No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

COMMITTEE OF EMERGENCY SITUATIONS
AND CIVIL DEFENSE
THE REPUBLIC OF TAJIKISTAN

THE STUDY ON
NATURAL DISASTER PREVENTION
IN PYANJ RIVER

FINAL REPORT

VOLUME 2 SUPPORTING REPORT

DECEMBER 2007

CTI ENGINEERING INTERNATIONAL CO., LTD.

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PROJECT COST ESTIMATE

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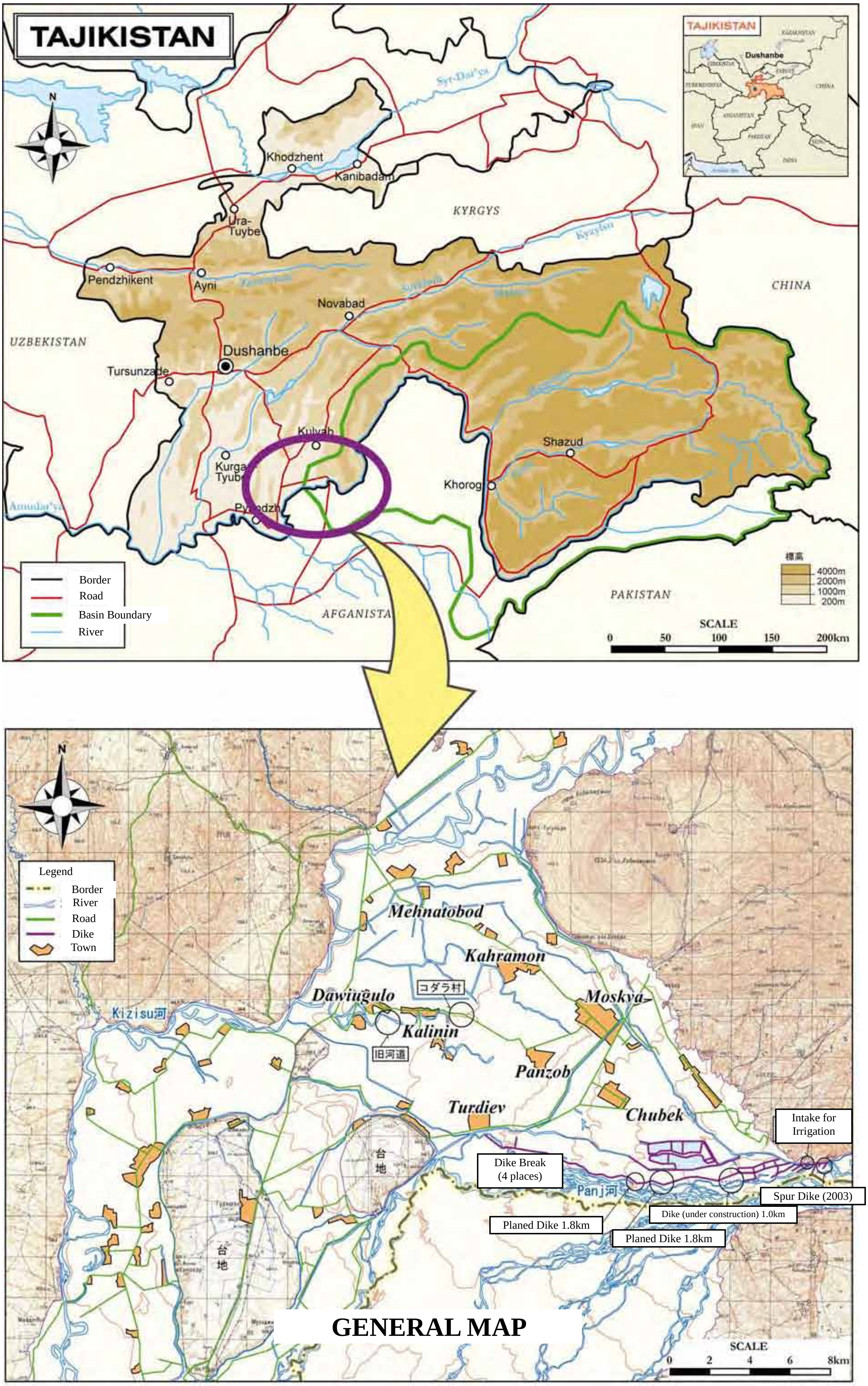

TAJIKISTAN
Khodzhent
Kanibadam
Ura-Tuybe
KYRGYS
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Ayni
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CHINA
UZBEKISTAN
Dushanbe
Tursunzade
Kulyab
Shazud
Kurgan-Tyube
Khorog
Pyandzh
Amudar'ya
Syr-Dar'ya
Kyzylsu
Border
Road
Basin Boundary
River
PAKISTAN
AFGANISTA
標高
4000m
2000m
1000m
200m
SCALE
0
50
100
150
200km
Dushanbe
N
Legend
Border
River
Road
Dike
Town
Mehnatobod
Kahramon
Dawiugulo
コダラ村
Kalinin
Moskva
旧河道
Kizisu河
Panzob
Turdiev
Chubek
Intake for Irrigation
台地
Dike Break (4 places)
Panj河
Spur Dike (2003)
Dike (under construction) 1.0km
Planed Dike 1.8km
Planed Dike 1.8km
台地
GENERAL MAP
SCALE
0
2
4
6
8km

VOLUME 2 : SUPPORTING REPORT

LIST OF SECTORS

ABBREVIATIONS

Organization

JICA	:	Japan International Cooperation Agency
ADB	:	Asian Development Bank
MoES	:	Ministry of Emergency Situation and Civil Defense (Changed into Committee or CoES)
MMWR	:	Ministry of Melioration and Water Resources
SDC	:	Swiss Agency for Development and Cooperation
DHI	:	Danish Hydraulic Institute
REACT	:	Rapid Emergency Assessment and Coordination Team
UNT	:	United Nations in Tajikistan
UNDP	:	United Nations Development Programme
UNICEF	:	United Nations International Children's EmergencyFund
USAID	:	United States Agency for International Development
WB	:	World Bank
WHO	:	World Health Organization
FHA	:	Focus Humanitarian Assistance
Tajikmeteorology	:	Agency on Hydrometeorology
IMAC	:	Information Management and Analytical Center

Unit

℃	:	Degree Centigrade
dia.	:	Diameter
g	:	Gram
Ghz	:	Gigahertz
Mhz	:	Megahertz
ha	:	Hectare
Kg, kg	:	Kilogram
Km, km	:	Kilometer
K	:	kilometer point (E.g. 2.0K)
L. l. lit.	:	Liter
m	:	Meter
m^3	:	Cubic meter
m^3/s	:	Cubic meter per second
mil.	:	Million
MLD	:	Million Liter per Day
MGD	:	Million Gallon per Day (1 MGD = 4.546 MLD)
Tjs.	:	Tajikistan Somoni
sec	:	second
t, ton	:	Tonnage
US$, USD	:	American Dollar
W	:	Watt

Others

CD	:	Civil Defense
CIS	:	Commonwealth of Independent States
EIA	:	Environmental Impact Assessment
ICRC	:	Internal Committee of the Red Cross
NGO	:	Non-Governmental Organization
M/P	:	Master Plan
F/S	:	Feasibility Study
P/P	:	Pilot Project
TA	:	Technical assistance
ToR	:	Terms of Reference

SECTOR 1 RIVER PLANNING AND HAZARD MAPPING

SUPPORTING REPORT

SECTOR 1 RIVER PLANNING AND HAZARD MAPPING

TABLE OF CONTENTS

Page

Tables

Figures

Annexes

LIST OF TABLES IN REPORT

LIST OF FIGURES IN REPORT

LIST OF TABLES AT THE BACK OF REPORT

LIST OF FIGURES AT THE BACK OF REPORT

SECTOR 1. RIVER PLANNING AND HAZARD MAPPING

1.1 RIVER MORPHOLOGY

1.1.1 Morphology of Pyanj River Basin

Pyanj River Basin, the largest river basin in Tajikistan, is as large as 82,500 km^2 at the head of Hamadoni Alluvial Fan and occupies 58% of the whole territory of Tajikistan (143,100 km^2). Pyanj River is the right bank tributary of the Amudarya River that originates in the Pamir Mountain Range at the highest region of Central Asia where the mountains are as much as 6000 m high. Fluvial detritus from the above watercourses form the Hamadoni Alluvial Fan at 400 m to 550 m in altitude. The radius of the fan in Tajikistan is 25 km and the area is about 470 km^2.

Annual average precipitation in this basin is estimated at 450 mm, more than 90% of which occurs during seven (7) months from December to May. Based on the results of hydrological analysis (See Chapter 2 of the supporting report), precipitation has the general tendency to increase from upstream of the Pamir mountain range to Hamadoni, ranging from 100 mm to 600 mm.

Melting snow and glaciers often generate serious damage to the study area (Hamadoni Alluvial Fan) between May and August. According to hydrological analysis in this study, the maximum flood discharge at Khirmanjo was 4,370 m^3/s in 1969, and the peak discharge of the 2005 flood that damaged the Hamadoni Rayon was estimated at 4,149 m^3/s. In addition, the annual mean discharge and the average of annual maximum discharges at Khirmanjo were calculated 900 m^3/s and 3000 m^3/s respectively.

The temperature gets warmer from the Pamir mountain range down to the Hamadoni alluvial fan at approximately minus 2.5°C to 17.0°C. According to the data measured by Tajikmeteorology in 2005, the daily average temperature around the Hamadoni alluvial fan vary between minus 2.6°C and 33.3°C. The hottest months are generally July and August (extreme maximum of more than 40°C has been recorded), and the coldest temperature normally occurs in the last half of January.

1.1.2 Morphology of Pyanj River

1) River System

As shown Fig. 2.1.1 in Chapter 2 of the supporting report, the Pyanj River system consists of 6 (six) major tributaries up to the Hamadoni alluvial fan, namely; the Shokhdara, Gunt, Bartang, Yazgulom, Vanj and Pamir rivers. There are also small mountain torrents and three (3) natural lakes in the basin, namely; Sarez Lake, Yashikul Lake and Zorkul Lake, all of which were formed naturally by filling up of the river by landslide materials. The total length of the Pyanj River is 921 km, and the length from its source up to Hamadoni is estimated to be 800 km. At the Hamadoni alluvial fan, Pyanj River is braided and breaks into a number of branches.

2) River Course Variation

The riverbed of Pyanj River is unstable with braids and meanders in the alluvial fan. Judging from the collecting 18 satellite maps from 1976 to 2006 the main river course flowed to the Afghanistan side until the 1980's, and from the 1990's the main flow changed its direction to the Tajikistan side. Considering the situation of sediment transport (refer to Chapter 2 of the supporting report), one of the reasons for the change of flow direction is sediment accumulation to a certain height that filled up the river course of Afghanistan in the 1980's. Fig. 1.1.1 shows a representative satellite map indicating changes in the river course.

3) Flow Regime

The volume of river flow shows an unequivocal variation between the flooded season and recession seasons. The river discharge starts to increase in April and reaches its peak in July, depending on the rise of temperature in the Pamir mountainous area.

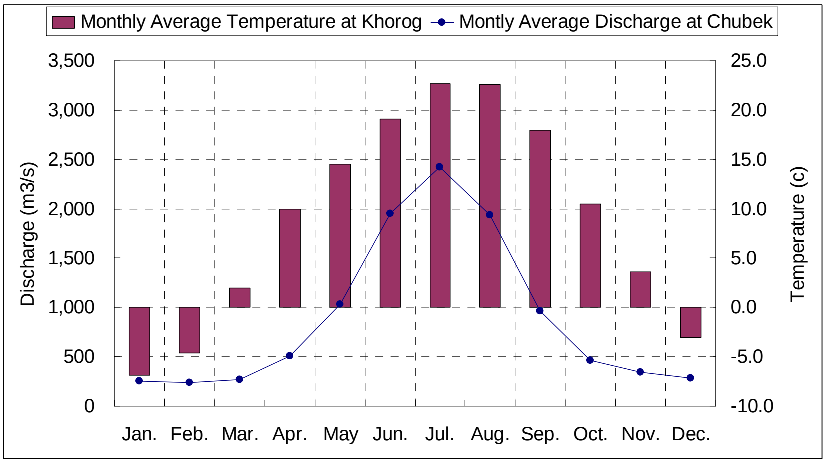


Fig. R 1.1.1 Averaged Mean Monthly Discharge (1967-2005)

4) Slope of Pyanj River

At the Hamadoni alluvial fan, the Pyanj River has the gradient of between 1/300 and 1/400 along the 20 km stretch between Chubek Weir and Sayyod Hill, as shown by the riverbed profiles in Fig. R 1.1.2. According to the topographic map with the scale of 100,000, the slope upstream from the head of the fan is about 1/200.

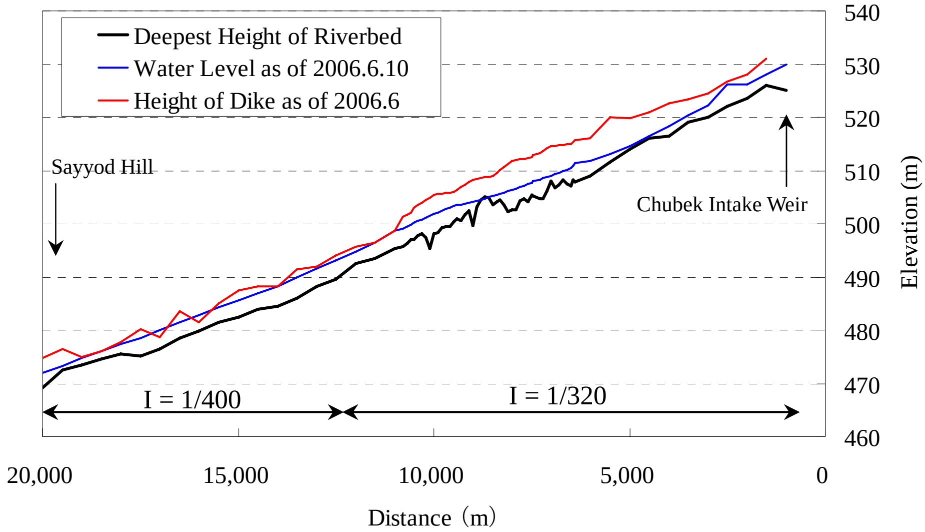


Fig. R 1.1.2 Slope of Pyanj River

5) Holm of Pyanj River

There are many holms in the Hamadoni alluvial fan, fixed along the direction of river flow into one side where they had accumulated to a certain height. In the study area, the some of holms that developed near the dike are affecting the direction of flood flow to attack the dike. There are more than 100 holms in Pyanj River in the territory of Tajikistan, as shown in Fig. R 1.1.3.

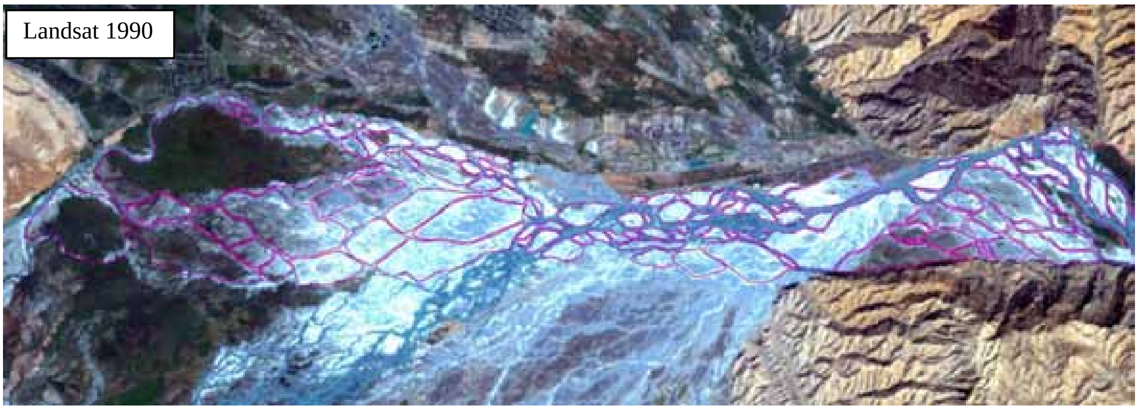


Fig. R 1.1.3 Holms of Pyanj River

6) Riverbed Material

A riverbed material survey was carried out in the channel of Pyanj River and the alluvial fan in the study area. The particle size distribution of each sample is summarized as gradation curve in Fig. R 1.1.4. Based on the analysis (refer to Chapter 2 of the supporting report), the average grain diameter of sand and gravel varies between 20 mm and 70 mm, which fit the standard characteristics.

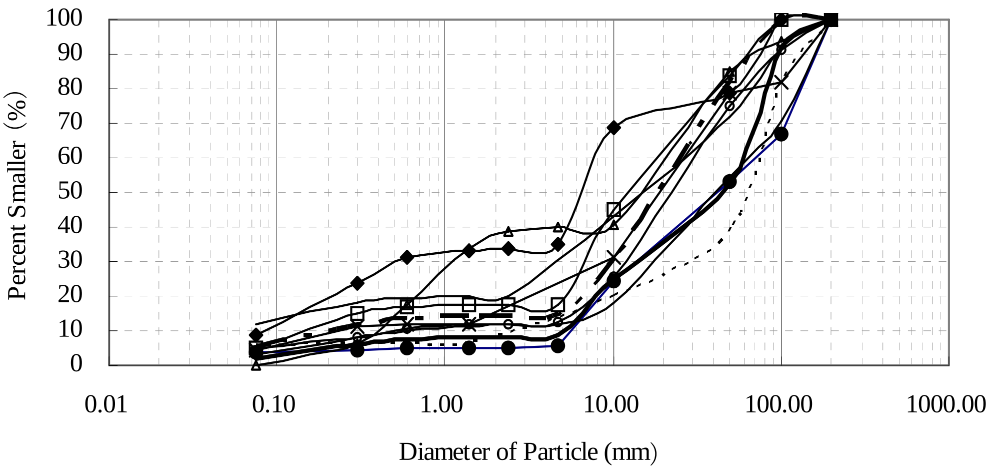


Fig. R 1.1.4 Graduation Curve of Riverbed Material

7) Sedimentation

Hydrological analyses (refer to Chapter 2 of the supporting report) attest to the fact that the average height of the riverbed at the Khirmanjo Hydraulic Observatory was stable from 1977 to 1986. This means that sediment movement was also in equilibrium during the period.

The estimation for the amount of the sedimentation is ongoing. According to WG, between January and May in 2005, around 123,000 m3 was excavated from 200 m to 300 m of the canal of Chubek Weir for a depth of about 1.0 m. Since MMWR had also carried out excavation of the canal in 2004, it is presumed that the volume excavated in 2005 had accumulated in a one - year period.

1.2 PAST FLOOD EVENTS

1.2.1 Chronicle of Flood Events

The record of past major flood events in the whole Tajikistan was collected from CoES (Department of Protection of Population and Territory) and the ADB report (see Reference 2), and summarized in Table 1. and Table 2. in the Annex. Based on the data collected, Tajikistan had suffered from disasters such as debris flow, flood and landslide over the ages. Records for the 1970s were however unavailable.

From the records mentioned above, only the flood events concerning the Pyanj River Basin were extracted, as summarized in Table 1.2.1. According to this table, 40 flood disasters occurred during the past 45 years despite the fact that no record for the 1970's was available.

Focusing on the Hamadoni Rayon , seven (7) flood disasters occurred during the past decade, as shown in Table R 1.2.1. In the 2005 flood, the Hamadoni Rayon received the biggest damage, amounting to some 7 million US dollars. Incidentally, according to MMWR, the Metintugay kishlak along the Dehkonobod Canal was washed out and the protected inland area was inundated in the 2004 and 2005 floods from the Pyanj River.

Table R 1.2.1 Past Flood Events in Hamadoni Rayon

No.	Date	Damage Condition	Damages ('000 US Dollar)	Discharge at Hamadoni (m^3/s)
1	1996	Due to the rising water level in the Pyanj River, the irrigation canals were in danger of dyke breach and floods will occur at Border Checkpoint No. 7 and No. 8.	N/A	N/A
2	1998/7	Dike was damaged, partially.	N/A	4,294
3	1999/7	Dike was damaged, partially.	N/A	2,849
4	2003/4	One (1) hectare of land was affected by heavy rainfall.	N/A	N/A
5	2003/6	Dike was damaged, partially.	N/A	3,190
6	2004/7	8 houses and 6 bridges were damaged. 0.68 km of flood protection structures was damaged. 47 hectares of agricultural land were affected. Private companies' buildings were damaged.	184	N/A
7	2005/6	266 houses were damaged. 3 facilities, including education, medical, social and cultural were damaged. 4.4 km of roads were damaged. 3 bridges were damaged. 5.2 km of flood protection structures were damaged. 7.1 km of canals and lodgments were damaged.	7,026	4,254
	2005/7	The central area of Hamadoni remained without electricity because an electric transformer was destroyed.	N/A	

Reference: Documents from IMAC, Department of Protection of Population and Territory and interview with the member of WG

1.2.2 Flooding Situation

As can be seen from hydrological records since 1969 (refer to Chapter 2 of the supporting report) and the flood damage in Hamadoni Rayon, the flood peak discharge is not proportional to the occurrence of flood damage even if there are large floods in 1960's and 1980's (there is no information on flood damage in the 1970's). Based on satellite map analysis, it can be said that one of the primary reasons on why flood damage began to appear in Hamadoni Rayon from the 1990's is that the main watercourse of Pyanj River changed from the Afghanistan side to the Tajikistan side in the beginning of the 1990's.

1.3 INVESTIGATION ON THE 2005 FLOOD CONDITION

1.3.1 Objectives

The 2005 flood was a large scale flood, the type of which rarely occurred in recent years in the Hamadoni Rayon. However, information on this flood is too scarce for this Study to figure out the flooding situation in detail (especially for the inundation analysis and the estimation of direct and indirect damages). In this investigation, therefore, information on flood damage was consolidated from results of (1) the questionnaire survey, (2) the field interview surrey, and (3) the satellite map analysis. In addition, the flood damage mechanism was investigated through interview with WG to define how the flood or its damage occurred and how the people took measures against the flood in more detail.

