JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
EARTHQUAKE RECONSTRUCTION AND REHABILITATION AUTHORITY (ERRA)

THE URGENT DEVELOPMENT STUDY ON REHABILITATION AND RECONSTRUCTION IN MUZAFFARABAD CITY IN THE ISLAMIC REPUBLIC OF PAKISTAN

FINAL REPORT I
VOLUME 2 : MAIN REPORT

January 2007

PACET Corp.
NIPPON KOEI CO.,LTD.

Report Organization

This report consists of the following volumes:

Final Report I

Volume 1	**:**	**Summary**
Volume 2	**:**	**Main Report**
Volume 3	**:**	**Sector Report**

Final Report II

Urgent Rehabilitation Projects

In Final Report I, **volume 1 Summary** contains the outline of the results of the study. **Volume 2 Main Report** contains the Master Plan for rehabilitation and reconstruction in Muzaffarabad city, Pakistan. **Volume 3 Sector Report** contains the details of existing conditions, issues to overcome, and proposals for future reconstruction by sector.

Final Report II deals with the results and outcomes on **the Urgent Rehabilitation Projects** which were prioritized and implemented in parallel with master plan formulation work under the supervision of JICA Study Team.

The exchange rate applied in the Study is:

(Pakistan Rupee)		(Japanese Yen)
Rs.1	=	¥1.91

(Pakistan Rupee)		(US Dollar)
Rs.60.30	=	US$ 1

PREFACE

In response to the request from the Government of the Islamic Republic of Pakistan, the Government of Japan decided to conduct a Urgent Development Study on Rehabilitation and Reconstruction in Muzaffarabad City in the Islamic Republic of Pakistan and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched the Study Team headed by Mr. Ichiro Kobayashi of Pacet, consisted of Pacet and Nippon Koei, to the Islamic Republic of Pakistan from February 2006 to August 2006. JICA set up an Advisory Committee chaired by Dr. Kazuo Konagai from the University of Tokyo, which examined the study from the specialist and technical points of view.

The Study Team held discussions with the officials concerned of the Government of the Islamic Republic of Pakistan and conducted the Study in collaboration with the Pakistani counterparts. Upon the last return to Japan, the Study Team finalized the study results for delivery of this Final Report.

I hope that this report will contribute to rehabilitation and reconstruction of Muzaffarabad city and to the enhancement of friendly relationship between the two countries.

Finally, I wish to express my sincere appreciation to all the officials concerned of the Government of the Islamic Republic of Pakistan for their close cooperation extended to the Study.

January 2007

Kazuhisa Matsuoka
Vice President
Japan International Cooperation Agency

Mr. Kazuhisa Matsuoka
Vice President
Japan International Cooperation Agency
Tokyo, Japan

January 2007

Letter of Transmittal

Dear Mr. Kazuhisa Matsuoka,

We are pleased to formally submit herewith the final report entitled "The Urgent Development Study on Rehabilitation and Reconstruction in Muzaffarabad City in the Islamic Republic of Pakistan".

This report compiles the results of the study, which was undertaken in the Islamic Republic of Pakistan from February 2006 to August 2006 by the Study Team organized jointly by Pacet and Nippon Koei under the contract with the JICA

The Final Report is composed of the "Executive Summary", "Main Report", and "Sector Report". In the Main Report, the emphasis was given that Muzaffarabad City should be reconstructed with strong urban structure against natural disaster as primary policy, including project long list for early implementation of the rehabilitation and reconstruction. In addition, the Sector Report compiles overall policies and procedures of rehabilitation and reconstruction in each sector. It is truly hoped that the outcomes of the Final Report will contribute to enhance rehabilitation and reconstruction of Muzaffarabad City and victims of earthquake will back to normal life soon.

Finally, we would like to express our sincere gratitude and appreciation to all the officials of your agency, the JICA advisory Committee, the Embassy of Japan in the Islamic Republic of Pakistan, and Ministry of Foreign Affairs. We also would like to send our great appreciation to all those who have extended their kind assistance and cooperation to the Study Team, in particular, relevant officials of Earthquake Reconstruction and Rehabilitation Agency (ERRA) and Azad Jammu Kashmir (AJK) Government.

Very truly yours,

Ichiro Kobayashi
Team Leader, JICA Study Team
The Urgent Development Study on Rehabilitation and Reconstruction in Muzaffarabad City in the Islamic Republic of Pakistan

Images of Proposed Project

The following pictures illustrate some of action plan projects (see *page 6-20*) which were selected in view of urgency and effectiveness among the entire long list of projects and programs.
(Under the supervision of JICA study team experts, Sathi Bagh Government Girls High School was successfully constructed, and West Bank By-pass road was studied on preliminary design.)

Image of Satellite Town

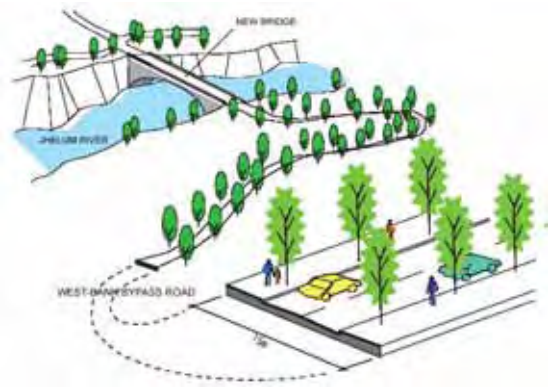
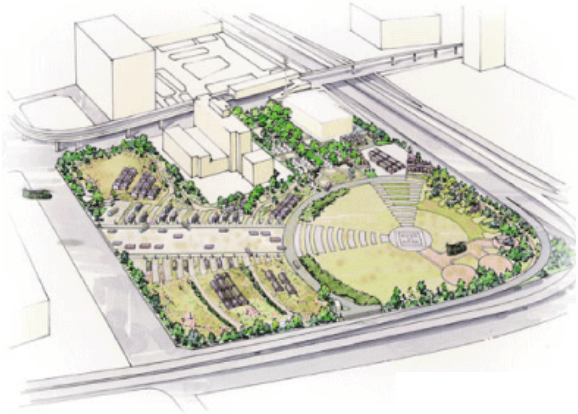
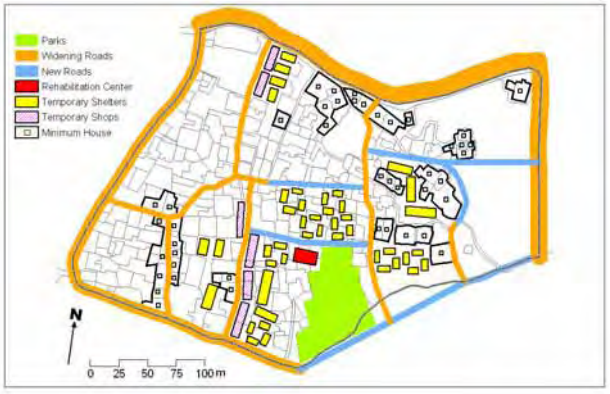


Image of West Bank By-pass Project

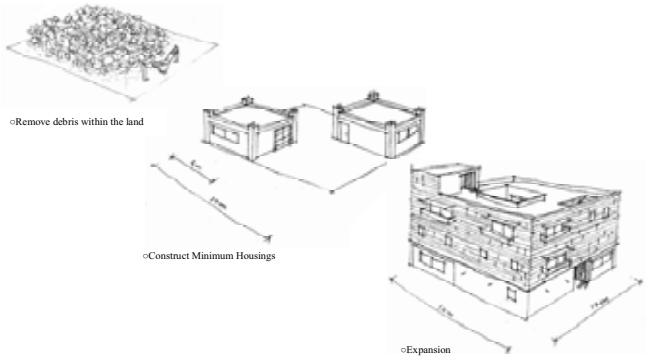


Disaster Management Park View



Temporary Urban Area

Sathi Bagh Government Girls High School



Construction of Minimum House

TABLE OF CONTENTS

List of Figures

List of Tables

List of Abbreviations

Abbreviation	Name
ACI	American Concrete Institute
ADB	Asian Development Bank
AJK	Azad Jammu and Kashmir
CBO	Community Based Organization
CIRES	Cooperative Institute for Research in Environmental Sciences
CISP	Community Infrastructure Support Program
CMH	Combined Military Hospital
DEM	Digital Elevation Model
DFID	Department for International Development
DRU	District Reconstruction Unit
ERRA	Earthquake Reconstruction and Rehabilitation Authority
FWO	Frontier Works Organization
GIS	Geographic Information System
GOAJK	Government of Azad Jammu and Kashmir
GOJ	Government of Japan
GOP	Government of Pakistan
GSP	Geological Survey of Pakistan
HFT	Himalayan Frontal Thrust
HIC	Humanitarian Information Center for Pakistan
IDA	International Development Association
IOM	International Organization for Migration
ISPR	Inter Services Public Relations
IRIS-DMC	The IRIS Data Management Center
JADE	Japan Agency for Development and Emergency
JICA	Japan International Cooperation Agency
LOC	Line of Control
MBT	Main Boundary Thrust
MCM	Municipal Corporation Muzaffarabad
MCT	Main Central Thrust
MDA	Muzaffarabad Development Authority
MGD	Million gallon per day
MMI	Modified Mercalli Intensity
MMT	Main Mantle Thrust
NGO	Non Governmental Organizations
NESPAK	National Engineering Service Pakistan
NHA	National Highway Authority
NWFP	North West Frontier Province

PERRA	Provincial Earthquake Reconstruction and Rehabilitation Agency
PGA	Peak Ground Acceleration
PHED	Public Heath Engineering Department
PIMS	Pakistan Institute of Medical Science
PSC	Programme Steering Committe
PWD	Paublic Works Department
RGH	Rawalpindi General Hospital
SERRA	State Earthquake Reconstruction and Rehabilitation Agency
UNICEF	United Nations Children's Fund
USDA	United States Department of Agriculture
USGS	US Geological Survey
USAID	U.S. Agency for International Development
UTM	Universal Transverse Mercator Projection
WB	World Bank
WGS	World Geodetic System
WTP	Water Treatment Plant

1. GENERAL

1.1. Introduction

In response to the request of the Government of Pakistan (hereinafter referred to as "GOP"), the Government of Japan (hereinafter referred to as "GOJ") has decided to conduct "The Urgent Development Study on Rehabilitation and Reconstruction in Muzaffarabad City in the Islamic Republic of Pakistan" (hereinafter referred to as "the Study"), within the framework of the Agreement on Technical Cooperation between GOJ and GOP signed on April 30, 2005 (hereinafter referred to as "the Agreement").

Accordingly, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of technical cooperation programs of GOJ, undertook the Study in accordance with the relevant laws and regulations in force in Japan.

On the part of GOP, the Earthquake Reconstruction and Rehabilitation Authority (hereinafter referred to as "ERRA") acted as the counterpart agency to the Japanese Study Team (hereinafter referred to as "the Study Team") and also as the coordinating body in relation with other governmental and non-governmental organizations concerned with the smooth implementation of the study. However, in the course of the implementation of the Study, the Government of Azad Jammu and Kashmir (hereinafter referred to as "GOAJK") will work together as a counterpart agency with the Study Team.

1.2. Background of the Study

1.2.1. 2005 Kashmir Earthquake

On October 8, 2005 an earthquake measuring 7.6 on the Richter scale occurred at 8:50 a.m. (Pakistani Standard Time). The seismic center was reported at 90 km north-northeast from Islamabad, at 34.493 degrees north latitude, and 73.629 degrees east longitude, and the epicenter was 26 km below ground level[1].

The location of seismic center is shown in Figure 1.2.1.

[1] United States Geological Study Reports (USGS).

Source: Pakistan Earthquake Seismic events map Reference Number X-26, Created on Oct. 14, 2005 by MapAction（www.mapaction.org）

Figure 1.2.1 Location of the Seismic Center

1.2.2. Background of the Formulation of Rehabilitation and Reconstruction Plan of Muzaffarabad City

Since the northern part of Muzaffarabad is located close to the epicenter and dislocation, many buildings and structures were damaged. And among them were many government buildings. The government, therefore, has not been functioning well since the event, and this has caused difficulties in formulating rehabilitation and reconstruction plans.

Furthermore, taking into consideration the present situation of the affected people and their hopes toward immediate reconstruction, it is needed to formulate a rehabilitation and reconstruction master plan in a short period, and it is also urged to implement some immediate countermeasures, which are a matter of urgent need.

1.3. Objectives of the Study

The Study aims at achieving the following two objectives:

1) Formulation of Rehabilitation and Reconstruction Master Plan (Target year: 2016)

2) Implementation of Pilot Rehabilitation Project, if necessary

1.4. Study Area

The Study covers Muzaffarabad city with an area of 17 km^2 and its surrounding areas. Muzaffarabad city has divided into 20 wards as shown figure below.

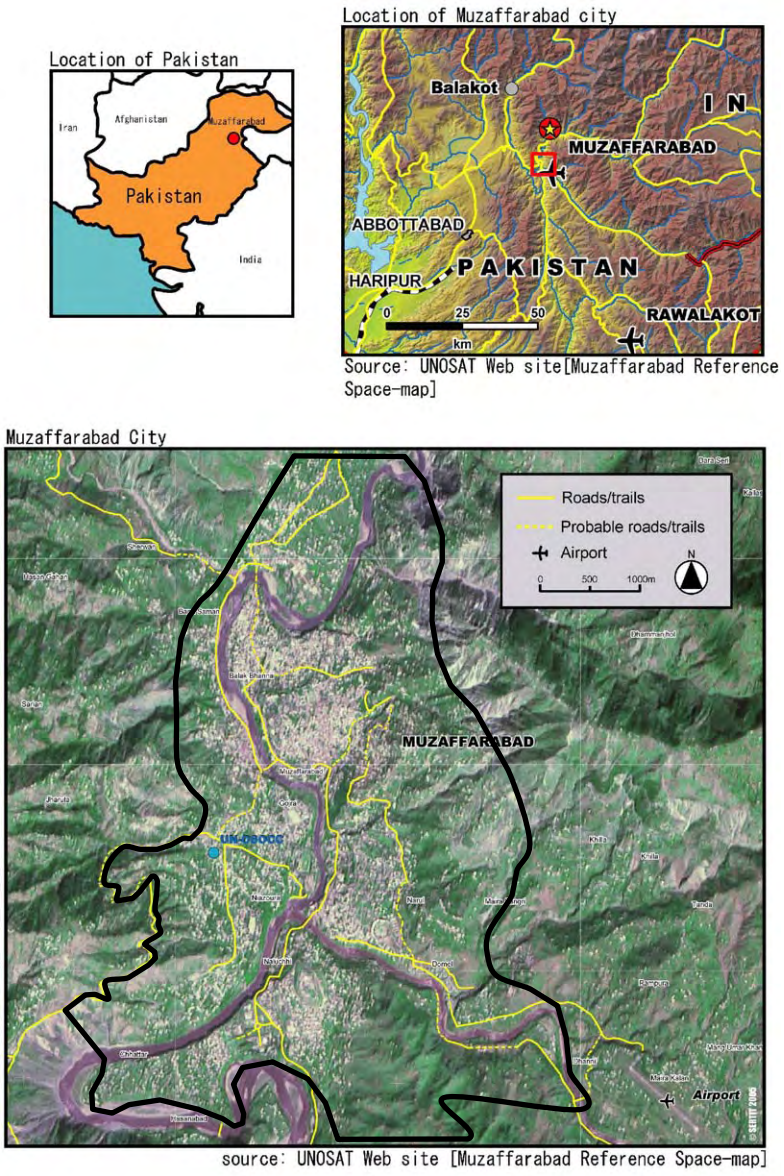


Figure 1.4.1 Study Area Location Map

1.5. Counterpart Agency

The Counterpart agency for the Study is Earthquake Reconstruction and Rehabilitation Authority (ERRA).

Pakistani and Japanese sides have agreed to set up the Steering Committee under the initiative of ERRA to effectively conduct the Study. Reports that include progress of the study are presented and discussed at Steering Committee meetings at each stage of the Study. The Committee is composed of the following authorities and organizations:

- Earthquake Reconstruction and Rehabilitation Authority
- Economic Affairs Division, Ministry of Economic Affairs and Statistics
- Planning and Development Department, GOAJK

- Central Design Office Works Department, GOAJK
- Public Works Department, GOAJK
- NESPAK
- Representation of Planning Division
- Any other member appointed by ERRA

The study is implemented under the following cooperation structure:

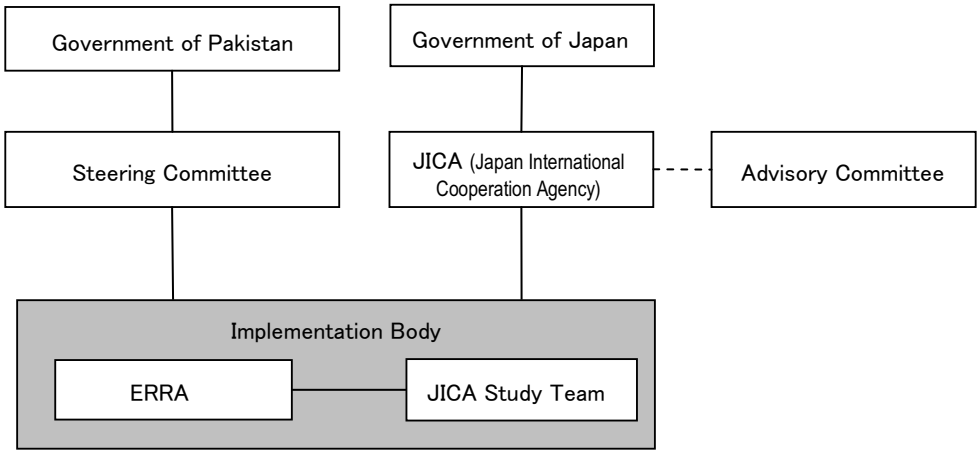
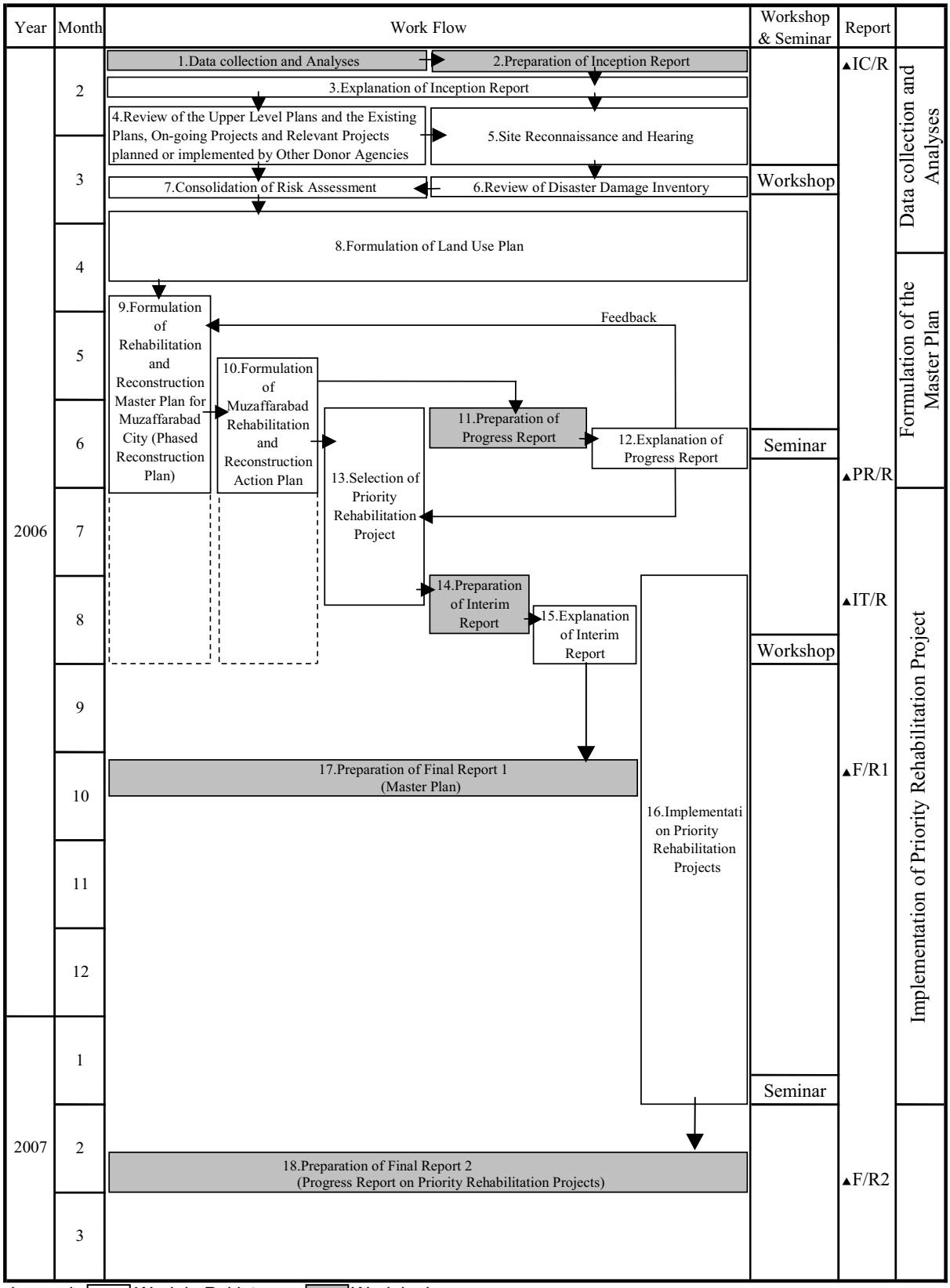


Figure 1.5.1 Cooperation Structure for Study Implementation

The work schedule of the tasks, interrelations among the tasks, and logical flow of the Study are shown in Figure 1.5.2.



Legend: Work in Pakistan Work in Japan
IC/R Inception Report PR/R Progress Report IT/R Interim Report F/R Final Report
Source: JICA Study Team

Figure 1.5.2 Work Flow of the Study

1.6. Important Meetings

The Study Team explained the contents of Inception Report to ERRA on February 15, 2006. Thereafter, several meetings and workshops with Pakistani side were held for more specific discussions as follows:

Date	Contents of Meeting and Discussions	Place
February 15	1st Steering Committee Meeting Explanation of inception report to ERRA	ERRA
March 6	Kick-off meeting at Muzaffarabad City	Secretary of Planning and Development of AJK government
March 29	Explanation of study progress chaired by General Nadeem of ERRA	ERRA
April 3	Explanation and finding of land use planning	Secretary of Planning and Development of AJK government
April 10	Explanation of present status of the Study	Director General of Planning and Development
April 17	1st public hearing meeting regarding rehabilitation and reconstruction of Muzaffarabad City	Organized by Municipal Cooperation of Muzaffarabad. More than 50 residents were attended the meeting.
April 27	Basic concept of rehabilitation and reconstruction of Muzaffarabad City	Brig. Sher Afghan Niazi Director General (M & E) ERRA
May 4	2nd Public hearing meeting of Muzaffarabad city	Organized by Municipal Cooperation of Muzaffarabad. More than 50 residents were attended the meeting.
May 13	Progress of rehabilitation and reconstruction study	ERRA
May 20	Urban Planning of Muzaffarabad City	Chief Secretary of AJK government
May 23	Urban Planning of Muzaffarabad City	Prim Minister of AJK government
May 29	Urban Planning of Muzaffarabad City	AJK government
June 29	2nd Steering Committee meeting Explanation of Progress report	ERRA and AJK government
August 12	Final comments on progress repost	ERRA and AJK government
August 23	Important proposed project for rehabilitation and reconstruction such as satellite town, commercial area, action	Secretary of Works of AJK government

	plan and long list.	
August 28	3rd Steering Committee meeting Explanation of Interim report	ERRA
September 2	Final presentation of the interim report at Muzaffarabad, attending Prim minister of AJK and General Nadeem	AJK government

1.7. Workshops and Seminar

Workshops and a seminar were held during the course of the Study. Detailed of the workshops and seminars are summarized as follows:

Kind	Date	Contents	Participants
Workshop 1	April 1	Study progress Rehabilitation and reconstruction direction	Approximately 50 participants from AJK government officials.
Workshop 2	April 28	Initial finding of Master Plan Study	Secretary of Planning and Development of AJK government
Workshop 3	August 30	Donor coordination meeting	More than 50 persons from donor agency
Seminar 1	June 27	Presentation of Progress Report	More than 100 persons attended the seminar in Muzaffarabad

2. STUDY AREA

2.1. Muzaffarabad City

2.1.1. Background

(1) General

Azad Kashmir in English means "Free Kashmir". In 1947 when the British granted independence to India, the people had already revolted against the Dogra ruler of the state. He was defeated by the Kashmir Liberation Army on October 24, 1947 and a provisional government of Azad Jammu & Kashmir (Free Kashmir) was established. Subsequently, the Indian army moved in to occupy two-thirds of the state and it has been under Indian occupation since. The remainder of the state still exists as Azad Jammu & Kashmir.

