which the PMS method irrigation project is applied, it is hoped that the knowledge and experience gained in each area will be utilized to update the method to more appropriate ones for continuous improved application.

1.4 Structure of the Guidelines

As shown in Figure 1.2, the Guidelines consist of eight Chapters corresponding to: the overview of the Guidelines, the basic concept building based on discussions with the residents, the river conditions survey, planning and design of irrigation and flood control facilities, constructing and managing the PMS method irrigation project, and operation and maintenance of the project facilities. Finally, the improvement of irrigated agricultural technology under the PMS method irrigation project is described in the last Chapter.

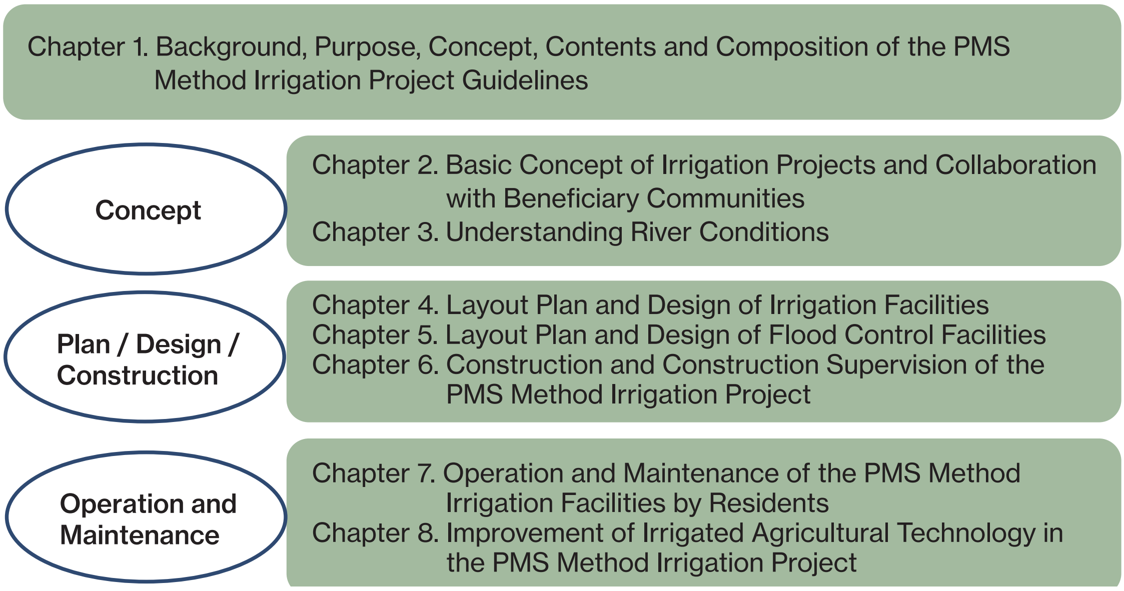


Figure 1.2 Structure of the PMS Method Irrigation Project Guidelines [2)]

Chapter 1 presents the background, purpose, concept, composition and targets for better understanding of the "PMS Method Irrigation Project Guidelines". Then, through presenting the overall picture of the PMS method irrigation project and applying basic civil engineering techniques, the characteristics of the PMS method irrigation project are elaborated, and the expected results of the irrigation project are presented. In addition, the contents of each chapter of the Guidelines are briefly introduced, along with the goals, activities to be implemented and contents to be decided at each stage of the PMS method irrigation project.

Chapter 2 explains the philosophy and the policy approach for developing the basic concept of the PMS method irrigation project and for building a consensus, while working with the communities in the beneficiary and surrounding areas, with respect to their governance system. This Chapter shows how the project's target area and the area under control of the beneficiaries (irrigation land area) are determined, the approximate amount of irrigation water is calculated, and the main irrigation canal route as well as the intake site, as along with the weir location are roughly determined. The possible sources of construction materials such as stones and embankment materials are also studied and compared, and the approximate project cost and project development period are also estimated. These surveys involve consultations, interviews and exchanges of opinions with the local residents and government engineers, based on the existing data and the results of river surveys described in Chapter 3.

Chapter 3 describes the survey methods for rivers and river basins, which are necessary for planning and design of the irrigation and flood control facilities of a PMS method irrigation project. This Chapter consists of the following sections:

- Survey Methods Using Existing Information

- How to recognize river flow and runoff.
- How to recognize the transition of river channel at the planned sites of river structures.
- Probability assessment of river flow (flood discharge, drought discharge, etc.).
- How to assess the impact of river structure construction on future flow conditions and channels.
- How to assess the impact of irrigation water intake on downstream water use.