1.3.2 Questionnaire and Interview Survey

1) Scope of Survey

The questionnaire survey was carried out in April to May 2006 to collect several aspects of damage by the 2005 flood. These included (1) inundation depth, (2) location of flood, (3) economic damage (on properties and income), (4) actions taken against flood (flood fighting, evacuation and others), and (5) requests and expectations on flood control programs of communities (or individuals). The questionnaire was distributed to 100 households in four (4) Jamoats, namely; Panjob, Turdiev, Kalinin and Dashtigulo, to identify the 2005 flooding situation. These Jamoats were chosen considering the flood stream course in 2005.

Field interview survey was also conducted in the beginning of August 2006 to make up for the questionnaire survey on the actual 2005 flooding condition. This survey included (1) Location of flood, (2) Inundation depth, (3) Inundation duration, (4) Initial time of inundation, (5) Flood Damage and so on. This survey was carried out at the kishlaks and farms along the stream course of the 2005 flood.

The satellite map analysis is described in item 1.3.3.

2) Results of Questionnaire and Field Interview Survey

The results of the questionnaire and filed survey from the viewpoint of flooding condition were abstracted, as summarized in Table R 1.3.1. In addition, specific explanations regarding (1) Flood Time Location of flood, (2) Inundation depth, (3) Inundation duration, (4) Initial time of inundation, and (5) Flood Damage are described in the table below on the basis of information from kishlaks and immigrants. Position of Kishlaks and boundaries of Jamoats are as shown in Fig. 1.3.1 in the Appendix

Table R 1.3.1 Situation of Inundation in the 2005 Flood

No.	Kishlak	Jmoat	Initial Time	Duration	Inundation Depth [1)](m)
1	Metintugay	Turdiev	23 June about 21:00 pm	About 3 weeks	0.5 – 1.0
2	Sovetobot	Turdiev	Not flooded	Not flooded	Not flooded
3	Safedob	Kalinin	23 June at night	2-3 weeks	0.5 – 1.0
4	Kodara	Kalinin	23 June late at night	2-3 weeks	1.0 – 1.5 (3.0)
5	Anjirkon	Kalinin	23 June late at night	2-3 weeks	0.5
6	Fayzobod	Dashtigulo	23 June late at night	2-3 weeks	0.5 – 1.0 (6.0)
7	Tagnob	Dashtigulo	23 June at night	2-3 weeks	About 0.5
8	West of Fayzobod	Dashtigulo	23 June at night	3 month	3.0 – 5.0
9	Fishpond	Panjob	-	-	About 1.0

1): ( ) means water depth at house floor constructed in middle of river bank

a) Flood Time and Location of Flood

According to WG, at 4:00 AM on 22 June 2005, about 45 m of the dike was broken and the breached length got wider although the MMWR and CoES tried to fill up the broken part with earth by using two bulldozers and prevent the expansion of damage by placing sandbags and gabions.

As shown in Fig. R 1.3.1, 2 km of the dike along the Pyanj River was washed out in the 2005 flood and flood flow headed towards inland along the former riverbed. Then the flood flowed down the Dehkonobod Canal to the Kizilsu River through the former river that was eroded and widened by the stream. At that time, the kishlaks and farmland along the former river suffered from flood damage in varying degrees.

There are eight (8) large kishlaks along the downstream of the former river, among which seven (7) kishlaks were damaged by the flood. In addition, the flood completely washed out the viticetum that spread in and around the former river behind the dike of Pyanj River, resulting in the change of viticetum into wasteland where only the roots of grapes can be seen on the sandy area like as of May 2005. Fig. R 1.3.1 indicate the kishlaks and farmland damaged by the flood.

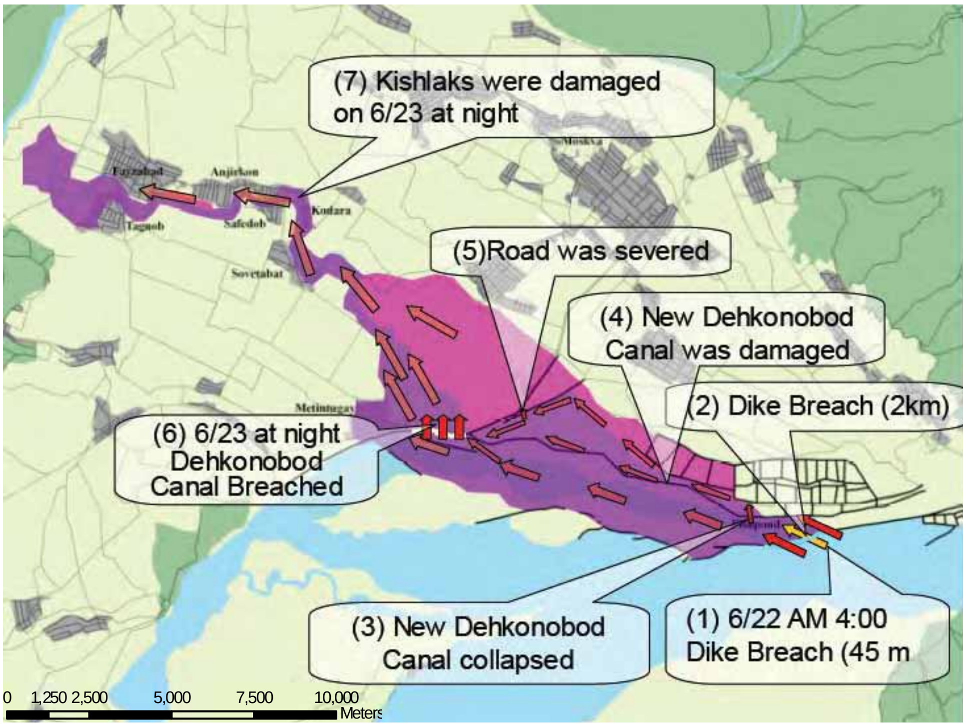


Fig. R 1.3.1 Flood Time and Location of Flood

b) Initial Time of Inundation

Based on the interview with the kishlak residents who suffered damage from the 2005 flood, it was likely that the inundation along the river course began late at night on 23 June 2005. The information from kishlak residents and evacuees are summarized as follows:

- According to eyewitnesses of the 2005 flood, the flood water level at Metintugay kishlak rose up to about the ground level at around 21:00 PM on 23 June., The eyewitnesses then informed the other residents about the danger and they evacuated to the direction of Sayyod Hill.
- In Safedob kishlak, on the night of 23 June some people were yet able to cross the bridge between Safedob kishlak and Kodara kishlak to evacuate to a safer area east of Kodara kishlak, but the next day the bridge became impassable because the approach road towards it was washed out and it was also impossible to cross the stream.
- On the night of 23 June, Jamoat and of CoES personnel gave Sovetobot kishlak residents an order to evacuate to Sayyod Hill, although the flood did not finally damage the kishlak.
- The riparian area of the former river at the Tagnob and Anjirkon kishlaks started

to be inundated late at night on 23 June and some of the few houses constructed along the lowland area of the former river in Anjirkon kishlak were completely washed out by the flood that eroded the bank of the former river by 5m to 15m in width.

- During the hazard map seminar, the residents of Kodara, Metintugay and Fayzobod explained that they started to evacuate at night on 23 June due to the rise of water level of the former river.

c) Inundation Depth and Flood Damage

The depth of floodwater from Pyanj River was up to about 10 m at the hinterland around the old disrupted dikes, while the depth of the downstream of the former river from Metintugay kishlak is inferred at between 3m and 7m at peak from the trace of floodwater level and residents' answers. The flood depth and damage around the former river is explained below. Incidentally, before the 2005 flood, there was no flow of spring water; however, spring water now flows down to the Kizilsu River.

i) Around Metintugay Kishlak

According to the Questionnaire and Interview survey, the inundation depth at Metintugay kishlak was between 0.5 m and 1.0 m but the flood damage was not so significant compared with the other kishlaks. There was no house washed out by the flood but the farmland was inundated at the depth of 0.5 m by the water that overflowed from the former river at the north and opposite side of Metintugay kishlak. The farmland west of this kishlak was inundated by infiltration water to a depth of about 0.3 m because of the high underground water table. The existing small dike with a height of 1.5 m constructed around Metintugay prevented the floodwater from spreading toward the west side of this kishlak.

ii) Between Metintugai and Sovetobot Kishlak

Between Metintugay and Sovetobot kishlak, farmlands spread at opposite sides of the former river. Based on information from a farmer, the farmland was inundated by 0.5 m of floodwater from the former river and part of it was damaged by riverbank erosion.

iii) Sovetobot Kishlak

This kishlak was not inundated during the 2005 flood, although the water level rose up to almost the ground level of the residential area at the north part of this kishlak.

iv) Safedob Kishlak

The Safedob kishlak is located opposite of the Kodara kishlak across the former river. In this kishlak, about ten (10) houses, a transformer station, road across the river and bridges were damaged in and along the former river although the kishlak was not inundated during the flood. The maximum depth of the former river was around 5.0 m. Some houses near the riverside were completely washed out by ground erosion. At the middle stretch of the river in this kishlak, the inhabitant's land was eroded by 15 m in width.

v) Around Kodara Kishlak

The floodwater overflowed from the former river to the residential area of this kishlak and the inundation depth was estimated at the range of 0.5 m to 1.5 m judging from the flood marks. About 17 houses were damaged and a few houses constructed at the riverbank were washed out completely. In addition, the road along the former river was partially washed away and farmlands in the lowland by the former river were also washed out completely.

vi) Around Anjirkon Kishlak

In this kishlak, the flood stream on the former river did not overflow to the main residential area. However, the bridges and road across/along the river were damaged and the southern part of this kishlak was inundated by spring water at a depth of about 0.5 m.

There is a farmland spreading at the opposite site of this kishlak. Soil erosion can be seen at that side of the riverbank, but no eyewitness or information regarding inundation was available.

vii) Fayzobod Kishlak

The inundation depth was varied depending on the relationship between the ground level and the water level of the former river because of the topographic aspect. In this kishlak, some part of the riverbank has gentle slop and south part of ground level is close to that of former riverbed although the ground level of main resident's area of this kishlak is higher about 5-6 m than former riverbed.

Especially, at the west of Fayzobod the inundation depth was between 3.0 m and 5.0 m in the riparian area of the former river, which resulted in the submersion of various infrastructures such as factory, bus station, road, bridges and houses. In addition, a few houses situated at the low lying areas along the former river were washed out.

viii) Around Tagnob Kishlak

The eastern part of Tagnob kishlak was partially inundated at a depth of 0.5 m. The flood stream never overflowed to the land on the southern part of this kishlak. The bridge across the river to Fayzobod kishlak was washed out, and the long term inundation compelled fruit tree roots to rot out.

ix) Kishlak around Fishpond (Additional Survey)

This kishlak situates between the fishpond and New Dehkonobod Canal and the entire kishlak was flooded to a depth of about 1.0 m by floodwaters that broke and crossed over the New Dehkonobod Canal.

d) Inundation Duration

As for the inundation duration, most residents along the former river explained that the kishlaks were inundated for 2 to 3 weeks except for the eastern area of Fayzobod where the inundation continued for approximately 3 months in the 2005 flood.

The long period of inundation in the eastern area could be because: 1) the former river flows into the inner area surrounding by the road embankment, and 2) the former river was affected by backwater from the Kizilsu River.

1.3.3 Satellite Map Analysis for Flood Condition

1) Satellite Photographs for Flood Inundation Analysis

Using the remote sensing technique, flood inundation area maps of the 2005 flood and the land use map were prepared in this Study. For flood inundation analysis, the two kinds of satellite maps were prepared, namely; SPOT and ASTER. To cover the Hamadoni Alluvial Fan, two photographs are required and, fortunately, satellite images around the time of flood were obtained; whereas, the image just at the peak of flood was not stocked in the archived data set.

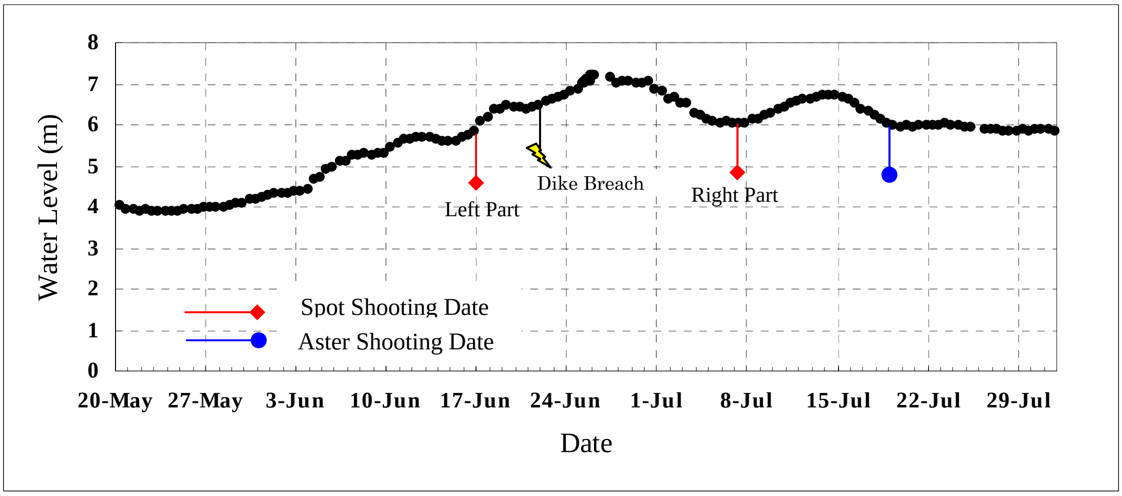


Fig. R 1.3.2 Shooting Date of Satellite Image during the 2005 Flood

a) SPOT

Two (2) SPOT photographs should have been taken on the same date, but due to the small coverage area of each photograph on the circuit course of satellite it was impossible to collect photographs on the same date. The collected sets consist of photographs of different dates; in particular, the set for the 2005 flood analysis is composed of photographs taken in 17 June for the left part and 07 July for the right part. The processed false color images of the 2005 flood are shown in Fig. 1.3.2 in the Appendix.

b) ASTER

ASTER photographs are also useful because same day shots can cover the whole Hamadoni Alluvial Fan of Pyanj River although their resolution is low compared with the SPOT. By using ASTER images, the flood inundation area along the former river as of 19 July 2005 could be traced. The processed false color images for the 2005 flood are also shown in Fig. 1.3.2 in the Appendix.

2) Flood Inundation Area

The satellite maps indicate the same inundation area as delineated using information from the field survey, although the condition of the agricultural area in Kalinin, Dashtigulo and Turdiev could not still be identified at the peak of the 2005 flood.

3) Duration of Inundation

The duration of inundation was figured out from the SPOT satellite maps showing that the duration excwwded at least one month inside the former river and around the inundation area situated to the east of Fayzobod.

1.3.4 Summary of Flooding Condition

In this section, the condition of 2005 flood is summarized based on the result of filed survey and satellite map analysis.

1) Delineation of Flood Inundation Area

Based on both surveys including the questionnaire survey (Subsection 1.3.2) and the satellite map analysis (Subsection 1.3.3), the inundation area of the 2005 flood has been delineated, as illustrated in Fig. R 1.3.1. The total inundation area has been estimated at about 3,900 ha, which almost corresponds to the value of the report from CoES.

2) Broken Part of Embankment

Based on the survey results, the part broken by the 2005 flood has been identified, as shown in Fig. R 1.8.3.

3) Process of Inundation

The flood had intruded and inundated from Pyanj River to the hinterland of Hamadoni, as explained in Table R 1.3.2.

Table R 1.3.2 Process of Inundation in the 2005 Flood

Date	Event
2006/6/22 AM 4:00	- Main bank was breached
↓ (about 2 day)	- Flood irrupted between the main dike and Dehkonobod canal - Flood flow washed out the river structure and military facilities
6/23 at night	- Dehkonobod canal was broken
↓ (less than half a day)	- Flood flow intruded into the former river - Infrastructure and agricultural area in and around former river were damaged
6/24 at morning	- Flood Flow reached at Fayzobod kishlak
↓ (about 2 or 3 weeks)	- Riparian area was inundated.
7/23	- Water level of Pyanj river decreased below the level at the beginning of dike breach
↓ (1 month)	- Part of floodwater remained around riparian area.
↓ (2 month)	- Some of people continued to stay at the evacuation area

4) Damage in the 2005 Flood

According to IMAC information, damages in the 2005 flood are summarized, as follows (Chapter 9 of the supporting report covers flood damage in Jamoat level in detail):

- 266 houses
- 3 facilities, including education, medical, social and cultural buildings
- 4.4 km of car roads
- 3 bridges
- 5.2 km of main dike along Pyanj River
- 7.1 km of canals (mainly Dehkonobod Canal) and lodgments
- Total damage was 7 million US dollars.

1.4 FLOOD HAZARD MAP WORKSHOP

1.4.1 Objectives

In August 2006, the hazard map workshop involving three (3) kishlaks that received damaged by the 2005 flood in Hamadoni District was held. The objectives of this seminar were: 1) To strengthen resident's consciousness regarding the importance of preparedness against flood; 2) To expand resident's knowledge on threat from floods and flood phenomena; and 3) To collect several aspects of the 2005 flood for improving the flood hazard map to be developed in this study.

1.4.2 Methodology, Schedule and Procedure

1) Methodology

For the workshop to achieve its objective, the study team and WG introduced the PRA (Participatory Rural Appraisal) approach, which was theorized by Robert W. Chambers in the 1980’s. In the discussions using this approach, the participants (beneficiaries) were directed to implement the field survey and to solve problems by themselves, i.e., discovering problems about the local community and their daily life in grasping the present situation by visualizing the information which they have and share, for example, the calendar making with the kishlak map, the chronological table of the community and so on.

2) Schedule and Place

The schedule of the seminar held at the three (3) kishlaks is as described in Table 1.4.1. Members of study team and staffs from the participating organizations carried out the dialogue with the participant residents directly.

The places where this 3 - day workshop were held are indicated in the figure below.

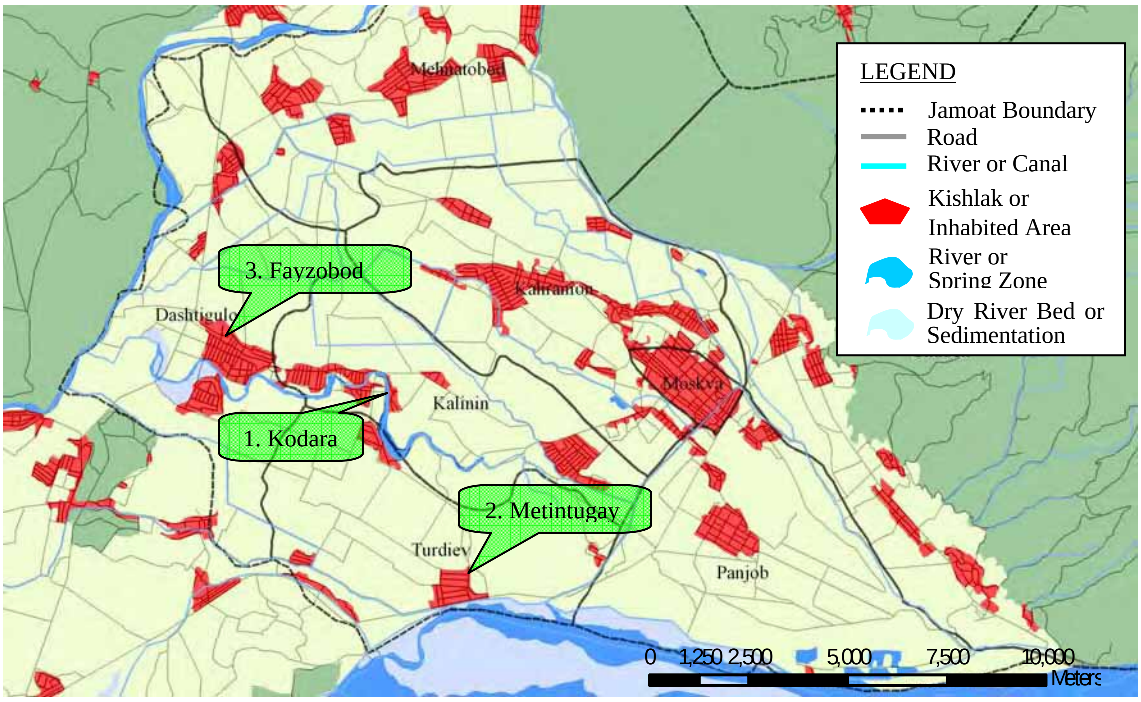


Fig. R 1.4.1 Places of Hazard Map Seminar

Table R 1.4.1 Schedule of Flood Hazard Map Seminar

No.	Place		Date and Time	Number of Participants	Participating Organizations
	Kishlak	Jamoat			
1	Kodara	Kalinin	01 August 2006, 10:00 - 14:00	54	WG (1), study team (3) Hukumad District Officer (1)
2	Metintugay	Turdiev	03 August 2006, 10:00 - 14:00	26	IMAC Staffs in CoES (2) Jamoat Officers (1), study team (4)
3	Fayzobod	Dashtigulo	05 August 2006, 10:00 - 14:00	49	Jamoat Officers (2), study team (3)

3) Procedure

In this Seminar, firstly, the facilitator had the flooding characteristic and mechanism in the Hamadoni Alluvial Fan including the situation of flooding in the 2005 flood presented. Secondly, through interview, the facilitator solicited information on the residents' consciousness about the flood damage and several aspects of the 2005 flood. Then, thirdly, based on the interview result, the facilitator guided the resident participants in the creation of a flood hazard map around their kishlak focusing mainly on the safety of resident constituents. Finally, the resident participants were made to explain the evacuation route and evacuation site as well as the dangerous points along the evacuation route.

