Publication of Environmental Impact Report of Hydropower Development in Upper Reaches of Ayeyawady River

CPI, which was awarded "Energy Conservation and Environmentally Friendly Enterprise" by United Nations Environment Program (UNEP) in 2008,is very serious in the environment issues relating to the project development process. In 2006, the overall environmental impact assessment of the river basin was started at the same time when CPI entrusted CISPDR to make the river basin planning of the projects. In December 2007, the river basin planning was completed. In March 2008, the terms of reference (TOR) of the river basin environmental impact assessment was completed in accordance with China's EIA standards and specifications and with reference to the EIA guidelines of the World Bank and the Asian Development Bank. After the TOR passed the assessment and examination of Chinese and Myanmar experts, it served as the guideline for the EIA of the river planning.

From December 2008 to May 2009, more than 100 experts from BANCA, CISPDR, Institute of Hydroecology under CAS and the Chinese Ministry of Water Resources, CAS South China Botanical Garden, CAS South China Institute for Endangered Species and other institutions spent more than half a year and jointly completed the environmental field investigation. During the field investigations, more than 8000 plant specimens, about 2000 animal and bird specimens, more than 1000 fish and aquatic organism specimens were collected, and 18 water quality sections, 17 atmospheric environmental monitoring sites and 7 acoustic environment monitoring sites were monitored.

Experts from China and Myanmar conducted many technical exchanges from June to September, 2009 in Myitkyina, Guangzhou, Wuhan and other places, and finished their respective reports of special subject research. In March, 2010, CISPDR finished the environmental impact assessment report according to the investigation results of the institutes of both countries. The relevant special subject reports and EIA report all passed the consulting and reviews from both countries.

The main conclusions of environmental impact assessment are as follows:

1. The original vegetations in the basin are extremely small in proportion. In particular, the vegetations in the river valleys where it is convenient for loggings to flow downstream are largely secondary in nature. The total submerged land area of the seven projects (660km$^2$) is only 1.4% of the total basin area. The effect of reservoir inundation on the vegetation cover is rather small.

2. The protected species like spinulose tree fern, arethusa and aquilaria malaccensis etc. are sparsely distributed in the reservoir area. However, they are widely distributed in the other regions out of the submerged line of the reservoir. The project construction and reservoir inundation will not have impact on the biodiversity of terrestrial plants.

3. About 195 species of fish are distributed in the river sections and only two species of fish, anguilla nebulosa and anguilla bengalensis, belong to long distance migratory types. In addition, they do not usually live in the river section above Myitkyina. No adverse impacts will be caused by the projects on the rare and endangered fishes.

4. The project development will have a minor impact on terrestrial animals and birds, with some apparent positive impacts on some species.

5. The assessment institutions performed public participation surveys on local people and ecologists, which covered people with different careers, ethnic groups, faiths and education backgrounds. According to the surveys, it is found that: 80.4% of interviewees were in the opinion that the hydropower development could bring more job opportunities and higher incomes to local people, 62.8% of the interviewees were in the opinion that the hydropower implementation could significantly promote development of local economy, 13.8% of the interviewees, who were mainly from Tang Hpe village of Myitkyina, did not support the projects and their major concerns were as follows: whether the property loss will be properly handled and compensated, whether there will be land to farm, whether infrastructure of new resettlement site will be better than before, and whether the quality of living will be lowered. At present, all of them have relocated to the new resettlement village.

6. The spoils, domestic sewage, garbage and excavations arising during the construction period will have some environmental impacts locally, but the adverse impacts can be mitigated after practicable environmental protection measures are implemented.

7. After Myitsone Dam is completed, the Myitsone confluence will be moved upward and a new confluence will be formed. The natural landscape combined with the human landscape and supported by the improved infrastructure, will boost the growth of tourism sector in the basin.

8. During the project construction and operation periods, there are no environmental limitations in the project implementation, and the projects are feasible environmentally.

The EIA report is now posted on-line so that the public can read it and have a true and full understanding of the impacts of the projects on the environment.

For harmonious development of the projects with environmental conservation, please contact us at UACHC@cpiyn.com.cn if you have any concerns or comments about this issue.

Attachment: Environmental Impact Report of Hydropower Development in Upper Reaches of Ayeyawady River

# Environmental Impact Report of Hydropower Development in Upper Reaches of Ayeyawady River

Changjiang Survey, Planning, Design and Research Limited Co.

March, 2010

# Environmental Impact Report of Hydropower Development in Upper Reaches of Ayeyawady River

Statement

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Changjiang Survey, Planning, Design and Research Limited Co.