- Survey Methods Based on Interviews with Local Residents
  - How to survey the situation of river, situation at the time of flood or drought, existing structures in the vicinity, situation of water intake, etc., by interviews with local residents.
- River Observation / Measurement Methods
  - Methods to identify the location of flood control facilities such as dikes*, spur dikes, and revetment works, for deciding on the location of the places where flooding and severe erosion is likely to occur.
  - Methods to grasp the flood water level and discharge required for planning and designing flood control facilities.
  - Methods of grasping river flow conditions and discharges and water levels during floods and droughts, which are necessary for location selection, planning and designing of intake weirs and intake gates.
  - Survey methods of riverbed material and grasping river sediment load, which is necessary for planning and designing of sand flushing ditch of intake weir, steep gradient of the main irrigation canal and sand basins (sediment trap).
- River Survey Methods
  - Methods of measuring the longitudinal profile and cross sections of rivers, required to calculate the discharges, water levels, flow velocities, etc., of rivers.
- Setting Basic Information for Irrigation Facility Plan and Design (Water Levels, Discharges, Sediment Particles Size and Sediment Transport Volume)
  - How to set the design drought discharge / drought water level, design flood discharge / flood water level, design sediment transport volume and sediment particles size, required for designing irrigation facility.

Chapter 4 presents the methods of irrigation facilities layout planning, design specifications and detailed design of structures. The outline process of the layout plan is as follows:

- The location of the intake is set according to the conditions of the alternative compared sites, selected as in Chapter 2, along with the route of the steep gradient main irrigation canal are set in consideration of topographical conditions, workability, and the size of the controlled land area.
- The sand basins and regulating ponds are placed at the junction of the existing irrigation canals and the new main irrigation canals. The layout of drainage canals for flushing sediment and evacuation of excess water discharges are located.
- The layout route of the main irrigation canal is arranged so as to connect the sand basin to the regulating pond at the starting point of the existing irrigation canal.
- The layout route of the drainage canals for prevention of waterlogging is decided in respect of layout of beneficiary farmland and topographical elevations of control area.
- The reservoir, the siphon and the flood passing bridge are installed at the location where flash flood flows and debris flow cross the irrigation canal.

Next, the main specifications of each irrigation facility are planned and designed as follows:

- The layout designs of the intake weir, intake gate, and sand flushing ditch are decided in consideration of the shape of the streamway and the stability of the riverbanks and sandbars.
- The elevations of the top of the intake weir and intake gate opening, and of the intake gate bottom/floor will ensure stable water intakes during both flood and drought periods.
- The layout designs of steep gradient main irrigation canals as well as main irrigation canals are designed in

* In Afghanistan, the word "levee" is often applied instead of the word "dike", but in these guidelines, it will be unified to the word "dike" hereafter.

a way that minimizes land acquisition will be as much as possible. Longitudinal profile and cross-section design, a standard cross section and profile gradient will all be determined in such a way that they can ensure required irrigation water flow and design flow velocities with appropriate water level for ensuring irrigation water amount, as well as preventing sediment deposition.

- For the sand basin (sediment trap), the capacity is set in such a way that can accommodate the suspended sediment load contained in the water from the intake. After studying the required design drainage volumes, the design of the longitudinal profile and cross sections of drainage canals will be determined so that the drainage network can drain the calculated design drainage volume.
- The planar scale of the reservoir is set as the size of the valley surrounded by mountains and the main irrigation canal.
- For the siphon, the cross section of the crossing culvert is designed in such a way that it can pass required amount of irrigation water.
- For the flood passing bridge, the width is designed so that the flood discharge can be safely evacuated downstream.

Finally, this Chapter presents determining of the detailed dimensions for each irrigation facility, structural specifications of main civil works, foundation works and all appurtenant and ancillary facilities.

Chapter 5 presents the methods of layout planning, design specification and detailed structural design of flood control facilities. The layout planning is structured as follows:

- The layout plan of the flood protection dikes is determined in consideration of the ground elevation. Where the ground elevation is lower than the design high water level of the river, flood dikes are planned in order to contain the flooded area and to protect the fields of the beneficiaries as well as the main irrigation canals along the river from flooding.
- The layout plan of stone spur dikes is designed for the purpose of stabilizing the streamway and preventing riverbank scour.

Next, the design specifications are as follows:

- For the layout plan design of flood dikes, the aim is to minimize private land acquisition as much as possible. The longitudinal profile and cross section are designed in such a way that the freeboard above design flood water level ensures dike safety and prevents overtopping.
- The layout plan design as well as the length and the installation interval of stone spur dikes are all set in consideration of the design high (and low) water levels and the width of the river.

Finally, the detailed dimensions of each flood control facility, structural specifications of main civil works, foundation works and appurtenant and ancillary facilities, are all specified in the design documents.

Chapter 6 describes the construction supervision and construction procedures for irrigation facilities, including flood control facilities. Construction supervision includes construction implementation arrangements, procurement of materials and equipment necessary for the construction, securing of labor force and training of labor personnel, security and safety measures during construction, control of construction schedule, quality control and cost management of the construction works.