Table R 1.4.2 Program of Flood Hazard Map Seminar

No.	Time	Item
1	10:00-10:10	Opening Speech
2	10:10-10:40	Presentation of the Study and the 2005 Flood
3	10:40-12:00	Interview with Residents
4	12:00-12:30	Break
5	12:30-14:00	Development of Flood Hazard Map

1.4.3 Result of Seminar

1) Constitution of Resident Participants

a) Kodara Kishlak

In this Kishlak, the number of resident participants was 50 people, 86% of which were females because most of the male population had emigrated to Russia in summer, 82% of which were farmers who engage in collective farming. If children and people who did not add their names to the attendance list were included, the number of resident participants was more than 65.

c) Metintugai Kishlak

In this Kishlak, the number of resident participants was 22 people, 55% of which were males and 45%, females. Half of them were farmers engaged in collective farming and the others were teachers, students, pensioners and so on.

d) Fayzobod Kishlak

In this Kishlak, the number of resident participants was 36 people with even number of males and females. One third of them were collective farmers and the others were classified into pupils, teachers, engineers, Jamoat staff and so on. If children and people who did not add their names to the attendance list were included, the number of resident participants was more than 45.

2) Information from Interview with Participants

a) Kodara Kishlak

According to the interview with residents, the 2004 and 2005 floods are remembered as remarkable floods, and some small scale floods occurred by the filtration of water between May and June. Depending on the ground surface elevation the inundation depth of the 2005 flood varied from 0.5 to 2.5 meters. As to the flood of 2004, the flood damage was not so significant.

The kishlak residents started to evacuate late at night on 23 June 2005 with the chief of kishlak and Jamoat officers as leaders. A large portion of the evacuees headed for the concrete factory at the center of Rayon, while the others went to the school, cotton field and tents near the kishlak. After evacuation, the flood flow damaged most houses in this kishlak, including 14 houses that were washed out completely.

The participant resident request the compensation for some damaged houses and rehabilitation of community facility.

e) Metintugai Kishlak

According to the interview with residents, only the 2005 flood is remembered as a remarkable flood as with the other two kishlaks. At that time, the overflow from the Pyanj River inundated almost the whole kishlak with flooding varying in depth from 0.5 to 1.0 meters.

The Minister of CoES had its personnel cut the road to try to change the flood flow direction with the aim of preventing the flow from overflowing to the Metintugai kishlak. When the flood was about to overflow to the kishlak site, however, some of the personnel observing the water level of Pyanj River and mounting sandbags on the riverside alerted the residents to evacuate on foot or on cars like trucks and tractors to the Sayed Kishlak at around 21:00 PM on 23 June 2005 with the chief of kishlak and Jamoat officers as leaders.

The chief of kishlak are requested the warning system for flood (siren or loudspeaker) in this kishlak when the CoES stuffs was explained their conception for Hazard Map to participant resident.

f) Fayzobod Kishlak

Only the 2005 flood is remembered as a remarkable flood as with the other two kishlaks. At that flood, the water level and water velocity of the former river along the kishlak increased although the former river normally had only reserved filtrated water from underground and had no flow before the 2005 flood. The flood damaged and washed out houses and communal facilities near the riverbank. The inundation depth varied from 0.5 to 6.0 meters.

The kishlak residents started to evacuate late at night on 23 June 2006 with the chief of kishlak and Jamoat officers as leaders. Some 80% of participant residents evacuated to the Sayyod Hill, school and hospital and almost all of the rest moved to a safer part of the kishlak where houses were constructed for the resettlement of evacuees after the flood.

The flood washed out 12 to 13 houses and the road, and damaged a few factory buildings, but there was no casualty on human lives. The residents were lucky to have successfully brought their belongings including livestock during the evacuation because of their own observation and quick judgment.

Fig. R 1.4.2 Scene of Hazard Map Seminar

3) Development of Flood Hazard Map

After giving a brief explanation of the study and the mechanism of the 2005 flood phenomena, the study team had the seminar participants practice the knowledge obtained from the workshop by having them construct a simple hazard map around their kishlaks.

Dividing the seminar participants into three (3) groups, the residents made three (3) flood hazard maps around their kishlak. In each map, the inundation area and depth, as well as the evacuation route, were described referring to the situation in the 2005 flood.

With the use of the flood hazard map, the seminar participants discussed the evacuation site, the safety route, and the probable flood inundation area and depth. As the result of discussion, the participants concluded that a flood hazard map is important for the mitigation of flood damage.

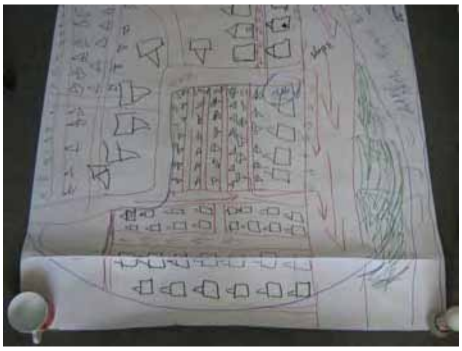


Fig. R 1.4.3 Some of Hazard Maps Elaborated by Participant Residents

1.5 EXISTING RIVER PLAN

In this section, the existing river plan is explained on the basis of information from Gyprowodkhoz and ADB reports. The design of structures to prevent flood of Pyanj River at Hamadoni Rayon was carried out by or through Gyprowodkhoz under MMWR.

1.5.1 Plan for Horizontal Arrangement of River Dike

After the 2005 flood, flood protection works at Hamadoni Rayon were carried out in accordance with the plan established for dike construction and rehabilitation by MMWR and CoES, as shown in Fig. 1.5.1 in the Appendix. A dike has already been constructed in all stretches, as well as the stretch outside the plan, as shown in Fig. 1.5.2.

CoES and MMWR mentioned an idea about a river plan for further dike strengthening and rehabilitation at Stretches A and C and the construction of spur dike at appropriate intervals in all stretches. However, their budget is unsatisfactory to do these in a short time.

1.5.2 Plan for River Dike Crest Level

Dike height is determined in accordance with the table below that specifies hydraulic quantities in case the maximum flood flow occurs in Pyanj River. The longitudinal profile is elaborated in Fig. 1.5.2 by using the dike crest level described in the cross sectional figure drawn by Gyprowodkhoz.

Table R 1.5.1 Hydraulic Quantities for Design

Stretch	Discharge (m^3/s)	Water Depth (m)	Slope
I	5,245	3.80	0.00350
II	5,245	3.18	0.00272
III	5,245	3.13	0.00347

Source: Gyprowodkhoz, As to the stretch I, II and III, refer to Fig 1.5.1

As shown in Fig. 1.5.2, the crest level does not have a straight profile or a certain slope. This was discovered when the engineer of Gyprowodkhoz determined the crest level by considering river depth from the present ground level in each place.

Actually, information on height of dike crest is scant for researching longitudinal profiles of dike, because of the following:

(1) Ground control point is different among drawings of several protection works;

(2) Lack of plan figure of present condition corresponding to the cross sectional drawings; and

(3) Person in charge cannot explain the drawings in a precise manner.

1.5.3 Probability of Design Flood

Gyprowodkhoz calculated the dike crest level by considering the scale of 100-year return period. However, they declined to give the reason for adopting that design scale in the Pyanj River.

Incidentally, the classification of structures and flood probability to be used for hydraulic structures are fully defined in SNIP 2.06.01 86. The flood probabilities required for the different design classifications of hydraulic structures are as shown in Table R 1.5.2. Class I refers to large structures defending sensitive areas, down to Class IV referring to small structures defending insensitive areas.

Table R 1.5.2 Design Flood Probabilities for Hydraulic Structures

Item	Design Flood Probability as Percentage and Return Period			
	Class I	Class II	Class III	Class IV
Main Design	0.1 (1000 year)	1.0 (100 Year)	3.0 (33 Year)	5.0 (20 year)
Design Check	0.01 (10,000 year)	0.1 (1000 year)	0.5 (500 year)	1.0 (100 year)

Source: SNIP 2.06.01-86 Hydraulic Structures – Basic Clauses/Provisions for Design

1.5.4 SNIPs

Gyprowodkhoz informed the study team that hydraulic designs for river structures conform to the "Construction Standard and Rules" (hereinafter called SNIPs), which were used by the Soviet Union as design and construction standards from the 1980's to early 1990's. Among the normative SNIPs documents, the main SNIPs for hydraulic design are listed in Table R1.5.3.

Table R 1.5.3 List of SNIPs for Hydraulic Design

SNIP Number	Titles
SNIP 2.01.15-90	The Engineer Protection of the Buildings and Structures from Dangerous Geological Processes; The basic Clauses/Provisions for Design
SNIP 2.01.14-83	Determination of the Calculated Hydraulics Specifications
SNIP 2.06.01-86	Hydraulic Structures, Basic Clauses/Provisions for Design
SNIP 2.02.02-85	Foundation of Hydraulic Structures
SNIP 12.?.04-82	Pressure and Influence of Hydraulic Structures
SNIP 11.7-81	Construction in Seismic Zone/Rayons, Standards for Design
SNIP 2.06.08-87	Concrete and Reinforced Concrete Construction of Hydraulic Structures
SNIP 2.06.05-84	Dam Construction Using Earthfill

Reference: TA No. 3495-TAJ Final Report: Strategy for Improved Flood Management

1.5.5 Budget for Flood Protection Works

Since 2003, the Coordination Center under CoES has been managing the budget for the construction of 340 facilities such as dike, bridge, road and buildings. According to the Coordination Center, the local budget for flood protection works in Hamadoni between 2003 and 2006 was 14 million Tjs, which is about 50% of the budget of 29 million Tjs during the recent 4 years for construction works in Tajikistan. The Coordination Center also said that there are two significant problems: 1) The budget is too small to complete dike construction (they insist 8 million Tjs is necessary for dike construction and rehabilitation in Hamadoni every year); and 2) Commencing time of construction cannot fully adjust to the dry period because distribution of the budget starts from March while the dry period is between November and April.

Information was also obtained that, in 2005, MMWR executed rehabilitation of damaged dike and construction of dike and spur dike at about 4.5 km along the Pyanj River, which were subsidized from a part of the ADB loan amounting to 7 million US dollars.

A broad description of the allocation of budget for emergency flood protection works at Hamadoni Rayon after the 2005 Flood is presented in Fig. R 1.5.1.

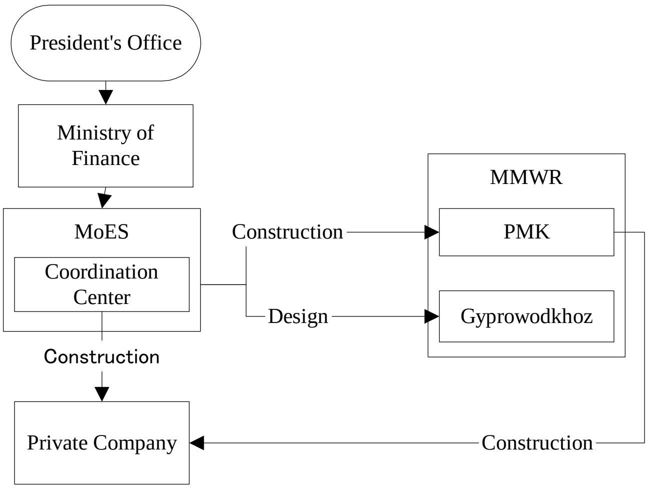


Fig. R 1.5.1 Flow of Budget Allocation for Flood Protection Works (Emergency)

1.5.6 Plan of Construction of Hydroelectric Dam

According to the Ministry of Energy, eight (8) hydroelectric dams construction plans in Pyanj River upstream from Chubek have been suspended.

1.6 EXISTING HYDRAULIC STRUCTURES

In this section, present condition of hydraulic structures such as dike, spur dike, canal, weir and etc. are explained in study area although the information about these structures is poor. Incidentally, according to the ADB Report in 2002 (Reference 1), the existing structural flood protection measures in Tajikistan extend over 375 km. Out of that, about 18 km involve the Pyanj River from Chubek Head Works to Pyanj Rayon as of 2001(the structural flood protection measures include dike construction and channel improvement through bank strengthening).

1.6.1 Dike

1) Client of Dike Construction

After the 2005 flood, the existing main dike along Pyanj River in the study area was rehabilitated, strengthened and constructed by both CoES and MMWR. The Flood protection works were continued until the end of May 2006 in anticipation of 2006 floods.

Two ministries, the CoES and the MMWR, conducted construction of the main dike of Pyanj River in study area. Stretch A with the length of about 5.0 km was constructed and rehabilitated by CoES, while Stretch B with about 4.5 km and Stretch C with about 3.0 km were constructed and rehabilitated by MMWR.

As to funds for construction, Stretch B was constructed with Grant Aid funds from ADB and the other two stretches were constructed with local funds of the Republic of Tajikistan. Stretches A and B in Fig. 1.5.2 indicate the parts constructed by CoES and MMWR respectively.

At the downstream of Stretch C, the old dike, which was constructed in the 1980’s, is laid discretely.

2) Alignment of Dike

a) Horizontal Alignment

The alignment of the existing dike is shown in Fig. 1.5.1. It was measured using GPS (Ground Positioning System) in August 2006 and analyzed using satellite maps taken in 31 July 2006 by the study team, because of the lack of latest and correct information regarding the dike alignment due to the ongoing work mentioned above during this study.

The length of the existing main dike is about 12.1 km from Chubek Weir to the end of the dike and its alignment has two inflectional points to avoid water flow during the construction of dike and because a settlement with Afghanistan was not achieved for the construction of dike up to the Afghanistan side and beyond the line where the old dike existed.

The existing dikes are composed of three (3) portions; one is Intake Guide Dike (IGD); one is Spillway Guide Dike (SGD); and the other is Flood Protection Dike (FPD). IGD is designed to intake river water steadily, to protect the Chubek Intake from sediment and to work as river training for guiding the flood flow to keep away from the facilities. SGD is designed to secure a capacity of waterway for spilled water from the intake, and to work as river training like IGD does. FPD is designed to protect the irrigation canal and population and territory from floods with embankment protected by revetment works and spur-dikes (see Fig. R 1.6.1).

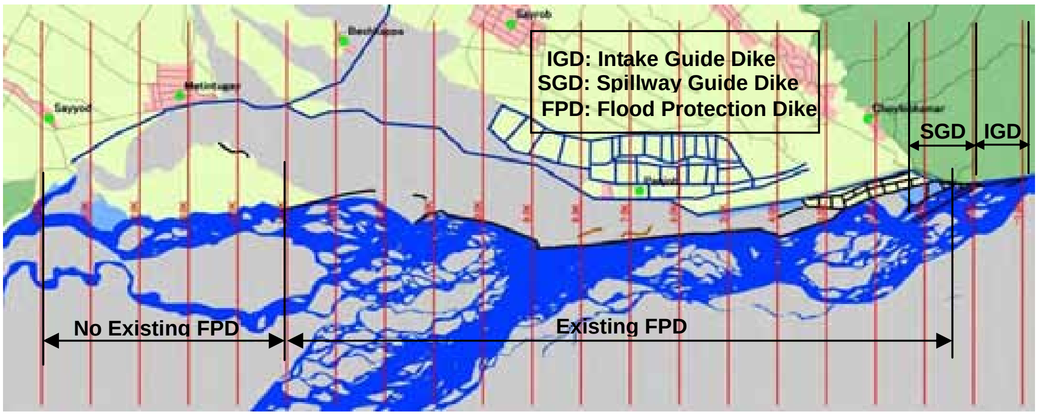


Fig. R 1.6.1 Cross-Section of Design Dike

b) Vertical Alignment

Vertical alignment of the dike and riverbed of Pyanj River as elaborated on the basis of cross sectional drawings for Pyanj River provided by Gyprowodkhoz is shown in Fig. 1.5.2. Unfortunately, however, the measuring range of almost cross sections was less than 500 m from the present dike and did not reach the country borderline.

As shown in Fig. 1.5.2, the slope of the main dike is not constant and, furthermore, the height of the existing dike is higher than the design dike crest level. These facts are probably due to the lack of coherent river channel planning. Indeed, during flood season in 2006, the heightening and strengthening of dike was carried out in the part damaged and threatened by flood on an ad hoc basis.

Besides, the captioned vertical alignment is not clear in respect of where is the ground control point. In this connection, the study team conducted the primary survey to examine the crest height of existing dike based on the ground control level at Chubek intake weir in which the ground control level is estimated at 436.37 m above mean sea level by Gyprowodkhoz. The result of this primary survey is presented in Fig. 1.9.3.

3) Dimension of Dike

The dimensions of the design dike for Stretch B are as shown in the figure below, but as to Stretches A and C, both design and present drawings are not available. The results of the field survey conducted by the study team show that some parts are smaller than the design dike scale in Stretches A and C.

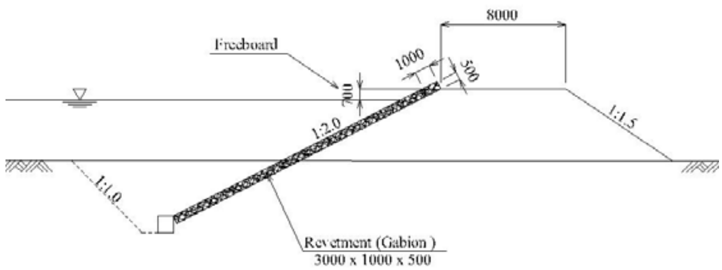


Fig. R 1.6.2 Cross-Section of Design Dike

Giprovodkhoz and WG said that the dimensions of dike conform to SNIPs, which defines nine (9) standard types of river embankment in Tajikistan, as shown Fig. 1.6.1. Judging from Fig. R 1.6.2, Type IV of embankment may be selected as the design dike type for the Pyanj River in the Hamadoni alluvial fan. For all rivers in Tajikistan, the freeboard of 0.7 m to 1.0 m is also defined in SNIPs.

1.6.2 Spur Dike

The study team conducted site survey on the existing spur dikes along Pyanj River at Hamadoni Rayon to investigate their effectiveness, and the results of the survey are as summed up below. In addition, the raw information from the survey; namely, damage of spur dike, accumulation of sediment at the downstream of spur dike, scouring depth at the toe portion of spur dike, dimension of spur dikes, interval of spur dikes, etc., was arranged by dike as shown in Table 1.7.1 in the Appendix.

1) Type of Spur Dike

Spur dikes that reduce flow velocity and encourage sedimentation around the main dikes are quite commonly used in rivers where the river course is wide and meandering and eroding the banks. The existing dike of Pyanj River is protected by a total of 38 spur dikes as of December 2005, and 18 of them are constructed along the main dike. The spur dikes are generally classified into two types; namely, Concrete Block Spur Dike and Round Head Spur Dike (made of soil embankment), as shown in Fig. R 1.6.3 and Fig. R 1.6.4.

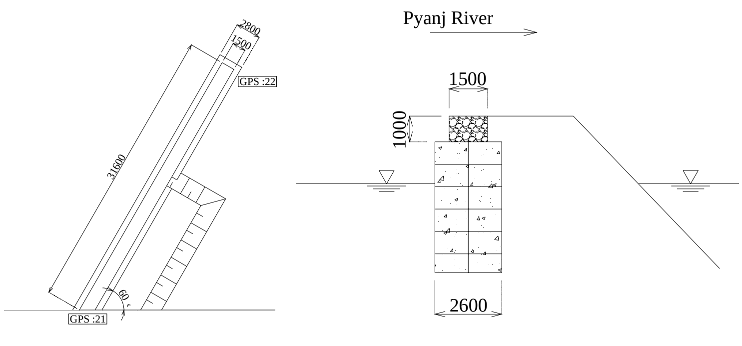


Fig. R 1.6.3 Photograph and Typical Design of Concrete Block Spur Dike

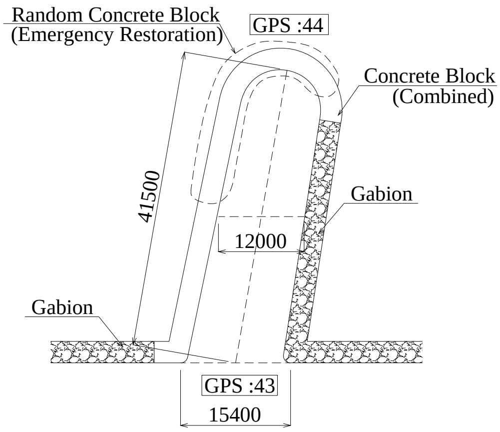


Fig. R 1.6.4 Photograph and Typical Design of Round Head Spur Dike

2) Allocation of Spur Dike

Along the main dike, a concrete block spur dike (hereinafter called CBS) is constructed in Stretch A, while a round head spur dike (hereinafter called RHS) is constructed in Stretch B. Both types of dike were designed in the Soviet era. The guide dike, spillway and canal of Chubek Weir are protected by 20 CBSs except for No. C10 that is similar to RHS and protected concrete blocks in front surface but not in back side of slope surface.

According to ADB report, the installation interval of spur dikes is determined by the length of spur dike, e.g., four or five times the length of dike in Tajikistan. The present dike is not arranged like that way because of insufficient budget and disturbance of the flood stream to protection works. Present allocation of all spur dikes are given in Fig R 1.6.6. The total number of spur dike is 38.