March, 2010

# Environmental Impact Report of Hydropower Development in Upper Reaches of Ayeyawady River


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| Phyo Thidar | San Wai Tint | Than Than Htay | Nay Myo Aung |
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## Foreword

The Ayeyawady River basin is situated at north latitude 15°30' ~ 28°50' and east longitude 93°16' ~ 98°42', with an approximate catchment of 410 000 $km^2$. It has two sources. The east one Nmaihka River originates at the southwest foot of Boshula Mountains, passing through Tibet and Yunnan provinces, China. It enters Kachin state of Myanmar around Maku of Gongshan Dulong Ethnic Group Autonomous County of Yunnan Province and converges with the west source at Myistone which is about 45km north of Kachin Myitkyina. The west one Malikha River originates at northern mountain area of Myanmar, which meets the east source after passing Putao Basin. The water course below the confluence is called the Ayeyawady River, passing through Myanmar from the north to the south, absorbing tributaries including Daying River, Shweli River, Chindwin River, Myitnge River, Mu River, Yaw River and Mon River. It goes across such cities as Myitkyina, Mandalay and Magway and flows into the southern delta. Then the Ayeyawady River is dispersed to several branch streams entering the Andaman Sea of Indian Ocean with a total mainstream length of 2714km and the annual average flow at the estuary of about 13000$m^3/s$. It is a river that has the longest riverway, the largest area and the highest runoff in Myanmar.

The Ayeyawady River above Myitkyina owes abundant water resources, which has relatively valueable development. In recent years, with the demand of social and economic development, Myanmar government lists hydropower development as the national priority, and at the same time, transforms its advantage of resources into economic advantage. According to the geological location and the condition of hydropower resources, Myanmar government plans to focus on developing hydropower resources in the Ayeyawady River above Myitkyin.

In December, 2006, Ministry of Electric Power No. 1, Myanmar (MOEP 1) and China Power Investment Corporation (CPI) signed *Memorandum of Understanding on Hydro-power Project in Nmaihka River, Malikha River and Myitsone of Ayeyawady River, Myanmar.* To provide scientific foundation for hydropower resources of Ayeyawady River above

Myitkyina, CPI entrusted Changjiang Survey, Planning, Design and Research Limited Co.(hereinafter referred to as CDC) to undertake the work for planning the development of hydropower project in Nmaihka River, Malikha River and Myitsone of Ayeyawady River, Myanmar

In December, 2007, CDC completed the compilation of the *Planning Report of Hydropower Development in Nmaihka River, Malikha River and Myitsone of Ayeyawady River, Myanmar* (hereinafter referred to as *Planning Report of Hydropower Development*).

In October, 2009, CDC completed the compilation of the *Feasibility Research Report of Myistone Hydropower Station of Upper reaches of the Ayeyawady Rive* and submitted it to DHPI.

According to the requirements of MOEP 1, an environmental impact report on the hydropower development of Ayeyawady River above Myitkyina should be compiled. In March 2008, CDC completed the compilation of *TOR of EIA on hydropower development of Ayeyawady River above Myitkyina* (hereinafter referred to as *TOR of EIA*). In May 2008, CPI submitted to MOEP1 the *TOR of EIA*, and in June, MOEP 1 approved the *TOR of EIA* (see Annex 1~2).

In the light of the approved *TOR of EIA*, CDC entrusts Institute of Hydroecology of Ministry of Water Resources & Chinese Academy of Sciences (hereinafter referred to as IHE) to conduct aquatic ecology study and the Botanical Garden of South China of the Chinese Academy of Science (SCBG) with the cooperation of the South China Institute of Endangered Animal (SCIEA) to carry out terrestrial ecology study. CPIYN entrusts Biodiversity And Nature Conservation Association (BANCA), a non-governmental environmental organization of Myanmar, to participate in the aquatic ecology and terrestrial ecology investigation and carry out baseline of environment. Under the organization of CPIYN, CDC and BANCA, from Jan. to May 2009, SCBG, SCIEA, IHE, and BANCA established a joint investigation group for the ecological environment of the Ayeyawady River above Myitkyina. The group conducted a deep investigation on the fundamental

situations of the aquatic ecology and terrestrial animals and vegetation. It also collected such first hand documents as the attitude of the people in the planning area on the hydropower development, the environmental issues concerned and the requirement by means of questionnaire and interview. In Sep. 2009, IHE, SCBG and SCIEA separately completed their analysis and assessment. After the investigation, BANCA also implemented verification and communication of the specimen with Chinese experts and the corresponding work report completed. In Oct. 2009, BANCA submitted its assumed preliminary report to CPIYN and exchanged their views on the major content of the report with CDC.

Based on the above work, CDC compiled and completed Environmental Impact Assessment of Hydropower Development on Upper reaches of the Ayeyawady River in Mar. 2010. It mainly includes: Chapter 1 Introduction, Chapter 2 Project Overview and Analysis, Chapter 3 Investigation and Analysis of Environmental Situation, Chapter 4 Identification of Environmental Impact, Chapter 5 Forecast and Assessment of Environmental Impact, Chapter 6 Forecast and Assessment of Social Impact, Chapter 7 Comparison and Selection of Environment of Hydropower Development Schemes, Chapter 8 Analysis of EI of Typical Hydropower Station, Chapter 9 Environmental Impact Mitigation Measures, Chapter 10 Public participation, Chapter 11 Environmental Management Planning and Chapter 12 Assessment conclusions and suggestions.

We hereby express our appreciation to MOEP 1, Myanmar Kachin Government, HydroChina Engineering Consultating Company, CPI, CPIYN, AWC, BANCA, IHE, SCBG and SCIEA undertaking relevant subjects for their support and help in compiling this environmental impact report.