- Construction material procurement section describes the methods of procuring materials such as boulders, reinforcing bars, cement, aggregate, earth and sand, bricks, and gabion iron mesh wires necessary for facility construction.
- Construction equipment procurement section describes how to procure heavy construction equipment such as dump trucks, backhoes, bulldozers, and compaction rollers, all of which are necessary for facility construction.
- The construction implementation arrangement at the building sites, organizational structure, group formation, and number of people in the construction implementation are described.
- Security measures and safety management, security measures and safety management training, in

collaboration with local self-governing body (*Shura / Jirgas*) and neighboring community leaders and elders are also described in this Chapter.
- The construction plan (construction procedures, operation process, project cost tracking ledger) describes the construction procedure of each irrigation facility, the laborers allocation plan, both during the flood season and the drought season, and the number of working days, the number of workers, and cost for each type of work.
- The section on quality management plan describes the procedures for ensuring the quality of earthworks, concrete works, reinforcement bar arrangement works, and for ensuring the adherence of the finished product to the original design.
- Training section describes training and education with a view of ensuring the quality of facility construction and effective maintenance after construction.

Finally, this Chapter includes the construction procedures for irrigation facilities such as intake weir and irrigation canals, as well as flood control facilities such as dikes and stone spur dikes.

Chapter 7 presents the operation and maintenance of irrigation facilities. The PMS method irrigation project aims to maintain sustainable irrigation facilities with farmers as the main actors. This Chapter describes the procedures for confirming and establishing an organizational structure for operation and maintenance, for formulating and operating regulations of fair and appropriate water distribution and use, and for carrying out daily, routine and occasional large-scale maintenance works including repairs and restorations.

Chapter 8 presents ways to improve irrigated agricultural technologies for more productive irrigation. It explores the problems of irrigated agricultural technologies observed in the existing PMS irrigation project and proposes useful technologies for improvement. The main sections are as follows:
- Establishment of demonstration farm for technical extension
- On-farm water management
- Cultivation technology
- Soil improvement technology

1.5 Target Beneficiaries of the Guidelines

The Guidelines target all those who want to learn about the PMS method irrigation project, but necessary contents and levels of learning differ depending on objectives of each Guidelines' user. Therefore, the Guidelines were prepared in two different versions corresponding to the assumed users as follows:
- **PMS Method Irrigation Project Guidelines for Planners and Engineers**
  This is the main part of the guidelines. It explains the philosophy and technical contents for appropriately disseminating the PMS method irrigation project, aiming at appropriate application, on each user's own judgement, of the PMS method irrigation project at the location where the application is planned.
- **PMS Method Irrigation Project Guidelines for Stakeholders and Decision-Makers**
  This is the summary of the guidelines. It is a compilation of key points of the PMS method irrigation project for stakeholders and decision-makers. It clearly explains the philosophy and project contents for disseminating the PMS method irrigation project. In addition, it is written in such a way that stakeholders can understand the effects and impacts of the PMS method irrigation project.
  In addition, the following brochure and video have been created to encourage understanding of the guidelines:
- **Brochure for Easy Understanding of the PMS Method Irrigation Project**:
  The main target users of this brochure are the decision-makers, donors, local residents and other stakeholders. The PMS method irrigation project is introduced in such a way as to encourage people to read the guidelines and implement them. To make it easier for the general public to understand the PMS

method, a lot of photographs are used to illustrate and explain the technical points.

- **Video Showing the Contents of the PMS Method Irrigation Project Guidelines**:
The main target users of this video are planners and designers. The video is an auxiliary teaching material for better understanding of the guidelines, focusing on "what kind of idea should be used to make a plan" described in Chapter 2 of the Guidelines, and on the content that explains the process of making a layout plan. It does not give detailed technical instructions but simple ones. It explains how the PMS method irrigation project differs from the methods adopted in past development projects of other donors and what responsibilities and roles of each person in charge including the residents are involved.
- **Key Reference Book, *The Afghan Green Ground Project* Written by Dr. Tetsu Nakamura**:
In the words of Dr. Tetsu Nakamura, the outline of the PMS method irrigation project is described in an easy-to-understand manner for beginners. This is a book that should be read first when introducing a PMS method irrigation project. After getting an overview of the PMS method irrigation project in this book, the PMS method irrigation project guidelines are referred to for a deeper technical understanding, and for practical application of the PMS method irrigation project.

1.6 Overview of the PMS Method Irrigation Project

1.6.1 | Outline of the PMS Method Irrigation Project

A PMS method irrigation project is an irrigation project in which water is directly drawn from rivers and conducted to farmlands. As shown in Figure 1.3, the PMS method irrigation system is composed of oblique weir, intake gate, steep gradient main irrigation canal, sand basin (regulating pond), main irrigation canal, main drainage canal, reservoir, siphon, flood crossing bridge, dike, and stone spur dikes. The PMS method irrigation project is implemented through the process shown in Figure 1.5, respecting the local communities and their governance system. The project implementation entities/persons are assumed to be a government agency, the private sector, etc. The aim is to be able to operate and maintain the irrigation system by involving local residents, starting from the basic concept stage, encouraging proactive participation by local residents from planning to design, construction, operation, maintenance, irrigated agricultural technology to ensure ownership and enhance the capacity of the local communities. In addition, locally available materials are procured, and facilities are designed for local people to operate and maintain easily.