Azad Kashmir is autonomous, with its own elected President, Prime Minister, Legislature, and High Court. The state is divided into two administrative divisions as follows.

Table 2.1.1 Administration of Azad Kashmir

Divisions	Districts	Area (km^2)
Mirpur	Bhimber	1,516
	Kotli	1,862
	Mirpur	1,010
Muzaffarabad	Bagh	1,368
	Muzaffarabad	6,117
	Neelum	
	Poonch	855
	Sudhnati	569
Total		13,297

Source: www.wikipedia.org/wiki/Azad_Kashmir

Azad Kashmir covers an area of 13,297 km^2 (5,135 sq. miles), with its capital in Muzaffarabad. “Azad Jammu and Kashmir” (AJK), termed ‘Switzerland of the East’, is located in North-East of Pakistan at 73.75 longitude 33.36 latitude. It has an estimated population of about 4 million. The official language of AJK is Urdu, with local languages of Kashmiri, Pahari, Gojri, Hindko and Kohastani.

Azad Kashmir is a cold, mountainous region that boasts some of the most scenic mountains and river valleys. The region includes a significant part of the Himalayas. AJK has some areas like Muzaffarabad, Poonch, Bagh and Kotli districts in mountainous zones, whilst Mirpur district lies generally in the foothills. Elevation above sea level ranges from 350 m in South to 6,325 m in North. Azad Kashmir, is 400 km (250 miles) in length with the width varying from 15 to 65 km (10 to 40 miles); it covers an area of 13,300 km^2 (5,135 miles). The climate is sub-tropical highland type with average monthly rainfall of 150 mm.

Snowline in winter is at a height of 1,200 m, whereas in summer it moves up to a height of 3,300 m. Main rivers include Neelum, Jehlum and Poonch.

(2) Kashmir Dispute

a. Land Issue

Kashmir has been the core disputed issue between Pakistan and India. Owing to the unmoved stance of both countries, there exists no international boundary of AJK towards Indian side; there is only a line of cease fire, which is called as Line of Control (LOC). Despite very high potential of tourism, many parts of Azad Kashmir are not open for tourists, especially foreigners, as there has always been extensive use of heavy artillery from both sides of the LOC.

Historically, the Pakistani claim on Kashmir has been based on the fact that the majority of Kashmir population is Muslim and, if given the option, most Kashmiris would vote to join Pakistan or seek independence. Since 1951, Pakistan has been demanding of India to hold a plebiscite in Kashmir as agreed by India in 1951. Pakistan claims that Kashmiris took a violent path to independence only when they became hopeless and disillusioned about their future. Pakistan claims that India is now using excessive state forces to suppress the freedom struggle of Kashmiris and in doing so, is causing severe human rights violations. This is also documented by several human rights groups.

b. Water Issue

Another reason behind the dispute over Kashmir is water. Kashmir is the origin point for many rivers and tributaries of the Indus River basin. They include Jehlum and Chenab which primarily flow into Pakistan while other branches—the Ravi, Beas and Sutlej—irrigate northern India and then pass through Pakistan. Pakistan has been apprehensive that, in case of dire need, India, under whose portion of Kashmir lies the origins of the said rivers, would use its strategic advantage and withhold the flow and thus choke the agrarian economy of Pakistan.

2.1.2. Characteristics of the Study Area

(1) General Characteristics

Muzaffarabad is at a distance of 138 km from Rawalpindi/Islamabad and 76 km from Abbottabad. It is the administrative capital of Azad Kashmir. Behind the Old Secretariat to the east is a road climbing above the town from where one can walk up to Pir Chinasi at 2,900 meters with good views of the Jehlum Valley and the higher mountains above the Neelum to the north. From the cool of the Abbottabad Road, one can walk along the ridge looking over Jehlum and Kunhar rivers.

(2) Administration

a. General

The State of Azad Jammu and Kashmir is divided into two divisions: the Muzaffarabad division which includes Muzaffarabad, Bagh, Poonch, Sudhnuti and Neelum districts, and the Mirpur division which includes Mirpur, Kotli and Bhimber districts. Muzaffarabad city is the capital of these eight administrative districts.

The people's participation in the political process is ensured through the elected AJK Legislative Assembly with 40 directly elected members, AJK Council with six elected members, and members of local council which cover over 1,646 villages of the state.

The city was founded by Sultan Muzaffar Khan of Bamba dynasty and was the seat of an independent State for quite a long period under his successors. The city is now a combination of old and new buildings and a blend of different cultures and languages. It has besides official buildings, farms, parks and the historic forts standing on the banks of the Neelum. AJK univerity is a symbol as the center of education in AJK.

Muzaffarabad, the capital city, is not only the hub of political and cultural activities but it also serves as a base camp for the tourists. It has various spots of leisure. The more enthusiastic tourist uses Muzaffarabad as base camp of stop over before departing for Neelum and Jehlum valley, whereas the less enthusiastic tourist only looking for change from the scenery of Murree hills stays at Muzaffarabad to enjoy its scenic beauty blended with urban fabric of life.

Another role of Muzaffarabad is the trading center of AJK. AJK is popular for its handicrafts, some of the varieties are even exported. Some of the popular handicrafts are hand made carpets, namda gubba, patto, silk & woolen clothes, woolen shawls, wood carving and Papie Mashie. Some natural products are mushroom, honey, walnut, apple, cherry, medicinal herbs & plants, resin, deodar, kail, chir, fir, maple and ash timber.

b. AJK Government

The State of Azad Jammu and Kashmir has a parliamentary form of government. The President is the constitutional Head of the State, while the Prime Minister, supported by a council of ministers, is the Chief Executive. The State has its own Supreme Court and a High Court. Legislative Assembly comprises 48 members, out of which 40 are directly elected and 8 are indirectly elected -- a member each from the technocrats, Mashaikh, Overseas Kashmiris and 5 women.

Functions of the Ministry:

According to the rules of Business 1973, the functions of Ministry of Kashmir Affairs and Northern Areas are as follows.

a. Policy, administration and development in Northern Areas

b. Administration of Jammu and Kashmir State Property in Pakistan

c. Relations with Azad Jammu And Kashmir Council and Azad Government of the state of Jammu and Kashmir

d. Matters relating to the settlement of Kashmir Dispute, other than those falling within the purview of the Foreign Affairs Division

e. Relief and Rehabilitation work in the Northern areas, including provisions of civil supplies

The Ministry of Kashmir Affairs and Northern Affairs serves as a link between the Government of Pakistan and the Government of Azad Jammu and Kashmir. Since The State inherited a backwards and underdeveloped economy, the major objective of the Pakistani Government has been to promote economic development with grants-in-aid, and also to cover the deficits in its budget.

c. Muzaffarabad Development Authority (MDA)

MDA was established under Development Authority Muzaffarabad Act, 1989 (Act II of 1989) with the following objectives:

Objectives:

- To prepare Master Plan for Muzaffarabad
- To launch modern housing schemes for the people of Muzaffarabad city
- To execute development schemes for provision of civic facilities to the people of Muzaffarabad city
- To regulate the construction of buildings/structures within notified area

Functions of MDA:

The main functions of Development Authority are:

- Preparation and implementation of Metropolitan Development Plan
- Development of new housing colonies
- Building controls
- Transport engineering and Planning

- Water supply, sewerage and drainages
- Deposit works
- Private sector participation

d. Muzaffarabad Municipal Corporation (MCM)

The functions and powers of the Municipal Corporation are as follows:

- To prepare spatial plans for the Municipality Area in collaboration with Development Authority, including plans for land use, zoning and functions for which the Municipality is responsible.
- To seek approval of the Municipal Administration for the spatial plans prepared by it after due process of dissemination and public enquiry, incorporating modifications on the basis of such inquiry.
- To execute and manage development plans.
- To exercise control over land use, land-subdivision, land development and zoning by public and private sectors for any purpose, including for agriculture, industry, commerce markets, shopping and other employment centers, residential, recreation, parks, entertainment, passenger and freight transport and transit stations.
- To enforce all municipal laws, rules and by-laws governing its functioning.

– Provided that the Municipality may, with the approval of Municipal Administration, exempt any zone from applying any specific provision of the by-laws made by the Municipal Administration under this Ordinance.

– Provided further that the Government may, on the recommendation of Municipality through District Government, exempt any zone or a part thereof from the application of rules relating to land use, building control, tax on property or in any other matter dealing with municipal services.

– Provided also that such exemption shall not extend to any organized housing schemes, zoning of industrial and commercial areas, and matters concerning environmental protection.

- To prevent encroachments.
- To regulate affixing of signboards and advertisements.
- To provide, manage, operate, maintain and improve the municipal infrastructure and services.

(3) Laws and Regulation for Urban Planning

There is also no comprehensive town and country planning law enacted in AJK to date covering the whole state of AJK. However, at local level the legislation is in place for urban planning (i.e., for preparation of master plans and site development schemes. These local laws covering urban planning in AJK are:

- Mirpur Development Authority ordinance of IV of 1974
- Development Authority of Muzaffarabad Act of II of 1989 as amended up to December 2001
- Kotli Development Authority Act XII of 1992 (AJK)
- Pearl Development Authority Act XIV of 1993
- Bagh Development Authority Act XIX of 1995
- The Azad Jammu and Kashmir Local Government Act 1990

But in spite of above local laws covering town planning there is no effective machinery and legal cover provided to initiate approval from the concerned agencies after public consultation and to implement these Plans. The master plan prepared for Muzaffarabad in 1976 by Associated Consulting Engineers has no formal approval and no procedure laid down on how to implement it and made amendments in it during implementation stage, if so deemed necessary. The other reason for its failure, among other things, was due to lack of proper and organized institutional setup headed and supported by qualified and experienced professional town planners as well as capable of mobilizing and utilizing resources for urban development.

2.1.3. Level of Infrastructural Services

(1) Road Network

The urbanization of Muzaffarabad city has been mainly developed on the river terrace formed peripherally by the Jhelum river and Neelum river. Since the Muzaffarabad city is located on the land adjoining steep peripheral mountains, the road network in Muzaffarabad is restricted.

a. Region-wide Road Network

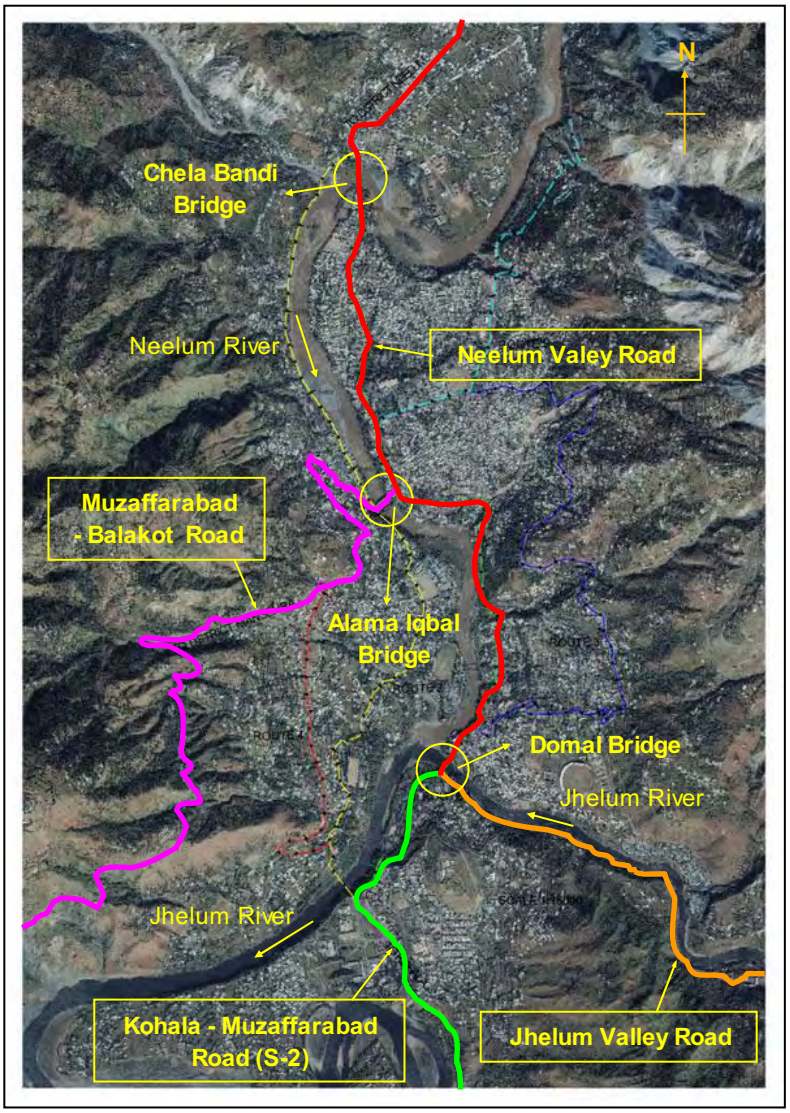
The region-wide road networks in Muzaffarabad city consist of the following four major routes (refer to Figure 2.1.1):

Kohala - Muzaffarabad Road (S-2)

Kohala - Muzaffarabad Road (S-2) is followed from N-75 that is started from Islamabad, and runs along on the left side bank of the Jhelum River and goes into Muzaffarabad city from the southern part of city. The said road sustained damages such as landslides, slope slips and collapses of road shoulder and carriageway down to the Jhelum River from the October 8 Earthquake. The National Highway Authority (NHA), which is road management body, is scheduling to rehabilitate the damaged sections using World Bank funds.

Neelum Valley Road

The Neelum Valley Road starts from the Domal Bridge, runs along the Neelum River and leads to Kel, which is a major town in AJK. Many internal roads on Upper/Lower Plate, Madina Market area and Old Secretariat area, which experienced heavy damages, are entered from Neelum Valley Road; therefore, it may be said to be a most important trunk road in Muzaffarabad city. This road also experienced heavy damage by the earthquake, of which the damage section between Muzaffarabad and Chilian, a distance is 50 km, was most serious. AJK government is planning to finance rehabilitatation using funds from Earthquake Emergency Assistance Project of ADB.



Source: JICA Study Team

Figure 2.1.1 Region-wide Road Network in Muzaffarabad City

Jhelum Valley Road

Jhelum Valley Road, with a length of 56 km, is one of the most important roads in AJK; it starts from Domal Bridge, runs along the Jhelum River to Chakothi where it is on Line Of Control and leads to Srinagal (India), and is a bus route between Pakistan and India. Since this road is located in parallel with the active fault caused by the October 8 Earthquake, the road experienced heavy damages over its entirety. Rehabilitation of the damaged road is scheduled to be financed by World Bank as well as by the Japanese Government's bridge reconstruction assistance fund.

Muzaffarabad - Balakot Road

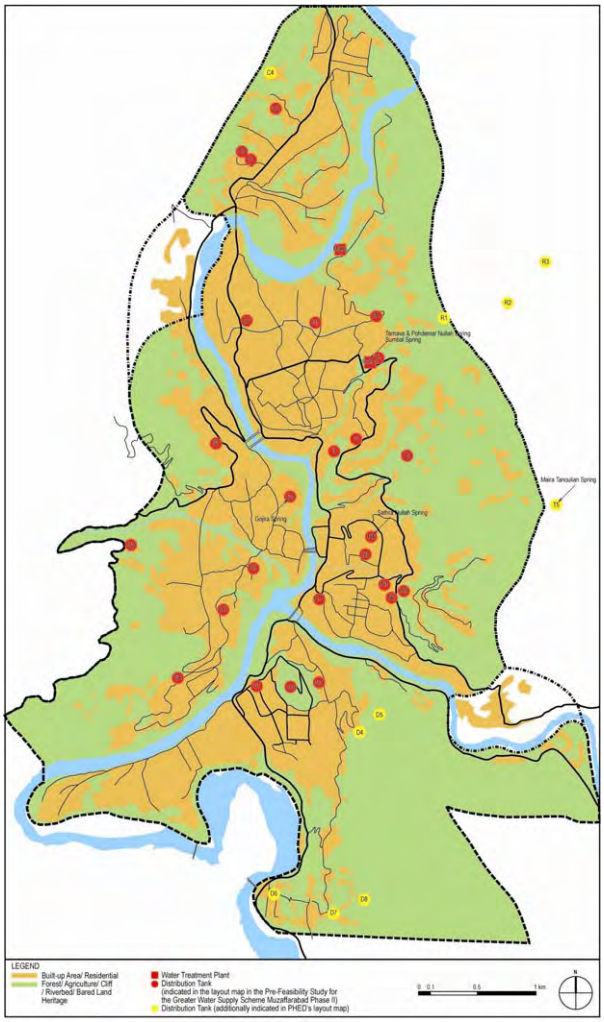
Muzaffarabad – Balakot Road separates from Neelum Road southward of Madina Market, crosses Alama Iqbal Bridge, and leads to Balakot to pass N-15 and to Manshera to pass N-35. The surroundings of Alama Iqbal Bridge are congested since a bus terminal is

located near the bridge and market shops are standing along the road. This road was damaged by rockfalls and slope slips; however, the damages do not affect the current road traffic on Muzaffarabad – Balakot Road since the damage level is not serious.

(2) Other Infrastructure

a. Water Supply

Main raw water was obtained from the Neelum river which flows in north and south direction in the west side of the old city. Pumped raw water from the Neelum river was treated at the Makri water treatment plant (WTP) located at the north of the old city, then pumped to M1 storage tank at the east of the old city. The Makri WTP had a treatment capacity of 4.0 million gallons per day (MGD). From M1 storage tank, the treated water was transmitted by gravity and pumping to other distribution tanks dispersed in the municipal area as shown in the figure below.



Source: PHED

Figure 2.1.2 Existing Water Supply System

The treated water from Makri WTP was supplemented by water resources of springs and streams. In the mountainous areas, raw water from springs was conveyed to storage tanks, then distributed to customers by gravity flow.

Tarnava Nala and Pohdemar streams flow in the northeast of Makri area. The streams supply the raw water of 0.72 MGD which is conveyed by open channel and treated in sedimentation and chlorination processes, then integrated into the treated water at Shanara storage tank.

Due to the rapid population growth in the 1990s, the municipality anticipated the shortage of water resources. The pre-feasibility study for the Greater Water Supply Scheme Muzaffarabad Phase II was consequently conducted in 2002 to identify new water resources capable of supplying the water demand in 2025. In the pre-F/S, the Neelum river was identified as the raw water resource for the target year.

Based on the conditions given in the Pre-F/S, the average daily water demand in 2005 before earthquake was estimated at 4.75 MGD, nearly equivalent to the capacity of existing water supply system of 4.72 MGD.

Table 2.1.2 Estimated Average Daily Water Demand in 2005 before Earthquake

Item	Unit	Qty.
Population*[1]	Person	114,864
Daily Domestic Water Demand per Capita*[3]	gallon/capita/day	30
Daily Water Demand for Commercial & Industrial Use*[2] (% of Domestic Demand)	%	10
Daily Water Demand for Public Use*[2] (% of Domestic Demand)	%	5
Sub-Total	million gallon/day	3.96
Unaccounted for Water*[2]	%	20
Total	million gallon/day	4.75

Source: *1 - Information obtained from MCM
*2 – Pre-Feasibility Study for Greater Water Supply Scheme Muzaffarabad Phase II, 2002
*3 – National Reference Manual on Planning and Infrastructure Standards

b. Sewerage Mnagement

Sewerage and storm water drainage system has been installed in the municipal area according to the Sewerage and Storm Water Drainage Scheme Muzaffarabad in 1998. Thereafter the Sewerage and Storm Water Drainage Scheme Muzaffarabad Phase II (1st Revision) was prepared in 2002 to cover the expanded urbanized areas due to the rapid population growth. In the revised study, the construction of the sewerage pipelines was proposed in the next consecutive seven years. However, before the completion of its implementation, the earthquake occurred in 2005.

Sewerage pipelines were installed in densely populated areas. The collected wastewater was carried to the streams and then discharged to Neelum and Jhelum rivers without any treatment process. There was no central treatment plant in the municipality.

c. Flood Protection and Storm Drainage

Storm drainage system was developed along with the sewerage system as mentioned in the previous section. Drainage system was, therefore, provided in the densely populated areas.

In 1992 the municipal area experienced the river flood. The water level rose up to the foot of the Domel bridge. Limited parts of urbanized areas located at the relatively lower ground levels experienced the inundation. The affected areas were limited to the lower lands around the Domel bridge and the riverbank in front of Block E.

d. Solid Waste Management

Solid waste in the municipal area is collected at 65 garbage deposit sites and transported to a landfill site. Daily collected volume of the solid waste is estimated to be in the range of 4,000 - 5,000 ft3. Municipality has faced insufficient provision of the landfill site and requested to the central government for the construction of new landfill site.

(3) Open Spaces

There are five parks and one stadium (Narul Stadium) in Muzaffarabad city. Also, there are footpaths beside the river in old city area.

The five parks are listed below.

- Jalalabad Garden: around 4 ha in Block-2
- Sathra Park: around 3 ha in Block-2
- Defense Park: around 1 ha in Block-3
- Thuri Park: around 12 ha in Block-3
- Neelum Park: around 3 ha in Block-4

The total area of five parks is estimated to be approximately 23 ha, the average park area per capita in whole city was estimated at 2.0 m^2 before the earthquake.

The park provision before earthquake (2.0 m^2/capita) is still low. Inadequate park provision can be highlighted by comparing it with figures in other countries (e.g., average of Japanese cities: 8.1 m^2/capita, Tokyo: 3.0 m^2/capita, London: 26.9 m^2/capita, Berlin: 27.4 m^2/capita, and New York: 29.3m^2/capita).

Especially, there is no park in the old city; therefore, the old city is a very high density area. Because of the lack of parks, park hierarchy and park network has not been established.

Regarding to the quality of parks, the construction level of the parks is still low, and there are not enough facilities in the parks.

On the other hand, there are resources to establish parks, such as historical monuments or ruins like red fort, beautiful landscapes, natural resources like rivers, etc. Based on the resources, new parks should be established. These parks are expected to be sources to expand tourism as visiting points for tourists.

The park related issues are summarized as follows.

- To expand the total park area, and establish park hierarchy
- To improve the quality of parks, especially, suitable park facilities are necessary
- To establish parks for disaster prevention, which can function as evacuation spaces
- To establish parks based on available resources to expand tourism
- To establish parks and green spaces networks connected by footpaths

2.1.4. Community in Muzaffarabad

Muzaffarabad city comprises 20 wards. Each ward can be divided into several *mohallahs* (villages). In terms of administrative structure, the city is a minimal body, but there is a representative in each ward as an administrative commander.

Gujar, Rajput, Mughal, Awan and Kashmiri are the main tribes of the district. These tribes usually live in specific areas. Muzaffarabad city is multi-ethnic and cosmopolitan in nature. Main languages spoken in the area are Kashmiri, Hindko, Punjabi and Urdu, which is the official language. In terms of culture, customs and traditions, Muzaffarabad district has close bonds between relatives and close neighbors such that events of happiness and sorrow are celebrated together. People help in such events by arranging in their houses, the reception and hosting of guests and helping in all sorts from buying the food to its cooking and serving. These traditions, no doubt, though getting weaker are still the strong ties and hold people together like brothers.

Another important aspect to mention about this region is the high literacy rate. The literacy rate of the district among the population aged 10 years and above is 46.95%, 63.13% in urban areas and 43% in rural areas. The male literacy rate is 63.27% compared to 29.40% for female.

Apart from this structure, there are community-based organizations (CBOs) in some wards. In the rural or mountainous wards, CISP (Community Infrastructure Support Program) has been implemented funded by World Bank (WB) since three years ago. In this connection,

CBOs were organized with WB's initiative based on the guideline of WB. The members of CBOs are mainly representatives of *mohallahs*; and they were elected. In this program, CBO was funded through Municipal Corporation of Muzaffarabad (MCM).

In addition to these CBOs initiated by WB, a CBO organized spontaneously. The CBO Ward 13 is this type of CBO. Some voluntary members in the ward started to support some community members who did not have enough money in case of marriage, etc. by donation.