Contents

**1 Introduction ..... 1**

1.1 Purposes and principles of the assessment ..... 1

1.2 Assessment basis and main technical specifications ..... 3

1.3 Assessment scope ..... 3

1.4 Assessment level year ..... 4

1.5 Objectives of environmental protection ..... 5

1.6 Methods to be adopted for environmental impact assessment ..... 11

1.7 Process and procedure of environmental impact assessment (EIA) ..... 12

**2 Project Overview and Analysis ..... 14**

2.1 Project type ..... 14

2.2 Planned scope of hydropower development ..... 14

2.3 Hydropower development mission and scale ..... 14

2.4 Hydropower development scheme and cascade arrangement ..... 15

2.5 Reservoir inundation ..... 30

2.6 Progress of hydropower development ..... 31

2.7 Overview of recent hydropower stations to be developed ..... 31

2.8 Coordination analysis of hydropower development plan ..... 32

**3 Investigation and Analysis of Environmental Situation ..... 34**

3.1 General of environmental situation investigation ..... 34

3.2 Natural environment ..... 40

3.3 Ecological environment ..... 47

3.4 Social environment ..... 117

3.5 Situation of environmental quality ..... 122

3.6 Major environmental problems ..... 135

**4 Identification of environmental impact ..... 137**

4.1 Preliminary analysis of environmental impact of hydropower development ..... 137

4.2 Identification of environmental impact ..... 138

4.3 Restrictive factors analysis of implementation of hydropower development ..... 141

**5 Forecast and assessment of environmental impact ..... 144**

5.1 Impact on hydrological regime ..... 144

5.2 Impact on water environment ..... 155

5.3 Impact on aquatic ecology ..... 158

5.4 Impact on terrestrial ecology ..... 175

5.5 Analysis of influences of water loss and soil erosion ..... 197

5.6 Analysis of local climate influences ..... 198

5.7 Comparative analysis of environmental impact in different development schemes ..... 202

**6 Forecast and assessment of social impact ..... 205**

6.1 Impact on migrants ..... 205

6.2 Impact on social economy ..... 206

6.3 Impact on religion and ethnic culture ..... 209

6.4 Impact on land resources ..... 211

6.5 Impact on water resources utilization ..... 213

6.6 Impact on Landscape and Tourism ..... 216

6.7 Impact on Infrastructure ..... 217

6.8 Impact on Population health ..... 218

6.9 Impact on Flood Control ..... 220

**7 Analysis of EI of Typical Hydropower station ..... 221**

7.1 Impact on Hydrology ..... 221

7.2 Impact on Water Quality ..... 226

7.3 Impact on Aquatic Ecology ..... 229

7.4 Impact on Terrestrial Ecology ..... 233

7.5 Impact on Social Environment ..... 238

7.6 Soil and water erosion ..... 245

7.7 Other Environmental Impact ..... 246

**8 Environmental Impact Mitigation Measures ..... 249**

8.1 Principles for preparation of environmental impact mitigation measures ..... 249

8.2 Environmental Impact Mitigation Measures ..... 250
**9 Economic Analysis on Environmental Impact ..... 261**
9.1 Environmental Benefit ..... 261
9.2 Losses of Environmental impact ..... 262
9.3 Cost-benefit Analysis on Environmental Influence ..... 263
**10 Public participation ..... 264**
10.1 Purpose and meaning ..... 264
10.2 Questionnaire ..... 265
10.3 Overview of survey process and mode ..... 265
10.4 Investigated Subjects ..... 269
10.5 Public opinions and suggestions ..... 272
10.6 Public participation comments and execution ..... 277
**11 Environmental Management Planning ..... 279**
11.1 Overview of Major Environmental Influence ..... 279
11.2 Summary of Mitigation Measures of Environmental Influences ..... 282
11.3 Environmental Monitoring Planning ..... 285
11.4 Statement of Public Consultation Activity ..... 292
11.5 Statement of Environmental Management Responsibilities ..... 293
**12 Assessment conclusions and suggestions ..... 295**
12.1 Assessment conclusions ..... 295
12.2 Advices ..... 296

## Annex

1. TOR of EIA on hydropower development of Ayeyawady River above Myitkina
2. Confirmation letter of DHPI for TOR of EIA on hydropower development of Ayeyawady River above Myitkina
3. Public participation questionnaires

## Appendix

1. The typical samplings data of the flora in terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River
2. The general checklist of the plant species in terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River
3. The fauna checklist of the assessment area in terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River
4. List of fish speecies of upper reaches of Ayeyawady River
5. List of phytoplankton speecies of upper reaches of Ayeyawady River
6. List of zooplankton speecies of upper reaches of Ayeyawady River
7. List of zoobenthos speecies of upper reaches of Ayeyawady River
8. List of benthic algae speecies of upper reaches of Ayeyawady River

## Attached Figures

1. Sketch map of geographic location of Ayeyawady River above Myitkyina
2. Drainage map of Ayeyawady River above Myitkyina

3. Layout chart of cascade hydropower stations of scheme I (recommended scheme) for hydropower development in upper reaches of Ayeyawady River

4. Longitudinal profile of cascade plant of scheme I (recommended scheme) for hydropower development in upper reaches of Ayeyawady River