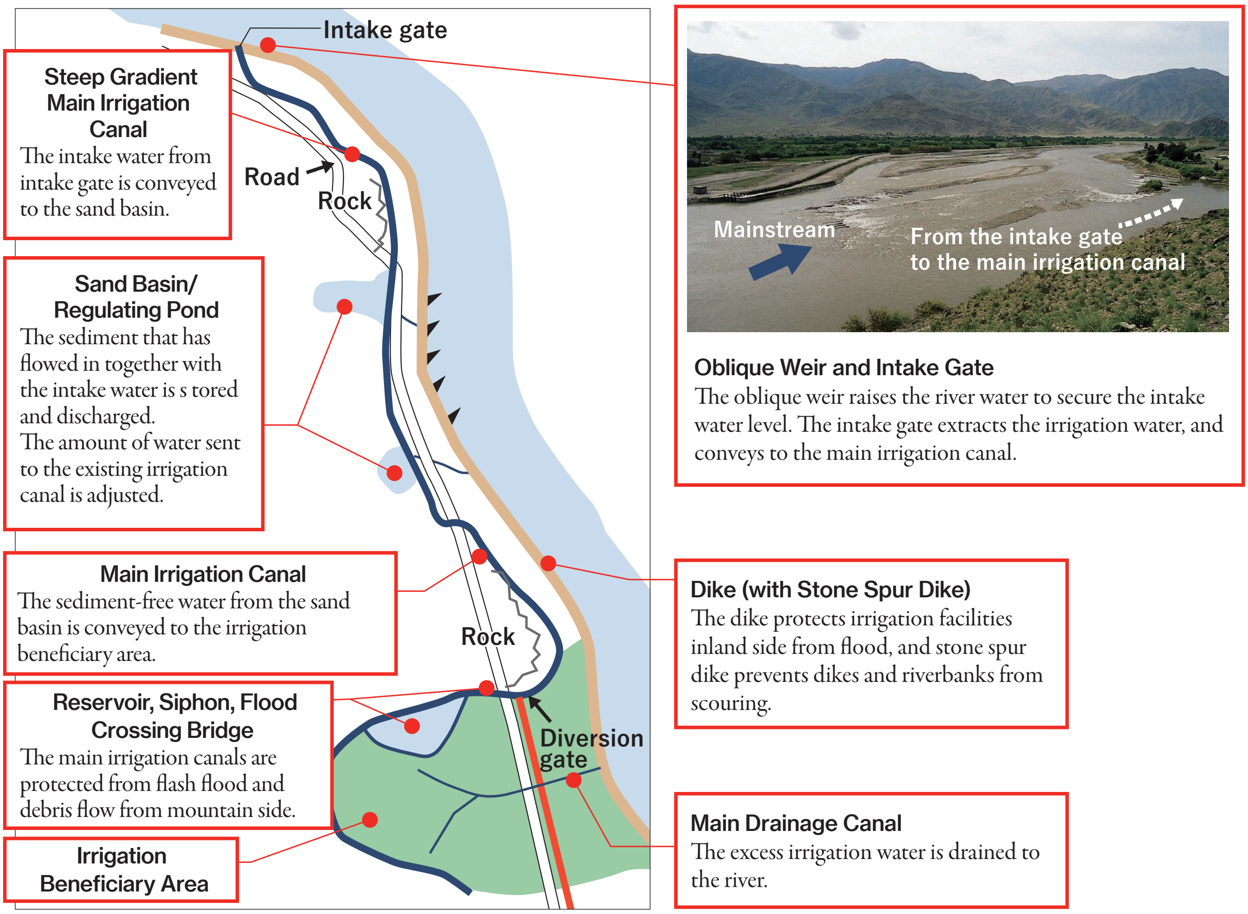
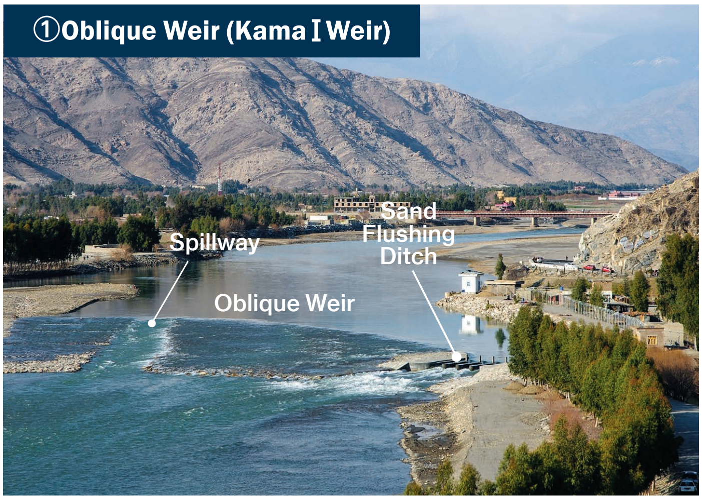