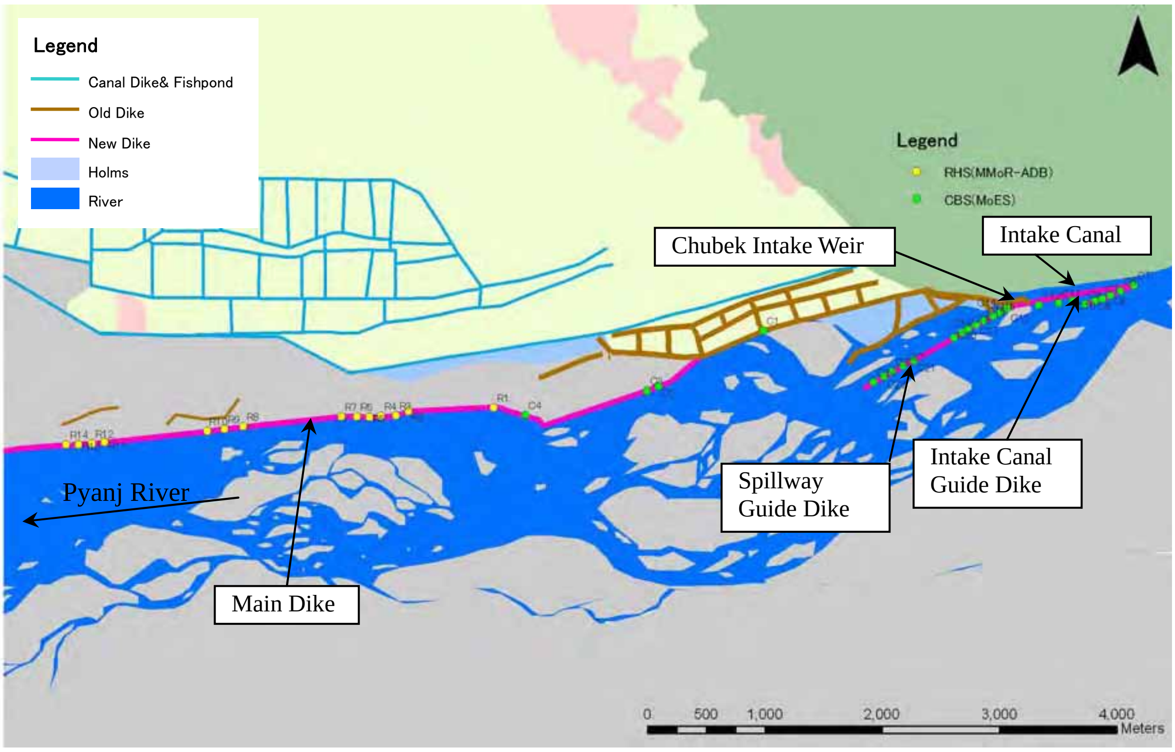


Fig. R 1.6.5 Allocation of All 38 Spur Dike

The allocation of spur dikes of the CBS type is illustrated in Fig. R 1.6.7. Among them, three (3) spur dikes are constructed in the Main Dike, eight (8) spur dikes are in the Intake Canal Guide Dike and the other 13 are along the Spillway Guide Dike.

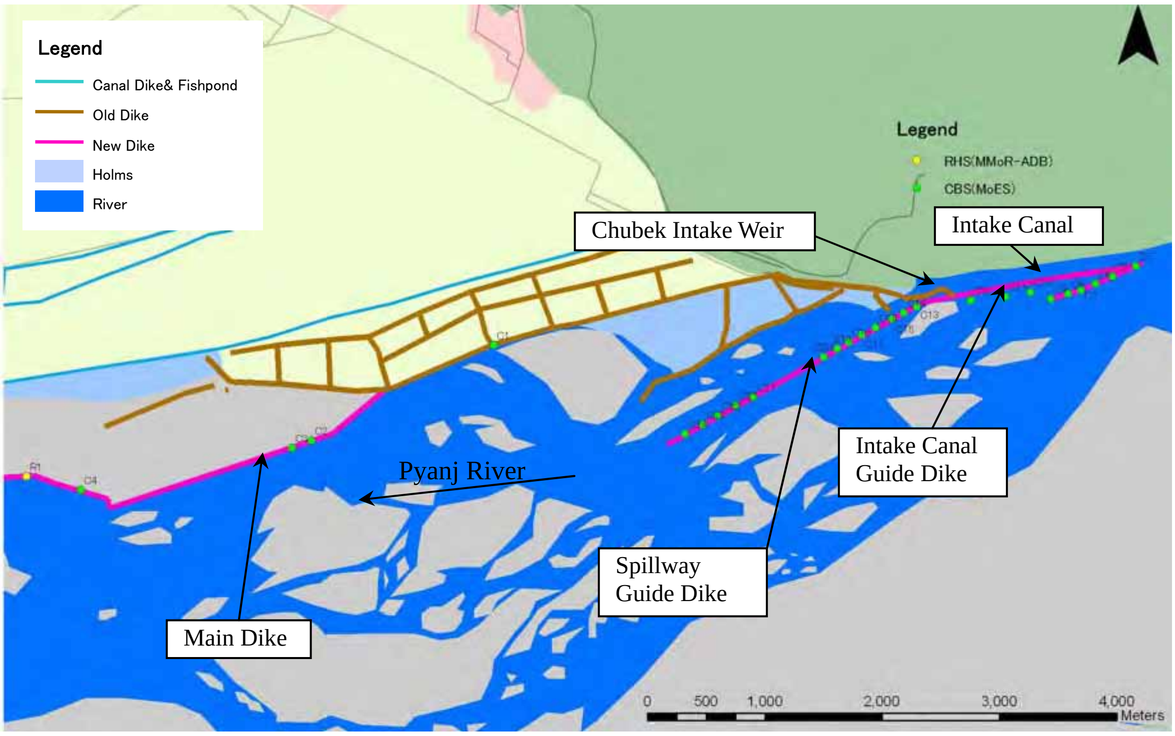


Fig. R 1.6.6 Allocation of CBS Type of 14 Spur Dikes

A total of 24 RHS type spur dikes were constructed along the Main Dike through a loan from the ADB after 2005. The allocation of RHS is illustrated in Fig. R 1.6.8.

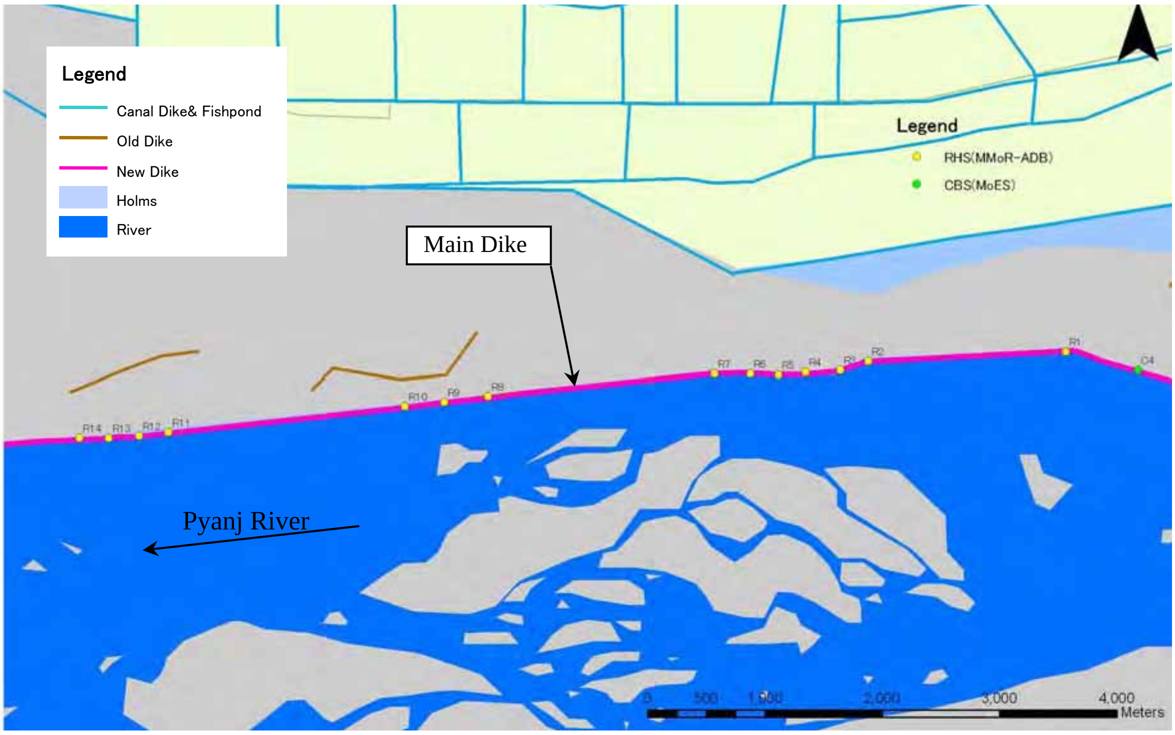


Fig. R 1.6.7 Allocation of RHS Type of 24 Spur Dikes

3) Dimension of Spur Dike

Length and width of spur dikes was measured in field survey and summarized the result in Table R 1.6.1 and Table R 1.6.2. The spur dikes are constructed along intake canal, intake canal guide dike, spillway guide dike and main dike to protect them.

Table R 1.6.1 Dimension of Spur Dikes (along Main Dike)

	No.	Type	Length (m)	Width (m)		Angle (degree)	Material of Revetment
				Joint	Middle		
Main Dike	C1	Concrete Block Spur Dike	29.9	2.1	-	40.7	Co
	C2	- ditto -	24.6	2.8	-	30.3	Co
	C3	- ditto -	26.4	2.6		29.9	Co
	C4	- ditto -	21.6	15	8.0	30.6	Co
	R1	Round Head Spur Dike	30.0	28.4	13.7	59.8	Co, Ga
	R2	- ditto -	48.0	42.8	15.0	50.1	Co, Ga
	R3	- ditto -	27.0	26.5	11.7	49.4	Co, Ga
	R4	- ditto -	27.4	24.5	11.4	50.1	Co, Ga
	R5	- ditto -	41.0	28.6	11.0	40.7	Co, Ga
	R6	- ditto -	42.0	18.0	8.5	55.0	Co, Ga
	R7	- ditto -	42.0	26.0	13.0	75.0	Co, Ga
	R8	- ditto -	42.0	21.0	12.0	50.0	Co, Ga
	R9	- ditto -	42.0	21.0	11.0	50.0	Co, Ga
	R10	- ditto -	45.0	21.0	10.0	50.2	Co, Ga
	R11	- ditto -	43.0	45.0	24.0	40.5	Co, Ga
	R12	- ditto -	45.0	44.0	19.0	40.4	Co
	R13	- ditto -	34.0	53.0	28.0	40.5	Co, Ga
	R14	- ditto -	48.0	46.0	25.0	60.5	Co, Ga

Co: Concrete Block, Ga: Gabion

Table R 1.6.2 Dimension of Spur Dikes (along Guide Dike)

	No.	Type	Length (m)	Width (m)	Angle (degree)	Material of Revetment
Intake Canal Guide Dike	CT	Protection Works	48.0	-	10	Co
	C5	Concrete Block Spur Dike	20.0	2.7	25	Co
	C6	- ditto -	30.0	2.6	20	Co
	C7	- ditto -	20.0	2.5	40.6	Co
	C8	- ditto -	20.3	2.7	30.4	Co
	C9	- ditto -	20.0	2.6	40.0	Co
	C10	- ditto -	20.0	2.6	48.2	Co
	C11	Round Head Spur Dike	110.0	20.0	50.3	Co
	C12	Concrete Block Spur Dike	48.0	3.0	30.0	Co
Spill Way Guide Dike	C13	- ditto -	10.0	2.0	20.1	Co
	C14	- ditto -	10.0	2.0	40.2	Co
	C15	- ditto -	15.0	2.0	15.0	Co
	C16	- ditto -	15.0	2.0	36.0	Co
	C17	- ditto -	20.0	2.0	28.0	Co
	C18	- ditto -	20.7	2.0	24.0	Co
	C19	- ditto -	21.0	2.7	24.0	Co
	C20	- ditto -	15.0	2.7	30.0	Co
	C21	- ditto -	25.0	2.9	26.0	Co
	C22	- ditto -	15.0	1.9	30.0	Co
	C23	- ditto -	20.0	2.9	34.0	Co
	C24	- ditto -	20.0	2.9	40.0	Co

Co: Concrete Block, Ga: Gabion

4) Hydraulic Barrier by Spur Dike

Some parts of main dike were damaged in the flood season of 2006 although the spur dikes protected the main dike in the groin field where hydraulic barrier generated by spur dikes protect the main dike. Generally, the range of hydraulic barrier is deeply bound up with the length of spur dike. Thus, to confirm the range of hydraulic barrier, the relationship between the length of RHS and the distance from damaged portion of main dike to RHS is surveyed and presented as shown in Fig. R 1.6.9.

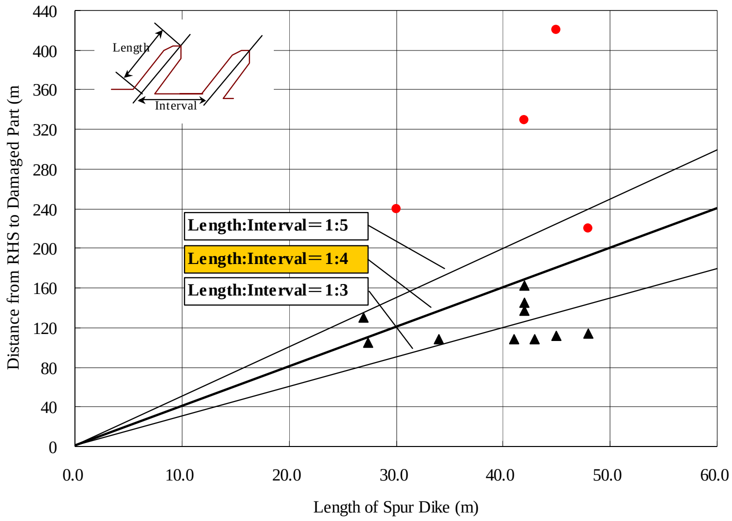


Fig. R 1.6.8 Result of Site Survey on Spur Dike Effect

The figure indicates that the present RHS can protect the downstream main dike in the range of four (4) times span of the RHS length at least. The red points show damaged portions and black triangle points show the distance from damaged portion to spur dike immediately upstream. The damaged portion in the main dike and the position of spur dike as of January 2007 is illustrated in Fig. 1.6.2 in the Appendix. In addition, the distance from the spur dikes to the damaged portions in the main dike is as summarized in Table 1.7.1 in the Appendix to this Chapter.

5) Damage of Spur Dikes and Formulation of Sedimentation

The result of survey is summed up in Table R 1.6.3. , which indicates that the sedimentations formed behind the spur dike become large as the length of that gets longer but the rate of damaged spur dike increase. As far as this survey result in target area, the spur dikes with the length of around forty (40) meters have been working for well protection of the main dikes without damage of spur dikes.

Table R 1.6.3 Damage of Spur Dike and Sedimentation Formed by Spur Dike

Length of spur dike	Damages at toe section	Damages in dike section inside groin field	Formation of sediment between spur dikes	Depth of scouring at the toe portions
Whole	Damaged 8 spur dikes among 14 (60 % damaged)	No Damages	12 super dikes among 14 formed sedimentation in front of the flood protection dikes. Condition of rest of 2 is unknown because they are still submerged at the time of research.	2.0m-2.6m (2 sample)
40m< L <50m	Damaged 6 among 10 (60% damaged)	No Damages	The lengths of sedimentation range 45m – 100m, and the widths do 12m – 34m	Submerged
30 m< L <40m	Damages 0 among 2 (0% damaged)	No Damages	The lengths range 50m – 65m, and the widths do 12m – 25m.	2.6m
L <30 m	Damaged 2 among 2 (100% damaged) These portions have strong flow collides.	No Damages	The lengths range 24m – 40m, and the widths are around 10m.	2.0m

L: Length of spur dike

1.6.3 Chubek Weir

The existing Chubek Weir whose main body was completed in 1963, and the spillway constructed in 1987, were designed and constructed by MMWR to divert water for irrigation at the average daily discharge of 120 m3/s (5 gates fully open) from the Pyanj River in the agricultural season. The maintenance of Chubek Weir is also carried out by MMWR.

The member concerned in the Committee of Water Resources for Middle Asia undertakes the gate control to meet the intake plan for irrigation water established by MMWR every year. This committee was established in 1993 with headquarters in the Republic of Kazakhstan and consists of four (4) member countries, namely; Uzbekistan, Turkmenistan, Kazakhstan and Tajikistan. Records of observation data (water level and discharge data) of intake water have been sent to this committee since 1993.

The horizontal conceptual plan of Chubek Weir is presented in Fig. R 1.6.6.

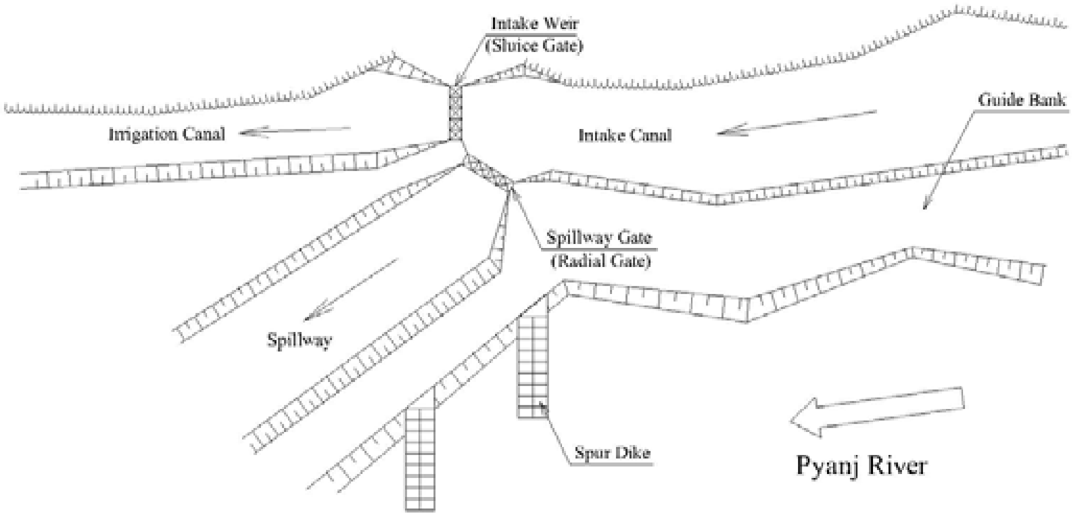


Fig. R 1.6.9 Horizontal Conceptual Plan of Chubek Weir

The Chubek Weir has five (5) sluice gates that limit the quantity of water to the Chubek main canal, and the redundant water pass through four (4) radial gates to the spillway. The location of Chubek Weir are shown in Fig. R 1.6.12. The size of sluice gate is 4 m by 6 m in width and height and the radial gate is 6m by 6m. According to the estimation by MMRW, the maximum flow capacities through the sluice gates and the radial gates are 120 m3/s and 700 m3/s respectively. Next figure show gates of Chubek Weir.

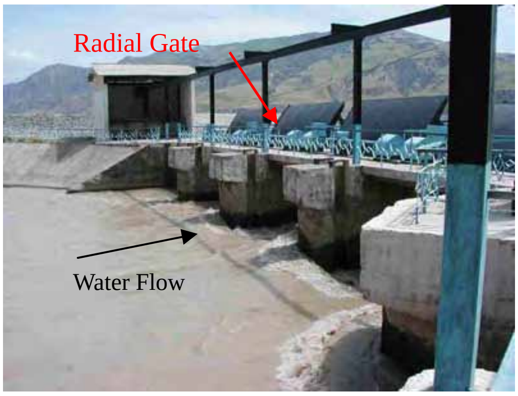


Fig. R 1.6.10 Photograph of Chubek Weir

1.6.4 Irrigation Canal Network

1) Canal Network

Based on the result of satellite map analysis, there are patently more than 400 canals and ditches with the total length of approximately 780 km in the alluvial fan in Hamadoni Rayon. Among them, the three major canals, namely, Chubek main canal, Dehkonobod canal and New Dehkonobod canal, play an important role in carrying irrigation water to the other Rayons.

The Dehkonobod canal and the New Dehkonobod canal have been diverted from the Chubek main canal that was constructed in the 1940's to convey water from the Pyanj River at an average of 120m3/s in the agricultural season. After the diversion to major and minor canals, the Chubek main canal flows north to the Kulob Rayon at 20 m3/s.

The Dehkonobod canal with the length of about 25 km (if including the Chubek main canal, the total length is about 40 km) was constructed in the 1940's from Chubek Weir to

Farkhor Rayon. Instead of widening the Dehkonobod canal, the New Dehkonobod canal was constructed in the 1950's to increase the amount of irrigation water to the Farkhor Rayon. Presently, these two major canals convey irrigation water to the Farkhor Rayon at 50m3/s after distributing water to the minor canals. The canal network is illustrated in Fig. R 1.6.12.

In the alluvial fan of Hamadoni Rayon, Kizilsu River serves as the outlet of the minor canals or ditches that draw water from the major canal or underground because, normally, the water level of the river is lower than the ground level even in the agricultural season.

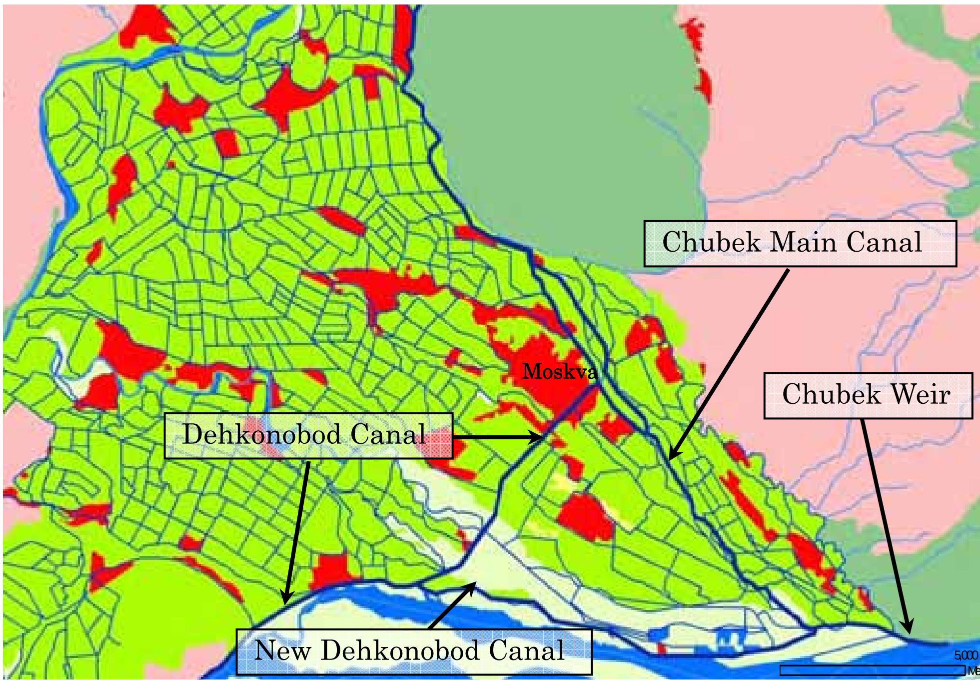


Fig. R 1.6.11 Canal Network in and around Hamadoni Rayon

2) Weirs

There are many numbers of weirs in the Dehkonobod canal and New Dehkonobod canal, which was designed by Gyprowodkhoz as shown in Fig R 1.6.13.