5. Layout chart of Myitsone Hydropower station hinge of scheme I (recommended scheme) for hydropower development of upper reaches of Ayeyawady River

6. Sketch map of reservoir submersion range of scheme I (recommended scheme) for hydropower development of upper reaches of Ayeyawady River

7. Satellite photo map of terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River

8. Layout map of investigation route and quadrat of terrestrial ecological environment in hydropower development of upper reaches of Ayeyawady River

9. Type map of main vegetations in terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River

10. Land use map of terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River

11. Distribution map I of rare and endangered mammals in terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River

12. Distribution map II of rare and endangered mammals in terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River

13. Distribution map III of rare and endangered mammals in terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River

14. Distribution map IV of rare and endangered mammals in terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River

15. Distribution map of rare and endangered amphibious reptiles in terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River

16. Distribution map of rare and endangered birds in terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River

17. Distribution map of rare and endangered butterflies in terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River

18. Distribution map of rare and endangered plants in terrestrial ecological assessment area in hydropower development of upper reaches of Ayeyawady River

19. Layout map of environmental monitoring points in hydropower development of upper reaches of Ayeyawady River

# 1 Introduction

## 1.1 Purposes and principles of the assessment

### 1.1.1 Assessment purposes

During the compilation of hydropower development plan and the project decision-making, the ecological environment problems which may be involved in the hydropower development in Ayeyawady River basin above Myitkyina have been given full consideration to, and the relationship between hydropower development and environmental protection of river basin as well as economic & social development has been coordinated, thus the possible adverse environmental impact of the hydropower development can be prevented and reduced, the water resources and the ecological environment of river basin can be effectively protected, and the sustainable development of economy & society of the river basin can be promoted.

Through environmental impact assessment of the hydropower development in the river basin, the suggestions for optimizing the hydropower development are put forward, to make the hydropower development more scientific and reasonable.

### 1.1.2 Assessment principles

(1) Principles of scientificity, objectivity and fairness

To scientifically, objectively and fairly analyze and evaluate effect of implementation of the hydropower development upon various environmental factors and their constituted ecological environmental system, to provide scientific basis for the hydropower development decision-making and project environmental protection.

(2) Principle of integrity

Comprehensively consider relationship between the lower reaches and the upper reaches and between main stream and branch stream from the viewpoint of the whole river basin of Ayeyawady River, systematically analyze and evaluate possible impact of implementation

of the hydropower development scheme of the river reach upon environment, and propose corresponding counter-measures.

(3) Principle of giving prominence to key points

Based on comprehensive identification of environmental impact brought about by implementation of the hydropower development, conduct overall, pro-found analysis, assessment and research of environmental impact which may arise from the hydropower development, and focus attention on accumulated impact and superimposed impact which may be caused by the hydropower development upon aquatic ecology, terrestrial ecology, water environment and social environment, as well as relevant prevention, mitigation and compensation measures.

In the recommended 7-cascade development scheme, considering that Myitsone Hydropower station occupies dominant position in the hydropower development of the river basin, and is arranged among the recent development projects, and its reservoir submersion and dam obstruction, as well as extent of its impact upon hydrological regime in its lower reaches, are relatively obvious, this report selects the project as typical one, and mainly predicts and evaluates its environmental impact.

(4) Principle of public participation

During assessment, CDC, through a wide variety of channels, broadly understands and solicits opinions and suggestions on implementation of the hydropower development and its impact upon environment from various circles of society, so as to make decision-making more scientific.

(5) Principle of operability

According to approved *TOR of EIA* and *Environmental Assessment Guidelines* of Asian Development Bank, and by reference to guidelines of World Bank and in respect of China's environmental impact assessment as well as environmental impact assessment reports of the hydropower project in Tamanthi, Chindwin River , this report adopts simple, practical,

feasible methods for assessment, to make assessment conclusions scientific and objective and environmental protection measures taken operable.

## 1.2 Assessment basis and main technical specifications

TOR of EIA of Hydropower Development in Ayeyawady River Basin above Myitkyina (CDC, 2008);

*Myanmar Forest Law*;

*Protection of Wildlife and Wild Plant and Conservation of Natural Areas Law of Myanmar*;

*Environmental Assessment Guidelines* (Asian Development Bank, 2003);

*Pollution Prevention and Abatement Handbook* (The World Bank, 1998);

The World Bank Operational Manual —Bank Procedures *Environmental Assessment* (OP/BP/GP4.01);

The World Bank Operational Manual —Operational Policies *Indigenous Peoples* (OP/BP4.10);

The World Bank Operational Manual —Operational Policies *Involuntary Resettlement* (OP/BP4.12);

*Convention on Biological Diversity* (Rio De Janeiro, 1992);

*Tamanthi Dam, Hydropower & Multipurpose Project Draft Feasibility Assessment Report* (Colenco, 2007);

*Planning Report of Hydropower Development in Nmaihka River, Malikha River and Myitsone of Ayeyawady River, Myanmar* (CDC, 2007)

## 1.3 Assessment scope

The scope of the hydropower development is the river basin of Ayeyawady River above

Myitkyina. According to size of affected areas, assessment scope of environmental elements (factors) should be properly extended outwards based on the river reaches of the hydropower development. Assessment scope of main environmental factors is shown in Table 1.3-1.