Figure 1.3 Main Structures of the PMS Method Irrigation System[2)]

Figure 1.4 Functions of PMS Method Irrigation Facilities [1), 2), 3)]

Menu of PMS Method Irrigation Facilities

❶Oblique Weir, ❷Sand Flushing Ditch(Movable Weir), Spillway, ❸Double Flush Board Intake Gate, ❹Steep Gradient Main Irrigation Canal (Gabion Works, Wicker Works), ❺Sand Basin with Transmission Gate and Drain Gate, ❻Main Drainage Canal, ❼Reservoir, Siphon, Flood Crossing Bridge, ❽Flood Control Facilities(Dike and Stone Spur dike)



Function of Oblique Weir ; By damming the river water and raising the water level on the upstream side, water intake during drought season will be easier. By extending the weir diagonally, the overflow water depth is lowered, the tractive force is reduced, and the weir is less likely to be broken.

Function of Sand Flushing Ditch ; Sand flushing ditch is installed as part of the intake weir adjacent to the intake gate and prevents the inflow of earth and sand into the intake gate.

Function of Intake Gate ; The intake gate is installed on the riverbank connecting to the boulder oblique weir abutment to draw water into the irrigation canal and adjusts the amount of intake water. Two rows of flush boards are installed in front and rear of the gate pier to create a reservoir. It reduces the water pressure applied to the lower flush board on the river side and prevents the flush board from breaking.

④Steep Gradient Main Irrigation Canal and Main Irrigation Canal

Function of Steep Gradient Main Irrigation Canal and Main Irrigation Canal ; The steep gradient main irrigation canal conveys the sediment contained water drawn from the intake gate to the sand basin without accumulating the sediments in the canal. The main irrigation canal conveys the sediment-free water from the sand basin to the irrigation beneficiary area.

⑤Sand Basin

Function of Sand Basin (Regulating Pond) ; Sedimentation and flushing out of earth and sand contained in the irrigation water. Control of transmission amount of irrigation water.

⑥Main Drainage Canal

Function of Main Drainage Canal ; Excess water other than the required amount of irrigation water will be promptly returned to the river through the main drainage canal to prevent wetland at the irrigation beneficiary areas and to consider downstream water use.

⑦Reservoir etc.

Function of Reservoir etc. ; Protecting the irrigation canal from flash floods and debris flows from the mountain, it secures water retention in dry area and contributes to the growth of vegetation. Where flash floods and debris flows from vallay cross a canal, siphons and flood crossing bridges are provided.

⑧Flood Control Facilities

Function of Flood Control Facilities ; The dike has the function of protecting irrigation beneficiary areas, residential areas, and irrigation canals along the river from floods. The stone spur dike prevents dikes and riverbanks from scouring and also has the function of fixing the alignment of river channel.