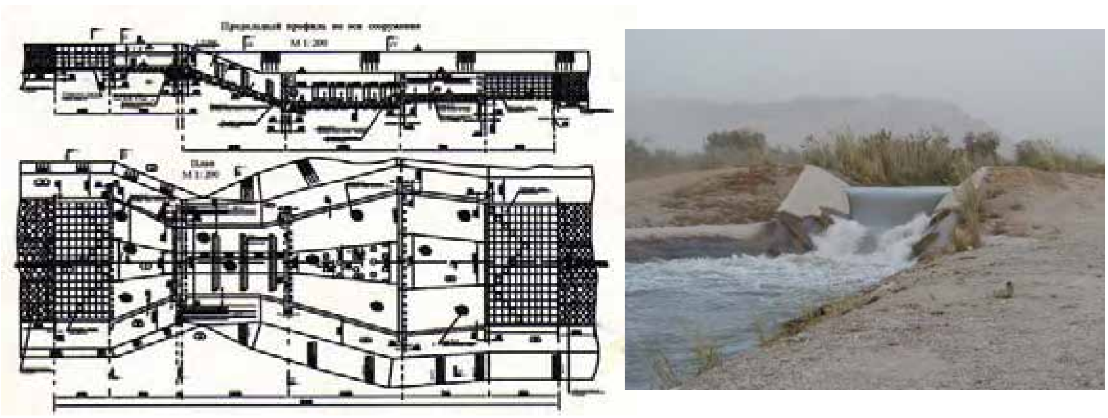


Fig. R 1.6.12 Weir in Dehkonobod and New Dehkonobod Canal

1.7 WATER USE

1.7.1 Water Allocation

According to one of WG, there are four (4) main intake points from Pyanj River and tributaries for the irrigation of Tajikistan farmlands, namely; Chubek intake (120m3/s from Pyanj River), Halqayor intake (60m3/s from Pyanj River), Big Vakhsh Canal (200m3/s from the Vaksh river), and Beshkent intake (100m3/s from the Kaferingan river).

The irrigation water for Hamadoni Rayon (16,000 ha) is supplied mostly from Chubek Weir through which irrigation water is also conveyed to Farkhor Rayon (24,000 ha), Vose Rayon (8,000 ha), and Kulob Rayon (4,000 ha). In addition, 500 thousand people utilize the water from Chubek Weir as drinking water.

In the MMWR, the water allocation plan is establish every year on a monthly basis considering the actual water use in the previous year. The plan and actual water allocation to Hamadoni Rayon is summarized for the last seven (7) years in the table below.

Table R 1.7.1 Water Allocation for Hamadoni Rayon (‘000m^3/year)

Year	Plan (1)	Actual water income (2)	% (2)/(1)
1999	176,917	187,124	106
2000	203,587	189,081	93
2001	151,800	189,600	125
2002	155,000	158,000	102
2003	155,511	160,790	103
2004	145,039	153,736	106
2005	127,210	129,820	104

Reference: MMWR

Water use has a tendency to decrease every year. One of WG explained that the decrease of water use is due to the imposition of water use charges from 1996, and MMRW has not been receiving 790,000 Tjs annually as the receivable account for water use from farmers.

The water allocation plan for all Rayons of Tajikistan is shown in Table 1.7.2 in the Appendix. According to the table, the amount of water use gradually decreased at Kulyab zone in Khatlon Oblast every year and that of Kurgan Tube zone also decreased until 2004. However, at the Kurgan Tube zone, the water use in 2005 suddenly increased by 1.5 times the quantity of water used in 2004, because of the political decision to develop 12,000 ha of farmland per year from 2005.

1.7.2 Condition of Water Supply System

According to CoES, due to the lack of financing, mechanical and electrical equipment of artesian wells, sluice of steel pipes, as well as the main lines, distributive network and locking regulating armatures are in dilapidated condition. The average percentage of deterioration is 70%. In addition, due to the corrosion of pipelines, water loss accounts for more than 60% and, it is premised that chlorination apparatus and instrumentation are in the same condition. Therefore, 19 settlements of Rayon with the total population of 12,496 people do not have a water supply system or are not provided with drinking water to meet the hygienic and existing ecological standards.

1.8 FLOOD INUNDATION ANALYSIS

The flood inundation analysis was carried out on several scales of flood, aiming mainly as follows:

(1) To define inundation area and depth to develop the flood hazard map
(2) To define the flood velocity and arrival time to develop the flood risk map
(3) To estimate the flood damage from result of hydraulic analysis and land-use

1.8.1 Methodology for Flood Inundation Analysis

To estimate the probable flood inundation area and reassess the hydraulic performance of existing and proposed structures, the extreme discharge transport during a single flood event is estimated using a two-dimensional variable flow model. The variable flow equation is also solved two dimensionally.

The entire study area is first divided into several square cells, called meshes, every one of which is given hydraulic attributes such as elevation and ground roughness. Then, the simulation is performed using also the hydrographs and overflow discharge from Pyanj River as the boundary conditions obtained for the Master Plan.

The simulation model for flood inundation analysis was established through model calibration, i.e., the numerical simulation model was elaborated through the trial and error process to adjust the condition to the past flood event.

1) Two Dimensional Variable Flow Model

Generally, in the variable flow simulation, the water depth is calculated by applying Euler's equation expressed in compressible fluid motion and the continuity equation for conservation of mass water, as follows:

Euler's Equation of Motion

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} = X - \frac{1}{\rho}\frac{\partial P}{\partial x}$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} = Y - \frac{1}{\rho}\frac{\partial P}{\partial y}$$

$$\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z} = Z - \frac{1}{\rho}\frac{\partial P}{\partial z}$$

Continuity Equation

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial z}{\partial z} = 0$$

where,
u, v, w : flow velocity of x,y,z direction
x, y, z : gravity of x,y,z direction
ρ : mass of fluid
P : pressure

The unknown quantities (u, v, w and P) can be thoroughly estimated using the above simultaneous equation. Normally, however, the numerical calculation as representative of the differential calculus is applied as a simple and quick method. Therefore, the basic differential equation derived from the above said equations is applied for the two-dimensional variable flow simulation, as follows.

Euler's Equation of Motion

$$\frac{\partial (Bh)}{\partial t} + \frac{\partial Q_x}{\partial x} + \frac{\partial Q_y}{\partial y} = 0$$

Continuity Equation

$$\frac{\partial u}{gA_x}\frac{\partial Q_x}{\partial t} - \frac{Q_x B_x}{gA_x^{\,2}}\frac{\partial H}{\partial t} + \frac{\partial H}{\partial x} + \frac{|Q_x|Q_x}{\left(\frac{1}{n}R_x^{2/3}A_x\right)^2} = 0$$

$$\frac{\partial u}{gA_y}\frac{\partial Q_y}{\partial t} - \frac{Q_y B_y}{gA_y^{\,2}}\frac{\partial H}{\partial t} + \frac{\partial H}{\partial y} + \frac{|Q_y|Q_y}{\left(\frac{1}{n}R_y^{2/3}A_y\right)^2} = 0$$

where,

Q_x, Q_y	:	Discharge of x, y direction
A_x, A_y	:	Cross sectional area of flow
B_x, B_y	:	Mesh width of x, y direction
R_x, R_y	:	Hydraulic radius
n	:	Manning's roughness coefficient
H	:	Water level
h	:	Water Depth

2) Target Area for Analysis

Flood Inundation Analysis is carried out at the flood plain of Hamadoni Rayon, which is delineated and squared off in Fig. R. 1.8.1.

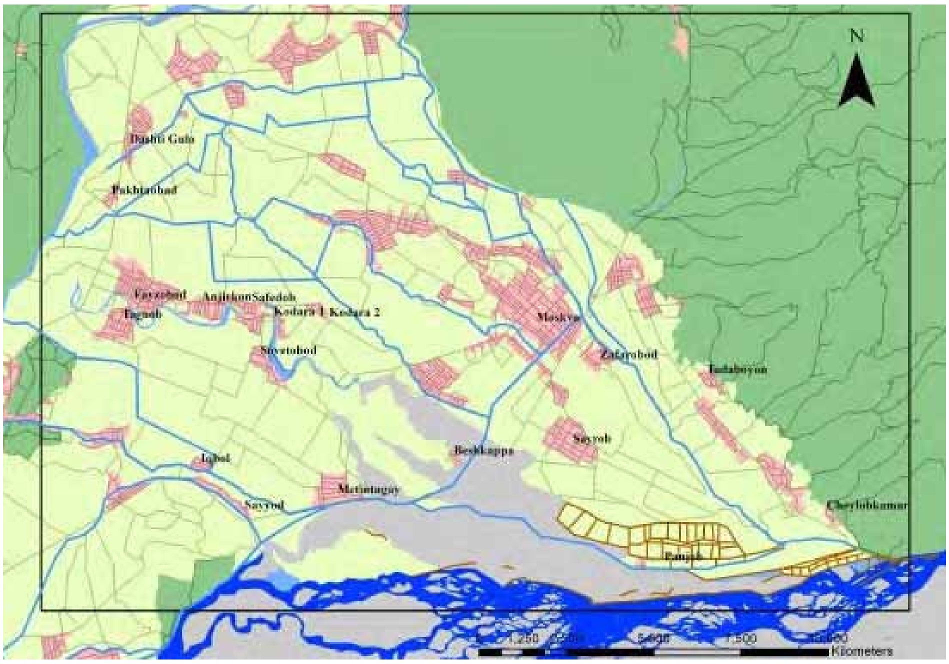


Fig. R 1.8.1 Boundary of Flood Inundation Simulations

3) Mesh Size for Simulation

In this two-dimensional variable flow model, the flood plain area of Hamadoni Rayon of 428.3 square kilometers (17.2 kilometers by 24.9 kilometers) is divided into 42,827 square cells with sides of 100m as shown Fig. R. 1.8.2.

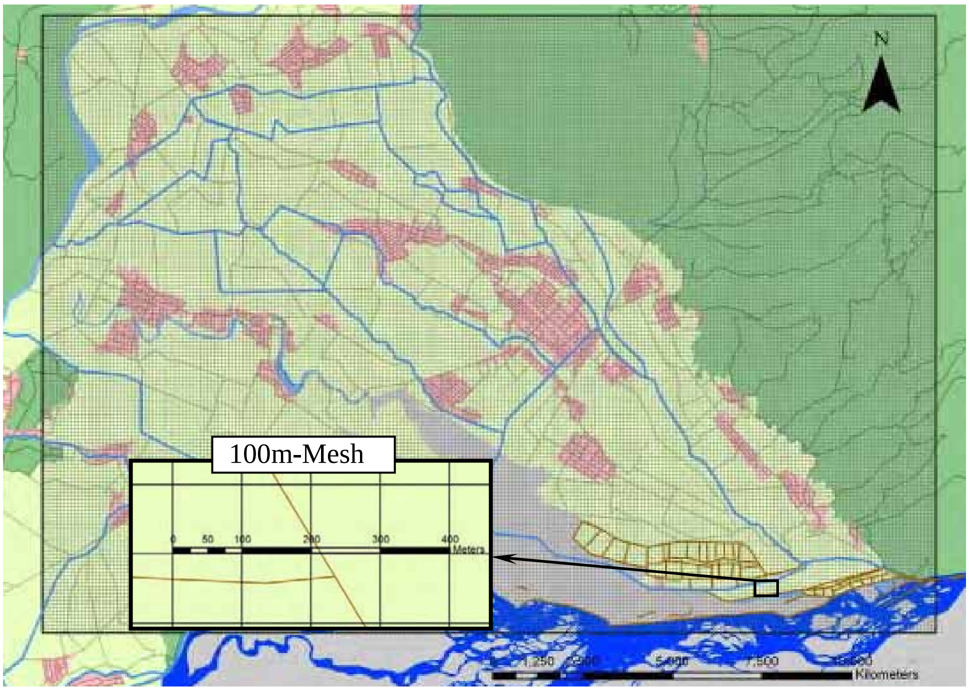


Fig. R 1.8.2 Flood Plain Divided into 42,827 Square Cells

Normally, the smaller mesh size is better to increase the accuracy of simulation results. Indeed, in Japan, the flood simulation is carried out considering the relation between mesh sizes and slope gradient of simulation area for keeping hydraulic accuracy. From that standpoint, 50m-mesh size is recommended in this area. However, if the 50m meshes are applied for the simulation in such a wide area, not only the accuracy of the simulation model but also the simulation time will increase very much. Additionally, in that case, the editing and arrangement of data including simulation results will be took a long time because of the large number of meshes, which will be over than 160 thousand. Therefore, the mesh size is decided through the model calibration in moderation. As a result of the model calibration (see Subsection 1.9.2), it be comes into clear that 100m meshes are applicable for the flood inundation analysis.

1.8.2 Elaboration for Flood Simulation Model

1) Boundary Condition

The hydrological and hydraulic analyses are still incomplete at the time of preparation of this report because of insufficient information as well as the difficulty of utilization of satellite DEM (Digital Elevation Map) that includes error with accuracy of 10 m. Thus, the result of inundation analysis will be included in the report for the next stage of this Study.

Condition.

g) Topographic Data and Roughness Coefficient

In this two-dimensional variable flow model the flood plain area of Hamadoni Rayon of 428.3 square kilometers (17.2 kilometers by 24.9 kilometers) is divided into 42,282 square cells with sides of 100m. Roughness coefficient and ground height are given into each cell.

The ground height is the average height of the interior of a cell obtained from the Digital Elevation Map established using the Satellite Map in 2003. The roughness coefficient for land use is given to each cell based on the standard authorized by the Public Works Research Institute in Japan, as presented in the table below.

Table R 1.8.1 Standard of Roughness Coefficient

No.	Land Use	Roughness Coefficient (n)
1	Paddy Field (n_1)	0.060
2	Road (n_2)	0.047
3	Others (n_3)	0.050
4	Housing Site (n_4)	$n_4^2 = n_o^2 + 0.020 \times \frac{\theta}{100-\theta} \times h^{\frac{4}{3}}$ where, θ : Rate of Occupied Area of Buildings θ h: Water Depth n_0: Integrated Roughness Coefficient $n_o^2 = \frac{n_1^2 A_1 + n_2^2 A_1 + n_3^2 A_3}{A_1 + A_2 + A_3}$ where, A_1, A_2, A_3 : Roughness Coefficient for Each Land Use

In addition, structures that hamper the smooth flow of inundation water such as road embankment, canal and dike are taken into consideration, assuming them as barriers between the cells.

h) Broken Part of Embankment on 2005 Flood

On 2005 flood, main dike, intake guide dike and spillway guide dike was partially washed. At that time, the main dike was breached at two parts as illustrated in Fig. R 1.8.3, which is defined by the comparison of two satellite images of the same part of main dike taken at different time. The part of broken embankment is set for the simulation in accordance with the fact of 2005 Flood.

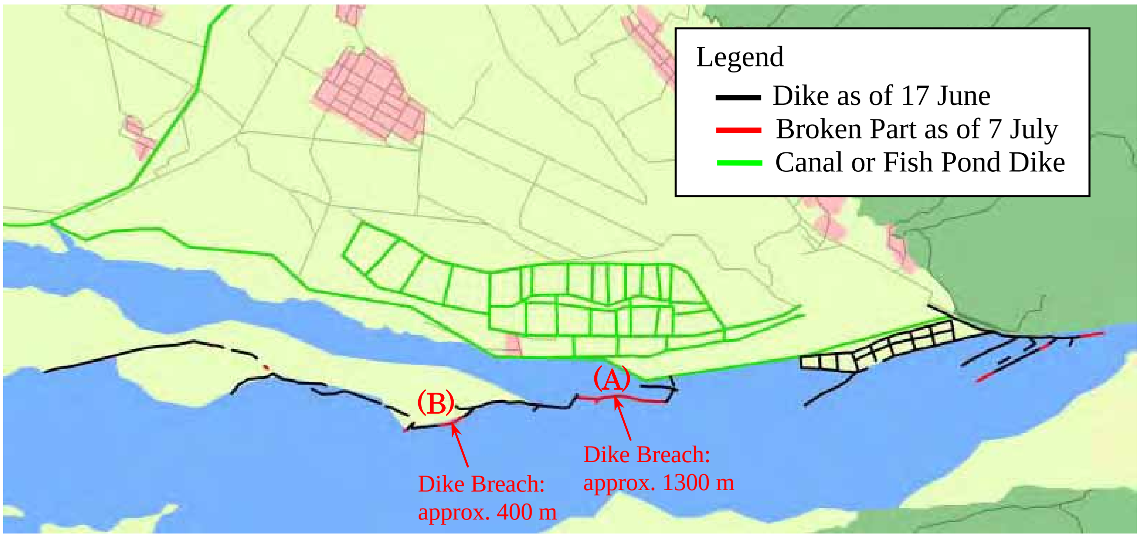


Fig. R 1.8.3 Broken Part of Embankment on 2005 Flood

2) Discharges Hydrograph for Pyanj River

i) Discharge Hydrograph at Chubek

The discharge in Hamadoni was calculated multiplying the daily average discharge in Khirmanjo observatory by the peak discharge ratio. The peak discharge ratio (1.124), which is the result of runoff simulation (see Chapter 2 of the supporting report) and which indicate the rate of discharge at Chubek on the basis of the discharge measured in Khirmanjo observatory, is used for setting the boundary condition of discharge in the Pyanj River at Hamadoni.

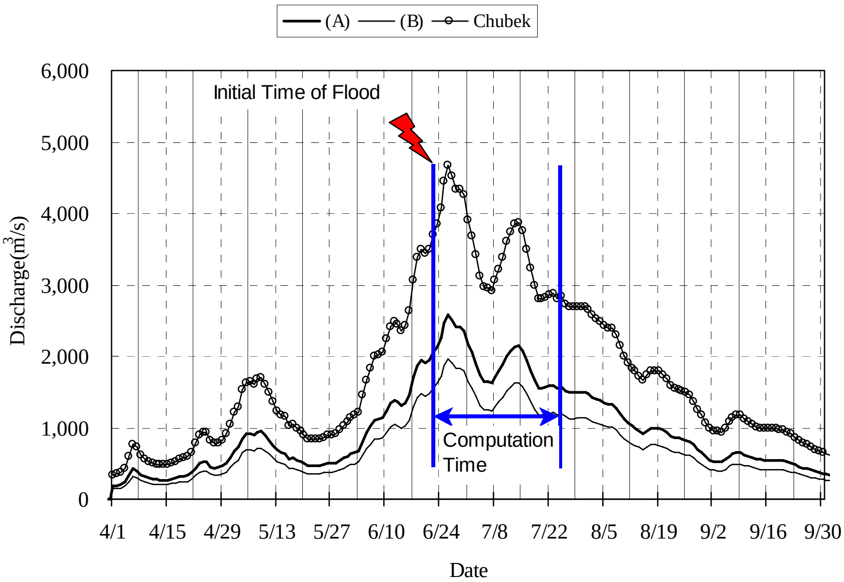
ii) Flood Duration for Simulation

The flood duration is fixed at one (1) month considering the result of the field survey described in Subsection 1.3.2 and the discharge hydrograph of the 2005 flood in Fig. R.1.8.4. Along the former river, the inundation duration is two (2), three (3) weeks. The discharge hydrograph in Fig. R 1.8.4 shows the twin peaks and depression under the initial discharge within one (1) month from the initial time of the 2005 flood.

iii) Discharge Hydrograph Considering Water Route Formulation by Holms

The flood flow along the main dike is divided into several flows by the holms to be headed for the Tajikistan and Afghanistan sides, as described in Chapter 2 of the supporting report. The flood discharge to the Hamadoni inland over the main dike should be estimated considering the amount of flow discharge in the water route at the Tajikistan side.

The water route discharge at the Tajikistan side was calculated by two dimensional flow distribution analysis as explained in Chapter 2 of the supporting report. The discharge hydrographs for water route at the dike broken parts (A portion and B portion in Fig. R 1.8.3) are calculated in accordance with the distribution rate at the same portions.



x

Fig. R 1.8.4 Discharge Hydrograph for Simulation

Incidentally, the distribution rate to Tajikistan side at A and B portions of the main dike are 0.555 and 0.421 respectively.

i) Overflow Discharge and Water Depth

The discharge through the overflow stretch is calculated by modified Honma's equation:

$$Q/Q_0 = (0.14 + 0.19 \times \log_{10}(1/I)) \times \cos(48 - 15 \times \log_{10}(1/I)) \quad \text{for I > 1/1580}$$

$$Q/Q_0 = 0.14 + 0.19 \times \log_{10}(1/I) \quad \text{for } 1/1{,}580 \geq I > 1/33{,}600$$

$$Q/Q_0 = 1 \quad \text{for } 1/33{,}600 \geq I$$

where,

$$Q_0 = 0.35 \times H_1 \sqrt{2gH_1} \times B \quad \text{(Honma's Equation)}$$

H_1 : water depth at breached point (m)
I : Slope of Riverbed
Cos(x):x is expressed in degree

Among of equations above, the equation for slope I>1/1,580 was selected to establish the inundation simulation model because of the characteristics of alluvial fan with 1/400 of the surface slope. The water depth (h_1) is given to the model from the result of simulation by the two-dimensional model, as described in Chapter 2 of the supporting report.

3) Model Calibration

Under the condition mentioned above, the flood inundation simulation was carried out. The result of simulation was presented in Fig. R 1.8.7 to R 1.8.9.

a) Inundation Area

The inundation area of the simulation is similar to the area of the 2005 flood, as described in Subsection 1.3.4, although the simulation result is a little larger than the present study result on the outline of the 2005 flood. The total inundation area is about 40 km^2 and the inundation area of inland area, which lies to the north of Dehkonobod canal, is about 30 km^2.