**Table 1.3-1 The scope of Environmental Impact Assessment of Hydropower Development in River Basin of Myanmar' s Ayeyawady River before Myitkyina**

| Assessment factor | Assessment scope |
|---|---|
| Hydrological regime | About 284km long river reach from end of Laza Reservoir of Malikha River to river mouth; about 341km long river reach from end of Yenan Reservoir of Nmaihka River to river mount; river reach of Ayeyawady River, including delta areas at river mouth, mainly river reaches above Myitkyina. |
| Aquatic environment | About 284km long river reach from end of Laza Reservoir of Malikha River to river mouth; about 341km long river reach from end of Yenan Reservoir of Nmaihka River to river mount; about 45km long river reach of Ayeyawady River above Myitkyina. The key is the river reach of cascade reservoir. |
| Terrestrial ecology | 45km long river reach above Myitkyina of Ayeyawady River, about 284km long river reach above mouth of Malikha River, about 341km long river reach above mouth of Nmaihka River; areas below the first level watershed at both sides of 10km river reach of branch streams within above-mentioned regions above river mouth; areas within 500m range of outward traffic roads. Assessment area covers 33,771km$^2$, the key part of which is cascade plant dam site and reservoir inundation zone. |
| Aquatic ecology | About 284km long river reach from end of Laza Reservoir of Malikha River to river mouth; about 341km long river reach from end of Yenan Reservoir of Nmaihka River to river mount, and about 10km river reach of branch streams within above-mentioned regions above river mouth; river reach above trunk stream of Ayeyawady River, especially river reach above Myitkyina. |
| Migration | Migration areas involved in hydropower development, and relocation areas for migrants |
| Social environment | Myitkyina City, Kachin State, especially construction area of cascade hydropower stations and reservoir inundation zone. |

## 1.4 Assessment level year

Base year of status assessment is 2009; according to MOA signed between MOEP 1 and CPI, level year of the prediction and assessment is 2024, in which the hydropower development schemes have been completed.

## 1.5 Objectives of environmental protection

### 1.5.1 Objectives of protecting environmental functions

(1) To coordinate the relationship between hydropower development and regional environmental protection and economic and social development, and to promote the sustainable development of the economy and the society of Kachin State, Myanmar.

(2) To rationally develop and utilize water resources of the river, and to avoid obvious adverse impact of the hydrological regime as much as possible.

(3) To maintain the existing water quality of the river reach for hydropower development and the water quality will not decline during and after the project execution due to the construction of the hydropower stations.

(4) To maintain the integrity and biodiversity of the ecological system, the ecological environment of the Ayeyawady River will not undergo great changes due to the implementation of hydropower development; within the scope of assessment, to alleviate possible adverse impact of hydropower development on endangered animal and plant species; to alleviate possible adverse impact on aquatic life, such as endemic fishes, migratory fishes and important economic fishes.

(5) Through scientific and reasonable resource development and allocation, to coordinate the relationship between hydropower development and relocation and resettlement, reducing the number of people to be relocated as possible; to make sure that the production conditions, living conditions and living standard of the relocated households are not lower than existing level and might be somewhat improved.

(6) To protect local national culture, to show respect for local religions, ensuring that they will not be adversely affected to a significant extent due to hydropower development.

(7) To protect forestry and farmland, to reduce loss of cultivated land as possible, to protect vegetations in forests, to reforest in areas occupied by temporary works, and to alleviate possible adverse impact of the project execution on landscape and ecological environment

in the river basin.

(8) To guarantee the health of construction personnel, preventing the spread of infectious disease or endemic disease within the construction area and during the construction period.

See Table 1.5-1 for the objectives of environmental protection of hydropower development in the upper reaches of the Ayeyawady River.

**Table 1.5-1 Objectives of environmental protection of hydropower development**

| Environmental system | Environmental factors | Environmental objectives |
|---|---|---|
| Natural environment | hydrological regime | • To rationally develop and utilize water resources of the river, to avoid obvious adverse environmental impact of the hydrological regime as much as possible. |
| | water environment | •To prevent the existing water quality of the river reaches for hydropower development from declining due to hydropower construction. |
| Ecological environment | bio-integrity | •To maintain the integrity of the ecological system and the regional biodiversity<br>•To alleviate the impact on rare animal and plant species<br>•To alleviate the impact on migratory fishes and endemic fishes<br>•To reduce soil and water loss resulting from the hydropower development |
| | terrestrial plants | |
| | terrestrial animals | |
| | aquatic life | |
| | soil and water loss | |
| Social environment | people to be relocated | •To guarantee that the production conditions and the living standard of people to be relocated and resettled will not be lower than the existing level and somewhat improved |
| | social economy | •To promote the sustainable development of the river basin and regional economy and society |
| | religions and ethnic cultures | •To protect local religions and ethnic cultures<br>•To show respect for local ethnic cultures and religions |
| | land resource | •To reasonably develop and protect land resources, occupying as few cultivated land and woodland as possible |
| | utilization of water resource | •To protect land resources, and to reduce occupied farmland and forestry |
| | landscape and tourism | •To improve local natural landscape and tourism resources |
| | infrastructure | •To improve the conditions of local infrastructure |
| | health of personnel | •To guarantee the health of construction personnel |
| | flood prevention | •To improve higher flood prevention criteria of Myitkyina in the lower reach |

### 1.5.2 Protection of environment-sensitive objects

After the field survey and the preliminary analysis of the characteristics of the hydropower development scheme, the environment-sensitive objects of this hydropower development are divided into 6 classes: aquatic life, mainly including such migratory fishes as Anguilla nebulosa, Bengal eel and 4 kinds of endemic fishes; terrestrial life, mainly consisting rare animals and plants listed into IUCN red list and CITES Appendices; people to be relocated; infrastructure; landscape; and religious facilities. See Table 1.5-2 for details.