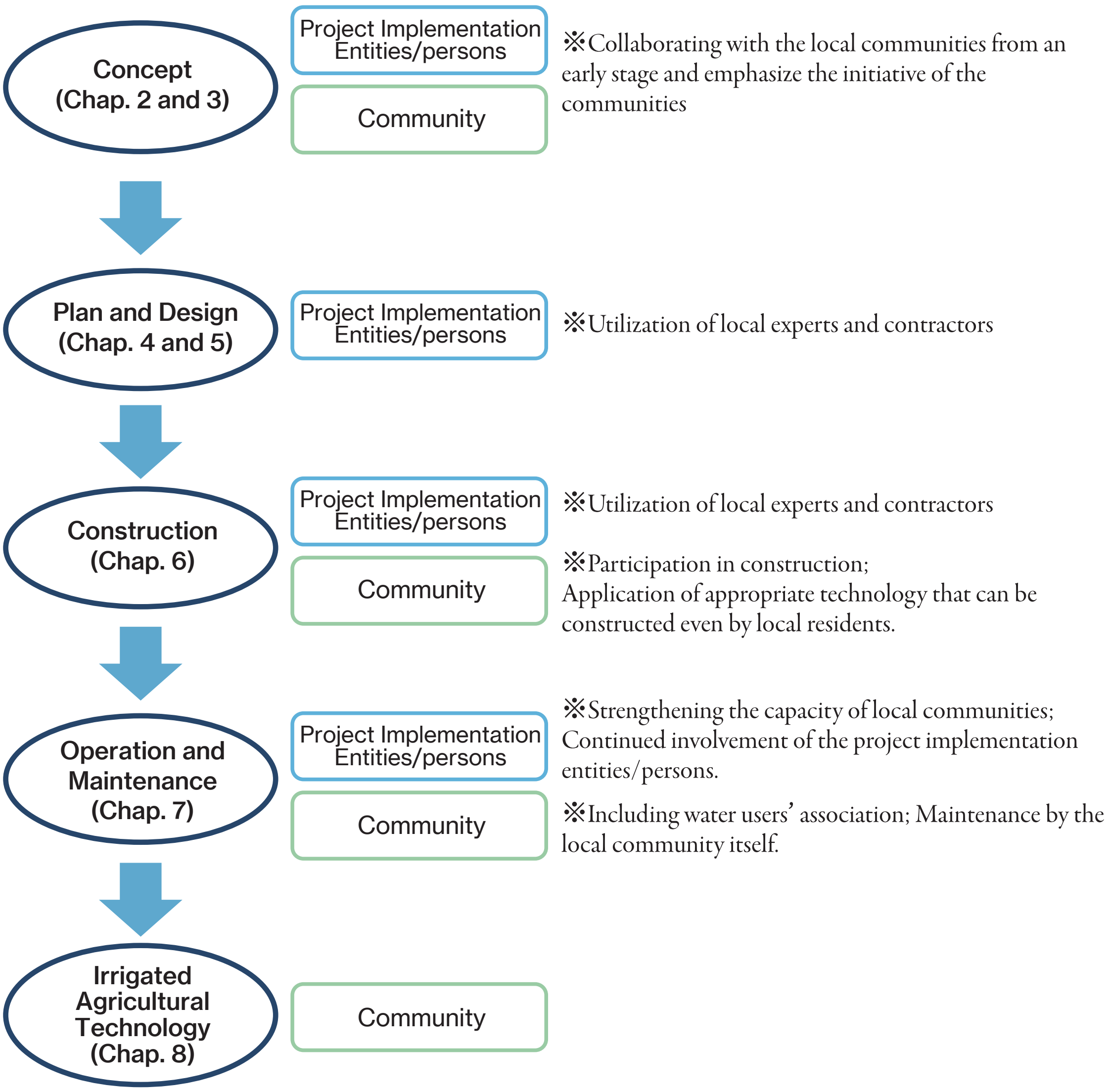


Figure 1.5 Procedures of the PMS Method Irrigation Project Which Emphasize Local Initiatives[2)]

1.6.2 | Characteristics of the PMS Method Irrigation Project

PMS Method is advantageous in situations where hydrometeorological data are limited, because PMS continuously observes the local rivers and structures to understand the situation and considers countermeasures to realize stable irrigation through trial and error. Given that limited funds are available, a large amount of natural building materials (mainly stones) that can be procured locally are used with as small number of concrete structures as possible (see Photo 1.1). The practice is aiming to construct a sustainable irrigation system which is strong during both flood and drought periods. Construction costs of the PMS method irrigation project are generally lower than those of a conventional irrigation project, because a large amount of locally available stone materials is used. Even if the facility is damaged to some extent due to floods or sediment disasters, the local people can usually deal with the damage by using natural building materials. Only in the case of large-scale damage, large-scale repairs are required. On the other hand, proper operation and maintenance of irrigation facilities during the project implementation is extremely important for the PMS method irrigation project. Once an irrigation facility is constructed, it is not an end of engagement, but the facility needs to be protected, maintained and nurtured in the community.

The PMS method irrigation project is a "simple and practical" irrigation project that matches the natural conditions of the region based on the operation and maintenance by the community beneficiaries themselves. That has become a major success factor which has led to various technical, economic, social and comprehensive achievements.

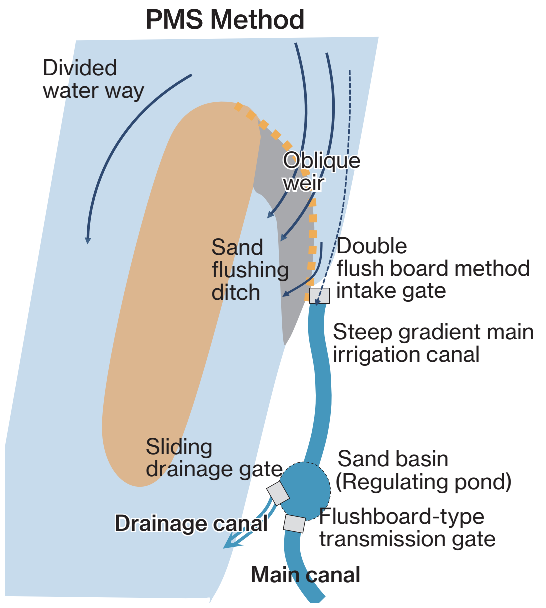
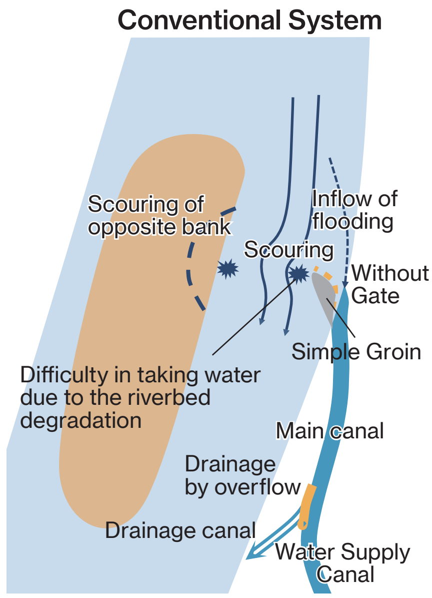
Weir Using Stone Material	Irrigation Canal Using Stone Material	Irrigation Canal Using Soil Cement
		