Some CBOs have been active and others not. According to people, there was some corruption by some members of CBO. Aside from CBOs, there were some active volunteers in many wards in the relief activities after the earthquake.

In terms of society and community, families have the strongest ties. Many families are combined families. For instance, if there are three families, they would be main family, the brother's and the son's families. They live on separate floors in a three-story house. In addition, relatives, neighbors, and tribes have strong bands of mutual help. All types of communities for mutual help including CBOs will play an important role for restoration and reconstruction. Especially in case of area-based restoration and reconstruction, CBOs can be considered as a key player in an area. For example, debris removal on small streets/foot passes in residential area, or considering neighboring parks in the area, such area-based organization for mutual help will be required; and CBOs are the most relevant form of community for restoration and reconstruction at present.

2.2. 2005 Kashmir Earthquake

2.2.1. Characteristics of Earthquake

Muzaffarabad city and its vicinity are located in one of the most earthquake-prone areas in the world. Examples of significant earthquake in this area are the 2005 Kashmir Earthquake and the historical earthquake that happened in 1555[1]. The earthquake motion caused by the 2005 Kashmir Earthquake gives important information for the rehabilitation plan of Muzaffarabad city. Characteristics of this earthquake are given below.

Because there had not been any seismograph set up in the Muzaffarabad city area, neither the intensity of the earthquake motion nor the distribution of the earthquake motion was measured directly.

However, the ground motion can be estimated from two items: the seismic source process and the propagation process. As already known, Muzaffarabad city is very near the source fault, and the rupture zone of the source fault was shallow. Therefore, the studies of Japanese researchers can offer a very good clue to identify the intensity of the earthquake motion and the distribution of the earthquake motion. Such studies are the results of detailed source rupture process analyzed by Yagi Yuji of University of Tsukuba[2], and the results of ground surface shift reported by the Japan Geographical Survey Institute[3].

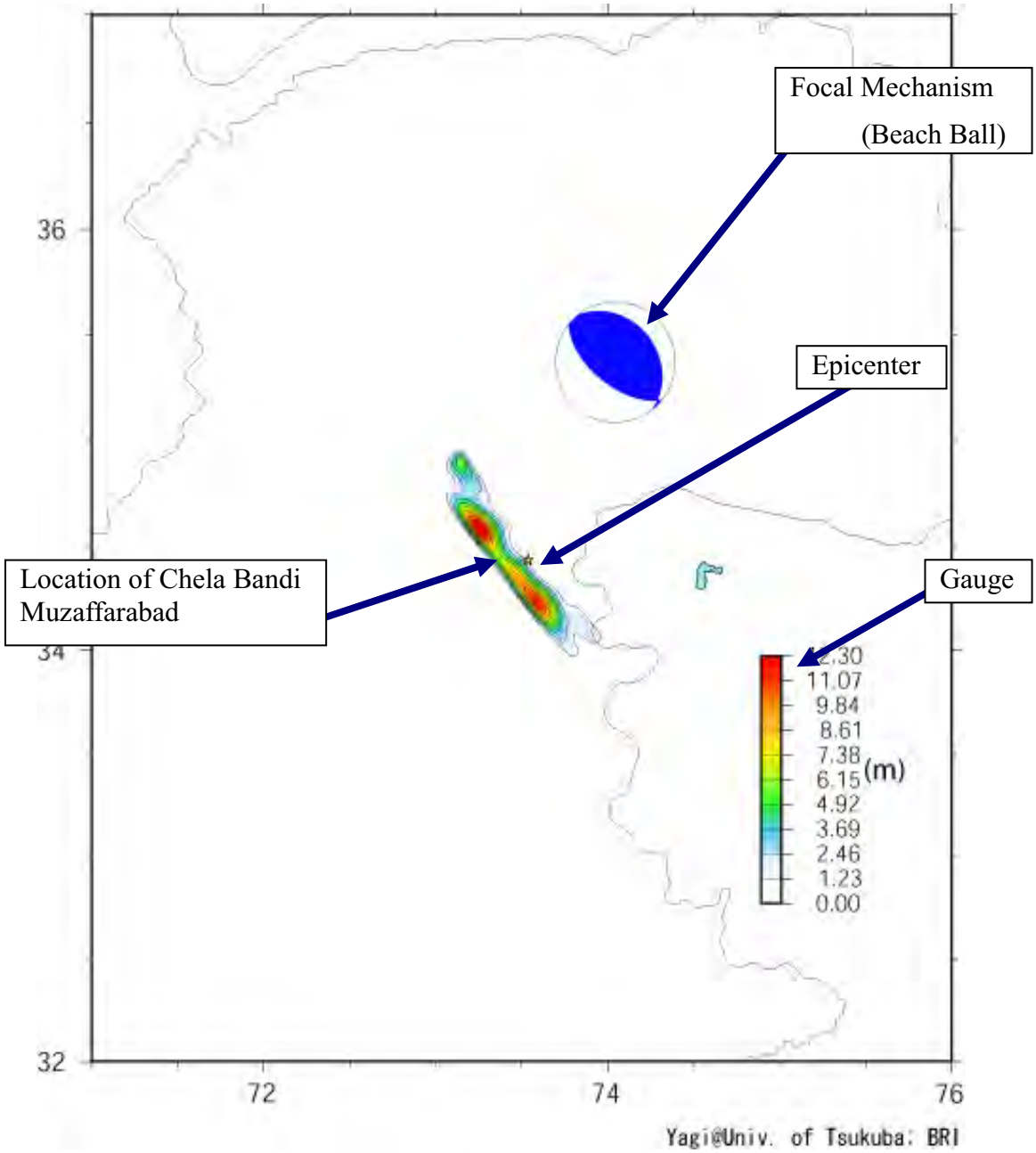
First of all, Yagi analyzed the distribution of slip of the earthquake fault referring waves which IRIS-DMC collected. The result of inversion analysis, which is shown in Figure 2.2.1, was examined by Yagi using seismograph records adopting the new inverse operation method. The result indicates that destruction in the fault plane was not homogeneous. This gives many explanations of bull and bear of ground acceleration, the reason why the damage at Chela Bandi was especially large for example.

[1] Y.Kumakura, T. Nakata: Active Fault in the Epicentral Area of the 2005 Pakistan earthquake, Research Center for Regional Geography Hiroshima University, March 2006

http://cires.colorado.edu/bilfam/Kashmir%202005.htm

[2] Source: http://www.geo.tsukuba.ac.jp/press_HP/yagi/EQ/2005Pakistan/

[3] Crustal Deformation of 2005 Pakistan Earthquake by SAR
Source: http://cais.gsi.go.jp/Research/space/pakistan/index.html



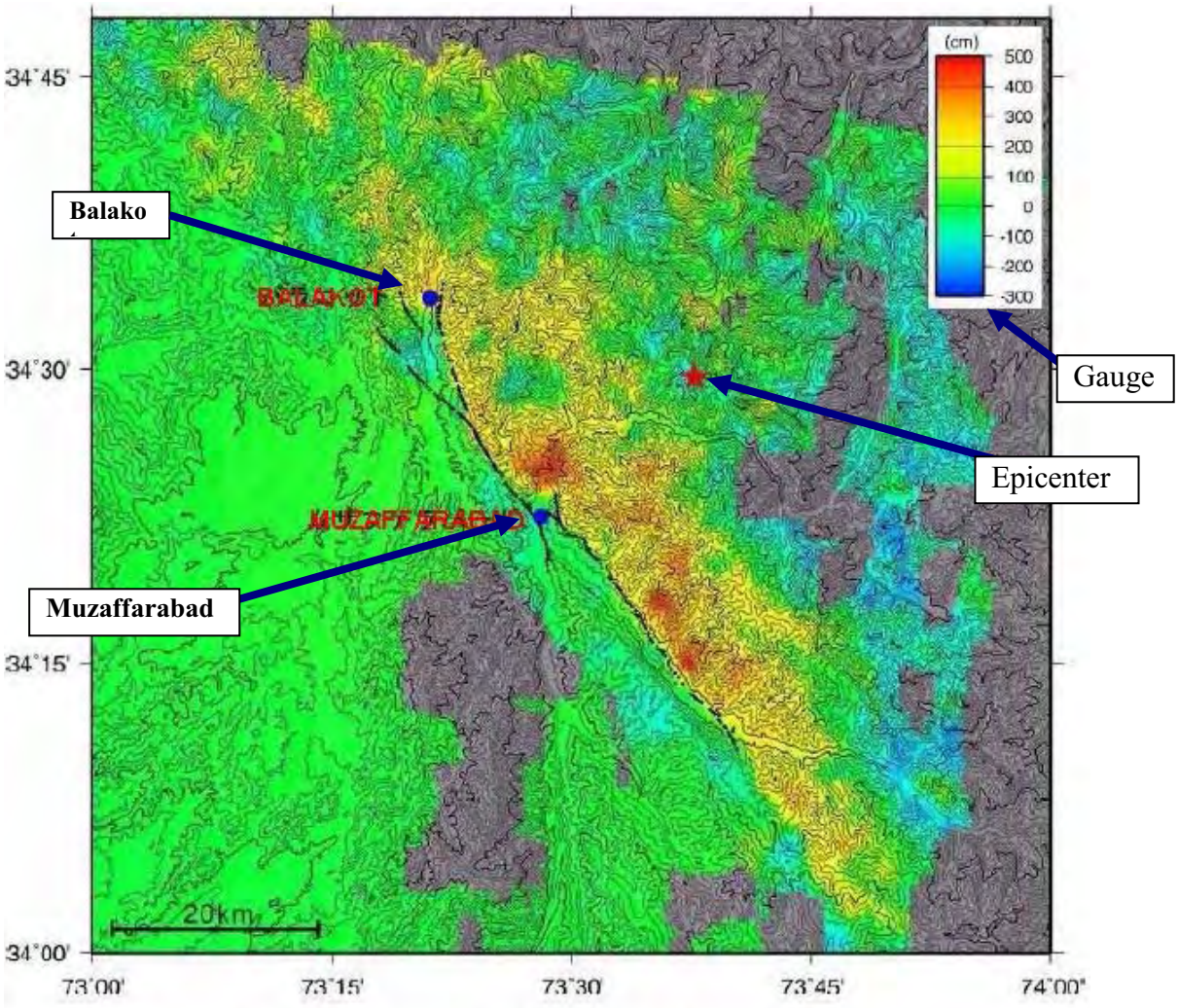
Source: http://www.geo.tsukuba.ac.jp/press_HP/yagi/EQ/2005Pakistan/

Figure 2.2.1 Distribution of the Fault Slip (by Yagi et. al.[4])

Japan Geographical Survey Institute also reported detailed information about the ground surface shift induced by crust shift. Distribution of the ground surface shift is shown in Figure 2.2.2. This figure was obtained by image matching method using the image from synthetic aperture radar set up in the satellite. This figure illustrates the factors behind the large earthquake motion of the northern part of Muzaffarabad (Chela Bandi) and Balakot.

[4] Distribution of fault-slip PAKISTAN 2005 October 8 03:50:38 UTC
(Source: http://www.geo.tsukuba.ac.jp/press_HP/yagi/EQ/2005Pakistan/)

Figure 2.2.2, on the other hand, shows the location of Tanda fault (black line) and epicenter (red star) identified by USGS.



(a) Japan Geographical Surveying Institute (JGSI)

Source: Japan Geographical Surveying Institute

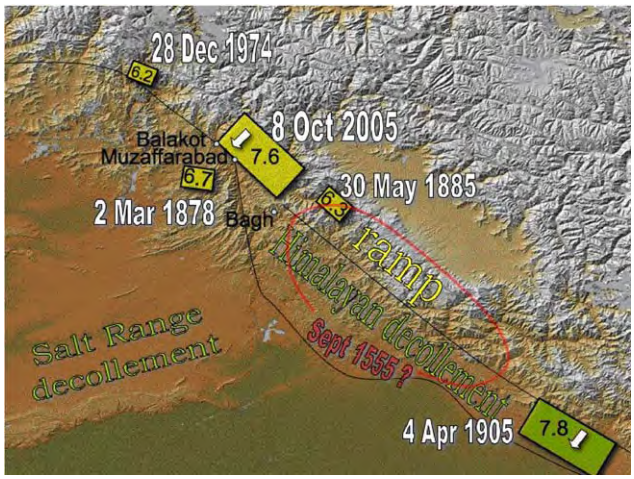
Figure 2.2.2 Distribution of the Ground Surface Shift

When Figure 2.2.1 and Figure 2.2.2 are observed, an idea is formed that the distribution of large slip in the fault and the distribution of crust shift explain the distribution of ground acceleration induced by this earthquake.

- Crust shift was concentrated to the northern part of Muzaffarabad close to the area designated as Chela Bandi.
- Significantly large effect at Balakot is understandable since Balakot is located on the hanging wall side of the fault plane.

Characteristic features of Tanda fault were clarified through the investigation done by GSP's and some Japanese researchers[5] after the 2005 Kashmir Earthquake. Their impressions are that the earthquake fault has the potential to slip again in near future because the strain of the crust of this area was not released so completely.

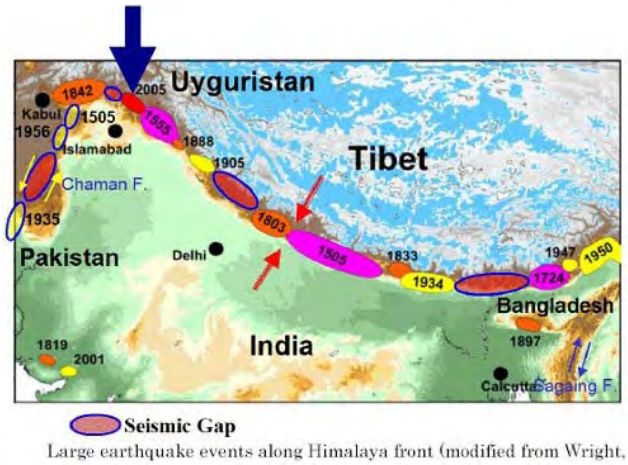
CIRES website shows a fault which is similar to Jhelum fault, but it reported that the data of earthquake in Kashmir occurring in 1555 is insufficient to assign it a magnitude or location (refer to Figure 2.2.3)



Source: http://cires.colorado.edu/~bilham/Kashmir%202005.htm

Figure 2.2.3 Fault near Muzaffarabad

When tectonics within a wide range is considered, the faults around this site are assumed to be part of the Himalayan front. (See the part marked by red circle 2005 in Figure 2.2.4)



Large earthquake events along Himalaya front (modified from Wright, 2005)

Source: http://cires.colorado.edu/~bilham/Kashmir%202005.htm

Figure 2.2.4 Himalayan Front

[5] Y. Kumakura, T. Nakata: Active Fault in the Epicentral Area of the 2005 Pakistan Earthquake, Research Center for Regional Geography Hiroshima University, March 2006

It is considered that the return period of occurance in this area is assumed to be over several hundred years.[6] Based on these observation, it is possible to say the following:

- It is necessary to understand that the fault which caused the 2005 Kashmir Earthquake is a target of disaster reduction for Muzaffarabad.
- Careful discussion is needed to evaluate the intensity of risk considering the precision of existing information.
- Some balance between risk and feasibility is needed for the next step.

2.2.2. Earthquake Damage of Building

This paragraph describes the situation of the building damage due to the 2005 Kashmir Earthquake. Good PGA accuracy cannot be obtained by conventional attenuation equation because the epicenter of the 2005 Kashmir Earthquake is extremely near to Muzaffarabad (about 20 km).

On the other hand, the distribution of the damaged buildings can offer good information on ground motion. Thus the building investigation at this time gives a broader perspective of earthquake damage in Muzaffarabad although it was not necessarily as detailed as an inventory study.

(1) Investigation method

The damage rate was evaluated by general observation since the accurate number of buildings cannot be specified because basic data of the building census etc. cannot be obtained in the locale.

The damage rate is a value defined in Equation (2.1).

$$Damage \cdot ratio = \frac{Number \cdot of \cdot Damaged \cdot Buildings}{Total \cdot Number \cdot of \cdot Buildings} \qquad (2.1)$$

It is assumed that the Number of Damaged Buildings is the number of buildings where damage state was more than ‘very heavy damage’ in European Macroseismic Scale 1992.

Investigation area was divided into 30 zones with reference to the boundary of regional division. Representative area with all sides of 100 m was selected, and the Number of Damaged Buildings and the Total Number of Damaged Buildings were counted.

[6] Y. Kumahara, T. Nakata: Active Fault in the Epicentral Area of the 2005 Pakistan Earthquake, Research Center for Regional Geography Hiroshima University, p. 8, March 2006

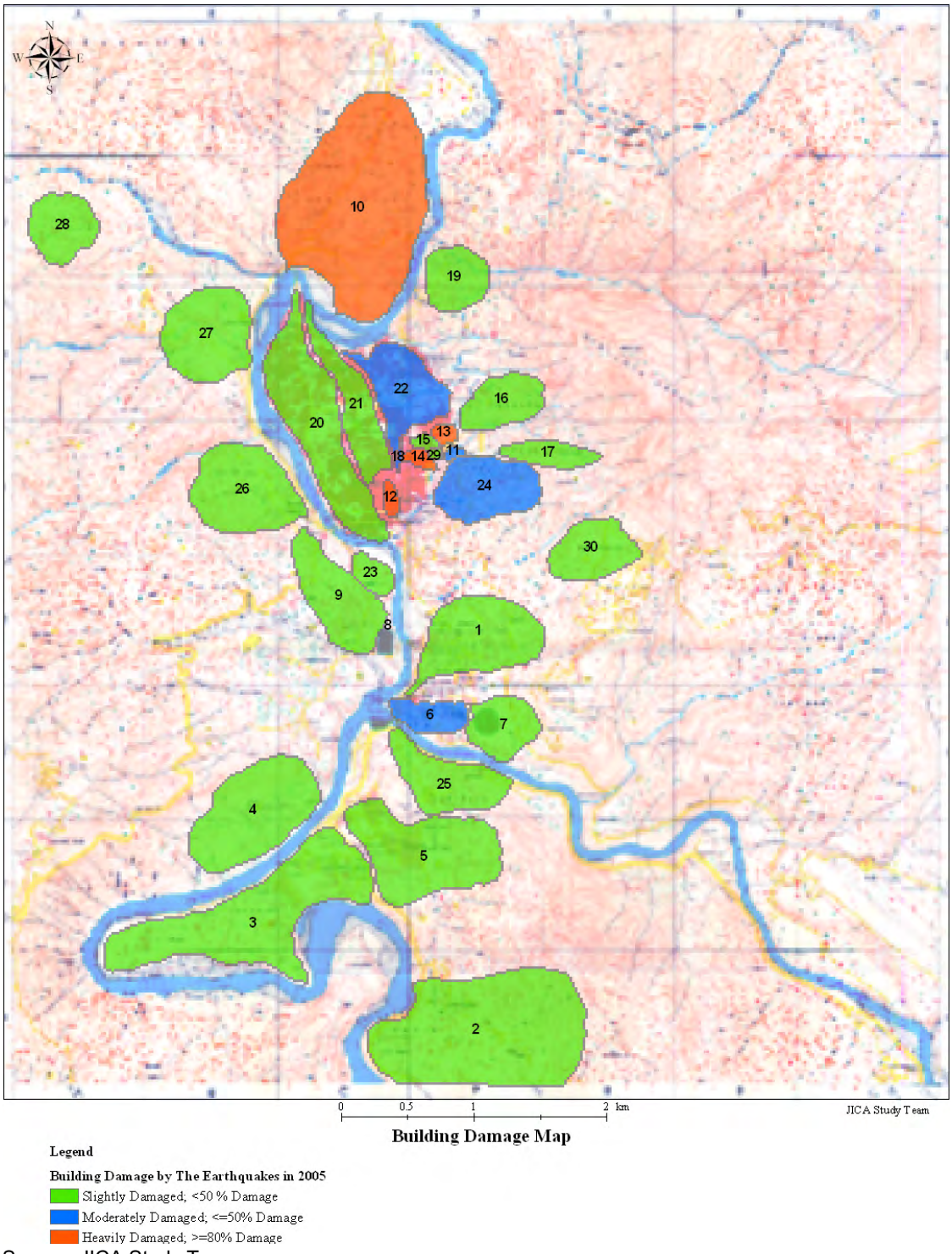
(2) Damage Rate

The investigation results are shown in Table 2.2.1. The distribution map of damage rate is shown in Figure 2.2.5. The value of damage rate in each zone was made difficult because each damaged building was in close contact with another. In addition, it was exceedingly difficulty to identify each building when they were totally collapsed.

Table 2.2.1 Building Damage Assessment Survey Results

Zone	Location	Damage Rate (%)	
		From	To
1	Jalalabad	40	45
2	Upper Ambor	20	25
3	Lower Chatter	12	15
4	Naluchi	40	45
5	Upper Chatter	20	25
6	Domel Syedian	50	55
7	Narrul	20	25
8	Chinar Camp	10	12
9	Gojra	15	20
10	Chela Bandi	70	75
11	A G Office (Satra Hill)	40	50
12	Madina Market	50	60
13	Sethi Bagh Mohalla	60	70
14	Shah Nara	60	65
15	Khawaja Mohalla	70	80
16	Dheri Syedian	30	45
17	Ranjatta	40	45
18	Gulshan Colony	50	55
19	Makri	20	30
20	Lower Plate	15	20
21	Center Plate	25	35
22	Upper Plate	45	55
23	Shaukat Line	20	30
24	Tariq Abad	50	60
25	Sund Gali (Upper Domail)	30	40
26	Baila Norr Shah	20	30
27	Panjgran	5	10
28	Shahwai	10	15
29	Babu Mohalla	40	45
30	Maira Tanoulian	35	40

Source: JICA Study Team



Source: JICA Study Team

Figure 2.2.5 Distribution Map of Damage Rates

(3) Factor of Damage

Damage state is caused by a combination of ground motion, capacity of ground, and seismic resistance of the building. If the attributes of the buildings in each area were specified, it could provide good data to calibrate the survey results and to identify the ground motion of each area. The attributes of the buildings in each area are shown in Table 2.2.2.