**Table 1.5-2 The distribution of environment-sensitive objects of hydropower development**

| Environment-sensitive objects | | Objects for protection | Level of protection | | Possible location in the planned region | Possible impact |
|---|---|---|---|---|---|---|
| | | | IUCN red list | CITES Appendices | | |
| Aquatic life | Endemic fishes | Garra poecilura | | | As recorded by FishBase, in the Ayeyawady river, but this survey hasn't found them, so it is unable to determine and plan the location | Reservoir impoundment and operation |
| | | Myanmar mystus | | | | |
| | | Schistura acuticephala | | | | |
| | | Schistura paucifasciata | | | | |
| | Migratory fishes | Anguilla nebulosa | | | | Dam obstructing |
| | | Bengal eel | | | | Dam obstructing |
| | Ayeyawady dolphin protected area | Ayeyawady dolphin | CR | | 330km from lower reaches of MS hydropower station, not distributed within planning areas | Reservoir operation |
| Terresterial plants | Endangered plants | Aquilaria malaccensis | VU | II | CW, WT, PS (altitude <500m) | Reservoir impoundment |
| | | Tetrameles nudiflora R.Br. | LR/LC | | CW, WT, PS, LS (altitude 200 ~ 700m) | Reservoir impoundment |
| | | mangifera sylvatica roxb | LR/LC | | WT (altitude 620 ~ 1900m) | Reservoir impoundment |
| | | Bhesasinica | LR/LC | | CW (altitude 50 ~ 500m ) | Reservoir impoundment |
| | | Cephalotaxus hainanensis | LR | | CW (altitude 1100m) | Reservoir impoundment |
| | | Dipterocarpus turbinatus Gaertn. F. | CR | | MS, LS, CW (altitude 20 ~ 500m ) | Reservoir impoundment |

**Table 1.5-2 The distribution of environment-sensitive objects of hydropower development**

| Environment-sensitive objects | | Objects for protection | Level of protection | | Possible location in the planned region | Possible impact |
|---|---|---|---|---|---|---|
| | | | IUCN red list | CITES Appendices | | |
| Terresterial plants | Endangered plants | Dipterocarpus retusus Bl. | VU | | MS, CW, WT, PS, LS (altitude <1100m) | Reservoir impoundment |
| | | Taiwania cryptomerioides | VU | | CW, KLP (altitude 500 ~ 2000m ) | Reservoir impoundment |
| | | Craibiodendron stellatum (Pierre) W.W. Smith | LR/LC | | CW (altitude 200 ~ 2700m ) | Reservoir impoundment |
| | | Caesalpinia sappan | LR/LC | | MS (altitude 50 ~ 700m ) | Reservoir impoundment |
| | | Holarrhena pubescens | LC | | MS (altitude 50 ~ 700m ) | Reservoir impoundment |
| | | Bretschneidera sinensis | EN | | MS, CW, WT, PS, LS ( altitude 500 ~ 1000m ) | Reservoir impoundment |
| | | Alsophila spinulosa (Hook.) Tryon | | II | MS, CW, WT, PS, LS, KLP, YN (altitude100 ~ 1500m) | Reservoir impoundment |
| | | Orchidaceae | | II | widely distributed in MS, CW, WT, PS, LS, KLP, YN | Reservoir impoundment |
| Terresterial plants | Endemic species | Kachin Ampelocalamus | | | MS (altitude 200m ) | Reservoir impoundment |
| | | Ayeyawady Theaceae | | | MS (altitude <300m ) | Reservoir impoundment |
| Terresterial animals | Endangered mammals | Tupaia belangeri | LC | II | YN | Reservoir impoundment and project construction |
| | | Nycticebus coucang | VU | I | KLP, MS | |
| | | Macaca leonina | VU | II | YN, KLP, LS | |
| | | Macaca mulatta | LC | II | YN, KLP | |
| | | Macaca assamensis | NT | II | YN, KLP, WT, CW, MS | |
| | | Macaca arctoides | VU | II | YN, KLP, CW, MS | |
| | | Trachypithecus pileatus | EN | I | YN, WT, CW, LS | |
| | | Hylobates hoolock | VU | I | YN, KLP, WT, CW, LS | |
| | | Manis pentadactyla | EN | II | CW, MS | |
| | | Manis javanica | EN | II | CW | |
| | | Canis aureus | EN | II | CW | |
| | | Ursus | VU | I | YN, KLP, WT, CW | |
| | | Helarctos malayanus | VU | I | PS, WT, CW | |
| | | Ailurus fulgens | VU | I | YN, KLP, PS, WT, | |
| | | Lutra lutra | NT | I | MS | |
| | | Viverra megaspila | VU | | MS | |
| | | Arctictis binturong | VU | | MS | |
| | | Prionodon pardicolor | LC | I | LS, MS | |
| | | Felis chaus | LC | II | YN | |
| | | Felis(Catopuma) temmincki | NT | I | CW | |