Photo 1.1 Irrigation Facilities Using Locally Procured Natural Materials (Mainly Stone Materials)[1)]

The PMS method irrigation system has the characteristics shown in Table 1.1, compared to the conventional irrigation systems which are implemented in Afghanistan. The most distinctive structure among them is the oblique intake weir with boulders. A typical example of this is the Marwarid-Kashkot continuous Weir or Kama Weir constructed on the Kunar River. The model for this weir was the Yamada Weir, which is an old oblique weir of masonry on the Chikugo River in Fukuoka Prefecture, Japan. The Marwarid-Kashkot continuous Weir and Kama weir are made of cobbles and boulders, which are abundant locally, combining old Japanese wisdom and the materials and masonry techniques of farmers of Afghanistan. With this weir, it was possible to create the irrigation system that would allow stable water intake during the drought season without being destroyed during the flood season.


Photo 1.2 Kama Weir in Afghanistan (Left) and Yamada Weir in Japan(Right)[1)]

Table 1.1 Comparison Between the PMS Method Irrigation System and the Conventional Irrigation System[2)]

Item	PMS Method Irrigation System	Conventional Irrigation System
Dam-up system	Oblique Weir	Simple Groin
Structure of the Intake Mouth	Double Flush Board Method	without the Intake Gate / with the Manually Sliding Sheet Type
Canal Bed Material	Soil Cement Lining	Simple Digging or Concrete Lining
Structure of the Irrigation Canal Wall	Gabion and Wicker Works	Same as the above
Storage Function	Install the Sand Basin (Regulating Pond)	None
Drainage of excess water	Adjust the amount of water by the intake gate. Drain the Bottom Water and sediment through the Sliding Drain Gate installed at the Sand Basin (Regulating Pond)	Overflow from a portion of the Main Canal Wall
Sedimentation Countermeasures	Combined with a Sand Flushing Dich at the Intake Weir, and the Drainage Gate installed at the Sand Basin (Regulating Pond)	None
Protection of irrigation canals from flash floods and debris flows	Installation of reservoir and siphon, flood crossing bridge	None
Schematic Diagram		

1.6.3 | Economic and Social Outcomes of the Existing PMS Irrigation Project

The existing PMS irrigation project has stabilized and recovered the irrigated farmlands which had been deserted. The project further constructed drainage canals on the part of the irrigated farmlands which had become wetland, reclaimed new irrigated farmlands, increased agricultural production, ensured people's livelihood, and finally turned the land which had been deserted into green land by implementing vegetation covered waterway protection and planting trees along canals. It also impacted micro-climate in the area by contributing to the reduction of local temperatures and sandstorm damages (see Photo 1.3).
The JICA Data Collection Survey on Agriculture and Rural Development in Afghanistan of 2018, the questionnaire survey aimed to compare the rural living conditions before and after the existing PMS irrigation project, shows that a stable supply of irrigation water can achieve positive economic and social outcomes including the improvement of living standards. Figure 1.6 shows these economic outcomes (direct effects) and social outcomes (ripple effects). The existing PMS irrigation project provided employment opportunities for villagers and returnees as workers and craftsmen during the construction stage and enabled the refugees to

return and resettle after the project, making a significant contribution to DDR (Disarmament, Demobilization and Reintegration) and peacebuilding. In other words, the existing PMS irrigation project has a large positive impact on sustainable agriculture, ensuring the livelihood of local residents, improving the local environment and building peace and stability.

Photo 1.3 Outcome of Irrigation Project[1)]