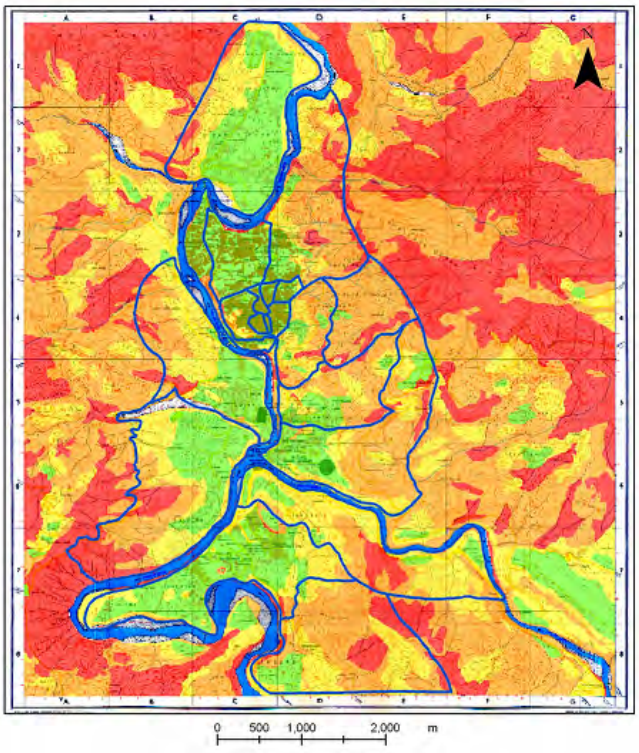
Table 2.2.2 Attributes of Buildings by Area

Sr.No	Location	Building Types % ages								
		RC Frame		Reinforced Masonry		Non Engineered Masonry				
		A	B	C	D	E	F	G	H	I
		RC frame with RC wall	RC frame with Brick wall	Cement Block	Brick (with RC floor)	Cement Block	Brick	Square shaped stone	Cobble	Adobe
1	Jalalabad	0.00	23.08	15.38	15.38	15.38	23.08	0.00	7.69	0.00
2	Ambor	0.00	0.00	0.00	50.00	0.00	50.00	0.00	0.00	0.00
3	Lower Chatter	0.00	0.00	0.00	20.00	20.00	60.00	0.00	0.00	0.00
4	Naluchhi	0.00	0.00	0.00	0.00	33.33	33.33	33.33	0.00	0.00
5	Upper Chatter	0.00	40.00	20.00	0.00	0.00	40.00	0.00	0.00	0.00
6	Domel Syedian	14.29	42.86	0.00	14.29	14.29	0.00	0.00	14.29	0.00
7	Narrul	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Chinar (Army)	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Gojra	0.00	40.00	0.00	0.00	40.00	0.00	0.00	20.00	0.00
10	Chehla Bandi	15.38	30.77	15.38	30.77	7.69	0.00	0.00	0.00	0.00
11	AG Office (Satra Hill)	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	Madina Market (Old City)	0.00	0.00	50.00	50.00	0.00	0.00	0.00	0.00	0.00
13	Sethi Bagh Mohalla	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
14	Shah Narra	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
15	Khawaja Mohalla	0.00	0.00	57.14	42.86	0.00	0.00	0.00	0.00	0.00
16	Dherian Syedian	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
17	Ranjatta	0.00	0.00	20.00	60.00	0.00	0.00	0.00	20.00	0.00
18	Gulshan Colony (Eid Gah Road)	0.00	33.33	50.00	16.67	0.00	0.00	0.00	0.00	0.00
19	Maakri	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00
20	Lower Plate	0.00	20.00	20.00	20.00	20.00	0.00	0.00	20.00	0.00
21	Center Plate	0.00	36.36	54.55	9.09	0.00	0.00	0.00	0.00	0.00
22	Upper Plate	0.00	28.57	57.14	14.29	0.00	0.00	0.00	0.00	0.00
23	Shaukat Lines	0.00	0.00	20.00	60.00	0.00	0.00	0.00	20.00	0.00
24	Tariq Abad	0.00	14.29	57.14	0.00	0.00	0.00	14.29	14.29	0.00
25	Sund Gali (Upper Domail)	0.00	8.33	50.00	0.00	25.00	0.00	8.33	8.33	0.00
26	Baila Noor Shah	0.00	33.33	66.67	0.00	0.00	0.00	0.00	0.00	0.00
27	Panjgran	0.00	40.00	20.00	40.00	0.00	0.00	0.00	0.00	0.00
28	Shawai	0.00	33.33	0.00	0.00	0.00	33.33	0.00	33.33	0.00
29	Babu Mohalla	0.00	80.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00
30	Maira Tanoulian	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

A	(E) RC frame with RC wall	B	(E) RC frame with Brick wall	C	(R.M) Cement Block
D	(R.M) Brick (with RC floor)	E	(N.E) Cement Block	F	(N.E) Brick
G	(N.E) Square shaped stone	H	(N.E) Cobble	I	(N.E) Adobe
E	**Engineered**	**R.M**	**Reinforced Masonry**	**N.E**	**Non Engineered**

Source: JICA Study Team

It was reported that a lot of buildings were damaged by landslides. Such landslides were found at several slopes. They were caused by supporting slope failures triggered by the earthquake. The slope inclination distribution map is shown in Figure 2.2.6 for reference.



Green: 0° - 7°

Yellow: 8° - 20°

Orange: 21° - 30°

Red: 31° - 90°

Source: A.J.K. State Government

Figure 2.2.6 Slope Inclination Map

(4) Understanding from Building Damage

Some observations from Table 2.2.1 and Table 2.2.2, and Figure 2.2.5 and Figure 2.2.6 are described below.

- The first impression from Figure 2.2.1 is that the damage rate of Chela Bandi (area 10) is very large compared with that of other areas. This finding can be supported by Figure 2.2.1 and Figure 2.2.2, which show the source location of the 2005 Kashmir Earthquake. Figure 2.2.7 shows the relation between the location of Chela Bandi and that of the source location of the 2005 Kashmir Earthquake. In a word, the location of Chela Bandi was the nearest to the relative displacement of the fault plane that caused the 2005 Kashmir Earthquake. Moreover, the surface faulting is winding in this part and surrounding Chela Bandi.

Based on these findings, it is reasoned by analogy that the earthquake motion of the base rock of this area was larger than that of other parts.

On the other hand, it is understood that there was a little difference of the amplification in the surface layer of different parts of Chela Bandi when damage of each part is observed in detail. In general, a comparatively high place vibrates freely and easily because the surface layer is thick. Therefore, damage of these parts was large because the earthquake motion was amplified.

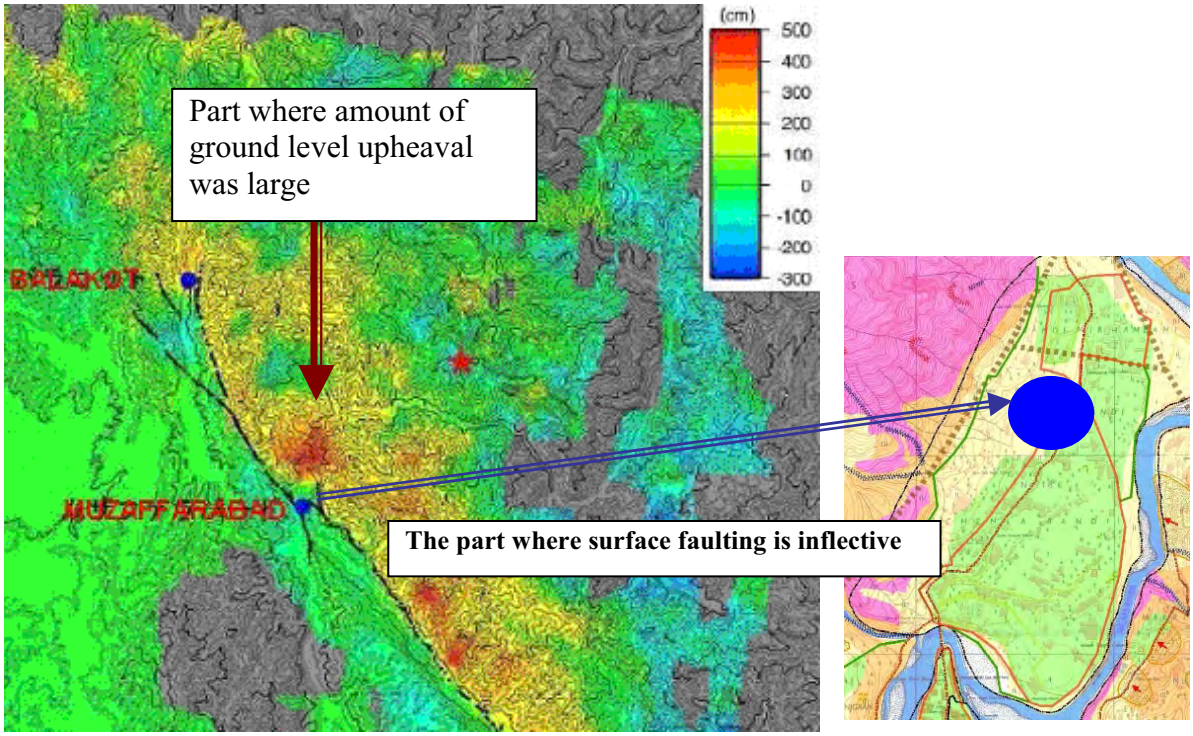


Figure 2.2.7 Situation near Chela Bandi

- The damage rates of Madina Market (Zone 12), Sethi Bagh Mohalla (Zone 13) and Shah Nara (Zone 14) were also large compared with that of another area.

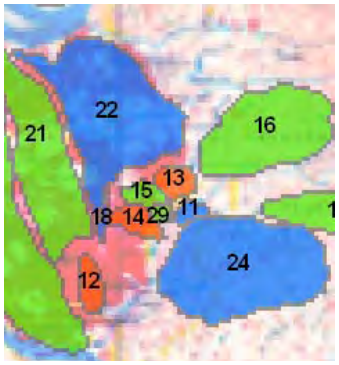
The reason why the damage rates of these areas were large is that they are comparatively high places where the ground vibrates freely and easily because the surface layer is thick. Moreover, these parts are located at the ridge of a cliff. A lot of examples of high ground motion were found in the areas in the previous earthquake disaster area. Therefore, damage of these parts was large because the earthquake motion was amplified.

- Tariq Abad (Zone 24) is an area where the slope is steep and the buildings are overcrowded. Insufficient masonry retaining wall was a common condition.

In this small developed area, each building with insufficient masonry retaining walls was destroyed due to circular slip of ground.

- The damage rates of Gulshan Colony (Zone 18) and Upper Plate (Zone 22) were also large compared with that of other areas.

The reason why the damage rates of these areas were large is also attributed to their comparatively high locations where the ground vibrates freely and easily because the surface layer is thick. Another reason of high damage rate of this area is that the predominant building type in this area was masonry.



Source: JICA Study team

Figure 2.2.8 Locations of High Damage Rate (50%～80%)

As mentioned above, reasonable explanations were given to each observation of very severely damaged area (over 80%) and severely damaged area (50%～80%).

2.2.3. Emergency Response Period

(1) Rescue and Relief Efforts

On the morning of October 8, 2005 an Earthquake shook the northern part of Pakistan. Its affect was felt in the areas over 500 km from the epicenter. The main earthquake and

aftershocks were evidence of the intensity of earthquake, but at that very moment no one realized the grave devastation done by the quake.

Within 20 minutes, the news of collapse of Margalla Towers, Islamabad, was aired and the focus of rescue teams was in Islamabad. Later on when it was known that the earthquake measured 7.6 on the Reichter scale and its epicenter was near Muzaffarabad in Azad Jammu and Kashmir (AJK), the people started to inquire about the devastation done by the earthquake in these areas.

The governments of Pakistan and AJK were taken by complete surprise as there had been no earthquake in this region especially of such shallow depth. Although the region was in an earthquake zone, the preparation for such an earthquake was far from what should have been in a high intensity earthquake zone. In terms of rescue, awareness, disaster preparation, debris removal equipment and techniques, landslide awareness, building construction techniques, organization of relief efforts, alternate transportation routes, air support, in all departments everything seemed inadequate. Besides the intensity of earthquake, it seemed that most of damage was done by poverty, lack of awareness and education regarding disaster management, delay in rescue, lack of knowledge regarding site selection for buildings, workmanship in building construction, use of materials, etc. The death toll rose gradually day by day and despite all efforts; thousands died under the debris waiting for rescue that never reached them.

(2) Government and Army Response

The Government of Pakistan has done an excellent job in working to address the needs of the disaster victims by utilizing the leadership skill, resources and organizational capability of the military.

The Pakistan Armed Forces took on the leadership role in controlling and focusing government relief efforts. They effectively demonstrated their ability to organize, manage and respond to the crisis. No other domestic agency could handle the logistical and manpower requirements of the relief operation.

According to Inter Services Public Relations (ISPR) sources, the Government received news about the devastation that the earthquake had done in AJK and NWFP within the first hour of the earthquake and Pakistan Army helicopters were airborne within 50 minutes of the news, to commence a seemingly unending rescue operation.

All roads leading to the earthquake affected areas were blocked owing to massive landslides along these roads. The only effective way to reach these areas was by helicopters. As always, the military responded and many unsung heroes deserve the admiration of the whole nation

as they flew uncounted sorties to these areas to fly out injured people to hospitals all over the country. Heroic efforts were made by helicopter pilots – some returning to villages at dusk to evacuate additional wounded.

Many doctors from army and civil sectors reached AJK and NWFP areas to provide medical treatment to the suffering people. Thousands of injured were treated by a team of 121 army doctors and 334 paramedics in forward areas. Similarly, hundreds of doctors and paramedics were busy at their respective hospitals all over Pakistan treating injured from earthquake affected areas.

Combined Military Hospital and Military Hospital Rawalpindi received the majority of patients. Army doctors at the Combined Military Hospital and Military Hospital Rawalpindi carried out 1,925 major operations and 3,100 minor operations. At Armed Forces Institute of Pathology and its affiliated laboratories over 12,000 tests were carried out and an almost similar number of X-rays were made.

In civil sector RGH, Rawalpindi and PIMS, Islamabad received maximum patients from earthquake affected areas. These patients included hundreds of patients with spinal, serious head injuries and multiple fractures. Most of these cases were treated by performing major operations.

Hundreds of Army soldiers were involved in removal of debris to rescue people and providing them medical assistance. Many soldiers were seen carrying 30 kg packs of relief supplies to remote areas in hills and returning with injured on their backs. These operations continued irrespective of time, weather and equipment constraints.

Another service given by various government and army agencies (NHA & FWO) was clearance and restoration of access in record time. This made it possible to transport relief workers and goods to the earthquake affected areas. Similarly, some other Government department did a tremendous job to provide services in restoration of electricity, water supply and communication.

The Pakistan Armed Forces embraced and accepted support and advice from other countries, organizations, and the private sector.

The government of Pakistan has shown strength and leadership by welcoming relief support from multiple international governments, relief agencies and the private sector. The government wisely and quickly implemented emergency powers for agencies that needed to increase their capacity to respond within a short timeframe.

In addition, the government of Pakistan constituted a presidential relief fund to collect donations for relief and direct the same, where they were needed most, for avoidance of duplication of efforts and to properly and efficiently serve the target group's needs.

Government response was not only in the form of military operations regarding rescue and relief, but also made some significant accomplishments in the form of organization of efforts done by various individuals and NGOs, by coordinating these efforts and directing them to where needed most. Similarly they organized checks on vehicles leaving earthquake areas to check on kidnapping of orphans and widows. Safety of the survivors was ensured.

Moreover, the government of Pakistan organized a Donor's conference to coordinate the efforts of various international donors and recorded their pledges and form of donation regarding the earthquake areas of AJK and NWFP.

(3) International Community Response

After the October 8 devastating earthquake in most parts of Azad Kashmir and NWFP, the world community contributed generously in terms of relief items for the survivors. According to the figures collected from different sources including the ISPR, 49 countries around the globe either donated the relief items or sent their medical or rescue teams to help people in the hour of distress and need.

(4) NGO's Response

Non government organizations both national as well as international levels have also contributed generously and remained sixth in the list of main contributors. The role played by NGOs in organizing these efforts was also marvelous. They provide help not only in the relief and rescue, but also in the rehabilitation of the people. Running tent schools, locating and securing safety of orphans and widows, organizing media campaign, providing information regarding hygiene, safety etc were some of the sectors in which local and international NGOs played a vital role.

(5) Individual's Response

There has been an outstanding unified response by the people of Pakistan. After the earthquake, and when access to the areas was secured, it seemed that all of Pakistan was traveling towards these hilly areas, with all the relief supplies they could arrange in this difficult time. Hundreds of civilian volunteers of all ages and walks of life were seen working day and night in these dangerous circumstances, to take out people from the debris, arranging the burial of dead, giving treatment to the injured, and providing moral, nutritive and financial support to the shocked. Never in the history of Pakistan was such an example of brotherhood, sharing, sacrifice seen, as people traveled from over 1,600 km with relief

goods and donations for their brothers affected by this massive natural disaster. This outreach was a sign of strength enabling Pakistan to do their best for the disaster victims.

Pakistani expatriates also contributed generously. They sent 11,523 tents, 779,418 blankets and huge quantity of other relief items, which included food and medicines for the quake affected.

(6) Media's Response

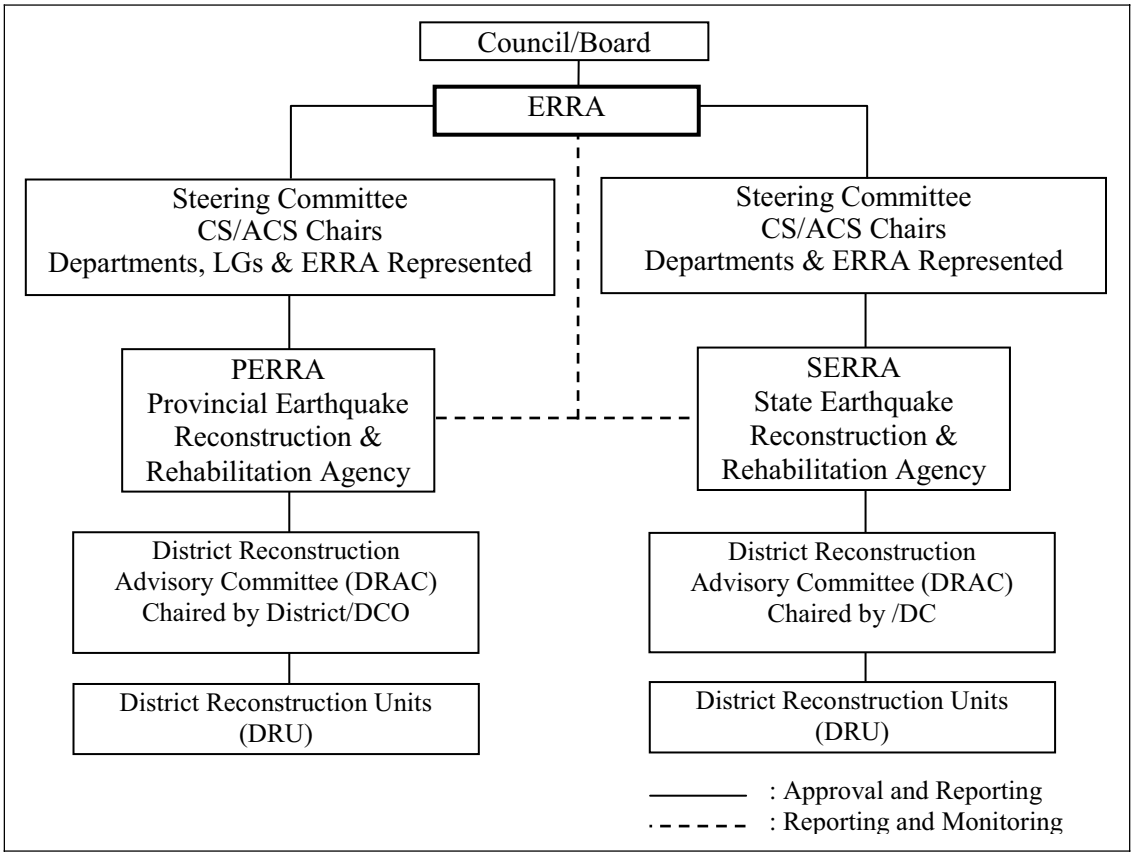
The role of media should not go without praise. In the entire rescue and relief effort, and even now in reconstruction and rehabilitation, the media played a very positive role. They provided news updates regarding the earthquake, informed people regarding the intensity of devastation, propagated the intensity and need of relief from the private sector, ran shows to provide updates of the relief, reconstruction and rehabilitation process, educated people regarding the reconstruction of their homes as per the requirement of earthquake zone, informed people regarding the procedures laid down by government agencies for seeking compensation and help, organization and coordinated efforts of various NGOs, government agencies and individuals, organizing live shows providing connection between the rescue and relief teams and the people of areas where the help had not reached at that time. It was due to efforts of media that the dire need for the combined and individual efforts was provided. In the rehabilitation sector, a lot of celebrities of TV and film visited earthquake affected areas to celebrate Eid and other festivals with earthquake affected people, and bringing gifts and financial assistance for them.

In reconstruction phase, the media is still playing its expected role of conducting live shows to provide updates regarding the reconstruction and rehabilitation activities. Besides providing people with requisite information and updates, these live shows serve to push the concerned officials to perform their duties more efficiently.

2.2.4. Recovery and Rehabilitation Progress

(1) Establishment of Administrative Organization

To provide further and ample organization and coordination of efforts, the Government established various bodies like ERRA, responsible for organizing and coordinating all reconstruction and rehabilitation works being undertaken in the earthquake affected areas. The organizational chart of the earthquake rehabilitation and reconstruction organization is shown as follows:



Source: ERRA

Figure 2.2.9 Organization Chart

a. Earthquake Reconstruction and Rehabilitation Authority (ERRA)

The ERRA is a special entity of the National Government of Pakistan. It is an autonomous organizational Authority created by the Government of Pakistan vide notification No. F1 (4)/005-Admn. dated October 24, 2005, for past disaster damage assessment, reconstruction and rehabilitation of the areas affected by the earthquake of October 8, 2005.

ERRA`s Headquarters is at the Prime Minister Secretariat Islamabad, of which it is apart. It has its sub offices in the earthquake affected areas both in NWFP Province and in the State of AJK. ERRA is responsible for the reconstruction, rehabilitation and development of earthquake affected areas. In this regard ERRA has the following functions/duties and powers.

The role of ERRA includes development of various policies and strategies regarding different sectors of development and rehabilitation. In this sector they have made comprehensive policies regarding housing, education and health. Similarly house designs have been prepared and handed over to concerned agencies to be disseminated among the masses free of cost. These designs provide information not only on construction of buildings

with various materials in a seismic proof manner, but also educating them regarding the site selection for construction of buildings.

b. Programme Steering Committee (PSC)

The President of AJK constituted a Program Steering Committee vide notification No. Adman/G-9(15)/2005 dated January 17, 2006. Chief Secretary Government is the chairman, Additional Secretary (Dev.) is the vice chairman and DG SERRA is Secretary of PSC.

PSC is AJK state's focal agency to interface with ERRA in development of implementation strategy, development of program documents, preparation of annual state & district plans, their approval and implementation of planned activities in an efficient manner.

c. State Earthquake Reconstruction and Rehabilitation Agency (SERRA)

The State Earthquake Reconstruction and Rehabilitation Agency is working under the direct control of AJK planning and development department, located in Muzaffarabad city. Since ERRA facilitates contributions by the private sector and bilateral donors, SERRA is the coordination agency in AJK to manage the allocated budget and operate the procedure for getting an approval of implementation project from ERRA.

d. District Reconstruction Unit (DRU)

District Reconstruction Unit shall be established in each district affected by the earthquake The DRU shall comprise such members as may be notified by the government of AJK.

The DRU shall have the following duties and responsibilities:

- Consolidate annual work plans on reconstruction and rehabilitation activities in the district and submit them for approval.
- Act as the secretariat for the District Reconstruction Advisory Committee (DRAC)
- Coordinate and facilitate planning and execution of all reconstruction and rehabilitation projects in district
- Monitor execution of each Project in the District
- Submit monthly and quarterly reports to PERRA and SERRA
- Disburse funds against the work done under a project
- Any other function assign to it by ERRA

(2) Policy Decisions of AJK Government

In a high level meeting held on August 2, 2006, in the office of the Chief Secretary AJK, the following policy decisions regarding organizational arrangement were taken for the implementation of actions suggested in the JICA report:

The Muzaffarabad Development Authority (MDA) shall be responsible for the implementation of actions suggested in JICA report for the rehabilitation and reconstruction project of Muzaffarabad, i.e., MDA will be the main focal point for one window operation. The Municipal Corporation, Dy-Commissioner office shall extend support to MDA.

The following tasks were identified to the authorities concerned as immediate follow up actions.

Demarcation of roads, shopping complex, schools, health centers and streets as per land use plan recommendation in the report. (Chairman of MDA)

- Listing up the families who will be dislocated due to land use plan of the city (DC Muzaffarabad)
- Selection of suitable land for the resettlement of people who will be dislocated in the vicinity of Muzaffarabad city. The acquisition of the land shall be processed on fast track. (DC Muzaffarabad)
- To enhance the capacity of MDA, it was decided that a PC-II shall be prepared by MDA immediately for approval by AJK development working on fast track; that is, anticipatory approval by the relevant forum. In PC-II, needs shall be assessed for technical assistance to strengthen the MDA through consultancy arrangement. (Chairman MDA)
- As a result of land use planning, the dislocated people shall be entitled to compensation on market rate. The Deputy Commissioner shall finalize the assessment of compensation and submit to the SERRA for release of funds from ERRA. (DC Muzaffarabad)

The relevant agencies shall prepare proposals for the approval of Government regarding the matters which require government approval such as;

- Formal decision on shifting of the District Offices.
- Approval of JICA land use plan may also be obtained from the Government formally. (Secretary of Works)
- The above actions will complete (positively) within a period of one month.

2.2.5. Donor's and NGO's Activities in Muzaffarabad

Muzaffarabad city, the capital city of AJK, has become the hub of relief efforts for the affected areas in AJK, receiving various international and domestic donors' assistance for emergency relief, such as rescue for survivors and provision of shelters and food based in the

city. Hence, there were several emergency camps organized by different agencies, inclusive of Japan Platform's in the urgent rehabilitation stage. However, after the Government stated that the tent villages should be closed by the end of April 2006, many donors withdrew from the areas.

As of June 5, 2006, some organizations are still there and working in the field shown in Table 2.2.3. Although camp management activities are not operating lately, the data issued March 27, 2006 is a reference.