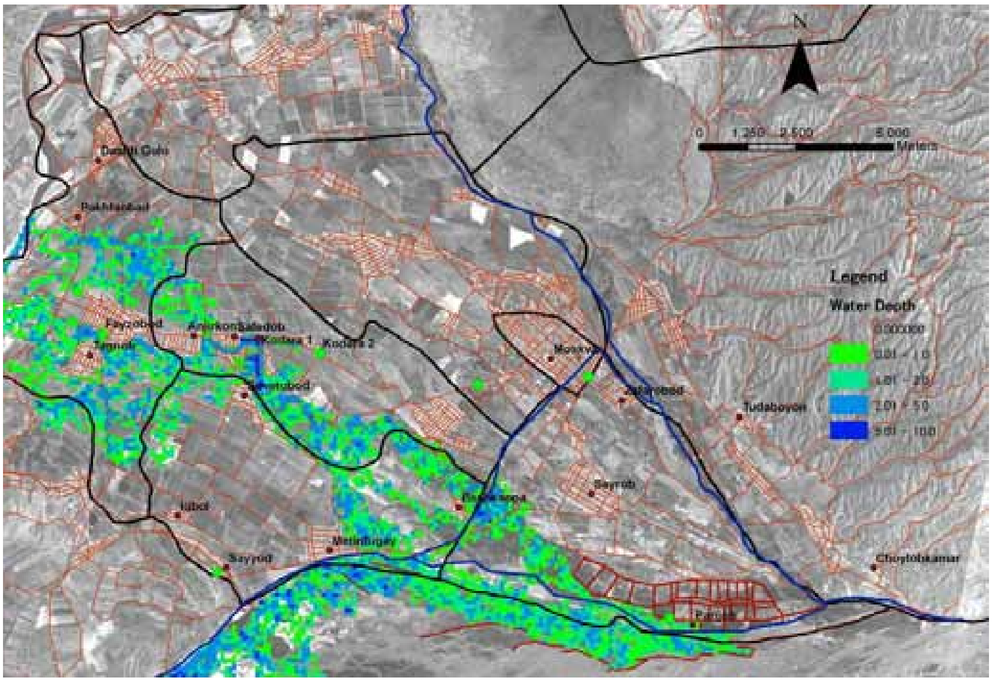


Fig. R 1.8.5 Simulation Result (Inundation Area)

b) Inundation Depth

Around the former river, the inundation depth of the simulation is more or less the same as the depth observed in the sight investigation of the flooding condition. The simulated depth of the former river is in the range of 2 to 5 m.

c) Flood Arrival Time

The flood arrival time from Metintugay to Fayzobod Kishlak is about six (6) hours, which is acceptable as compared with the result of field survey described in Subsection 1.3. According to the field survey, the dike of Dehkonobod was broken at 23 June at night and by the next morning the bridge around Kodara and Fayzobod kishlaks were broken.

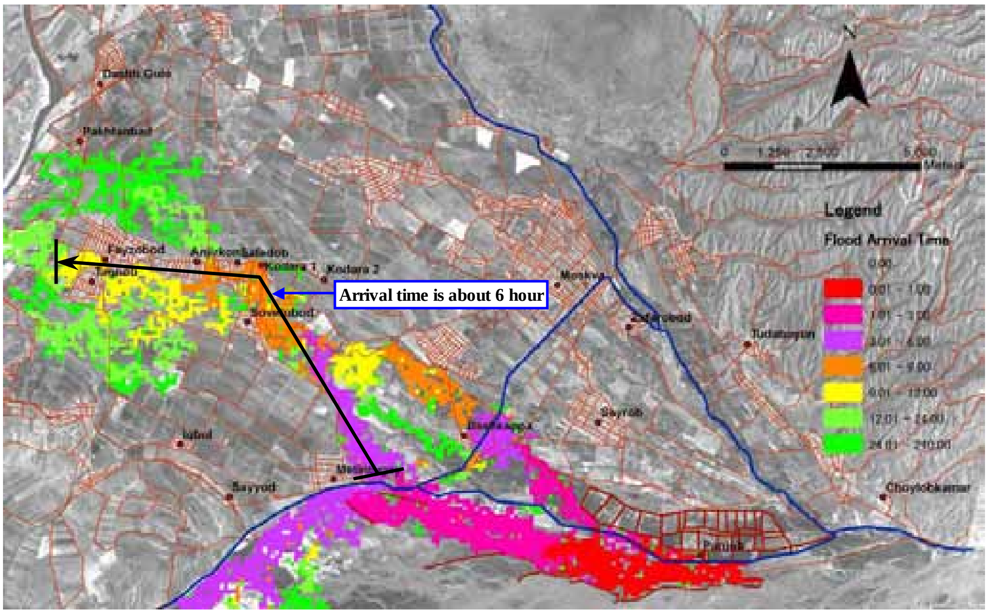


Fig. R 1.8.6 Simulation Result (Arrival Time of flood)

d) Velocity of Flood Flow

The flood flow velocity at a portion of the former river is 1.5 m/s on average and the velocity partially reached up to 6m/s. Fig. R.1.8.9 shows that the flow velocity from Metintugay to Sovetobot Kishlak is relatively smaller than that at the downstream from Sovetobot.

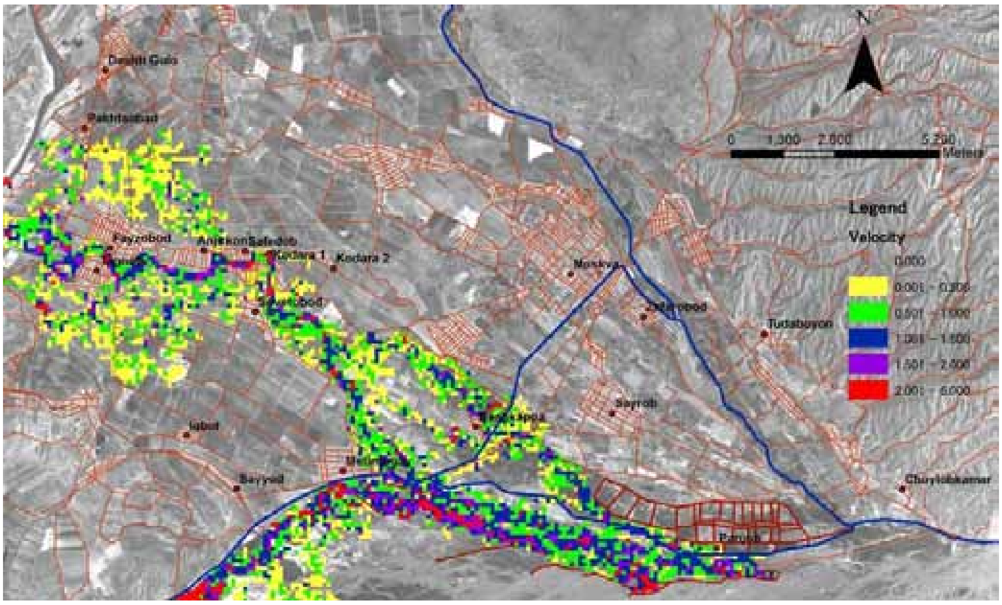


Fig. R 1.8.7 Simulation Result (Arrival Time of flood)

1.8.3 Simulation under Several Flood Scale

In this section, the simulation of flood inundation was executed under several flood probable discharges, as estimated in Chapter 2 of the supporting report.

1) Boundary Condition

The boundary condition was determined, as shown in Table R.1.8.2. In items a) to c), the way to reach the condition is explained.

Table R 1.8.2 Boundary Condition

Items	Calibration Result	Simulation for Probable Discharges
Topographic Data	Revised DEM of 2003 year	Same as the calibration
Roughness Coefficient	N = 0.060. 0.047, 0.050 (see 1.9.2)	Same as the calibration
Length of Dike Breach	1.5 km in accordance with 2005 flood	Totally 2 km [see item a] in this section]
Place of Dike Breach	Broken part in 2005 flood	Two places [see item b] in this section]
Discharge Hydrograph	Measured hydrograph in 2005 Flood	Enlarged hydrograph of 2005 flood by comparing probable discharge with the peak discharge in 2005 flood
Simulation Period	One month	Same as the calibration
Over Flow Discharge	Set by revised Honma's formula	Same as the calibration

2) Length of Dike Breach

The total length of dike breach is set as 2.0 km for the simulation. In Japanese flashy streams similar to Pyanj River, there is an empirical adequacy in the relationship between river width and dike breach length, as shown in Fig. R.1.8.10. The length was figured out using this relationship and, incidentally, the main dike of Pyanj River was broken for around 2.0 km and the river width was also about 2 km in the 2005 flood, which conforms to the empirical rule mentioned above.

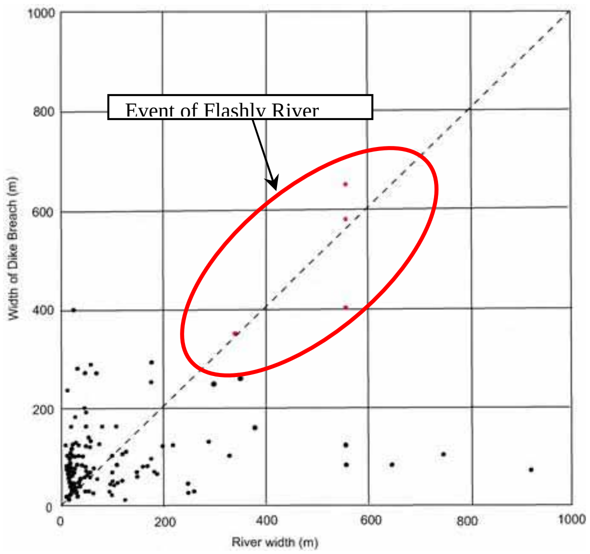


Fig. R 1.8.8 Empirical Adequacy between River Width and Dike Breach Length

3) Breach Point of Dike

a) Dynamic State of Flood Flow into Floodplain

As a result of sensibility study of the flood inundation model and the two dimensional hydraulic simulation model, the characteristics of flood flow were analyzed, as shown in Fig. 1.8.1 in the appendix and explained as follows:

- The floodwater is expected to flow into inland through the same course in the 2005 flood, as shown in Fig. 1.8.1 if any place of main dike between P(3.0) to P(11.0) is breached.
- The inundation area is considered to widely spread if the floodwater enters inland from top of the alluvial fan, as shown in Fig. 1.8.1. Incidentally, in the

2005 flood, the frontline among the threefold dikes upstream of the main dike from P (3.0) was partially washed out. There is a possibility that the threefold dike may be broken by a flood with the scale of over the 2005 flood, which was about 15 year return period.

b) Selected Portion

In consideration of the characteristics of flood dynamic state at the Hamadoni alluvial fan mentioned above, the broken parts for the simulation should be determined separately according to the scale of flood. Thus, in this simulation, dike breach portions were selected, as given in Table R 1.8.3.

Table R 1.8.3 Selected Breach Portion

Scale of Flood	Breach Portion	Total Length of Breach
Up to 15 Years Flood	(A) From P (5.0) km to P (6.5) km (B) From P (8.0) km to P (8.5) km	2.0 km
Over 15 Years Flood	(A) From P (5.0) km to P (6.5) km (B) From P (8.0) km to P (8.5) km (C) From P (1.0) km to P (1.5) km	2.5 km

For the breach potions of dike, a total of three (3) points were selected, as shown in the Fig. R.1.8.11. Among of these breach points, portions (A) and (B) were selected in consideration of the past damage of dike and weak points from the viewpoints of super elevationalal flow in the present condition. Portion (C) was selected on the assumption that a critical situation is brought by the scale of over the 2005 flood if the flood flow irrupts from top of the alluvial fan.

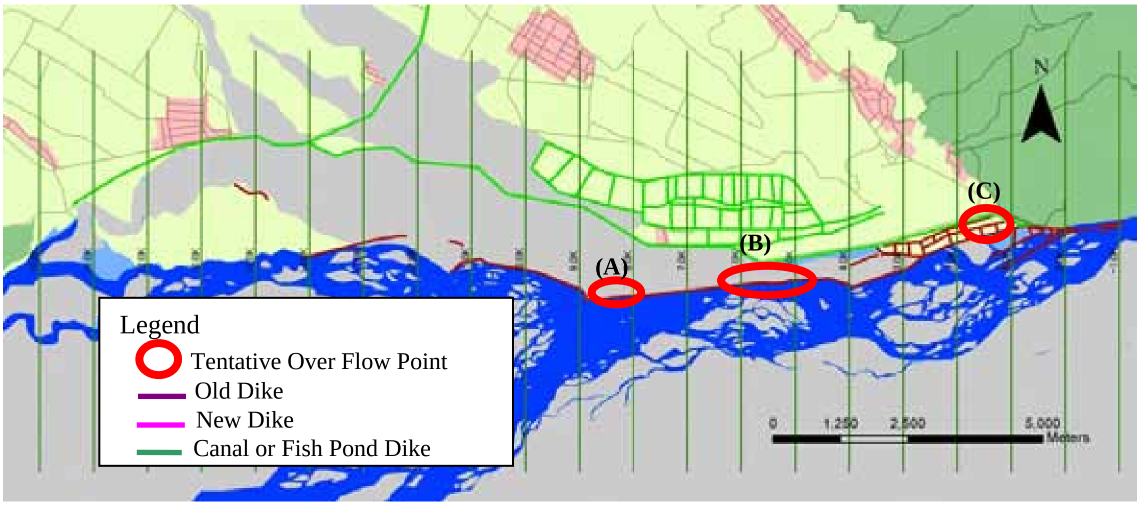


Fig. R 1.8.9 Dike Breach Point for Simulation

e) Expected Future Basin Condition

The Republic of Tajikistan has developed and maintained cotton farms and relevant industries as part of the national strategy. Therefore, considering the importance of cotton production, the study area is to be kept in the current condition.

4) Case of Simulation

Six (6) cases of simulation were carried out based on probable discharge, as summarized in Table R 1.8.4. The shape of hydrograph discharge in the 2005 flood was used to establish the design discharge hydrograph.

Table R 1.8.4 Selected Breach Portion

Case	Scale of Flood	Peak Discharge (m^3/s)	Extension Rate	Breach Portion
1	5 year flood	3,987	0.855	(A), (B)
2	10 year flood	4,440	0.951	(A), (B)
3	20 year flood	4,875	1.045	(A), (B), (C)
4	30 year flood	5,126	1.099	(A), (B), (C)
5	50 year flood	5,439	1.166	(A), (B), (C)
6	100 year flood	5,862	1.257	(A), (B), (C)

5) Simulation Result

The inundation area estimated by the simulation is summarized in Table R 1.8.5 and illustrated in Fig 1.8.2 in the Appendix.

Table R 1.8.5 Inundated area with Each Scale Flood

Flood Scale	Inundation Area (km^2)		
	Built-up Area	Agricultural Area	Total
5 year	0.53	26.22	26.74
10 year	0.55	27.99	28.54
20 year	1.75	77.61	79.36
30 year	1.80	78.21	80.02
50 year	2.01	79.85	81.86
100 year	2.10	82.16	84.26

Notice: Inundation Area do not include buffering area between Dehkonobod Canal and Present Dike

The inundation depth was summarized, as follows:

Table R 1.8.6 Inundation Areas according to Depth of Flood (m^2)

Inundation Depth (m)	Return Period (Year)					
	5-yr	10-yr	20-yr	30-yr	50-yr	100-yr
0.0 – 0.5	7.1	7.4	18.8	18.8	18.9	19.1
0.5 – 1.0	6.4	6.6	15.5	15.6	15.9	16.4
1.0 – 2.0	11.5	12.3	27.2	27.2	27.6	28.2
More than 2.0	12.3	13.2	29.7	30.3	31.4	32.5

Notice: Inundation Area include buffering area between Dehkonobod Canal and Present Dike

1.8.4 Flood Risk Map and Hazard Map

Based on the result of flood inundation analysis, the flood hazard and flood risk maps as prepared in this section make it inevitable to analyze and judge flood disasters. The definitions of these maps are given in Table R 1.8.7.

Table R 1.8.7 Definition of Maps

Kinds of Map		Contents	Applications
Flood Hazard Map		Inundation areas with recommended evacuation places and routes	In which areas are residents required to evacuate, knowing where they have to go.
Flood Risk Map	Flood Depth Map	Depth of flood	The residents know how much of danger on the flood together with velocity map, and influence to lives and the properties.
	Flood Arrival Time Map	Velocity of flooding flow	The residents know the extent of danger to lives on flood through the attached explanation on velocity-danger relation

	Flood Velocity Map	The time when the flood will arrive from the dike to the places after the dike broken.	The residents will know how of time they have for evacuation or taking the other actions.
	Hazard Rank Map	Rank of flood estimated on the basis of both flood depth and velocity.	The residents will know the scale of hazard to life and difficulty of evacuation from the condition of inundation.

1) Elaboration of Flood Hazard Map

The flood hazard map will serve a guide to facilitate the evacuation during flood occurrence. In the study area, the flood hazard map corresponding to the following two (2) patterns of dike breach were prepared in consideration of the flooding characteristics described in Section 1.10. The elaborated hazard map is presented in Fig. 1.8.3.

- Breach of main dike at downstream of P (2.5)
- Breach of main dike at upstream and downstream of P (2.5)

a) Evacuation Area and Lead-Time

The location of evacuation areas in the 2005 flood is described in Chapter 8 of the supporting report. These evacuation areas had performed very well at that time, but based on the flood inundation analysis, some of the evacuation areas may not be secure at the occurrence of larger scales of flood. Thus, the evacuation site should be set with due consideration on lead-time and flood arrival time. The lead-time is estimated at 4 to 5 hours in Chapter 2 of the supporting report.

b) Evacuation Speed

The walking speed for evacuation is set at 4 km per hour based on the Japanese empirical rule. This means that an evacuee can at least move 16 to 20 km before dike breach if the lead-time estimated above is considered

In addition, the flood arrival time is also considered as leeway to evacuate after breach of dike. The flood can reach the end of the former river in 6 hours (refer to Item 2, Flood Risk Map).

c) Evacuation Route

The evacuation route was selected under the following conditions:

- Basically, the main road should be selected considering the refugees traveling by car.
- The evacuation route was selected with the intention to guide the residents to the hill or mountain, assuming that; finally, the inundation area would spread covering the whole study area.

d) Other Information

On the assumption that the Lake Sarez would burst, the flood hazard map was prepared under "Lake Sarez Risk Mitigation Project, Disaster Management Plan" and published by Focus Humanitarian Assistance in July 2002. That hazard map is a rough sketch of flood hazard area and contains Hamadoni-wide information for evacuation as described in Chapter 8 of the supporting report.

Incidentally, the hazard map instruct residents to evacuate to the mountain or hills, namely, Urtabaz (Sayyod hill), Zoli Zar, Olimtoy, Khoja Mumin Mountail (Salt Mountain) and the other mountainous area. These mountains and hill is located as shown Fig. 1.8.3(2).

The hazard map by this study was elaborated considering the result of the project mentioned above, because the simulation result of a 100 year flood indicate that the inundation water cover almost all of the Hamadoni alluvial fan like the case of rupture of Lake Suarez.

2) Flood Risk Maps

A flood risk map will provide the residents living on the flood plain with information on the flood danger level of their own area, and it is expected to increase the resident's awareness on the necessity of evacuation.

a) Inundation Depth

The inundation map and flood velocity map for the two patterns with the scale of 100 year is presented in Fig.1.8.3 and Fig.1.8.4 respectively in the Appendix.

b) Flood Arrival Time

The flood arrival time from Dehkonobod canal to the end of the former river is estimated at about six (6) hour as shown in Fig 1.8.5 in the Appendix.

c) Flood Risk Rank

Flood Risk Rank is judged by using synergic effect between the inundation depth and flood velocity as illustrated in Fig. R.1.8.12. On the basis of empirical rule, the rank of risk is expressed red and green colored meshes as shown in Fig. 1.8.6 in the Appendix. The red meshes indicate that the area is situated at dangerous zone for residents to move on foot and the green one indicates the movement on foot is relatively possible.

According to Fig. 1.8.6, once flooding happen, it is difficult to evacuate on foot in floodwater. For the refugee in Hamadoni, it is substantially difficult and dangerous to move in flowing water on foot. This map would be noticed the difficulty and danger for moving under the flooding condition so that the evacuation well in advance of the start of flooding.

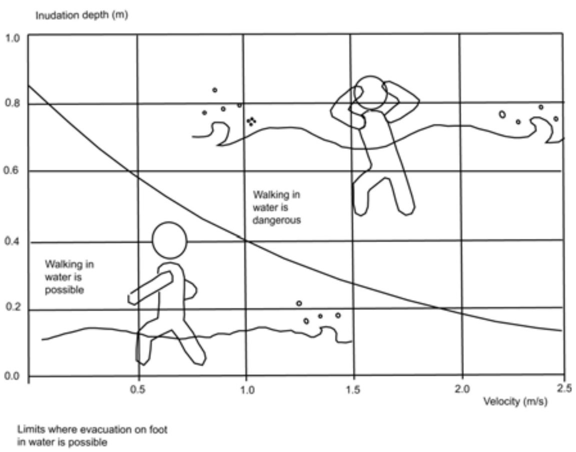


Fig. R 1.8.10 Degree of Flood Risk

1.9 RIVER IMPROVEMENT FOR MASTER PLAN

1.9.1 Definition of Bench Marks and Station Points

For convenience of reference for the position along the dike of Pyanj River, the study team defined the Bench Marks (BM) and Station Points (P), as given in Fig. 1.9.1 and Fig. 1.9.2 in the Appendix.

1) Station Point

The station points denote direct distances from the Chubek intake weir. According to the station point in Fig. 1.9.1, the Chubek intake weir is positioned at the station point of 0.0 km [abbreviated as P(0.0)], and the end of the dike is located at P(11.4). Incidentally, the distance from Chubek intake weir to Sayyod hill is 19.0 km based on the station point.

2) Bench Mark

The study team drove small wooden piles on the crest of the main dike from Chubek intake weir to the end of the present dike. The interval of BMs was about 500 m and based on the BM, the alignment of main dike was estimated to be 12.155 km.

1.9.2 Basic Condition of Master Plan for Structural Measure

In this study, appropriate project scales and target years for the Master Plan will be decided in consideration of economical and social aspects as well as the current flood control plan. Based on the general concept at present, the conditions proposed for the Master Plan Study are as summarized in the table below.

Table R 1.9.1 Basic Condition

Item	Condition
Target year	2015
Project scale	100 year return period

The above basic conditions are described as follows:

1) Target Year

The target year of around 2015 has been agreed between the Tajikistan and Japanese sides in the Scope of Work of this Study. However, the target year may be extended to a few more years in accordance with the components of the Master Plan.