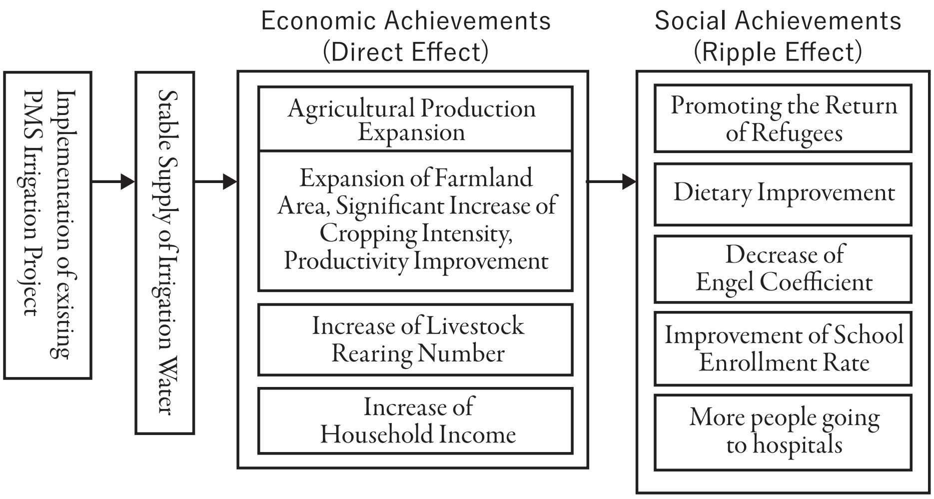


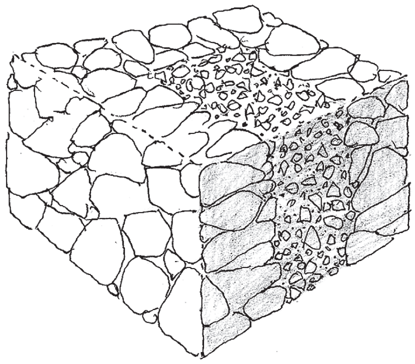
Figure 1.6 Economic and Social Outcomes of the Existing PMS Irrigation Project[5)]

1.7 Basic Civil Engineering Techniques Used in PMS

After the completion of the PMS method irrigation project, the farmers responsible for operation and maintenance of the facilities should command the techniques for gabion works, wicker works, soil cement works and masonry. In the process of implementing the PMS method irrigation project with the local farmers, these techniques must be transferred to them for their capacity development. Local farmers became able to operate and maintain the PMS method irrigation facilities by acquiring these techniques. This section is only an introduction, and details are given in Chapters 4 and 5.

1.7.1 | Gabion Works

Gabions are made of iron wire mesh baskets filled with local stones to form square or rectangular blocks, which can be used for various purposes such as protecting the inner walls of irrigation canals and road slopes, material for revetments and stone spur dikes, and reinforcing joints between sand bars and weirs. An example is shown in Figure 1.7 below. The reason for using stone rather than heavy use of concrete is to enhance sustainability in the area by using local materials that farmers are accustomed to.



PMS Method: Pile up square stones along the outermost edges of the frame as if to create walls, and then fill the inside space with crushed stones and gravels.

Figure 1.7 Gabion Works at Irrigation Canal[1)]

1.7.2 | Wicker Works

Wicker works are used to protect the waterfront by planting trees such as willow trees, edging used in combination with gabion, and the Pinholder type and fascine works for protection of the surface of sandbars. Trees are also planted for windbreaks function, erosion control and deceleration of debris flows from valleys. Appropriate type of tree planting shall be selected depending the vegetation on the purpose. The willow root eventually entangles with the gabion stones and acts to strengthen canal wall. It also creates shade, lowers temperature, and contributes to a richer ecosystem.

Photo 1.4 Wicker Works[1)]

1.7.3 | Masonry

Masonry is a pile of rubble stones which is used for small canal walls as well as outer walls of irrigation canals. Basically, it is dry masonry, but mortar masonry is also applied where some reinforcement is needed. Use of stone instead of concrete also contributes to reduction of the maintenance and facilitation of diverse ecosystems.

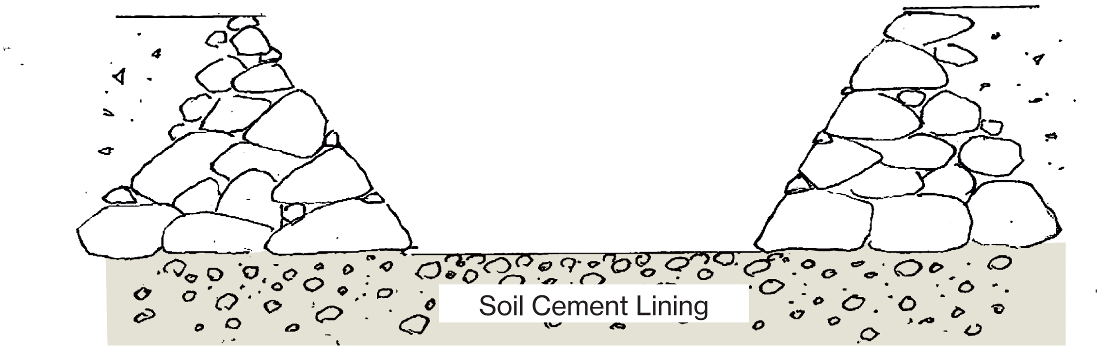


Figure 1.8 Masonry[1)]

1.7.4 | Soil Cement Works

Soil cement works consist of a mixture of local soil and cement, and are mainly used for lining bottoms of irrigation canals. (See Photo 1.5)

Photo 1.5 Soil Cement[1)]