Table 2.2.3 Activities of Donors in Muzaffarabad MC

Sector	Donors
Food	Turkish Red Crescent Society, Ummah Welfare Trust, Noor Social Welfare Organization, National Rural Support Programme
Emergency Shelter	Médicins Sans Frontières (Holland), Islamic Relief, Conern, International Organization for Migration, Turkish Red Crescent Society, Ummah Welfare Trust, Noor Social Welfare Organization
NFI (Non-Food Item)	Médicins Sans Frontières (Holland), Islamic Relief, Conern, International Organization for Migration, United Nation High Commissioner for Refugees
Health Supplies & Services	International Committee of Rescue Centre, Agha Khan Support Programme (AKSP), Doctors Worldwide, Médicins Sans Frontières, District Health Office, Canadian Relief Foundation, Turkish Red Crescent Society, Ummah Welfare Trust, Central Design Office, Noor Social Welfare Organization
Wastan	Oxfam, Médicins Sans Frontières, PCRWR, Turkish Red Crescent Society
Education	AL-FALAH Welfare Society, Programme for Rehabilitation of Hearing Impaired, PROHI, Turkish Red Crescent Society, National Rural Support Programme, Read Foundation, Rasees-ul-Ahrar, National Education Foundation
Protection	Save the Children (UK)
Camp Management	Al Khidamat Foundation, Al Mustafa Network, Al Mustafa Welfare Society, Al Rasheed Trust, Al Suffa Foundation, Community Group, Daily Newspaper Khabrain, Dewan Mushtaq Group, Ehssas Relief Foundation, Fatima Welfare Trust, Idara Khidmat-e-Khaliq Foundation, Khubaib Foundation, Lighthouse Association, Turkey, Minhag Welfare Foundation, MQM, Muslim Hands, Pakistan People's Party, Peera Da Bagh, Star Management Group, Veerjee Manir Singh, Youth Federation, Youth Group, HF-G, UWT, NSWO

Note: Sectors except Camp Management issued May 31, 2006
Camp Management Sector issued March 27, 2006
Source: HIC

(1) SERRA

ERRA was established by the government in October 2005, for reconstruction and undertaking strategic planning in the affected districts. There are two regional offices under the umbrella of ERRA, i.e., PERRA and SERRA. PERRA, which stands for Provincial Earthquake Reconstruction and Rehabilitation Agency, is over NWFP.

According to the updated document issued by SERRA in May, the committed amount for AJK by donors is around Pak Rs. 64,420 million, which is equivalent to US$ 1,073 million as shown in Table 2.2.4. The main donors are ADB, Japan, Saudi Fund, IDA/WB and Germany.

Table 2.2.4 Sector/Donor-Wide Reconstruction Estimates and Pledges for Reconstruction/Rehabilitation of Earthquake Area of AJK

Million

S.#	Sector	Estimated Raconstruction Cost	Donors Pledges/Commitments															TOTAL	BALANCE
			ADB	JAPAN	SAUDI FUND	Bosnia	IDA/WB	PRCS	GERMANY	USAID	OPT HEART BEAT	MGPO	PAK NAVY	KRCS	UAE	IDB	APCA		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Transport & communication	6140.4	5055.750	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5055.750	1084.650
2	Physical Planning & Housing	5153.226	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5153.226
3	Local Development & Rural Dev.	4297.153	0.000	0.000	0.000	0.000	1038.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1038.000	3259.153
4	Education	28239.670	1416.45	3015.642	2700.000	22.568	1323.540	85.044	39.784	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8603.028	19636.642
5	Health	5926.171	1782.000	932.799	0.000	10.785	0.000	43.140	1099.260	414.117	155.277	10.785	51.759	10.785	640.472	1340.52	640.472	5926.171	0.000
6	Live Stock	8504.133	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8504.133
7	Agriculture	3686.643	0.000	0.000	0.000	0.000	38.460	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	38.460	3648.183
8	Electricity	781.850	781.85	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	781.850	0.000
9	Hydro Electric Board	104.819	104.819	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	104.819	0.000
9	Foresty	506.273	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	506.273
10	Industries/ sericulture	907.120	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	907.120
11	Social Welfare	78.189	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	78.189
12	Tourism	76.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	76.000
13	Information Technology	19.231	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	19.231
	Total Pak Rs.	64420.050	9140.040	9101.667	2700.000	33.372	2400.000	128.184	1139.044	414.117	155.277	10.785	51.759	10.785	640.472	134.520	640.472	21547.250	42872.800
	Total US $	1073.668	152.334	151.694	45.000	0.556	40.000	2.136	18.984	6.902	2.588	0.180	0.863	0.180	10.675	2.242	10.675	359.121	714.547

Source: SERRA

(2) Education Sector

Because the Department of Education was not functioning properly after the earthquakes, UNICEF is playing the role of coordination body to have meetings with other donors, organizing sub-groups such as reconstruction, teacher training and camp school. The groups are functioning through fortnight coordination meetings. UNICEF is taking care of private sector as well as public sector in terms of education.

According to information on school construction plan gained from UNICEF, other donor agencies including DFID, UNICEF and WB are focusing more on rural areas than urban, so there has not been much donor intervention so far within the Study's target area of Muzaffarabad. Only ADB has already committed to construct 132 middle schools and 9 high schools, covering some permanent structured schools in the municipality. Additionally, it does not mention that Turkish NGOs have commenced to construct 6 schools, including 2 colleges and 4 high schools. They are prefabricated buildings and cannot be used for permanent buildings. Other donor's activities are shown in Table 2.2.5.

Table 2.2.5 Partners School Construction Plans in AJK

Semi-Permanent Structures								
Implementation partners	Semi-permanent	Permanent	Ucs	No of Schools	No of Classrooms	Design	Descriptions	Remarks
International Rescue Committee (**IRC**)	*		Danna, Kacheli, Katker		100	Foundation and 3 feet stonewall, Structure of Wood and GI Sheet	Foucusing on primary schools;2 rooms per school ;To be lasted for min 5 yrs	Children and Community involved in construction
Save the children (SCF-UK)	*		Charakpura, Langerpura	55 by end Oct;25-30 by June		Steel Frame and easy to carry	Last for 15 years	
Diakonie/ Support to Life (DEA/STL)	*		Salmia, Mera Kalan	100		CGI Sheet Frame	Focusing on Primary, Middle and High Schools, can be used at least 5 years	
	*		Mera Kalan	15 Community Centers				Use for Child Friendly spaces,vocational training for women and community activities
National Rural Support Programme (NRSP)	*		Panjgran and Heerkotli	38		Steel Frame and CGI Sheet	Focusing in two Union Councils	
		*	Gojra	12		Permanent	Focusing 2 schools through USAID funding	
Premire Urgence(PU)	*		Machira	17		Restrengthening of School tents/shelters	Focus on UC Machira	
		*		1			Develop Girls Primary School Machira as	
Canadian Relief Foundation (CRS)	*		Hatian Bala, Balgran, Gojra Bandi and Kahliana	50			Focus on Primary Schools	
Khawara Development Organisation (KDO)	*		Khatker	10 Private Schools		26×6 meters Classroom and 3 toilets	Focusing private Schools	Cardid Netherland based NGO is providing support
Idara Taleem-o-Aagali (ITA)		*	Collecting information to construct some private schools					Got some funding from ITA Office UK for Schools construction
CWS	Collecting information to construct some Schools							
Permanent Structures								
DFID		*		739 Primary Schools			Focus on Primary Schools	
UNICEF		*		250 Primary Schools			Focus on Primary Schools	Constructing model school in Ucs
ADB		*		132 Middle Schools and 9 High School			Focus on middle and High Schools	
WB		*		240 Primary Schools			Focus on Primary Schools	
Saudi Govt.		*	250 Schools+ Colleges					

Source: UNICEF

(3) Debris Removal

The Study Team implemented debris removal project in Ward 13 as a social experiment. Relevant to this, the International Organization for Migration (IOM) is conducting rubble clearing in eight sites in Old Madina Market in Muzaffarabad city, which has funding of US$1.5 million by USAID, and cleared 40,000 ft^3 debris within a year. The project was launched in April 2006 and targeted to remove an estimated 16 million ft^3 of rubble in the

next nine months. As the Muzaffarabad rubble coordinating agency, IOM is organizing coordination meetings in order to share the information with other donors working on rubble clearing.

(4) Rehabilitation and Reconstruction

Regarding Rehabilitation and Reconstruction projects in the study area, the information gained by the Study Team excluding the education sector is shown in the table below.

Table 2.2.6 Rehabilitation and Reconstruction Projects

Name of Organization	Sector	Targeted Infrastructure	Remarks
French Embassy	Basic Infrastructure	Rehabilitation of Water Supply and Sanitation	Held Meeting (16 May)
KfW (German Development Bank)	Health	Reconstruction of Abbas Institute of Medical Sciences	Held Meeting (17 May)
UAE	Health	Reconstruction of CMHs	
ADB	Health	Reconstruction of Jinnah Dental Hospital	
IOM	Environmental Infrastructure	Neelum Park alongside the river	

Source: JICA Study Team

3. HAZARD ASSESSMENT

3.1. Hazard Evaluation

3.1.1. Earthquakes

(1) Basic Consideration

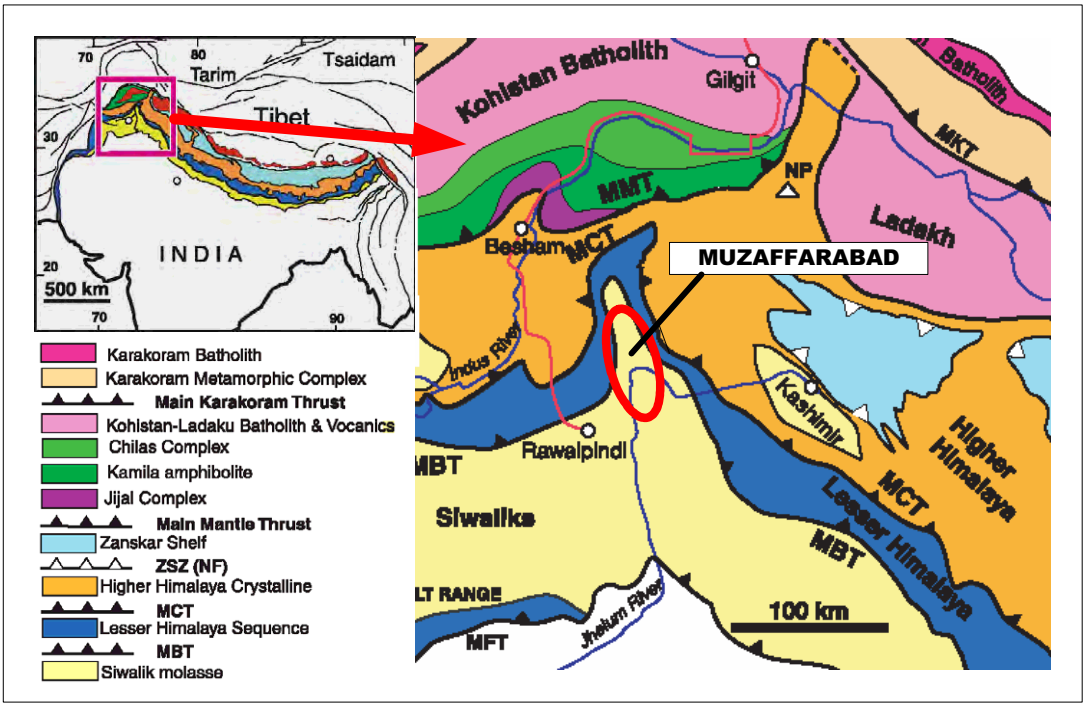
a. Geology

Muzaffarabad city lies within an area characterized by hilly terrain, where there is a high potential for natural hazards such as landslides and earthquakes to occur. A number of examples of these events have already occurred, with the most recent major event being the devastating earthquake that occurred on October 8, 2005.

Muzaffarabad city is located in one of the most geologically active terrains in the world, where the Indian Continental Plate and the Eurasian Continental Plate have been colliding since the Paleocene epoch (about 50 million years ago). The collision of these two continents has resulted in creation of the great mountain chain known as the Himalaya Mountains. The Himalaya Mountains have been tectonically developed by thrusting of the Eurasian Continental Plate over the Indian Continental Plate (Figure 3.1.1), along with the creation of major thrust faults such as the Main Mantle Thrust (MMT), the Main Central Thrust (MCT), and the Main Boundary Thrust (MBT). Movement of the Earth's crust on these major faults has resulted in unique and complicated geologic features that are characteristic of the Himalaya Mountains. Of these major faults, the MBT is the most geologically important thrust fault in the Muzaffarabad region. The MBT marks the southern limit of the Lesser Himalayas and pushes Precambrian and Paleozoic rocks southwards over the Tertiary "molasse[1]" of the Siwalik Group sediments of the Sub-Himalayas. The thrusting has propagated even further south into the Indian foreland basin. Today, the basement rock[2] of the Muzaffarabad region comprises mainly Precambrian-Tertiary rocks. These rocks often show various minor geologic structures, such as fractures and cleavages, which have been induced by the tectonic movement, for example, thrusting and folding according to development of the MBT. Therefore, the basement rock in the Muzaffarabad region is often brittle. The basement rocks in particular areas, especially along the Neelum river and the Jhelum river, are currently partially covered by Quaternary (Pleistocene-Holocene) deposits. These Quaternary deposits have not been consolidated. The Quaternary deposits form a flat or very gentle slope in Muzaffarabad city.

[1] Molasse: Detritus derived from newly formed mountains. (Source: http://www.lithoprobe.ca/media/slideset/slides/growth9.asp)

[2] Basement Rocks: The oldest rocks in a given area. (Source: http://evolution.berkeley.edu/evolibrary/glossary/glossary.php)



Source: Gansser, 1964; Searle et al., 1999

Figure 3.1.1 Tectonic Setting around Muzaffarabad

b. Ground Motion

For earthquake disaster, mitigation plan must be based on the biggest earthquake (maximum credible earthquake) which can occur in the region. A significant earthquake from this viewpoint is the 2005 Kashmir Earthquake, and another is the historical earthquake that happened in 1555.

The source of the earthquake damage can be divided into ground acceleration and relative displacement induced by the earthquake. In the succeeding paragraphs, some considerations about ground acceleration and relative displacement are described while referring to damage situation generated in Muzaffarabad at the 2005 Kashmir Earthquake and referring to another earthquake source—the Jhelum fault.

Ground Acceleration

The factors related to intensity of the ground acceleration can be summarized as follows.

Distance from fault plane where slipping occurs

The dip of the Tanda fault which caused the earthquake at this time was towards the northeast. As for the Muzaffarabad city region, earthquake motions were not so large even though the city is very close to the fault.

It is believed that the acceleration of base rock in Muzaffarabad area was almost the same because the gentle tendency of attenuation is generally shown in a range near the fault.

Regarding the acceleration of base rock, only the acceleration of A Zone (Ward 18), where the strike line of the fault is inflective, was larger than that of other parts.

Amplification in surface layer

The shear wave velocity of surface layer is assumed to be 400 m/s in NESPAK's report[3]. The value of this layer can be considered equal to base rock for the dynamic analysis carried out for engineering purposes. Therefore difference of amplification in the surface layer may be almost negligible.

Amplification caused by shape of ground surface

Amplification caused by shape of ground surface can be seen at the following locations:

1) Place where soft surface layer becomes shallow gradually, and it touches an outcrop in stiff stratum
2) Place where free vibration can be excited (i.e. cliffs, etc.)
3) Place where the quake converged on it (i.e. isolated hills, etc.)

There is no soft surface layer in Muzaffarabad area. Therefore, some cliffs and isolated hills are the places where the quake can be amplified.

As a result, the average intensity of earthquake motion of Muzaffarabad area is estimated at about MMI 9. Intensity of earthquake motion of A Zone and the specific parts described above (soft surface layer, some cliffs and isolated hills) is thought to be about MMI 10.

Relative displacement on fault

Relative displacement is a motion that each side of the ground moves to opposite direction at the fault line. Structures that are built on the fault line will be torn apart when relative displacement occurs. Thus the effect of the relative displacement is limited just on the fissure caused by earthquake.

Regarding Tanda fault, the location of fault line can be identified comparatively accurately because the 2005 Kashmir Earthquake yielded such important findings. The place where Tanda fault is located is almost limited to the steep area and A Zone as described in the next section. Since there is a risk of landslide along steep slope fault line area, caused by land deformation by earthquake, construction limitation should be considered based on landslide risk evaluation.

It is hard to identify the location of Jhelum fault compared with that of Tanda fault. Part of E Zone, F Zone and G Zone is traversed by Jhelum fault, thus fissure can develop within this

[3] Earthquake Reconstruction and Rehabilitation Authority (ERRA):Seismic Hazard Microzonation of Major Town's Affected by Earthquake of October 08, 2005,Report on Seismic Hazard Microzonation of Muzaffarabad, AJK

region and measures are needed. Therefore, a regulated belt along forecasted fault line about 400 m width is recommended so that further damage of structure will not develop. However, excessive regulation of construction is not realistic when thinking of the extent of accuracy of fissure location. Some kind of moderate restriction is needed. Construction of emergency response facilities especially facilities that give emergency assistance in this belt area must be avoided. Small-sized buildings, mainly individual residences, may be built in the area, yet need to follow earthquake resistant design[4].

(2) Evaluation for Each Area

The possibility of the earthquake hazard caused by ground acceleration in Muzaffarabad city region is almost the same basically. In a word, the risk of the earthquake hazard in the entire city region is evenly high. There is only a slight difference caused by amplification of acceleration in surface layer of ground and relative displacement on fault. The earthquake hazard for each part shown in Figure 3.1.2 is described as follows.

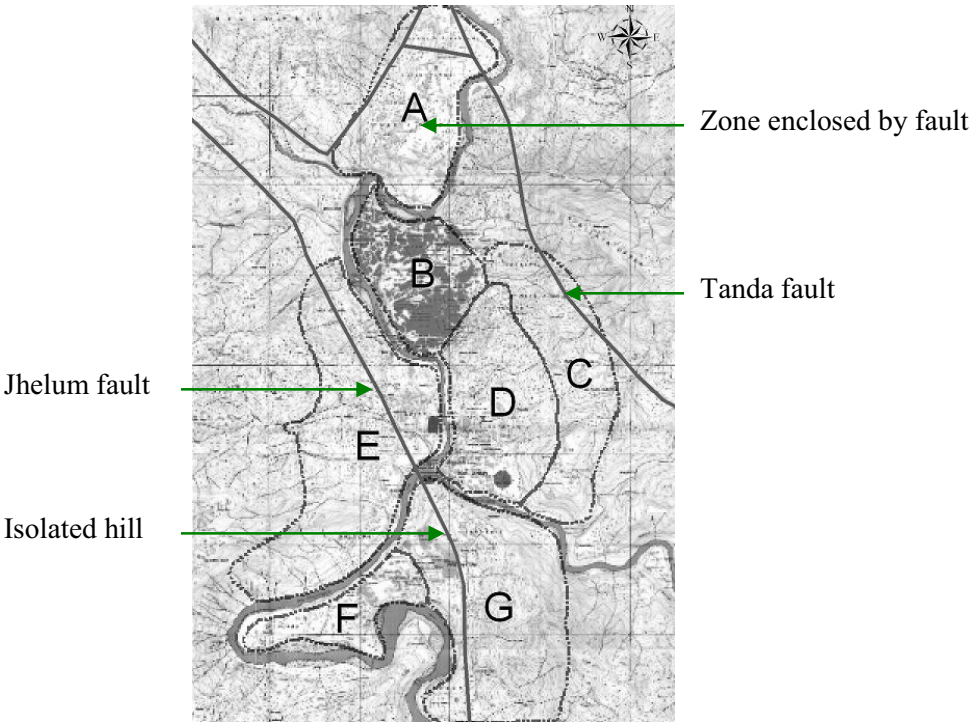


Figure 3.1.2 Zoning of Muzaffarabad for Earthquake Hazard Assessment

[4] For example, government of Japan is now promoting a project in order to determine the location of fault and probability of earthquake caused by corresponding fault more accurately than the assumption which had been approved so far. Major active faults are being reexamined one by one and are classified into 3 categories. If the probability of exceedence in 30 years is larger than 3%, the risk of that fault is classified as "Very high". If simple definition is applied to the above "probability of exceedence in 30 years is 3%", return period corresponds to 985 years. (about 1000 years) In addition the period of last occurrence of earthquake and whether the strain is released sufficiently needs to be taken into account for the evaluation. The investigation utilizing trench excavation is progressing under the viewpoint of seismic archeology. When the building is planned on the active fault line, which is announced by public organization, a more detailed investigation might be obligated in order to identify the exact location of the fault.

a. A Zone (Ward 18)

Special consideration is needed for this area because there may be comparatively large ground motion when the Tanda fault slips. Comparatively large damage was reported in this area for the 2005 Kashmir Earthquake. The strike line of the fault is inflective, so this zone is enclosed from the north side, the east side and the west side by the surface faulting.

- Special consideration of earthquake resistant design and construction is needed for lifeline structures such as water supply and electric power lines. Adopting flexible joints or some other special elements is possible for this purpose.

b. B Zone (Wards 8, 9, 10, 12, 13, 14, 15, 16, 17)

The matter which requires attention for this area is special consideration for the buildings which are located at the edge or bottom of cliffs.

- Construction of public buildings should be avoided at the edge or bottom of cliffs.
- Some limitations are needed for private buildings which are located at the edge or bottom of cliffs. Some rules of set back in the building codes of Japan and the US can give effective information about this matter.
- If buildings are constructed in this danger area, protection work to prevent cliff collapse and suitable measures to prevent the penetration of the cliff should be installed.

c. C Zone (a part of Ward 11 and Ward 4, Ward 6)

Many landslides were observed which may have been caused by shaking radiating through the fault in this zone, but those are limited to steep ground (about 30°or more). This area is not suitable for urbanization.

The judgment of NESPAK's report 1)[5], which specifies that some width from the fault line on map is "attention necessary" zone, is also supported basically in this report. A similar zone is shown also in the hazard map in this report, but this does not mean that all building construction should be forbidden in this area. The construction of the small-scale buildings for agriculture work is assumed to be acceptable, but some warning needs to be announced to inform landowners of the risk. An effective method should be sought on how to execute the announcement.

[5] Earthquake Reconstruction and Rehabilitation Authority (ERRA):Seismic Hazard Microzonation of Major Town's Affected by Earthquake of October 08, 2005,Report on Seismic Hazard Microzonation of Muzaffarabad, AJK

d. D Zone (part of Ward 7, Ward 5 and Ward 4)

Part of the section of the small river under the cliff has high risk. Landslides are expected during the rainy season although this is not an earthquake hazard.

e. E Zone (Ward 19, Ward 20)

Jhelum fault has crossed this area. Construction of the following structures needs to be prohibited as much as possible.

- Hospitals and schools (They are important for urgent rescue and relief operations after an earthquake.)
- Bridges (They are needed for access between a damaged area and other areas.)
- Administration buildings

Special consideration of earthquake resistant design and construction is needed for lifeline structures such as water supply and electric power lines. Adopting the flexible joints or some other special elements is possible for this purpose.

f. F Zone (Ward 2)

Notes for this zone are similar to F zone. Regarding part of the cliff top on the north side, the measures mentioned in B zone are necessary.

g. G Zone (Ward 1, Ward 3)

The majority of this zone is steep ground, and an isolated hill where the quake may converge exists in this area. It is therefore not suitable for urbanization.

3.1.2. Landslides

(1) General

Landslide hazard assessment was carried out on the basis of topographical interpretation and field check. The purposes of landslide hazard assessment were mainly:

1) To identify potential and active landslide areas
2) To make preliminary hazard and risk assessment of identified landslide areas
3) To prepare a landslide hazard map covering Muzaffarabad city and its surroundings
4) To give some suggestions for landslide hazard mitigation

(2) Procedure and criteria of hazard and risk assessment

Figure 3.1.3 gives the general work flow of the hazard risk assessment of landslides, including the performed works in this study and the proposed additional work to be done in

the future. Detailed procedures and methodology for the performed works are described below.