2) Project Scale

The target design flood scale is proposed at 100-year return period as the ultimate goal of the project with consideration on the following three items:

a) Gyprowodkhoz under MMWR recommends the scale of 100-year return period. MMWR and CoES carried out the flood protection works in Hamadoni after the 2005 flood based on the design scale of 100-year return period.

b) Hamadoni Rayon is a very important place for the production of cotton as well as other agricultural products. According to the National Bank of Tajikistan, cotton production occupies about 9% of the GDP of Tajikistan, half of which is from Khatlon Oblast. The Hamadoni and Farkhor Rayons are the leading areas of production.

c) In addition, there is the Dehkonobod Canal that conveys irrigation and drinking water to the Farkhor, Vose and Kulob Rayons. If this canal is damaged, agricultural production will drastically decrease. Indeed, due to the 2005 flood with the scale of only 15-year return period, the quantity of cotton output went down to 50% compared with average cotton production in normal years in Hamadoni Rayon.

1.9.3 Key Consideration for Establishment of Structural Countermeasure

Generally, the structural flood protection plan (hereinafter called SFPP) to be established aims to confine more floodwater in the enlarged river cross section by providing dikes, widening or deepening of the river channel, or by temporarily storing floodwater with the construction of a retarding basin or dam. However, especially in the study area, the SFPP should be established considering such restrictions as the existing borderline with Afghanistan, the unstable river course, the flow capacity, the superelavational flow, the limited construction period and so on. In section 1.9, the concept of the SFPP is examined in consideration of the circumstances mentioned above.

1) Flow Capacity of Present Dike

a) Information from Gyprowodkhoz

According to Gyprowodkhoz, the dike has enough height to prevent a flood discharge of 5,327 m^3/s in the construction section financed by ADB funds in 2006. However, the flow capacity in other sections was not confirmed.

b) Estimation of Flow Capacity

The flow capacity at height of present dike was estimated considering relationship between the water level and flow discharge at any section. The relation was calculated by the non-uniform flow calculation.

i) Model Calibration

The calibration of the non-uniform calculation was carried out adjusting the calculation water level to the flood marks of flood season on 2006. Incidentally, the peak discharge in the 2006 flood season was estimated at about 2,800 m^3/s at Chubek. As a result of calibration, the Manning's Roughness Coefficient was confirmed at 0.035.

ii) Condition for Calculation

For establish of the relation between water level and discharge at any section, the non-uniform flow calculation is carried out on the conditions stated in Table R 1.9.2.

Table R 1.9.2 Boundary Condition for Non-Uniform Flow Calculation

No.	Boundaries	Contents
1	Objective River Reach	From P(-0.5) to P(11.4) (From BM 0.0 km to BM 12.155 km)
2	Water Depth of Starting point	The water level at starting point P (11.4) is assumed to give the hydraulic critical water depth, taking into consideration the steep riverbed slope (1/400). The water levels corresponding to various discharges at this point are determined by a hydraulic formula.
3	Discharge Distribution	The calculation is carried out on several discharge cases from 1,000m^3/s to 6,000m^3/s in Chubek Intake Weir. In this regard, the river discharge along the main dike comes under the influence of superelevational flow by holms. Thus, the discharge distribution is determined based on the river course discharge rate and total discharge in Chubek intake weir, as described in Chapter 2 of the supporting report.
4	River Cross Section	Cross-Sections are constructed from DEM developed from satellite image of SPOT. The cross-sectional calculation area is decided considering the river course range which is defined by using two-dimensional flow model as explained in Chapter 2 of the supporting report.
6	Manning's Roughness Coefficient	N = 0.035 (at equal value as used in the two-dimensional model)
7	Height for Calculation of Flow Capacity	The height of present dike was used, which is measured by the primary survey conducted by the study team on December 2006 using level machine.

In addition, before the construction of cross section data, the elevation of DEM was converted to the corresponding height by the ground control point at Chubek intake weir. According to Gyprowodkhoz, the height of the control point is 436.37 m above mean sea level.

iii) Estimation result

As a result of the calculation, the height of dike between BM (0.0) to BM (12.155) is acceptable to prevent to overflow by the 100-year flood, except for two sections, namely, between BM (2.0) and BM (3.6) and between BM (9.3) to BM (11.5). The flow capacity of these sections is slightly below the 30-year return period scale.

The water level corresponding to the discharge of 100-year return period was drawn as well as the height of present dike, riverbed, etc., in Fig. 1.9.3 in the Appendix.

iv) Notice

Unfortunately, CoES was not able to prepare the topographic map of 1/2000 scale on time for this study. Thus, the study team executed hydraulic analysis using DEM information. However, the study team expected to estimate the flow capacity by using the cross sectional data from a more detail scaled topographic map in the present condition because accuracy of the DEM is insufficient for the calculation.

2) Existing Condition of River Structure

a) Damage Condition of River Dike

After the flood season of 2006, the study team conducted the river structural survey to investigate the condition of the dike of Pyanj River. The survey results are as detailed in Fig. 1.6.2 of the Appendix. Based on Fig. 1.6.2, damages to the existing dike were extracted as summarized in Table R 1.9.3.

Table R 1.9.3 Damage of Existing Dike

Case	Damage Type	Total Length	Section
1	Riverbed Scour	520 m	- BM (0.8) to BM (1.8) in Patches - BM (2.3) to BM (2.6) - BM (3.5) to BM (3.6)
2	Broken Gabion	430 m	- BM (5.0) to BM (5.1) - BM (7.8) to BM (8.0) - Around BM (8.1) - BM (8.6) to BM (8.8)
3	Rusty Gabion	5,260 m	- BM (0.8) to BM (1.8) - BM (4.4) to BM (5.6) - BM (5.7) to BM (8.3) - BM (8.4) to BM (8.9)
4	Washed Away Revetment	50 m	- Around BM (3.0)
5	Disorganized Concrete Brock	1,100 m	- BM (2.3) to BM (3.3)
6	Fluvial Erosion	3,300 m	- BM (8.9) to BM (12.1)

The damages were inflicted on the existing dike during the flood of 2006 whose peak discharge was only 2,799 m^3/s in Chubek and lower than the annual mean maximum discharge (3,400 m^3/s).

b) Sectional Condition of Dike

The existing FPD has different condition in respect of erosion and influence of superelevational flow. Therefore, countermeasures against flood should be designed to adjust to the sectional conditions; Intake Guide Dike (IGD) section, Spillway Guide Dike (SGD) and Flood Protection Dike (FPD). FPD also should be designed sectionally because the present conditions of the dikes are situated under the different conditions as shown in Fig. R 1.9.1.

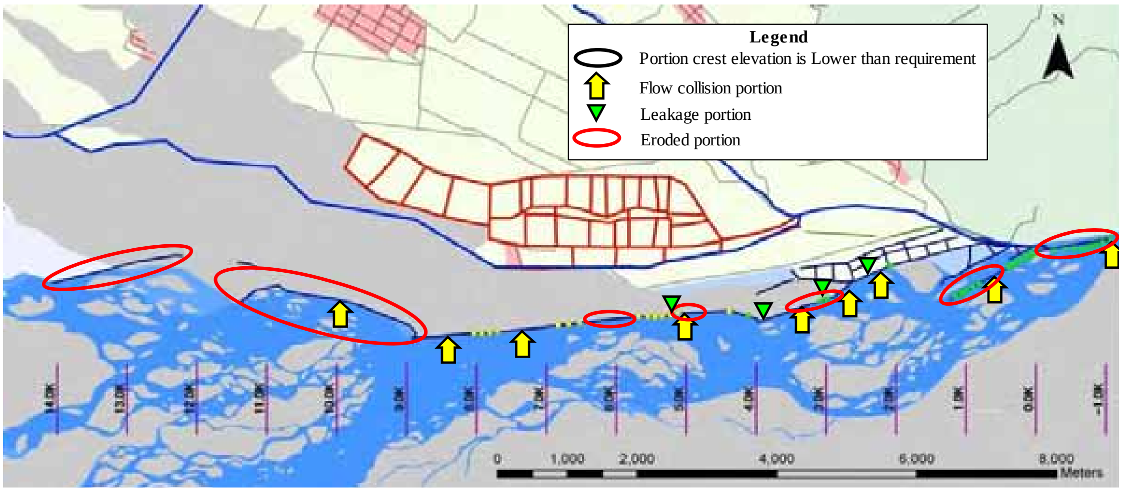


Fig. R 1.9.1 Different Conditions of Main Dike and Guide Dike Sections

3) Cause of Dike Breach

The dike of Pyanj River was broken in the 2005 flood when the flow discharge in Chubek reached 3,700 m^3/s, which corresponds to the scale of 3-year return period flood. However, according to WG, at that time, the water level did not rise up to near the crest of the river dike. Therefore, based on that information, the dike breach may have been caused by scouring of the riverbed and erosion due to water colliding by superelevational flow and the shoddy workmanship during the limited and short implementation period.

4) Dynamic State of Inundation Water

The river morphological features suggest that as long as the IGD and SGD are effectively working, the FPD up to P (2.0) is well protected by them. In case the dike between P (0.0) and P (2.5) is broken, the flood flow will intrude inland toward Murkowski and Chubek bringing serious damage. In case the dike between P (2.5) and P (12.0) is broken, flood flow goes toward the Dehkonobod irrigation canal and intrudes into the inland area (see Fig. R 1.8.1). However, according to the results of hydraulic analysis in Chapter 2 of the supporting report, in case the dike in the downstream side from P (12.0) is broken, the flood flow goes back to the river side, not toward the inland side according to a result of the flooding analysis.

1.9.4 Flood Protection Method

Judging from the circumstances and characteristics of the study area, basically, the following considerations shall be taken into account for the SFPP to mitigate flood damage:

- Stabilization and keeping river course away from main dike,
- Rehabilitation and strengthening of main dike and guide dike, and
- Construction of a new dike or spur dikes.

Based on the consideration for SFPP, the basic plan was proposed as described below.

1) Basic Plan for Long and Middle Term Plan

The rehabilitation of existing dike up to the 100-year scale is proposed as the basic master plan, as shown in Fig. R 1.9.2 and as detailed in Fig. 1.9.5 in the Appendix. For the prevention of dike breach by scouring and erosion, the existing main dike in Section (2) and the guide dikes in Section (1) are to be enhanced by adequate revetment and the RHS allocated at proper intervals.

Then, a new dike is to be constructed in Section (3) without the allocation of spur dike. The flow velocity of Pyanj River in this section is about two (2) to three (3) m/s. In comparison with the velocity of 5 m/s at the upstream section, the velocity of section (3) is very slow so that the proper revetment work enables to secure the dike without the spur dike.

As for Section (4) and Section (5), the riverbank is to be protected by revetment of riprap with only two meters of heightening of dike because the inland area of these sections is relatively higher due to the large holm. According to the hydraulic analysis in Chapter 2 of the supporting report, a small quantity of floodwaters is confirmed to flow into the inland area from Sections (3) and (4), but when that happens no floodwater will overflow from the Dehkonobod canal.

In addition, the top of intake guide dike at P (-1.0) is designed to broaden out compared with the present condition, as shown Fig. 1.9.4 in the Appendix, because this part was broken many times in the past due to its vulnerability to rapid flow. Incidentally, the intake guide dike would be protected against 30-year return period flood because the hinterland of this dike is only mountainous area.

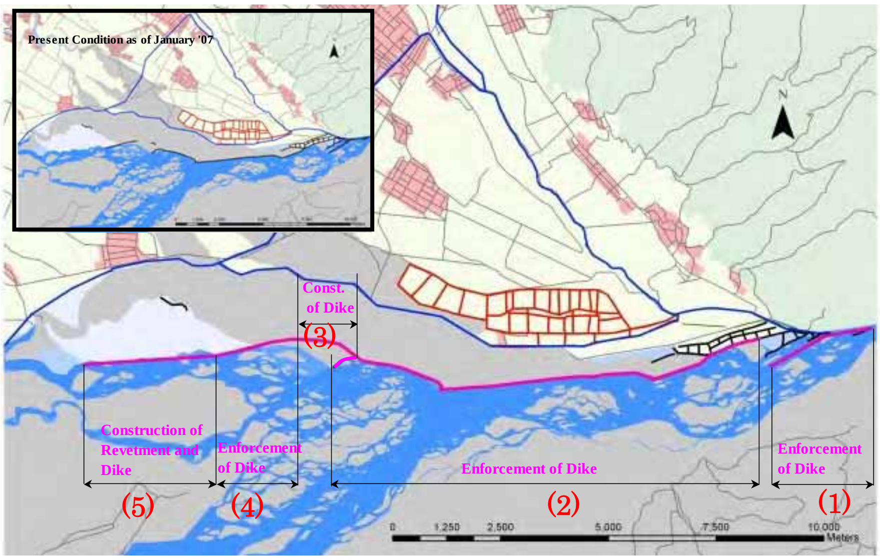


Fig. R 1.9.2 Diagram for Basic Plan for Long and Middle Term Plan

The contents of basic plan are summarized by section in Table R 1.9.4.

Table R 1.9.4 Basic Plan for Long Term Plan

Section	Station Point	Contents
(1)	- P (-1.0) to P (0.0) (Intake Guide Dike)	- Heightening (up to 30 years) and widening of intake guide dike - Construction of spur dikes - Widening of top of guide dike
	- P (0.0) to P (1.2) (Spillway Guide Dike)	- Heightening (up to 100 year) and widening of spillway guide dike - Construction of spur dikes - Completion of revetment works by concrete block and gabion
(2)	- P (2.0) to P (10.9)	- Widening of dike (width of crest is 8 m) - Heightening of dike (up to 100 year around P (2.0)) - Construction of spur dikes (RHS) in proper interval - Revetment by concrete blocks and gabions
(3)	- P (10.9) to P (12.1)	- Newly construction of main dike and revetment by gabion (up to 100 year)
(4)	- P (12.1) to P (14.0)	- Enforcement of existing revetment by riprap - Heightening of Dike with height of 2 m
(5)	- P (14.0) to BM (17.1)	- Newly construction of revetment by riprap - Construction of Dike with the height of 2 m on Holm

2) Alternative Plans

For flood mitigation in Hamadoni, three (3) alternative plans were provided, namely; Alternative 1 (Stabilization of River Course); Alternative 2 (Construction of Inland Dike);

and, Alternative 3 (Enhancement of River Dike without Spur Dike). The only difference among these alternatives is the means of providing the flood protection measures. These Alternatives Plan are detailed in Fig. 1.9.5 to Fig. 1.9.7 in the Appendix.

a) Alternative Plan 1 (Stabilization of River Course)

The Pyanj River may require the stabilization of river course and keeping the course relatively far from the main dike not to be broken the main dike. The stabilization of river course may be executed by the following means:

- Deepening riverbed by excavation;
- Enhancement of main dike without spur dike;
- Enhancement of guide dikes;
- Extension of spillway guide dike with spur dikes; and,
- Construction of new dike and revetment.

The contents of alternative plan 1 are as presented in Fig. R 1.9.3 and in Table R 1.9.5 by section.

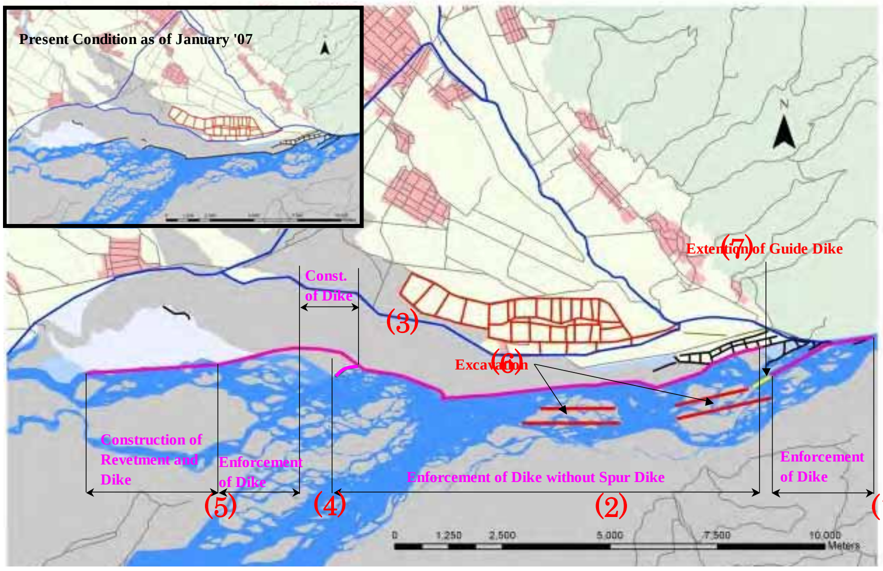


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Fig. R 1.9.3 Diagram of Alternative Plan 1

Table R 1.9.5 Alternative Plan 1

Section	Station Point	Contents
(1)	- P (-1.0) to P (0.0) (Intake Guide Dike)	- Same as Basic Plan
	- P (0.0) to P (1.2) (Spillway Guide Dike)	- Same as Basic Plan
(2)	- P (2.0) to P (10.9)	- Widening of dikes (width of crest is 8 m) - Heightening of dike [up to 100 year around P (2.0)] - Revetment by concrete blocks and gabions
(3)	- P (10.9) to P (12.1)	- Same as Basic Plan
(4)	- P (12.1) to P (14.0)	- Same as Basic Plan
(5)	- P (14.0) to P (17.1)	- Same as Basic Plan
(6)	- P (1.2) to P (3.9) - P (5.0) to P (7.0)	- Excavation of Riverbed and Holms
(7)	- P (1.2) to P (1.7)	- Extension of spillway guide dike

According to the hydraulic analysis in Chapter 2 of the supporting report, it can be said that these works does not directly make adverse impact on Afghanistan side in respect of hydraulic matter and the watercourse could be kept away from main dike although the maintenance work to keep the excavated watercourse on the borderline may be needed every year.

However, since special attention must be given in order not to increase the damage potential to the Afghanistan side, the excavation around the national border should be considered as the ultimate method although a bilateral understanding is crucial to the implementation of construction work.

b) Alternative Plan 2 (Construction of Inland Main Dike)

The mainstream of Pyanj River is approaching the main dike and this increases the difficulty of construction and strengthening of the present dike. Hence, the following flood protection works are proposed:

- Construction of inland dike (enhancement of Dehkonobod canal);
- Construction of sill behind the existing main dike;
- Partial enhancement of main dike and guide dike; and,
- Construction of new dike and revetment.

The contents of alternative plan 2 are as exposited in Fig. R 1.9.4 and in Table R 1.9.6 by section.

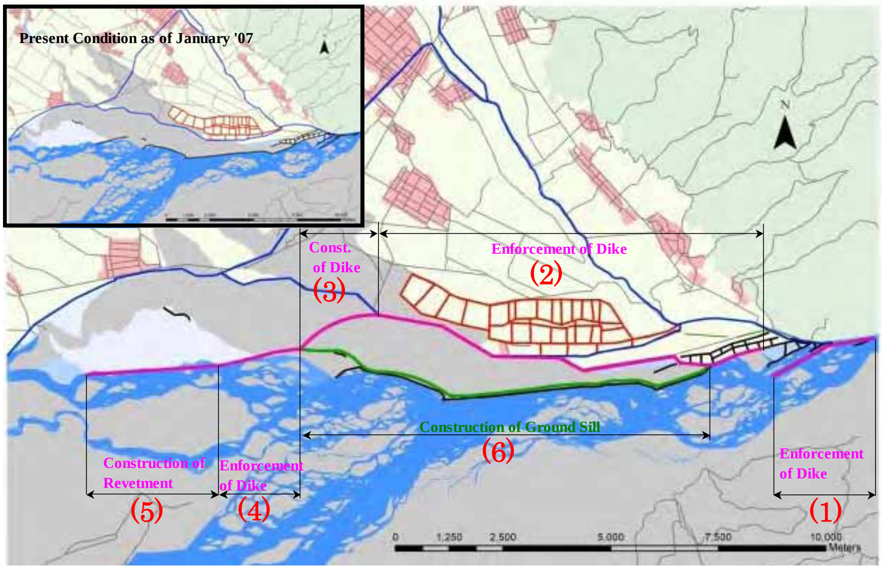

Fig. R 1.9.4 Diagram for Alternative 2

Table R 1.9.6 Alternative Plan 2

Section	Station Point	Contents
(1)	- P (-1.0) to P (0.0) (Intake Guide Dike)	- Same as Basic Plan
	- P (0.0) to P (1.2) (Spillway Guide Dike)	- Same as Basic Plan
(2)	- P (2.0) to P (10.5)	- Heightening (up to 100 year) and widening of spillway guide dike - Construction of spur dikes - Completion of revetment works by concrete block and gabion
(3)	- P (10.9) to P (12.1)	- Newly construction of dike - Construction of spur dikes - Completion of revetment works by concrete block and gabion
(4)	- P (12.1) to P (14.0)	- Same as Basic Plan
(5)	- P (14.0) to P (17.1)	- Same as Basic Plan
(6)	- P (1.5) to P (12.1)	- Construction of Sill behind the present dike

The protection works for this alternative plan are easy to complete because the requirement of temporary cofferdam for the construction of main dike may be not much. However, the sill behind the present dike should be constructed to keep the borderline in status quo, but this might actually cause high cost for this plan compared with the other alternatives.

In this plan the flood would flow near the inland area, that is, the potential of flood inundation seems to be raised up and the lead-time for evacuation seems to be shorten due to the loss of buffering area between the Dehkonobod canal and the existing dike. However, the strengthened foot protection works to prevent the increase of the potential would explicitly secure a stable function of the dike and the evacuation plan established in this study would keep the proper lead-time for the refugees.

Incidentally, Metintugay kishlak is situated along the former river course that remains as a hazard to the Dehkonobod Canal. In the 2005 flood, the floodwater overtopped the canal and most of the damage occurred downstream along the former river. To avoid a similar occurrence, the construction of guide dike in section (3) is proposed.

c) Alternative Plan 3 (Enhancement of Existing Dike without Spur Dike)

Generally, the construction of spur dike will be done based on the side erosion empirical rule for flashy streams in Japan and Tajikistan. Recently, however, some Japanese flashy rivers can be controlled by only dike with strengthened foot protection. In case of this plan, strengthened foot protection works would be provided for the settlement of base concrete to secure the main dike without spur dike.

- Enhancement of main dike without spur dike;
- Enhancement of guide dike with spur dike; and,
- Construction of new revetment.