**Table 1.5-2 The distribution of environment-sensitive objects of the hydropower development in the upper reaches of the Ayeyawady River**

| Environment-sensitive objects | | Objects for protection | Level of protection | | Possible location in the planned region | Possible impact |
|---|---|---|---|---|---|---|
| | | | IUCN red list | CITES Appendices | | |
| Terresterial animals | Endangered mammals | Prionailurus bengalensis | LC | II | YN, KLP, PS, WT, CW, LS, MS | Reservoir impoundment and project construction |
| | | Prionailurus viverrinus | EN | II | CW, MS | |
| | | Pardofelis marmorata | VU | I | YN, WT | |
| | | Neofelis nebulosa | VU | I | LS | |
| | | Moschus berezovskii | EN | II | CW | |
| | | Cervus unicolor | VU | | WT, CW, LS, MS, | |
| | | Bos gaurus readei | VU | I | MS | |
| | | Budorcas taxicolor | VU | II | YN, KLP, PS, WT | |
| | | Naemorhedus Caudatus | NT | I | YN, KLP, PS, WT, CW | |
| | | Capricornis sumatraensis | NT | I | YN, KLP, PS, WT, CW | |
| | | Naemorhedus cranbrooki | VU | I | KLP | |
| | Endangered birds | Ratufa bicolor | NT | II | YN, KLP | |
| | | Ardea insignis | CR | | LS | |
| | | Haliaeetus leucoryphus | VU | | LS | |
| | | Tragopanblythii | VU | I | KLP | |
| | | Capella nemoricola | VU | | WT, CW | |
| | | Aceros nipalensis | VU | I | YN, KLP, WT, CW, LS, MS | |
| | | Stachyris oglei | VU | | KLP | |
| | | Sitta formosa | VU | | YN, KLP, WT, CW | |
| | | Anhinga melanogaster | NT | | MS | |
| | | Ichthyophaga ichthyaetus | NT | | YN, LS | |
| | | Ichthyophaga humilis | NT | | KLP, MS | |
| | | Arborophila atrogularis | NT | | YN, PS, CW | |
| | | Alcedo hercules | NT | | YN, CW, LS | |
| | | Buceros bicornis | NT | II | YN, KLP, WT, CW, LS, MS | |
| | | Brachypteryx hyperythra | NT | | CW | |
| | | Spelaeornis chocolatinus | NT | | KLP, WT, CW | |
| | | Rimator malacoptilus | NT | | KLP, WT, CW | |
| | | Garrulax nuchalis | NT | | YN, KLP, CW, LS, MS | |
| | | Ciconia nigra | | II | WT, CW, LS | |
| | | Polyplectron bicalcaratum | | II | YN, WT, CW, LS, MS | |

**Table 1.5-2 The distribution of environment-sensitive objects of the hydropower development in the upper reaches of the Ayeyawady River**

| Environment-sensitive objects | | Objects for protection | Level of protection | | Possible location in the planned region | Possible impact |
|---|---|---|---|---|---|---|
| | | | IUCN red list | CITES Appendices | | |
| Terresterial animals | Endangered birds | Anthracoceros coronatusII | | II | LS, MS | Reservoir impoundment and project construction |
| | | Leiothrix lutea | | II | YN, KLP, CW | |
| | | Leiothrix argentauris | | II | YN, KLP, WT, CW, MS | |
| | | Acridotheres albocinctus | | II | LS, MS | |
| | | Gracula religiosa | | II | CW, LS, MS | |
| | | Falco peregrinus | | I | CW, LS, MS | |
| | Endangered amphibians and reptilias | Python molurus bivittatus | NT | I | MS, LS, PS (altitude 200 ~ 700m ) | |
| | | Naja kaouthia | | II | MS, LS, CW, WT, PS altitude ( 100 ~ 1000m ) | |
| | | Ophiophagus hannah | | II | MS, CW, KLP, PS altitude ( 150 ~ 1000m ) | |
| | | Xenochrophis piscator | | II | MS altitude ( 100 ~ 400m ) | |
| | | Varanus dumerili | | II | MS altitude ( 200 ~ 450m ) | |
| | | Tanmophis sirtalis | | II | MS & LS altitude ( 200 ~ 450m ) | |
| | | Kachuga dhongoka | EN | II | MS altitude ( 100 ~ 300m ) | |
| | | Mauremys mutica | EN | | MS, LS & YN altitude ( 150 ~ 500m ) | |
| | | Indotestudo elongata | EN | II | MS altitude ( 300 ~ 600m ) | |
| | | Melanochelys tricarinata | NT | | MS & LS altitude ( 250 ~ 700m ) | |
| | | Heosemys grandis | VU | | LS altitude ( 100 ~ 300m ) | |
| | | Takydromus amurensis | NT | | LS altitude ( 200 ~ 500m ) | |
| | | Euphlyctis hexadactylus | | II | CW altitude ( 300 ~ 600m ) | |
| | | Rhacophoridae | NT | | KLP ( 600 ~ 800m ) | |
| | Endangered rare butterfly species | Pathysa agetes | | II | CW & WT | |
| | | Troides rhadamantus | | II | CW, WT & PS | |
| Migration | | migrant houses, farmlands, gardens and economic forest affected by reservoir submersion | | | Most part is located in MS Hydropower station reservoir | Reservoir impoundment |