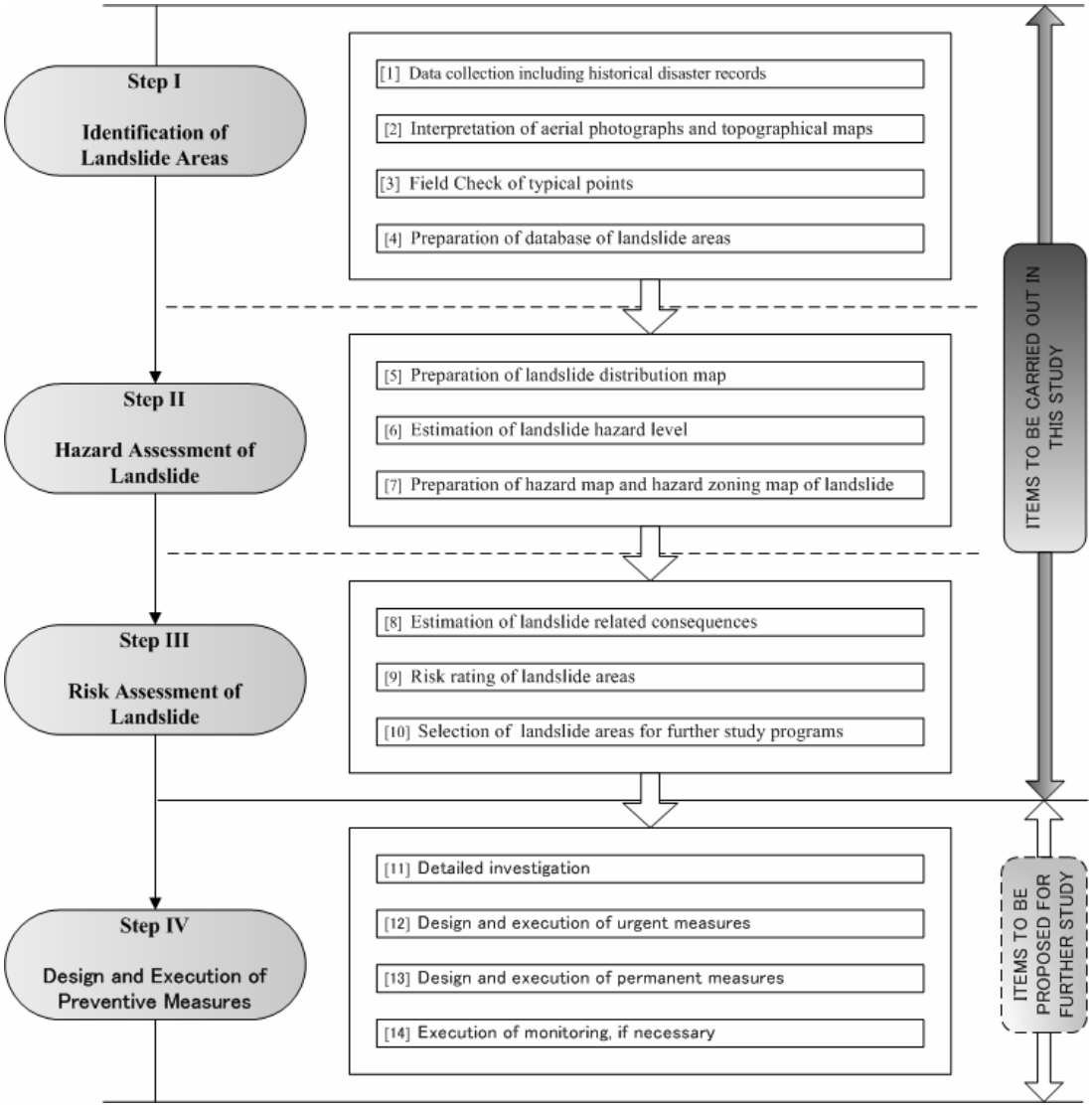
a. Step I — Identification of landslide areas

Step I consists mainly of a) Data collection and review of existing data, b) Interpretation of aerial photographs and topographic maps, c) Field check, and d) Final interpretation of aerial photographs and topographic maps. The information obtained through the above-mentioned activities was prepared in a database, analyzed to evaluate the landslide hazards, and used to make a landslide hazard map.

a) Data collection

The collected data is as follows:

- Satellite image (approximate1y 1:10,000)
- Topographic maps (1:10,000 and 1:50,000)
- Geological maps (1:50,000)
- Existing geological investigation reports and study reports



Source: JICA Study Team

Figure 3.1.3 Flowchart of Risk Assessment and Selection of Landslide Areas for Further Study Programs

b) Interpretation of aerial photographs and topographic maps

Because aerial photographs were not available, potential and new landslide areas were identified in and around Muzaffarabad district within an area of about 40 km^2 through interpretation of satellite image (S=1:10,000) and topographic map (S= 1:10,000).

Commonly, the upper part of landslide areas shows a horseshoe-shape or rectangular scarp, and the middle part a flat or gentle slope. There are concavities, depressions, cracks, etc. or there is a long and narrow depression in hill slope or at the top of a mountain. The typical points for the identification of landslide areas are listed in Table 3.1.1.

Table 3.1.1 Main Items for the Identification of Landslide Areas

Item		Remarks
1	Surface deformation	head scarps, cracks, toe collapses, a marshy zone or a crack on one or both sides of landslide area
2	Micro-relief	depressions, bulge, small steps, and irregular undulation of slopes
3	Abnormal landforms	convex ridge, concave mound, steep scarp on a gentle slope
4	Water fluctuation	pond, swamps, marshes, linear alignment of springs, and small gullies
5	Irregular contour lines	contour lines are dense in the upper section of a landslide area, spare in the middle section, and dense again in the lower section
6	Vegetation	landslide area is generally covered by thinner vegetation than its surrounding areas
7	Landslide area	bordered by head scarps (or cracks), toe bulges (or small collapses) and side cracks
8	Movement direction	perpendicular to head scarps or head cracks, and almost parallel to side cracks
9	Landslide type	landslide is generally subdivided, in terms of deformation processes, into rocks slides, weathered rock slide and soil slides
10	Depth of sliding surface	approximately equal to 1/7 to 1/10 of the width of a landslide
11	Shape of sliding surface	by using the locations of toe and head of a landslide, landslide type and the depth of sliding surface
12	Geologic information	lineament, rock type, joint condition, weathering

Source: JICA Study Team

On the basis of the landslide characteristics of the identified items, landslide areas were identified and plotted on a landslide distribution map (S=1:10,000) for field checking.

c) Field check

Field check was carried out for all the identified landslides and other landslides found during field check in order to collect information for the hazard and risk assessment of landslides. Items to be checked are listed in Field Check Sheet.

Because of difficult access, a few landslide areas were not field checked. This mapping represents only features that were observed during field check, and was not representative of all the landslide activity in the study area.

d) Preparation of database

The information that was collected during field check was prepared in a database for hazard and risk assessment.

b. Step II — Hazard assessment of landslide areas

e) Preparation of landslide distribution map

On the basis of the field check results, all landslides, active and potential, were determined and designated in detail on the Landslide Distribution Map on a scale of 1:10,000.

f) Estimation of landslide hazard level

The hazard level assessment of landslide areas was carried out on the basis of the following criteria regarding topographic conditions and ground deformation. The result of assessment was ranked as A (high), B (medium) and C (low) as shown below .

Table 3.1.2 The Assessment Criteria of Landslide Hazard

Hazard Level		Description
Slide	(A) High	• A large number of obvious slide topography such as scarps, bulges, stepped land, ponds and swamp, and • Many visible ongoing and active movements of cracks, subsidence, upheaval, toe erosion, small toe collapse as well as spring.
	(B) Medium	• Obvious slide topography such as bulge, stepped land, ponds and swamp, but • Less or small ongoing movements of cracks, subsidence, upheaval and small toe collapse.
	(C) Low	• No obvious slide topography such as bulge, stepped land, and • Invisible ongoing movements of cracks, subsidence, upheaval, small toe collapse.
Soil Collapse and Rock Mass Collapse	(A) High	• A large number of obvious traces of collapse, toppling and rock slopes of daylight structures, and • Visible ongoing slope collapse.
	(B) Medium	• Obvious traces of slope collapse, toppling and rock slopes of daylight structures, but • Less or small ongoing slope collapses.
	(C) Low	• A large number of obvious slide topography such as scarps, bulges, stepped land, ponds and swamp, and • Many visible ongoing and active movements of cracks, subsidence, upheaval, toe erosion, toe collapse as well as spring.

Source: JICA Study Team

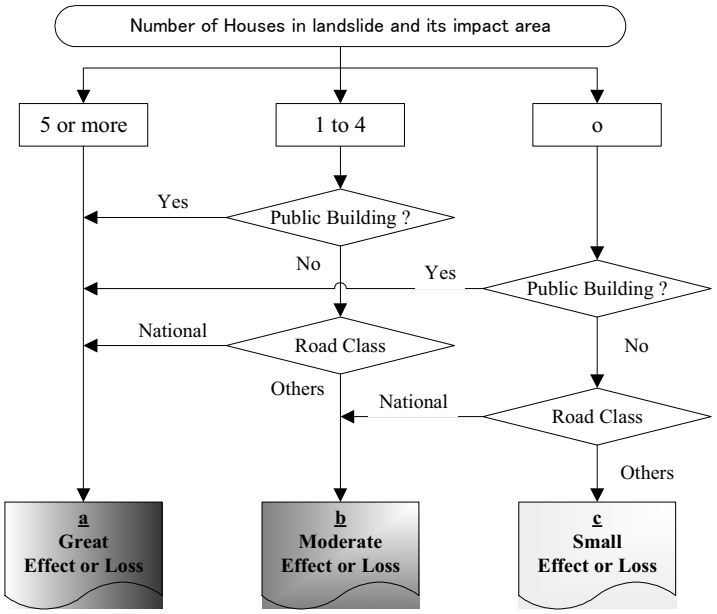
g) Preparation of landslide hazard map

Following the estimation of landslide hazard level, the landslide areas were divided, in terms of hazard level, into A, B and C, and prepared as Landslide Hazard Map with different color. The hazard map shows: a) the areal extent of threatening processes, b) where landslide processes have occurred in the past, c) where they are occurring now, and d) the likelihood in various areas where a landslide may occur in the future.

c. Step III — Risk assessment of landslide

h) Estimation of landslide related consequences

Estimation of landslide related consequences is made to evaluate loss potential and other potential socio-economic impacts if a landslde occurs. In the Study, the landslde related consequences include public buildings, residential houses and roads. Figure 3.1.4 gives the estimation procedure.



Source: JICA Study Team

Figure 3.1.4 Estimation Procedure of Landslide Related Consequence

i) Risk Rating of landslide areas

Risk assessment was carried out in consideration of 1) landslide hazard level and 2) landslide related consequences as shown in Table 3.1.3. According to the result of the assessment, the necessity of further study was determined.

Table 3.1.3 Risk Rating of Landslide Areas

Landslide Risk Assessment (I to IV)		Consequences		
		a	b	c
Hazard Level	A	I	II	III
	B	II	III	IV
	C	III	IV	IV

Source: JICA Study Team

(3) Field Check Results

Seventy-one landslide areas were identified by interpretation of topographical map and satellite image and field check. The distribution of these landslide areas is shown in Landslide Hazard Map. As shown in the map, the landslide areas are distributed mostly on eastern part of Muzaffarabad city, and concentrated especially along the active fault.

a. Types and features of landslides

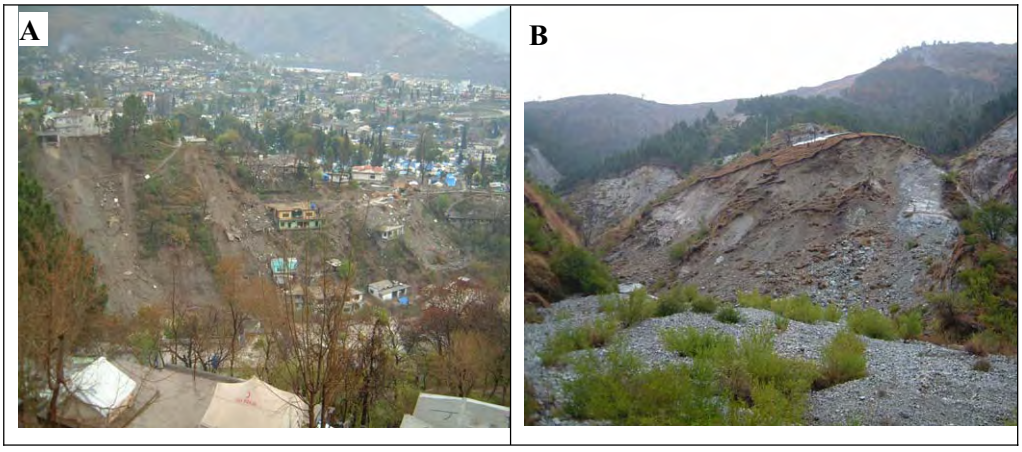
The landslides in the study area mainly include three types: a) soil collapses, b) slides and c) rock mass collapses. Their typical characteristics and occurrence mechanism are summarized below.

Soil collapses

Soil collapses can be subdivided, in terms of their locations and geological constituents, into two subgroups. One occurs in stream channel deposit in populated area (Figure 3.1.5A, Landslide No. NL30), and the other happens on talus deposits in the mountainous areas (Figure 3.1.5B, Landslide No. NL43).

The former lies mainly on the steep cliffs of stream channel deposits, which have a height of approximately 50 to 100 m and a slope angle of 70 to 80 degrees. The stream channel deposit, which consists of silt, sand and gravel, is loose and susceptible to erosion. In spite of the shaking of the 2005 Kashmir earthquake, its occurrence is attributed mainly to stream erosion and human activities such as house building and road construction. Furthermore, because the soil collapses are distributed mostly in populated areas, they may cause great loss of lives when they fail.

In comparison with the former, the latter involves talus deposit overlying on bedrocks in mountainous areas. The talus deposit, which is generally 1 to 3 m, occasionally up to 5 m in thickness, is composed mainly of silt, sand, gravel and rock fragments. Because the soil collapses are distributed on the mountainous areas, they would cause less direct damage except to farmlands and forest. However, they are the main source sites of debris flows, and the subsequent debris flow may reach the populated areas, similarly posing a very considerable hazard to life and property.



Source: JICA Study Team

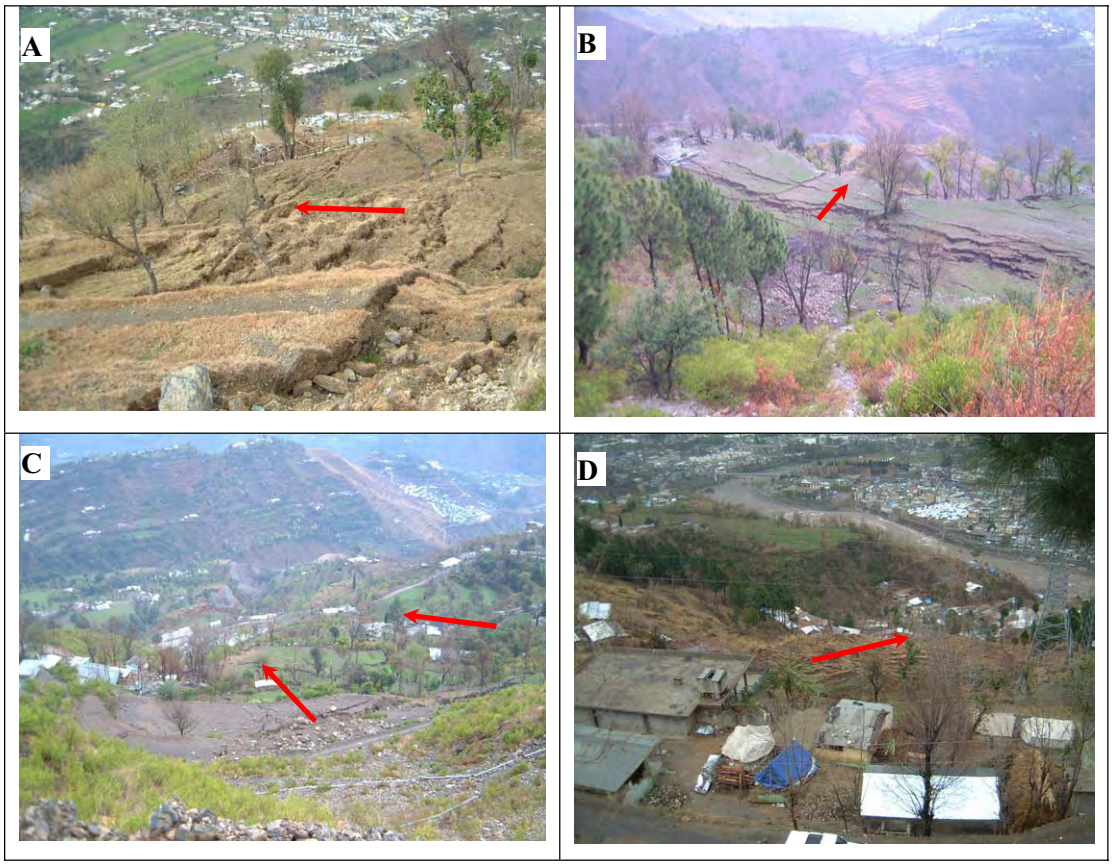
Figure 3.1.5 Soil Collapses Occurred mainly on the Cliff Face of Stream Channel Deposit (A) and Talus Deposits (B)

Slides

More than 30 slides were identified in the study area. The slides lie mainly on the gentler hill slopes of 20 to 40 degrees and have a width of 150 to 500 m. They mainly involve surface deposits and partially bedrocks.

Most of the slides are old ones and were reactivated by the 2005 Kashmir Earthquake. After the 2005 Kashmir Earthquake, many slide areas have become active, and have large and continuous tension cracks on the upper slope of slide areas. Slide materials remain mostly on the slope of slide areas (Figure 3.1.6 A and B, respectively from Landslide Nos. NL5 and JL 43).

Because of old slides, pre-existing sheared or weakened planes (sliding surface) are present in these slide areas. The earthquake shaking not only pushes out the unstable parts above the sliding surface but also leads to reduced strength of the sliding surface by liquefying it if underground water exists around the sliding plane.



Note: A and B show large and continuous tension cracks and sinkings at their head. C and D show many houses standing in slide areas and their impact areas. Arrows show sliding direction.
Source: JICA Study Team

Figure 3.1.6 Slide Areas

The sides, which have large and continuous tension cracks, are more likely to move during the coming rainy season, if no actions are taken to stabilize them. The presence of the

tension cracks at their head contribute largely to infiltration of surface water and rainfall into the sliding surface, leading to increased pore water pressure and reduced strength of the sliding surfaces, thereby reducing the stability of the landslide areas, and consequently causing the sliding down of the whole slide areas. On the basis of local interviews, it was learned that Landslide No. NL 65 (Figure 3.1.6D) started to move without any rainfall in the middle of February 2006; this indicates that the present safety factor of the slide is almost equal to 1 (whereas to avoid failure the safety factor must be > 1) and so it could slide down with less or no external force.

Furthermore, the slides are distributed in or close to populated areas, shown in Figure 3.1.6 C and D. The slides have thus posed considerable threat to people and property.

Rock mass collapses

Various sizes of rock mass collapses are distributed primarily on the steep rock outcrops of limestone, sandstone and shale that are strongly jointed and cracked. After rock mass collapses, the exposed rock faces have mostly deteriorated into CL class and locally into D class rock mass (refer to Figure 3.1.7).

Source: JICA Study Team

Figure 3.1.7 Rock Mass Collapses Occurred on Limestone (A) and Sandstone and Shale (B).

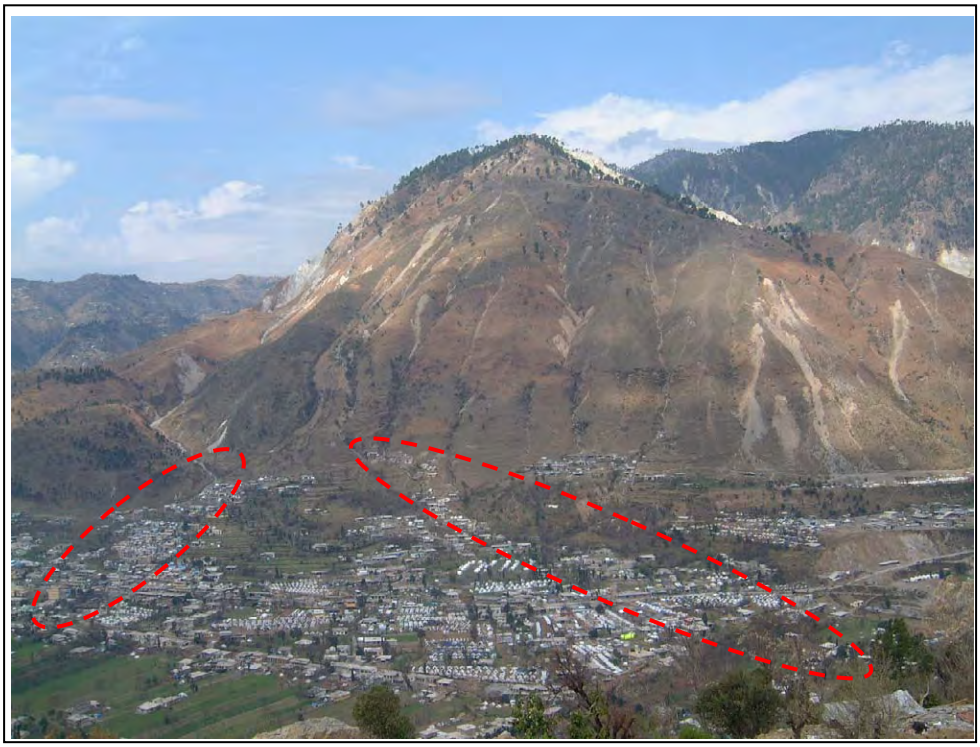
On the basis of the field check, further rock mass collapse in the study area are considered to be less likely to occur because of the exposed CL class or higher class rock mass. However, some rock fall, minor rock mass collapse around the scars of collapses, may take place during and/or after earthquake or heavy rainfall. The collapses are small in volume, but they may cause considerable damage to road facility and local people.

Debris flows

Debris flows are of limited occurrence up to the field check. However, as shown in Figure 3.1.8 as well as the Landslide Hazard Map, in the eastern part of Muzaffarabad city, distributed are various sizes of landslides that are mostly active and much likely to become

landslides during this coming rainy season. Subsequent to becoming landslides during rainy season, the landslide materials could become fluidized by mixing with rain water. Once fluidized, the landslide materials may move rapidly down slope, killing people and destroying houses or other structures in their path.

In the worst case, a severe rainstorm could trigger many landslides at the same time, and the landslide materials could come together and form a huge debris flow, which could cause devastating damage to Muzaffarabad city. Therefore, similar to other types of landslides, debris flow also poses a great potential hazard to people and property.



Source: JICA Study Team

Figure 3.1.8 High Potential Hazard from Debris Flow on the Eastern Part of Muzaffarabad City

b. Main causes of landslides

Earthquake and landslides

On the basis of the field check results, after the 2005 Kashmir Earthquake, 55 landslides (including hazard A and B landslides) showed movement indications such as crack, collapse, sinking, and so on. They account for 77.5% of the identified 71 landslide areas. Evidently, the 2005 earthquake was a main trigger of the landslides.

Fault and landslides

The relationship between distribution of landslides and distances from landslides to faults was examined as shown in Table 3.1.4. The faults used for this examination were the ones

shown in the Landslide Hazard Map, and the distance of landslides from these faults was based on the topographical map with a scale of 1:10,000.

As Table 3.1.4 shows, about 80% of landslides are distributed within 1 km of these faults. This indicates that the distribution and occurrence of landslides in the study area is related closely with these faults.

Table 3.1.4 Distribution of Landslides and its Distance from Faults

Fault	Proximity of Fault					
	< 1km		1 – 5 km		> 5 km	
	Number	Percentage	Number	Percentage	Number	Percentage
HFT Fault	45	63.4	13	18.3	0	0
MBT Fault	11	15.5	2	2.8	0	0
Total	56	78.9	15	21.1	0	0

Note: Total number of landslides identified was 71.
Source: JICA Study Team

Stream erosion and landslides

On the basis of the field check and the prepared Landslide Hazard Map, the relationships between the 71 landslides and rivers as well as streams were analyzed; the results are shown in Table 3.1.5.

Table 3.1.5 Relationship Between the Identified 71 Landslides and Rivers/Streams

Location of Rivers and Streams		Landslide Areas	
		Number	Percentage
1	At toe of landslides	29	40.9
2	At sides of landslides	14	19.7
3	Within landslide areas	9	12.7
4	No relationship	19	26.7

Note: When rivers are located at toe and at sides of a landslide, number of landslides was counted only once.
Source: JICA Study Team

As shown in Table 3.1.5, more than 70% of landslides were influenced by the river/stream flow (see items 1, 2 and 3 in the table above).