The contents of Alternative plan 3 are as presented in Fig. R 1.9.5 and in Table R 1.9.7 by section.

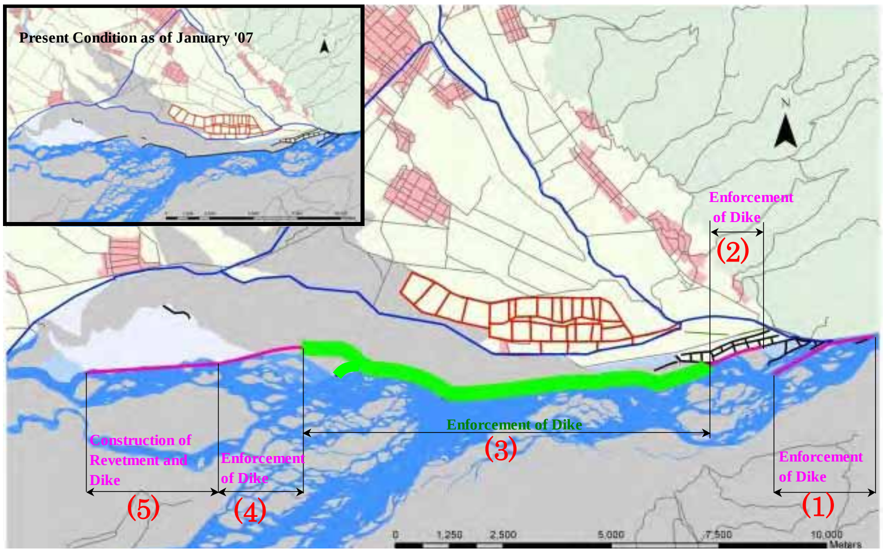

Fig. R 1.9.5 Diagram for Alternative Plan 3

Table R 1.9.7 Alternative Plan 3

Section	Station Point	Contents
(1)	- P (-1.0) to P (0.0) (Intake Guide Dike)	- Same as Basic Plan
	- P (0.0) to P (1.2) (Spillway Guide Dike)	- Same as Basic Plan
(2)	- P (1.5) to P (2.6)	- Heightening (up to 100 year) and widening of spillway guide dike - Construction of spur dike - Completion of revetment works by concrete block and gabion
(3)	- P (2.6) to P (11.4)	- Enhancement of main dike with foot protection works without spur dike - Completion of revetment works by concrete block and gabion
(4)	- P (12.1) to P (14.0)	- Same as Basic Plan
(5)	- P (14.0) to P (17.1)	- Same as Basic Plan
(6)	- P (1.5) to P (12.1)	- Construction of Sill behind the present dike

This plan may be completed to have the enough performance to prevent floods at the same cost as the basic plan. Besides, maintenance works could be carried out quickly in respect of the fewer amounts of protection works compared with the basic plan.

However, this plan seems to lose two reasonable functions of spur dikes for flashy river. One is the function of buffering tolerance and the other is to keep away the river course from main dike. In this connection, the strengthened revetment and foot protection works instead of spur dike would sustain the main dike.

3) Short Term Plan

The objective section for the shot-term plan was selected in consideration of vulnerability to flood condition. The selected section is illustrated in Fig 1.9.9 in the Appendix. This plan involves strengthening and rehabilitation of existing dike, and heightening of dike up to level with the scale of 30 years return period. These require activities for construction of spur dike, revetment and dike heightening to be accomplished in a 5-year period.

Design and Cost for Construction for the captured plans are detailed in Chapter 5 and 6 of the Supporting Report. Besides, these plan are evaluated by environmental and economical way in Chapter 7 and 9 in the Supporting Report.

REFERENCES

1. TA No. 3495-TAJ Final Report: Strategy for Improved Flood Management

TABLES AT THE BACK OF REPORT

Table 1.2.1 Flood Damage in Pyanj River Basin

No.	Date	Rayon	River or Canal	Damage
1	1961/7/28	Vanj	Pamir river	Flood at Daray-Rovand caused by a glacial lake outburst on a Pamir river in the Vanj region
2	1962	N/A	Ghunt river	Glacial lake outburst on the Gardjvindara a tributary of the river Ghunt
3	1963	Vanj	Vanj river	Flood on Vanj river following release of water blocked by movement of Medvezhiy glacier across Abdukagor river, a tributary of Vanj. Flood wave washed away bridges, farms, electricity lines down the vally, even sweping away a plan on an airfield at the District Centre 75 km downstream. Millions of robles of damage.
4	1965/8/9	Jafar	Tributary of Pyanj	Flood Caused by the heavy rainfall on a tributary of the Pyanj river in the Jafar rayon 40 km above Kakaihumb
5	1967/7/20	Vanj	N/A	Flood in the Vanj Rayon, 7km above Paymasar village - caused by an outburst from the Ravak glacial lake
6	1968/ - 1969	All	N/A	Heavy snow and rain resulted in debris flows throughout the country
6	1983/4/5		Tebroy Canal	Heavy rain causes loss of 300 cattle and 2500 ha crops in Tebolay Canal
7	1985/4/12	Hamadoni	Chubek Canal	Pyanj river destroys 700 m od head reach of Surhob canal, damages Chubek canal
8	1991/9	Roshtqala	Khidjevdori	Glacial lake outburst flood (altittude 4,680 m) in the headwater river of Khidojevdori in west pamir - peak discharge was 200 m3/s - Khidjev village in the Roshtqala rayon sufffered with 9 houses demolished and 8 damaged, the House of Culture was destroyr
9	1994/3	Hirmanjo	N/A	Mudflow of Hirmanjo rayon caused by heavy rainfall
10	1996/2	Hamadoni	Pyanj River	Because of rising level of water in the Pyanj River, the irrigation canals were in danger of dyke breach and flood at the border check point No. 7 and No. 8.
11	1996/5	Hamadoni	N/A	As a result of the dyke breach of irrigation canal system in Kulobdara, 40-50 meters of the canal were destroyed and 35 meters of the dyke was washed away. A bakery and five (food) stores of the consumers union were destroyed.
12	1998/7	Hamadoni	N/A	Dike breach
13	1999/7	Hamadoni Farkhor	N/A	Flood
14	2000/5	Shugnan	Pyanj River	4 houses were damaged. 1,160m of coast-protecting dtructures were washed out. 5km of car road was damaged.
15	2000/7	Khorog	Ghunt	640m of coast-protecting structures were washed out.
16	2001/6	Rushan	Pyanj River	2,230 m of coast-protecting structures were damaged.
17	2001/6	Vanj	Vanjov	192 hectres of forests were damaged.
18	2002/4	Vose	Surkhob River, Kizilsu	55 houses were damaged. 1.17km of coast-protecting structures was damaged.
19	2003/4	Vose	Surkhob River, Kizilsu	45 houses were damaged. 3km of car road was damaged. 6 bridges were damaged. 3.27km of coast-protecting structures was damaged.
20	2003/5	Temurmalik	Kizilsu River	383 houses were damaged. 4.75 km of coast-protecting structure was damaged.
21	2003/6	Hamadoni	N/A	Floods
22	2004/4	Kulyab City	Surkhob River	2.24 km of coast-protecting structure was damaged. 196 hectres of agricultural crops lands were damaged.
23	2004/4	Vose	Surkhob River	247 houses were damaged. 8 km of car roads were damaged. 5 bridges were damaged. 4 km of power line was damaged. 0.2 km of coast-protecting structure was damaged. 3 km of canals were damaged. 14 km of lodgement was damaged. 2 Transformer Sub Power Station
24	2004/4	Hamadoni	N/A	453.5 hectares of agricultural field (including 168 hectares of cotton), 31.7 kilometres of canals
25	2004/6	Farkhor	Pyanj River	0.3 km of coast-protecting structure was damaged.
26	2004/6	Pyanj	Pyanj River	1.65 km of coast-protecting structures were damaged. 35 hectres of agricultural crops lands were affected.
27	2004/7	Hamadoni	Pyanj River	8 houses were damaged. 6 bridges were damaged. 0.68 km of coast-protecting structures were damaged. 47 hectres of agricultural crops lands were affected.
28	2004/7	Tavildara	Khingov River	43 houses were damaged. 2 km of car roads were damaged. 3 bridges were damaged. 2 km of coast-protecting structures were damaged. 15 km of canals were damaged. 11 hectres of agricultural crops lands were affected.
29	2005/3	Kulyab City	Yakhsu River	35 houses were damaged. 1 bridge was damaged. 4.25 km of coast protecting structures were damaged. 173 hectres of agricultural crops lands were affected.
30	2005/3	Vose	Surkhob River	65 houses were damaged. 1 bridge was damaged. 0.75 km of coast-protecting structure was damaged. 2 Hydrotechnical Facilities were damaged. 168 hectres of agricultural crops lands were damaged.
31	2005/3	Farkhor	Pyanj River	2.17 km of coast-protecting structure was damaged.
32	2005/4	Vose	Surkhob River	38 houses were damaged. 3 km of car roads were damaged. 1 bridge was damaged. 5 km of canals and lodgements were damaged. 630 hectres of agricultural crops lands were affected.
33	2005/5	Kulyab City	Yakhsu River	10 houses were damaged. 1,75 km of car roads were damaged. 6 bridges were damaged. 0.05 km of coast-protecting structure was damaged.
34	2005/5	Murgab	Karasu River	20 houses were damaged. 41 km of car roads were damaged. 5 bridges were damaged. 7.5 km of communication line was damaged. 0.07 km of coast-protecting structure was damaged. 0.02 km of canals were damaged. 1 Hydro technical Facility was damaged. 22 other
35	2005/5	Rushan	Pyanj River	18 houses were damaged. 1 school was damaged. 20 km of car roads were damaged. 20.5 km of power line and communication line were damaged. 5 km of coast-protecting structures were damaged. 124 km of canals and lodgments were damaged. 1 Hydro technical Fac
36	2005/6	Farkhor	Pyanj River	5.75 km of coast-protecting structures were damaged. 1 hydrotechnical Facility was damaged. 1760 hectres of agricultural crops lands were affected.
37	2005/6	Ishkoshim	Pyanj River	43 houses were damaged. 11 educational, medical and public facilities were damaged. 90 km of car roads were damaged. 13 bridges were damaged. 20.5 km of power line were damaged. 40 km of communication line was damaged. 8.3 km of coast-protecting structure
38	2005/6	Hamadoni	Pyanj River	266 houses were damaged. 3 Facilities, including education, medical, social and cultural were damaged. 4.4 km of car roads were damaged. 3 bridges were damaged. 5.2 km of coast-protecting structures were damaged. 7.1 km of canals and lodgements were dama
39	2005/7	Pyanj	Pyanj River	1.5 km of coast-protecting structure was damaged. 1 cattle-breeding firm was damaged. 1000 hectres of agricultural crops lands were affected.
40	2005/7	Hamadoni	Pyanj River	The central area of Hamadoni remained without electricity because an electric transformer was destroyed .

Table 1.7.1 Result of Field Survey for Spur Dike and Sedimentation

	No.	Order	Length (m)	Width (m)		Angle	Distance to Damaged portion of Main Dike	Material	Damage Description of Spur Dike		Could	Formation of Sedimentation			Scouring Depth around Spur Dike	
				Joint	Middle	(degree)			Spur Dike	Main Dike in Groin Field	Revetment Works	Length	Width	Depth	Flank	Toe
Main Dike	1	C1	29.9	2.1	-	40.7	-	Co	Misalignment among concrete blocks	Nothing	Implemented	17.0	14.6	0.9	3.0	2.4
	2	C2	24.6	2.8	-	30.3	-	Co	Partial collapse	− Ditto −	− Ditto −	No	No	No	Submerged	Submerged
	3	C3	26.4	2.6	-	29.9	-	Co	Partial collapse	− Ditto −	− Ditto −	43.6	6.2	1.1	− Ditto −	− Ditto −
	4	C4	21.6	15.0	8.0	30.6	-	Gr, Co	Washed out 9m of total length (original length=30m)	− Ditto −	− Ditto −	48.0	15.3	1.0	1.8	1.8
	5	R1	30.0	28.4	13.7	59.8	8.0	Gr, Co, Ga	Nothing	Nothing	Implemented	66.5	18.0	0.5-0.9	2.2	2.6
	6	R2	48.0	42.8	15.0	50.1	2.4	Gr, Co, Ga	Toe was damaged	− Ditto −	− Ditto −	65.0	34.0	0.5-0.8	Submerged	Submerged
	7	R3	27.0	26.5	11.7	49.4	4.8	Gr, Co, Ga	Toe and flank is damaged	− Ditto −	− Ditto −	40.0	10.0	0.8-0.9	1.0	2.0
	8	R4	27.4	24.5	11.4	50.1	3.8	Gr, Co, Ga	Toe is damaged	− Ditto −	− Ditto −	23.8	7.0	0.5-0.6	Submerged	Submerged
	9	R5	41.0	28.6	11.0	40.7	2.6	Gr, Co, Ga	Toe is damaged	− Ditto −	− Ditto −	Submerged	Submerged	Submerged	− Ditto −	− Ditto −
	10	R6	42.0	18.0	8.5	55.0	3.3	Gr, Co, Ga	Toe is damaged	− Ditto −	− Ditto −	− Ditto −	− Ditto −	− Ditto −	− Ditto −	− Ditto −
	11	R7	42.0	26.0	13.0	75.0	7.9	Gr, Co, Ga	To e is damaged	− Ditto −	− Ditto −	100.0	24.0	0.5-0.7	− Ditto −	− Ditto −
	12	R8	42.0	21.0	12.0	50.0	3.9	Gr, Co, Ga	Toe and flank is damaged	− Ditto −	− Ditto −	101.0	19.0	0.8-0.9	− Ditto −	− Ditto −
	13	R9	42.0	21.0	11.0	50.0	3.5	Gr, Co, Ga	Nothing	− Ditto −	− Ditto −	50.0	12.0	0.6-0.8	− Ditto −	− Ditto −
	14	R10	45.0	21.0	10.0	50.2	9.3	Gr, Co, Ga	Nothing	− Ditto −	− Ditto −	94.0	20.0	0.7-0.8	− Ditto −	− Ditto −
	15	R11	43.0	45.0	24.0	40.5	2.5	Gr, Co, Ga	Toe and flank is damaged	− Ditto −	− Ditto −	48.0	25.0	0.5-1.0	− Ditto −	− Ditto −
	16	R12	45.0	44.0	19.0	40.4	2.5	Gr, Co	Nothing	− Ditto −	− Ditto −	52.0	18.0	0.4-1.0	− Ditto −	− Ditto −
	7	R13	34.0	53.0	28.0	40.5	3.2	Gr, Co, Ga	Nothing	− Ditto −	− Ditto −	52.0	12.0	0.4-0.9	− Ditto −	− Ditto −
	18	R14	48.0	46.0	25.0	60.5	4.6	Gr, Co, Ga	Toe is damaged	− Ditto −	− Ditto −	45.0	21.0	0.5-0.9	− Ditto −	− Ditto −
Intake Canal Guide Dike	-	CT	48.0	2.7	-	10.0	-	Co	Misalignment at Toe	Erosion	Nothing	No	No	No	No	No
	1	C5	20.0	2.7	-	25.0	-	Co	Nothing	− Ditto −	− Ditto −	16.0	5.0	0.4-0.7	1.9	3.0
	2	C6	30.0	2.6	-	20.0	-	Co	− Ditto −	− Ditto −	− Ditto −	23.0	5.0	0.2-0.8	0.5	2.0
	3	C7	20.0	2.5	-	40.6	-	Co	− Ditto −	− Ditto −	− Ditto −	15.0	4.0	0.2-0.3	0.8	2.7
	4	C8	20.3	2.7	-	30.4	-	Co	− Ditto −	− Ditto −	− Ditto −	No	No	No	0.9	3.0
	5	C9	20.0	2.6	-	40.0	−	Co	− Ditto −	− Ditto −	− Ditto −	No	No	No	2.3	4.0
	6	C10	20.0	2.6	-	48.2	-	Co	− Ditto −	Nothing	− Ditto −	23.0	10.0	0.3-0.9	4.3	5.2
	7	C11	110.0	20.0	-	50.3	-	Co, Gr	Collapse of concrete block at Toe	− Ditto −	− Ditto −	No	No	No	3.0	5.0
	8	C12	48.0	3.0	-	30.0	-	Co	Nothing	− Ditto −	− Ditto −	13.0	9.0	0.8-1.3	2.1	2.2
Spill Way Guide Dike	1	C13	41.0	2.0	-	20.1	-	Co	Nothing	Erosion	− Ditto −	No	No	No	0.6	1.4
	2	C14	10.0	2.0	-	40.2	-	Co	− Ditto −	− Ditto −	− Ditto −	No	No	No	1.7	2.5
	3	C15	15.0	2.0	-	15.0	-	Co	− Ditto −	− Ditto −	− Ditto −	No	No	No	1.7	2.5
	4	C16	15.0	2.0	-	36.0	-	Co	− Ditto −	− Ditto −	− Ditto −	No	No	No	2.3	4.0
	5	C17	20.0	2.0	-	28.0	-	Co	− Ditto −	− Ditto −	− Ditto −	No	No	No	1.8	3.7
	6	C18	20.7	2.0	-	24.0	-	Co	− Ditto −	− Ditto −	− Ditto −	No	No	No	0.9	2.6
	7	C19	21.0	2.7	-	24.0	-	Co	− Ditto −	− Ditto −	− Ditto −	No	No	No	0.0	2.0
	8	C20	15.0	2.7	-	30.0	-	Co	Collapse of concrete block at Toe	− Ditto −	− Ditto −	No	No	No	Submerged	Submerged
	9	C21	25.0	2.9	-	26.0	-	Co	Collapse of concrete block at Toe	− Ditto −	Around Spur Dike	No	No	No	− Ditto −	− Ditto −
	10	C22	15.0	1.9	-	30.0	-	Co	Collapse of concrete block at Toe	− Ditto −	Around Spur Dike	No	No	No	− Ditto −	− Ditto −
	11	C23	20.0	2.9	-	34.0	-	Co	Nothing	− Ditto −	Nothing	No	No	No	− Ditto −	− Ditto −
	12	C24	20.0	2.9	-	40.0	-	Co	− Ditto −	− Ditto −	− Ditto −	No	No	No	− Ditto −	− Ditto −

Table 1.7.2(1) Allocation of Irrigation Water (Khatlon Oblast)

('000m^3)

Zone	Rayon	1,999			2,000			2,001			2,002			2,003			2,004			2,005		
		Plan	Fact	%	Plan	Fact	%	Plan	Fact	%	Plan	Fact	%	Plan	Fact	%	Plan	Fact	%	Plan	Fact	%
Kulyab Zone(1)	Kulyab	128,379	128,354	100	81,963	84,519	103	81,200	82,300	101	82,000	65,000	79	82,244	83,056	101	78,053	79,159	101	65,965	65,969	100
	Muminobod	-	-	-	9,437	9,234	98	10,200	9,000	88	10,000	7,000	70	3,355	3,355	100	3,355	3,362	100	3,355	3,355	100
	Shurobod	-	-	-	722	382	95	700	600	95	7,000	5,000	71	722	737	102	722	728	101	704	714	101
	Vose	272,109	264,045	97	203,587	188,081	92	200,500	196,100	98	167,800	133,000	79	207,921	206,049	99	194,788	197,817	102	158,894	160,488	101
	Temurmalik	20,637	14,842	72	7,240	4,682	65	6,900	4,300	62	7,000	4,000	57	7,929	6,212	78	6,977	6,233	89	5,788	4,097	71
	Farkhor	386,610	394,619	102	313,730	251,839	80	310,000	252,100	81	322,000	243,000	75	247,256	258,496	105	241,407	270,840	112	210,842	213,600	101
	Hamadoni	176,917	187,124	106	203,587	189,081	93	151,800	189,600	125	155,000	158,000	102	155,511	160,709	103	145,039	153,736	106	127,210	129,820	102
	Khovaling	16,885	14,619	87	6,551	2,488	38	6,500	2,400	37	4,700	1,500	32	6,551	6,790	104	4,585	4,631	101	3,085	3,085	100
	CSO Dangara	701,238	741,404	104	61,463	57,227	93	52,700	50,000	95	53,400	43,400	81	49,277	39,272	80	48,558	48,048	99	37,795	37,964	100
	Total	1,702,775	1,745,007	102	888,280	787,533	89	820,500	786,400	96	808,900	659,900	82	760,766	764,676	101	723,484	764,554	106	613,638	619,092	101
Kurgan Tube Zone (2)		3,582,974	3,833,293	107	3,157,116	2,580,382	82	2,654,000	2,494,600	94	2,539,043	2,645,700	104	2,567,036	2,545,663	99	2,561,373	2,661,465	104	4,349,699	4,115,502	95
Khatlon Oblast (1)+(2)+(3)		5,285,749	5,578,300	106	4,045,396	3,367,915	83	3,474,500	3,281,000	94	3,347,943	3,305,600	99	3,327,802	3,310,339	99	3,284,857	3,426,019	104	4,963,337	4,734,594	95

Resource : MMWR

Table 1.7.2(2) Allocation of Irrigation Water (Tajikistan)

('000m^3)

Oblast	1,999			2,000			2,001			2,002			2,003			2,004			2,005		
	Plan	Fact	%	Plan	Fact	%	Plan	Fact	%	Plan	Fact	%	Plan	Fact	%	Plan	Fact	%	Plan	Fact	%
Khatlon Oblast	5,285,749	5,578,300	106	4,045,396	3,367,915	83	3,474,500	3,281,000	94	3,347,943	3,305,600	99	3,327,802	3,310,339	99	3,284,857	3,426,019	104	4,963,337	4,734,594	95
Other Oblasts	4,348,987	3,578,233	82	3,938,844	2,743,866	70	3,569,329	2,961,637	83	3,635,733	2,503,375	69	3,115,429	2,683,894	86	3,065,037	3,029,171	99	2,694,100	2,701,039	100
Total in Tajikistan	9,634,736	9,156,533	95	7,984,240	6,111,781	77	7,043,829	6,242,637	89	6,983,676	5,808,975	83	6,443,231	5,994,233	90	6,349,894	6,455,190	102	7,657,437	7,435,633	97

Resource : MMWR