(4) Assessment of Hazard and Risk of Landslides

The identified 71 landslides were first classified according to the assessment criteria of landslide hazard, as mentioned earlier, thereafter classified by risk rating, into four categories. The assessment results are outlined in Table 3.1.6.

Table 3.1.6 Summary of Hazard and Risk Assessment Results

Level of Hazard and Risk		Landslide Areas	
		Number	Percentage
Hazard Level of Landslides	**A**	22	31.0
	B	31	43.7
	C	18	25.3
Risk Level of Landslides	**I**	18	25.3
	II	12	16.9
	III	13	18.3
	IV	28	39.5

Source: JICA Study Team

Since a very active landslide does not always adversely affect human activities or cause great damage to lives and properties, a landslide with a high hazard level is not always the one with a high risk level.

The assessment results show that 18 landslide areas are much likely to move and may cause great damage, as shown in Table 3.1.7.

Table 3.1.7 List of Landslides with High Risk

No.	Landslide No. [1)]	Types of Landslides [2)]	Hazard Level	Risk Level	Remarks
1	NL05	2	A	I	
2	NL16	1	A	I	
3	NL19	2	A	I	
4	NL20	2	A	I	
5	NL21	2	A	I	
6	NL34	2	A	I	
7	NL35	1	A	I	
8	NL36	1	A	I	
9	NL37	2	A	I	
10	NL38	2	A	I	
11	JL39	1	A	I	
12	JL41	2	A	I	
13	JL45	2	A	I	
14	JL46	2	A	I	
15	JL47	2	A	I	
16	JL48	2	A	I	
17	JL49	2	A	I	
18	NL65	2	A	I	

Note: 1) Landslide No. is same as that in Landslide Check Sheet.
2) Types of Landslide, 1 = Soil collapse, 2 = Slide

Source: JICA Study Team

3.1.3. Other Hazards

Another potential hazard expected in Muzaffarabad city is flooding. An immediate risk is a break in a natural levee made by the landslide of Hattian in the 2005 Kashmir Earthquake.

The natural levee made of deposited sand would be easily broken by overflow of river water. There is the potential threat that the flood caused by the break of levee will affect Muzaffarabad city.

3.2. Zoning for Urbanized Area in Muzaffarabad City and Adjacent Areas

3.2.1. Land Classification Policy

(1) Objective of Land Suitability Assessment

Muzaffarabad city lies within an area characterized by hilly terrain, where there is a high potential of natural hazards such as landslides and mudflows to occur.

The first objective of the land suitability assessment is to identify possible natural hazards in and around Muzaffarabad city.

The second objective is to formulate suitable land for urban planning that has relatively low potential of natural hazards in Muzaffarabad city and its vicinities. When implementing the land suitability assessment, the Study Team gave special consideration to the mitigation or avoidance of natural hazards such as landslides, mudflows, and relative displacement of the ground surface that are caused by ground movement near active faults.

The results of the land suitability assessment presented in this report were used as base for preparing land use plans for Muzaffarabad city.

(2) Data, Information, and Methodology, etc.

a. Field reconnaissance

The Study Team determined the current land use in and around Muzaffarabad city by referring to a hard copy of QuickBird Satellite images and topographic maps having a nominal scale of 1:10,000. Field reconnaissance work was also undertaken several times during March 2006.

b. Collection of existing data and related maps

Existing data and related maps useful for assessing land suitability were complied by the Study Team. This data was collected from various resources. Details of these data are mentioned in the Sector Report. Table 3.2.1 shows the list of the collected existing maps and data for the land suitability assessment for Muzaffarabad city.

Table 3.2.1 Existing Maps and Data Collected in the Study

Title of data	Contents	Use
Muzaffarabad guide map	Publisher: The Survey of Pakistan A nominal scale: 1:10,000 Data currency: 1995-1996	Base map
QuickBird satellite image	Publisher: DigitalGlobe, Inc. Date of acquisition: October 22, 2005 Resolution: 0.6 m Type of image: Natural color/pan-sharpened	Reference image
Slope classification map	Publisher: Planning and Development Department of the AJK State Government A nominal scale: 1:10,000 Data currency: Late 1990s – fefore 2005	Reference map
Geological hazard map	Publisher: JICA Study Team A nominal scale: 1:10,000 Data currency: March, 2006	Reference map
Building Damage assessment map	Publisher: JICA Study Team A nominal scale: 1:25,000	Reference map

Source: JICA Study Team

In addition to the collected data shown in Table 3.2.1 above, related geological reports for Muzaffarabad city prepared by NESPAK was used for reference.

c. Discussions and interviews with the local government officers

Discussions and interviews with the local government officers were held several times in March 2006 to assist with preparation of the zoning for urbanized area.

d. Integration of data and maps in GIS

The collected data and maps were digitized, and integrated in a Geographic Information System (GIS). The contents of the GIS data were shown in section 3.4 in this report.

e. Delineation of land suitability (land use zones)

Mapping was done at a nominal scale of 1:10,000 in GIS format. The GIS allowed digital versions of various thematic maps to be overlaid on a topographic base map. Land use zones were defined by analyzing the information and drawing polygons (area features) on the map.

3.2.2. Basic Concepts of Zoning for Urbanized Area

(1) Preliminary Land Use Zones

The results of the land suitability assessment allowed land use zones to be defined as follows:

a. Primary Urban Zone

Primary Urban Zone is suitable for the area that includes important city-core functions such as general hospitals, main government offices, schools, universities and technical colleges, large parks, and the commercial and business district, as well as high-density housing. This

zone comprises the majority of Muzaffarabad city, as it existed prior to the earthquake that occurred on October 8, 2005.

b. Secondary Urban Zone

Secondary Urban Zone is considered to be suitable for the area that is generally outside of the Primary Urban Zone. This zone was generally not developed when the earthquake occurred on October 8, 2005. This area has been designated to allow Muzaffarabad city to expand when the need arises in the future. Secondary Urban Zone includes medium-density residential buildings and subsidiary city-core functions, such as community parks, shopping centers, light industrial areas, medical clinics, and schools.

c. Rural Zone

Rural Zone is the mixed area of rural settlement, agricultural land, forest land, and land set aside for nature conservation. The area will not be urbanized in general. However, some infrastructure still needs to be developed to support the smaller communities living in this zone.

Rural Zone includes areas that have been set aside to mitigate or avoid future disasters. These areas include areas that are potentially hazardous, such as landslide or slope failure zones, which should not be used for urban development.

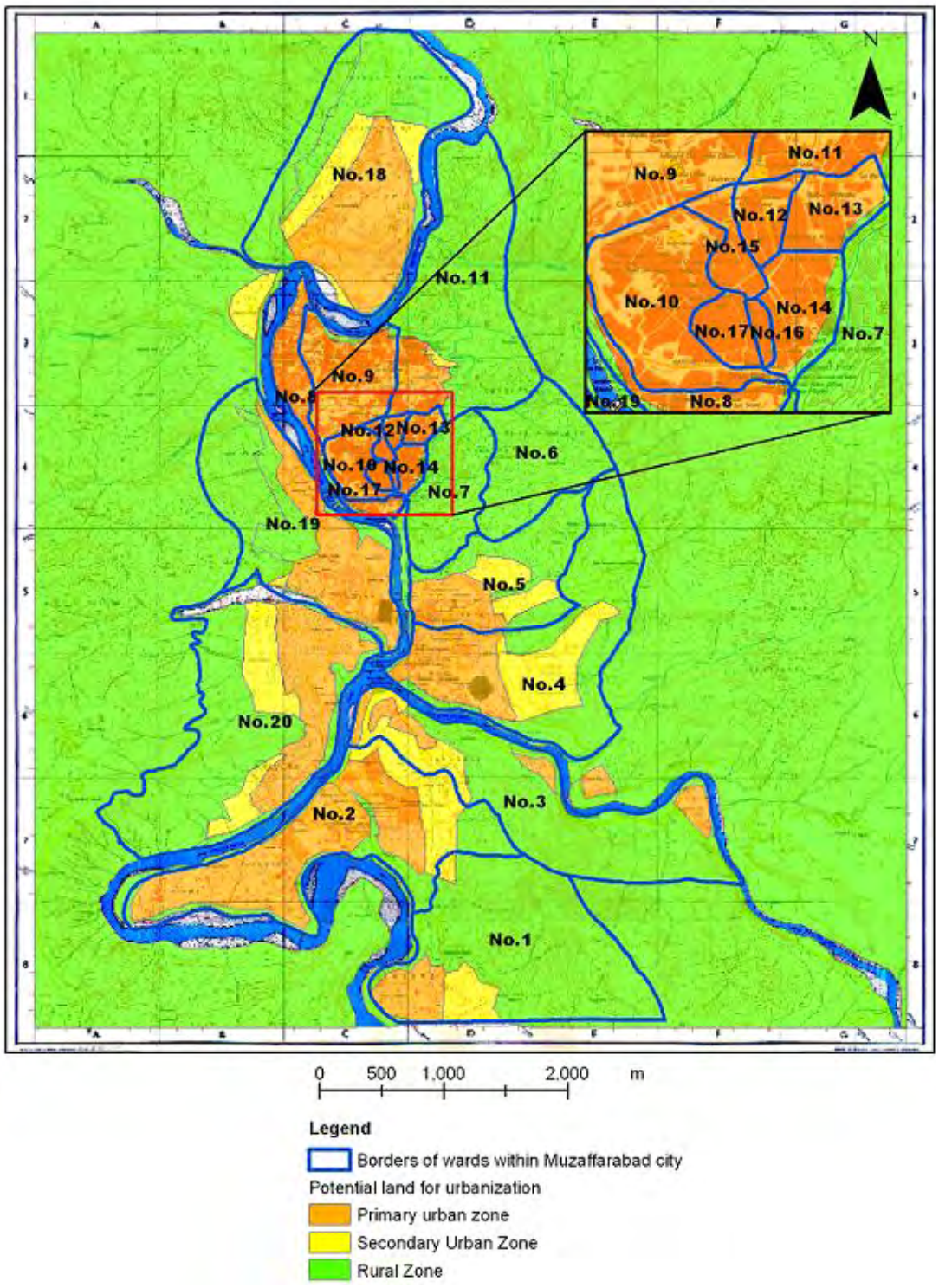
The three land use zones defined above are summarized in Table 3.2.2 below.

Figure 3.2.1 shows the land use zoning for Muzaffarabad city.

Table 3.2.2 Summary of Land Use Zones

	Primary Urban Zone	Secondary Urban Zone	Rural Zone
Priority to Urbanize	Primary areas for urban development	Secondary areas for urban development	Not for urban development
Slope gradient	0°-7°	8°-20°	20°-90°
Location	Along Nilam and Jhelum Rivers	Suburbs of Primary Urban Zone	Areas outside of Primary Urban Zone and Secondary Urban Zone
Land Suitability	City	City	Rural
Development Priority	Primary	Secondary	-
Possible City Functions	Important and main city-core functions including: general hospitals, high education facilities, big parks, main commercial centers.	Residential areas including: community parks, small shops for communities, light industries, clinics, low grade schools.	Areas for small-scale agriculture, or conservation areas with natural conditions set aside for disaster management

Source: JICA Study Team



Source: JICA Study Team; Base map: "Muzaffarabad Guide Map" (The Survey of Pakistan)

Figure 3.2.1 Proposed Zoning for Urbanized Area in Muzaffarabad City

(2) Delineation of Land Use Zones

a. Topographic Factors

The AJK State Government has already prepared a land capacity classification system that is to be adopted for the Azad Jammu and Kashmir State. Because the major economic activity

in the region is agriculture, the AJK State Government's land capacity classification system is based on the hilly terrain land capability classification system that was developed by the United States Department of Agriculture (USDA). The definition of each land capability class used by the AJK State Government is summarized in Table 3.2.3 below.

Table 3.2.3 Azad Jammu Kashmir (AJK) State's Land Capability Classification System

Class	Definition or Description
I	Land with 0°-7° slopes, broad level terraces with stable protected riser, good soil cover. Exhibits little or no erosion hazard or dissection of topography. Attention to field drainage and waterway protection required. Cultivated land.
II a	With slopes 8°-20°, steeper than Class I land, but still with well constructed terraces, good soil cover. Exhibits limiting factors in a minor way, erosion, dissection of topography. Conservation treatments required, attention to terrace risers, field drainage, and protection of water ways and stream channel banks. Cultivated land.
II b	Land with 8°-20°, slopes, major limiting factors presents; soil erosion extensively in evidence, shallower or poorer quality soils, stony broken terrain. Major attention to physical conservation measures required, including improved terracing. Cultivated land.
II c	Slopes 8°-20°, severe limitation present; shallow soils, rocky broken terrain, severe erosion and gullying of the landscape, underlying bedrock influencing topographic variations. Intensive soil and water conservation treatments required. Not to be recommended for cultivation. Should be maintained under some type of perennial vegetative cover.
III a	Steeply slopping land 21°-30°, but whilst exhibiting major limiting factors, attention has been paid to improved terrace construction and there is adequate soil cover, erosion is an ever-present hazard which requires appropriate treatments. Cultivable land under careful management.
III b	Steeply sloping land 21°-30°, with severe limitations, poor soil cover, erosion and gullying of the landscape, dissection of topography, stony soil with rock outcrops. Often on unsuitable slopes intensive conservation treatments required. Not to be recommended for cultivation, should be maintained under some type of perennial vegetative cover.
IV	All land with greater than 30° slopes, including cliffs or expose bedrock. Exhibits extreme limitations; patchy soil cover, rocky broken terrain, severe erosion hazards often in evidence, dissected landscape, areas may be under active or potential land sliding. No-cultivated land. Conservation treatments not usually economically justifiable unless to protect surrounding better quality lands.

Source: The Planning and Development Department of the AJK Government

The land capability classification shown above does not include the capability/suitability of land for urban development. Therefore, the suitability for urban development in each land use zone was determined by the Study Team, as shown in Table 3.2.4 below. The assessment undertaken by the Study Team was based on the slope classification map prepared by the AJK State Government.

Table 3.2.4 Land Suitability for Urban Development by Slope Gradient Class

Land Use / Suitability Class/ Slope Gradient	Primary Urban Zone	Secondary Urban Zone	Rural Zone	
			Rural/ Agriculture	Natural
I : 0° - 7°	Suitable	Suitable	Suitable	-
II : 8° - 20°	Conditional	Conditional	Conditional	-
III : 21° - 30°	Unsuitable	Unsuitable	Conditional	-
IV : 31° - 90°	Unsuitable	Unsuitable	Conditional	-

Source: JICA Study Team

Land categorized as Class I (0° - 7° slope gradient) is considered to be suitable for Primary Urban Zone, Secondary Urban Zone, and Rural Zone. Therefore, when preparing the zoning for urbanized area in Muzaffarabad city, the Study Team determined that land in Category I could be assigned for urban development. Similarly, land in Category II (8°- 20° slope gradient) may be assigned to the Primary Urban Zone, Secondary Urban Zone, and Rural Zone, with the condition that protective measures to ensure land stability be applied. However, Category II land should primarily be assigned to the Primary Urban Zone. Assignment of Category II land to the Secondary Urban Zone and Rural Zone would have a secondary priority.

The steeper sloping land in Category III (21° - 30° slope gradient) is generally unsuitable for assignment to either the Primary Urban Zone or the Secondary Zone. If the slopes were to be made gentler, to increase the area available for urban development, this would require not only huge expenditure, but may also induce potential natural disasters, such as landslides.

Hence, Category III land should be assigned to the Rural Zone, and specifically to “Areas Not to be Urbanized”. This will allow Category III land to be used for nature reserves, parks, or rural/agriculture land. For example, around Muzaffarabad city, many terraces have been artificially developed on slopes in the hilly areas.

These terraces have been used for single dwelling housing sites, small-scale farms, or pasture. Such traditional land use seems to be suitable for Category III land.

b. Geology

The presence of two major active faults near Muzaffarabad city has been suggested by geologists and seismologists. These active faults have been named the Tanda fault and the Jhelum fault. The devastating earthquake that occurred on October 8, 2005 is considered to have been induced by reverse faulting of the Tanda fault. The Jhelum fault, a sinistral (left-lateral) slip fault, is inferred to run through the western part of Muzaffarabad city, extending from the northwest to the southeast, or from the north to the south. The Jhelum

fault is considered to have been formed in the last stage of activity of the MBT (Main Boundary Thrust). However, the MBT itself is considered to be inactive today.

The 2005 Kashmir Earthquake triggered landslides near Muzaffarabad city, especially along the Tanda fault. Once a landslide is initiated, it is not easy to prevent further movement, or to control it economically. Basically, such landslide area should be avoided for urban use and for large-scale development projects that may accelerate the landslide movement.

c. Active faults

The hazard map prepared by the Study Team delineates the inferred position of these two active faults. Relative displacement of the ground surface due to faulting will directly harm life and property in the vicinity of the fault lines.

3.2.3. Suggestions on Muzaffarabad Recovery and Rehabilitation Plan

There are likely to be significant natural hazards that will threaten Muzaffarabad city in the future, as mentioned above. The special suggestions on these natural hazards for urban planning in Muzaffarabad city are described below, based on the results of the hazard assessment done through this study.

(1) Landslide

Landslide areas are excluded from lands suitable for the Primary Urban Zone and Secondary Urban Zone development. However, the Rural Zone includes landslide areas.

a. High activity area

In cases where no suitable countermeasures can be constructed for the high activity areas, possible land use should only be Nature Reserve (protected land) Zone. Land development, public facilities, and new residential site development should be avoided unless countermeasures are employed.

b. Moderate activity area

In cases where no suitable countermeasures can be constructed for the moderate activity areas, possible land use should be Rural/Agriculture Zone. Again, as well as high activity area, public facilities and new residential site development should be avoided unless countermeasures are employed.

c. Low activity area

In cases where no suitable countermeasures can be constructed for the low activity areas, possible land use should be Rural/Agriculture Zone as well as the land use for the moderate activity area. Open space, such as parks or sports grounds, or footpaths can be planned conditionally. New residential site development should be made under license/permission to be given by the government authorities.

If a landslide area is completely secured by effective countermeasures, the area can be used for Secondary Urban Zone or Rural/Agriculture Zone, based on the land suitability for the slope gradient class. Table 3.2.5 and Table 3.2.6 summarize the suggestions mentioned above.

Table 3.2.5 Suggestions on Countermeasures and Urban Planning for Landslide Areas

Hazard Level	Countermeasure		Recommendation for Urban Planning
	Short-term	Long-term	
A (High)	- Monitoring (urgent especially in monsoon season) - Early warning - Urgent measures (Surface and subsurface drainage, removal of unstable landslide debris, catch type concrete or gabion wall etc.)	- Permanent Slope - Stability work - Education on natural hazards - Relocation of houses (for Hazard level A and B)	Prohibition on construction of public facilities and new residential sites unless appropriate countermeasures are employed.
B (Moderate)	- Monitoring - Early warning - Urgent measures		
C (Low)	- Monitoring		Public facility construction should be prohibited Residential site development requires permission to be given by government authorities.

Source: JICA Study Team

Table 3.2.6 Possible Land Use without Countermeasures for Landslides

Landslide Activity	Possible Land Use
A: High	Nature reserve (Protected land) - Natural forest - Natural land
B: Moderate	Rural/agriculture - Natural land - Pasture - Small scale agriculture
C: Low	Rural/agriculture - Pasture - Small scale agriculture

Source: JICA Study Team

(2) Mudflows

Debris that was produced from the recent landslides has reached down to, and been deposited in, mountain streams which run across the planned Primary Urban Zone and Secondary Urban Zone for Muzaffarabad city. Actually, a mudflow affected a residential and

a tent town located in Ward 18 on July 24, 2006. The death toll was at least 12 and this figure could go up.

It is necessary to pay attention to possible mudflow hazards in the land use zones planned for future urban development.

(3) Active Fault Zone

Currently there are no internationally agreed or authorized standards governing land use in the vicinity of active faults. And there are no sufficient analyses concerning seismic ground motion which might be triggered by the active faults located in and around Muzaffarabad city.

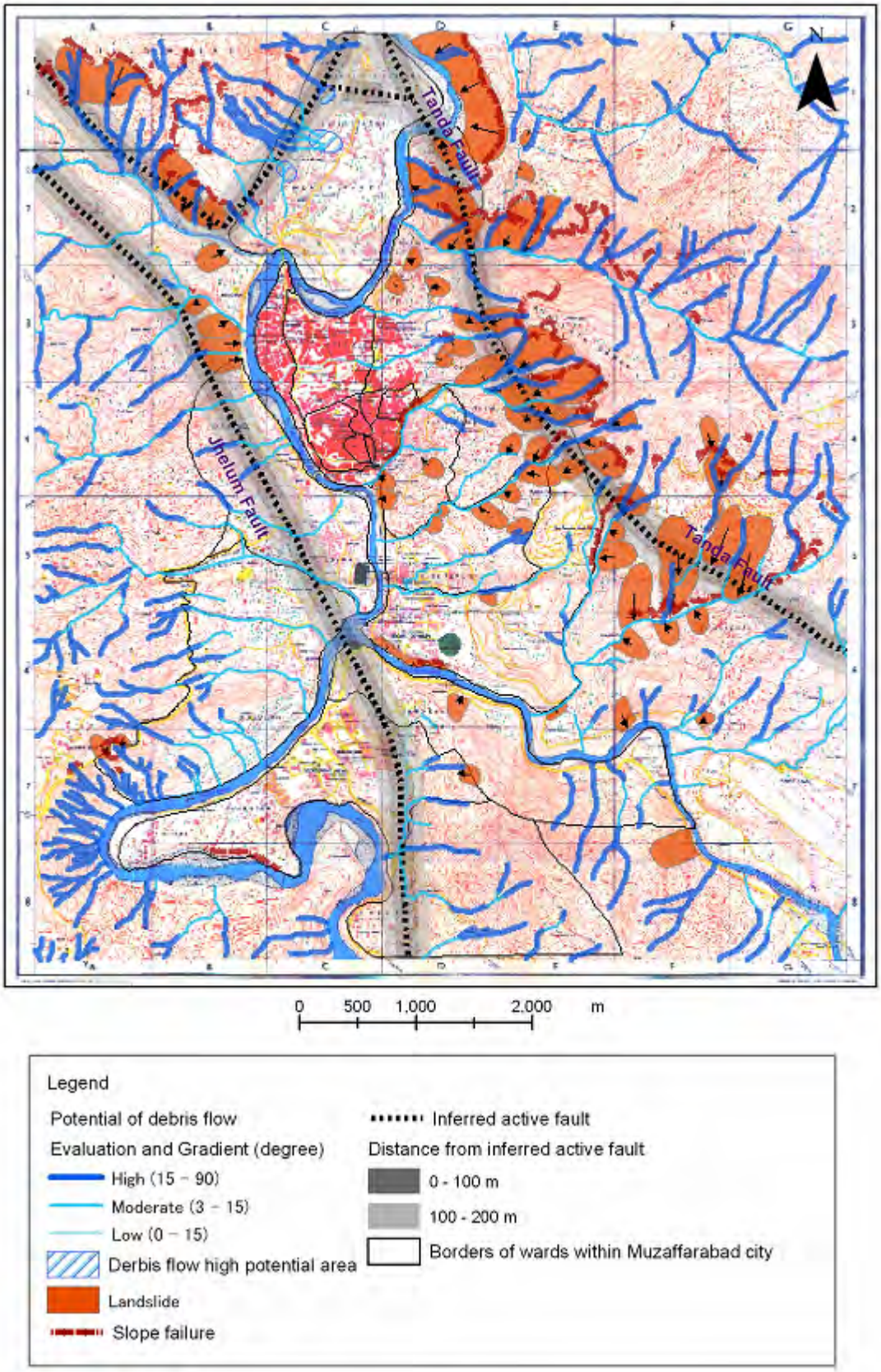
However, Table 3.2.7 below provides general remarks to be considered in conjunction with the land use zones prepared for Muzaffarabad city.

Table 3.2.7 Possible Guidelines for Zoning in the Vicinity of Inferred active Fault Lines

Distance from Inferred Active Fault Line / Zoning	~ 200m	~ 400m	Over 400m
a. Important public buildings used in emergencies, and relatively tall buildings	Unsuitable	Conditional	Possible
b. Open space (park, sports ground)	Possible	Possible	
c. Ordinary housing (including small scale private/ commercial buildings)	Conditional		
d. Residential site development			
e. Road construction			
f. Utility supply and communication network		Conditional	
g. Water storage and power generation, etc.	Unsuitable	Unsuitable	Conditional
h. Small scale infrastructure/facilities, etc.	Conditional	Possible	Possible

Source: JICA Study Team

Figure 3.2.2 shows the geological constraints on the zoning for urbanized area in Muzaffarabad city.



Source: JICA Study Team; Base map: "Muzaffarabad Guide Map" (The Survey of Pakistan)

Figure 3.2.2 Geological Constraints on Zoning for Urbanized Area in Muzaffarabad City

3.3. Land Potential Assessment for Future Satellite Towns of Muzaffarabad

The population of Muzaffarabad city for 2006 was estimated at 176,750 persons, based on the population data given by MCM. And there is a possibility that residential sites within Muzaffarabad city will not be able to accommodate about 22,000 people in 2016. Additional new land to accommodate the future population growth of Muzaffarabad has to be found in and around Muzaffarabad city.

In this connection, a rapid and simplified land potential assessment was undertaken in this study, based on information (map and data) and methodology as mentioned below.

3.3.1. Target Area

An area located in the southeast of Muzaffarabad city was targeted to be as land for future satellite towns in the Muzaffarabad region. There is relatively large and flat/gentle sloping land along the right bank side of Jhelum river. This area includes rural settlement, grassland, agriculture land, forest land, nature land, and airport land.

3.3.2. Maps and Data

The following maps and data were used in the land potential assessment for the target area.

(1) Base Map (Satellite Image)

A pan-sharpened natural color version of the QuickBird image of the target area was provided by NESPAK. The image was taken by the QuickBird satellite on October 22, 2005.

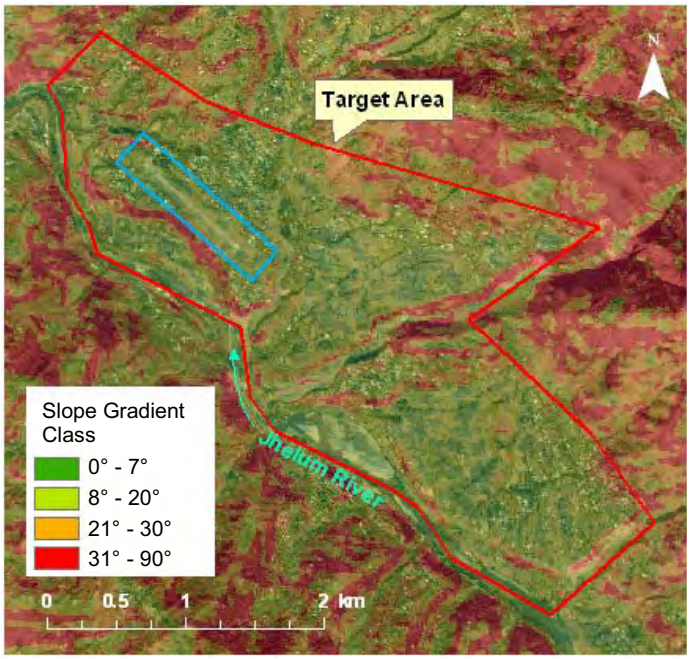
(2) Elevation data

ASTER digital elevation model (DEM) data acquired after the 2005 Kashmir Earthquake in 2005 was used for generating a slope gradient map. Each cell of the DEM grid has a size of 15 m x 15 m area.

(3) Slope Classification Map

Slopes were classified based on the modified AJK State's land capability classification system mentioned in the previous sections. Figure 3.3.1 shows a slope classification map for the target area.

The slope classification map was prepared by processing the DEM data in GIS format. The prepared slope gradient map was used as a reference map in delineating the potential land for future satellite towns in the Muzaffarabad region.



Source: JICA Study Team; Base map: QuickBird Image © COPYRIGHT 2005 DigitalGlobe, Inc; Digital Elevation Model: ASTER DEM

Figure 3.3.1 Distribution of Slope Gradients in and around Target Area

3.3.3. Applied Methodology

(1) Criteria for Slope Gradient Class

Criteria applied for slope classification for the target area (refer to Table 3.3.1) is prepared by simplifying the criteria applied for the Muzaffarabad city mentioned in the previous sections.

Table 3.3.1 Land Suitability for Future Satellite Towns (City) by Slope Gradient Class

Slope Gradient	Land Suitability
0° - 7°	Suitable
8° - 20°	Conditional
21° - 30°	Unsuitable
31° and more	Unsuitable

Source: JICA Study Team

(2) Selection of Potential Land within the Target Area

A GIS (ESRI ArcGIS) was used as a tool in the land potential assessment. Mapping potential land was done at a nominal scale of 1:5,000. This mapping was done through interpreting the QuickBird satellite image and the slope gradient map prepared by the Study Team. The potential land was selected on the (QuickBird) satellite image, considering possible natural hazards in the target area. It is necessary for responsible institutions in Pakistan to undertake more detailed surveys on the target area at various points of views such as geology and topography in future.

3.3.4. Potential Land for Future Satellite Towns

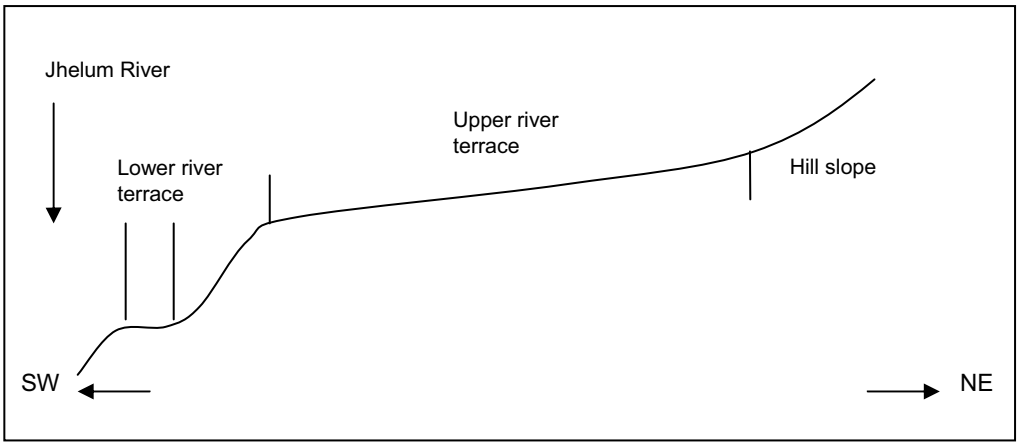
(1) Potential Land

Applying the simplified methodology mentioned in section 3.3.3, potential land was selected and was divided into three (3) sites, i.e., 'Site I'(Maira Kalan), 'Site II'(Miani Bandi and Kardala) and 'Site III'(Langar Pura). Within the selected potential sites above, the following land use classes could be identified on the QuickBird satellite images.

- Building land
- Airport land
- Mixed agriculture land (grassland (bare land), agriculture land)
- Forest

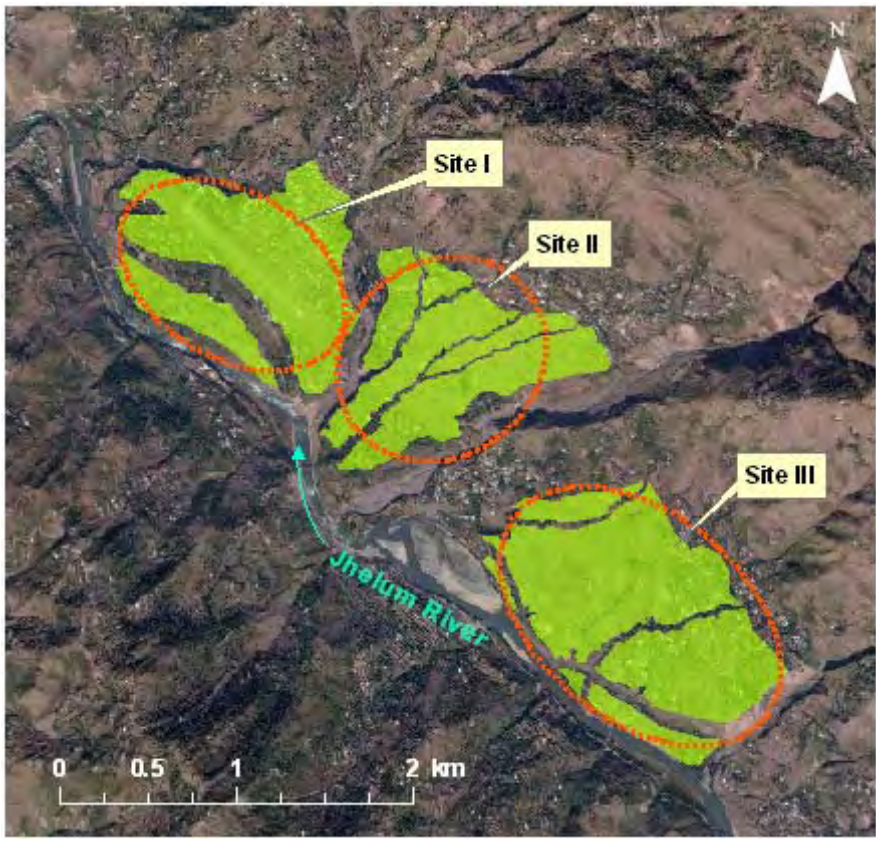
Topographically, the potential land can be divided into three topographic locations as shown in Figure 3.3.2.

- Lower river terrace level
- Upper river terrace



Source: JICA Study Team

Figure 3.3.2 Topographic Profile of the Potential Land



Source: JICA Study Team; Base map: QuickBird Image © COPYRIGHT 2005 DigitalGlobe, Inc.

Figure 3.3.3 Possible Sites for Future Satellite Towns

Gross extent (ha) of each site is shown in Table 3.3.2 below.

Table 3.3.2 Extents of Possible Sites

Site	Extent
Site I (Maira Kalan)	101.5 ha
Site II (Miani Bandi and Kardala)	86.1 ha
Site III (Langar Pura)	137.1 ha
Total	**324.7 ha**

Source: JICA Study Team

The total extent (ha) of the three (3) potential sites is 324.7 ha.

Table 3.3.3 below shows current land use condition within each possible site.

Table 3.3.3 Land Use Condition by Potential Site

Site/ Sub-site	Airport	Mixed agriculture land	Buildings	Forest	Total (ha)
Site I	21.3	74.1	5.6	0.5	101.5
Site II	0.0	85.2	0.9	0.0	86.1
Site III	0.0	133.2	2.1	1.8	137.1
Total	21.3	292.5	8.6	2.3	324.7

Source: JICA Study Team

(2) Evaluation of Potential Site Capacity

The extent (ha) of each potential site as future satellite towns in the target area was calculated in GIS. The capacity (ha) of each site was calculated using the following simplified formula:

[Capacity (ha)] = [Extent (ha)] – ([Airport land] + [Building land]).

The calculated capacity for each site is shown in Table 3.3.4 below.

Table 3.3.4 Capacity of Each Site for Future Satellite Towns

Site name	Extent (ha)	Capacity (ha)
Site I	101.5	74.6
Site II	86.1	85.2
Site III	137.1	135.0
All sites above	324.7	294.8

Source: JICA Study Team

Total extent of 294.8 ha is considered to be usable as new satellite town development in future, based on the calculation above.

Sub-sites within the three (3) potential sites are divided into two (2) topographic locations (refer to Table 3.3.5), according to topographic location shown in Figure 3.3.3 above.

Table 3.3.5 Groups of Sub-sites According to Topographic Location

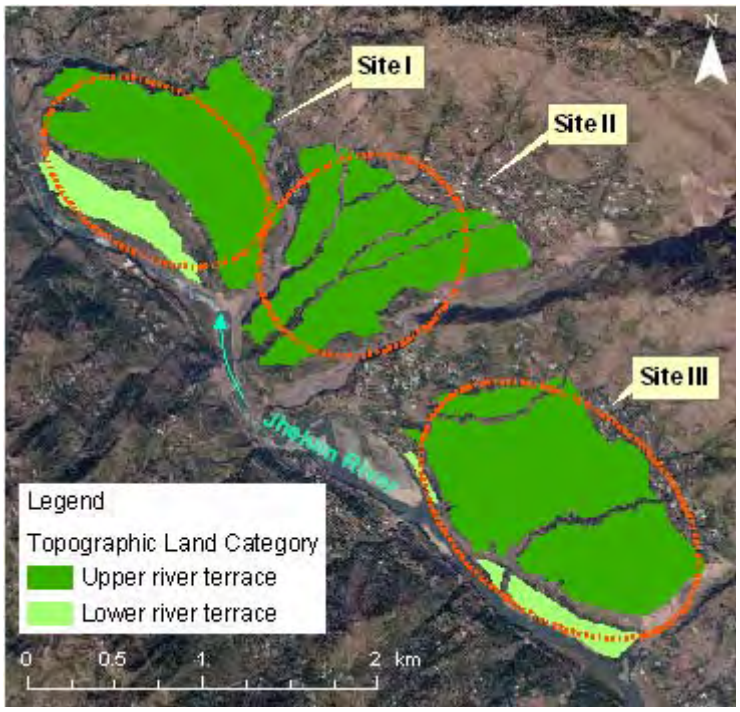
Topographic location	Extent (ha)	Related sub-sites
Lower river terrace	30.7	I-a, III-a and III-d
Upper river terrace	264.1	I-b, II-a, II-b, II-c, II-d, II-e, III-b, III-c and III-e
Total	294.8	

Source: JICA Study Team

Of the suitable area of 294.8 ha within the three (3) sites mentioned above, an extent of 264.1 ha is located on the upper river terraces where it is easy to be utilized for development, and an extent of 30.7 ha is located on the lower river terraces where it might have flood potential within the potential sites.

Figure 3.3.4 shows the topographic division for each of the three (3) sites.

The land suitability assessment mentioned above was undertaken by the Study Team preliminarily and quickly. Natural hazard potential in and around the potential sites should be studied in detail by responsible institutions in Pakistan, when needing suitable land for future satellite town development.



Source: JICA Study Team; Base map: QuickBird Image © COPYRIGHT 2005 DigitalGlobe, Inc.

Figure 3.3.4 Topographic Division of Potential Sites

3.4. Preparation of GIS Database for Muzaffarabad City

3.4.1. Area of Interest

The GIS (Geographic Information System) database prepared in the Study targeted an area of about 70 km^2 that includes Muzaffarabad city and its suburbs, which almost coincides with the extent of the Muzaffarabad Guide Map (Second Edition) published by the Survey of Pakistan. A nominal scale of the GIS layers was planned at 1:10,000, the same scale as the Muzaffarabad Guide Map.

3.4.2. Collected/Prepared Geographic Information

(1) Base Map/Image

a. Muzaffarabad Guide Map

A copy of the Muzaffarabad Guide Map (Second Edition), having a nominal scale of 1:10,000, was used as the base map for the land suitability assessment undertaken for Muzaffarabad city.

This map is published by the Survey of Pakistan and it is based on survey results from 1995-1996. The contour interval shown in the Muzaffarabad Guide Map is 10 meters.

b. QuickBird satellite image

On October 22, 2005 the QuickBird satellite acquired an image of Muzaffarabad city. The date of acquisition was just two weeks after the disastrous earthquake that occurred on

October 8, 2005. The QuickBird satellite image was used extensively as a reference image when undertaking the land suitability assessment, urban planning and other planning for Muzaffarabad city. A pan-sharpened natural color version of the QuickBird image was supplied. This image has a resolution of 0.6 m and it was useful for interpreting the current land cover and land use in and around Muzaffarabad city.

(2) Thematic Map/Image

a. Slope (classification) map

A slope classification map was used to assist with the land suitability assessment for Muzaffarabad city. This slope classification map was originally prepared by the Planning and Development Department of the AJK Government, and it shows the slope classes that existed before the earthquake that occurred in October 2005. The slope classification map shows four categories of slopes in and around Muzaffarabad city, as listed in Table 3.4.1 below.

Table 3.4.1 Classification of Slopes

Class	Gradient
Class I	0° - 7°
Class II	8° - 20°
Class III	21° - 30°
Class IV	31° - 90°

Source: The Planning and Development Department of the AJK Government

The slope classification map prepared by the Planning and Development Department of the AJK Government was one of the most important resources used by the Study Team when undertaking the land suitability assessment for Muzaffarabad City.

b. Geological hazard map

A geological hazard map of the Muzaffarabad region was prepared by the Study Team. This map identifies the location of existing landslides, and potential mudflow and debris flow hazards. The existing landslides located in and around Muzaffarabad city were divided into three categories, based on their relative activity: (i) High, (ii) Moderate, (iii) Low.

Photo-interpretation of the QuickBird satellite image showed that many landslides had reached down to the mountain streams that run through the existing city center and urban communities. Mudflows in the vicinity of the landslides are expected to occur in the rainy season.

Major probable active fault lines and fault zones are also shown in the hazard map prepared by the Study Team.

c. Building damage assessment map

The Study Team undertook a preliminary building damage assessment, and prepared a map based on the results of this assessment. Building damage rankings were assigned to urban areas, based on the ratio of damaged to undamaged buildings. Three categories of damage were defined, as shown in Table 3.4.2 below.

Table 3.4.2 Urban Area Building Damage Categories

Damage category	Ratio of damaged to undamaged buildings (R)
Moderately damaged areas	R<50%
Heavily damaged areas	50%=<R<80%
Severely damaged areas	R>=80%

Source: JICA Study Team

d. Maps for urban planning

Maps concerning urban planning for Muzaffarabad city were prepared by the Study Team. Mapping of current land use and urban plans for Muzaffarabad city and its vicinities was done by analyzing the information and drawing polygons (area features) on the QuickBird satellite image.

(3) Other Data/Images

Other maps related to urban/sector plans were collected through the Study. NESPAK carried out a study on seismic hazard micro-zoning for Muzaffarabad. The figures (maps) enclosed within the report were scanned and stored as raster data for reference.

3.4.3. Software and Data Format

(1) Software

ESRI ArcGIS (ArcView) was mainly used for preparing GIS data and maps. Autodesk AutoCAD was used for digitizing geographic features, too.

(2) Data Format

a. Vector data

The GIS data were prepared in ESRI shapefile format. The shapefiles are readable or convertible with common commercial GIS software (program), or “free” GIS data-viewer programs that are available on the Internet. Attribute data for each vector element were also prepared as needed. In addition to the “feature” dataset, existing statistical data and planning data were also digitized and prepared in the Study.

b. Raster data

The raster data sets were prepared as GeoTIFF files, which are readable with common GIS software or image processing software such as Adobe Photoshop.

(3) Projection and Datum

The geographic data were basically projected for UTM Zone 43 N (WGS 1984).

There is some position accuracy difference among the GIS data layers. This difference is mainly caused by the difference of position accuracy between Muzaffarabad Guide Map and the QuickBird Satellite image that were used for digitizing the ground features. This difference can not be corrected without exact GCP (ground control point) data[6].

3.4.4. Prepared GIS Data Layers

The following GIS data layers were prepared in the Study. These GIS data layers were used to prepare necessary thematic maps for the rehabilitation and reconstruction plans for Muzaffarabad city. Those maps are also shown as figures in this report.

(1) Vector Data

Table 3.4.3 shows the list of the vector data set prepared in this study. The data were prepared by digitizing features shown on the base images (maps) at nominal scales of 1:5,000-1:10,000.

[6] It was difficult to obtain the GCP data due to security (military) reason in Pakistan.

Table 3.4.3 List of Vector GIS Data Layers

Condition	Target Feature	Vector Type	Base Image
Existing	Buildings	Point	QuickBird
Existing	Buildings	Polygon	QuickBird
Existing	Damaged buildings (by 2005 Kashmir Earthquake)	Point	QuickBird
Existing	Built-up land	Polygon	QuickBird
Existing	Main roads	Polyline	QuickBird
Existing	Main road land	Polygon	QuickBird
Existing	Local roads	Polyline	QuickBird
Existing	Bridges	Polygon	QuickBird
Existing	Bridge centerlines	Polyline	QuickBird
Existing	Water (rivers)	Polygon	QuickBird
Existing	Water lines	Polyline	QuickBird
Existing	Airport land	Polygon	QuickBird
Existing	Airport landing field centerline	Polyline	QuickBird
Existing	Airport buildings	Point	QuickBird
Existing	Transportation facilities	Polygon	QuickBird
Existing	Landslides	Polygon	MGM
Existing	Inferred active faults	Polyline	MGM
Existing	Inferred active fault names	Annotation	MGM
Plan	Buffers of inferred active fault lines	Polygon	MGM
Existing	Arrows representing landslide movement directions	Polyline	MGM
Existing	Slope map classification	Polygon	MGM
Existing	Water (rivers)	Polygon	MGM
Existing	Stream lines	Polyline	MGM
Plan	Streams having mudflow potential	Polyline	MGM
Existing	Danger scarps on slopes	Polyline	MGM
Existing	Building damage assessment result	Polygon	MGM
Plan	Potential land classification for urban planning	Polygon	MGM
Plan	Land use plan for Muzaffarabad city (for area calculation)	Polygon	QuickBird
Existing	Existing landuse	Polygon	QuickBird
Existing	Borders of wards within Muzaffarabad city	Polygon	MGM
Plan	Trunk road network for Muzaffarabad city	Polyline	MGM

Note: QuickBird: QuickBird Satellite Image, MGM: Muzaffarabad Guide Map
Source: JICA Study Team

(2) Raster Data

Table 3.4.4 shows the list of the raster GIS data prepared in this study. Raster data were mainly used as base images when digitizing needed features for use in GIS.

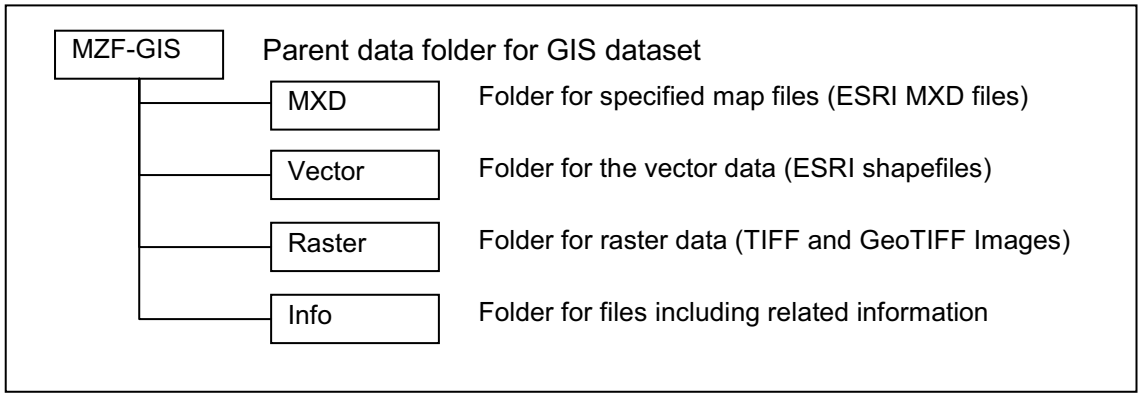
Table 3.4.4 List of Raster GIS Data Layers

Condition	Target	Format	Remarks
Existing	Muzaffarabad Guide Map	GeoTIFF	Rectified
Existing	Scanned maps for creating vector GIS data	GeoTIFF	Rectified
Plans	Scanned maps for creating vector GIS data	GeoTIFF	Rectified

Source: JICA Study Team

(3) Data Compilation

The prepared GIS dataset (database) was stored according to the folder scheme as shown in Figure 3.4.1. 'MZF-GIS' is the parent folder for the GIS database for Muzaffarabad city. 'MZF-GIS' includes four sub-folders. 'MXD' is the folder to store ESRI MXD files to represent important thematic maps for the plans for Muzaffarabad city. 'Vector' and 'Raster' are the folders for the native GIS datasets being used in MXD files. 'Info' includes information of the GIS dataset contained in 'MZF-GIS'.



Source: JICA Study Team

Figure 3.4.1 GIS Data Folders

3.4.5. Utilization of GIS Database

The GIS database was used as a planning tool for the Study Team to assist with the planning process for rehabilitation and reconstruction of Muzaffarabad city. The GIS had generated various thematic maps and results of analyses needed for the planning, which enabled the planners of the JICA Study Team to consider and solve spatial and non-spatial problems relevant to rehabilitation and reconstruction.