**Table 1.5-2 The distribution of environment-sensitive objects of the hydropower development in the upper reaches of the Ayeyawady River**

| Environment-sensitive objects | Objects for protection | Level of protection | | Possible location in the planned region | Possible impact |
|---|---|---|---|---|---|
| | | IUCN red list | CITES Appendices | | |
| Infrastructure | Roads, bridges, schools, hospitals, etc. affected by reservoir submersion | | | Most part is located in MS Hydropower station reservoir | Reservoir impoundment |
| Landscape | Convergence of Malikha River and Nmaihka River | | | Located in MS Hydropower station reservoir | |
| Religious facilities | Topes, religious memorial halls, temples, churches, etc. | | | Most part is located in MS Hydropower station reservoir | Reservoir impoundment |

Remark: *CR-Critically Endangered, EN-Endangered, VU-Vulnerable, NT-Near Threatened, LR-Least Concern*

## 1.6 Methods to be adopted for environmental impact assessment

Based on the main environmental factors involved in this hydropower development, the methods for predicting and assessing each environmental factors are comprehensively analyzed and determined, including mathematical model method, scenario analysis method, comparative analysis method, analogous analysis method and ecological mechanism analysis method. Please see Table 1.6-1 for details.

**Table 1.6-2 Prediction and assessment methods of environmental impact of hydropower development in the upper reaches of Ayeyawady River**

| Environmental factors | Prediction and assessment methods |
|---|---|
| hydrological regime | mathematical model method, analogous analysis, comparative analysis |
| water quality | comparative analysis |
| terrestrial life | field survey, estimation of biological productivity, ecological mechanism analysis, biodiversity index, map overlay method etc. |
| aquatic life | field survey, ecological mechanism analysis, analogous analysis |
| soil and water loss | comparative analysis |
| people to be relocated | statistical analysis, analogous analysis |
| social economy | statistical analysis, analogous analysis |
| religions and ethnic cultures | analogous analysis |
| land resources | statistical analysis |
| utilization of water resources | statistical analysis, analogous analysis |
| landscape and tourism resources | qualitative analysis |
| infrastructure | statistical analysis, analogous analysis |
| flood prevention | qualitative analysis |
| health of personnel | analogous analysis |
| local climate | analogous analysis |
| construction environment | Statistical analysis, analogous analysis, qualitative analysis |

## 1.7 Process and procedure of environmental impact assessment (EIA)

### 1.7.1 Process of EIA

As required by MOEP1 of Myanmar, the hydropower development in the upper reaches of the Ayeyawady River needed to compile an environmental impact assessment (EIA) report. In July 2008, CPIYN formally commissioned the CDC to compile the *Environmental Impact Assessment Report of Hydropower Development in upper reaches of Ayeyawady River.*

In March 2008, the CDC finished the *TOR of EIA of hydropower development of Ayeyawady River basin above Myitkyina* (hereinafter referred to as "*TOR of EIA*"), which clarified the criteria, scope, focus and main technical approach of the assessment. In May, 2008, CPTYN submitted to MOEP1 *TOR of EIA*. In June, 2008, MOEP 1 approved the *TOR of EIA*.

According to the approved *TOR of EIA*, CDC commissioned IHE to conduct special research on aquatic ecology and commissioned SCBG and SCIEA to conduct special researches on terrestrial ecology; meanwhile, CPIYN commissioned the non-governmental environmental protection organization of Myanmar, BANCA to assist status survey of terrestrial and aquatic ecology and environmental quality as well as compilation of special reports. Having been organized by CPIYN and CDC, from January to May of 2009, IHE, SCBG, SCIEA and BANCA formed the joint investigation team of the ecological environment in upper reaches of Ayeyawady River, making a thorough investigation for the status of aquatic life and terrestrial animals and plants in 7 regions which will be planned to develop cascade hydropower stations, conducting the investigation of public participation in the ways of questionnaire and interview and collecting first-hand information about attitudes of the people in the planning area, environmental concerns and requirements etc. In September 2009, IHE, SCBG and SCIEA completed their tasks respectively. After investigation, BANCA also based on the investigation work, communicated with Chinese experts on identification and assessment of specimens and completed corresponding work reports. In the same month, BANCA submitted its preliminary report and exchange opinions with CDC on the main contents of the report.

Based on the work stated above, CDC finished *Environmental Impact Report of Hydropower Development in the Upper Reaches of Ayeyawady River* in March, 2010.

### 1.7.2 Procedure of EIA

See Table 1.7-1 for the block diagram of procedure of EIA for hydropower development in the upper reaches of Ayeyawady River.

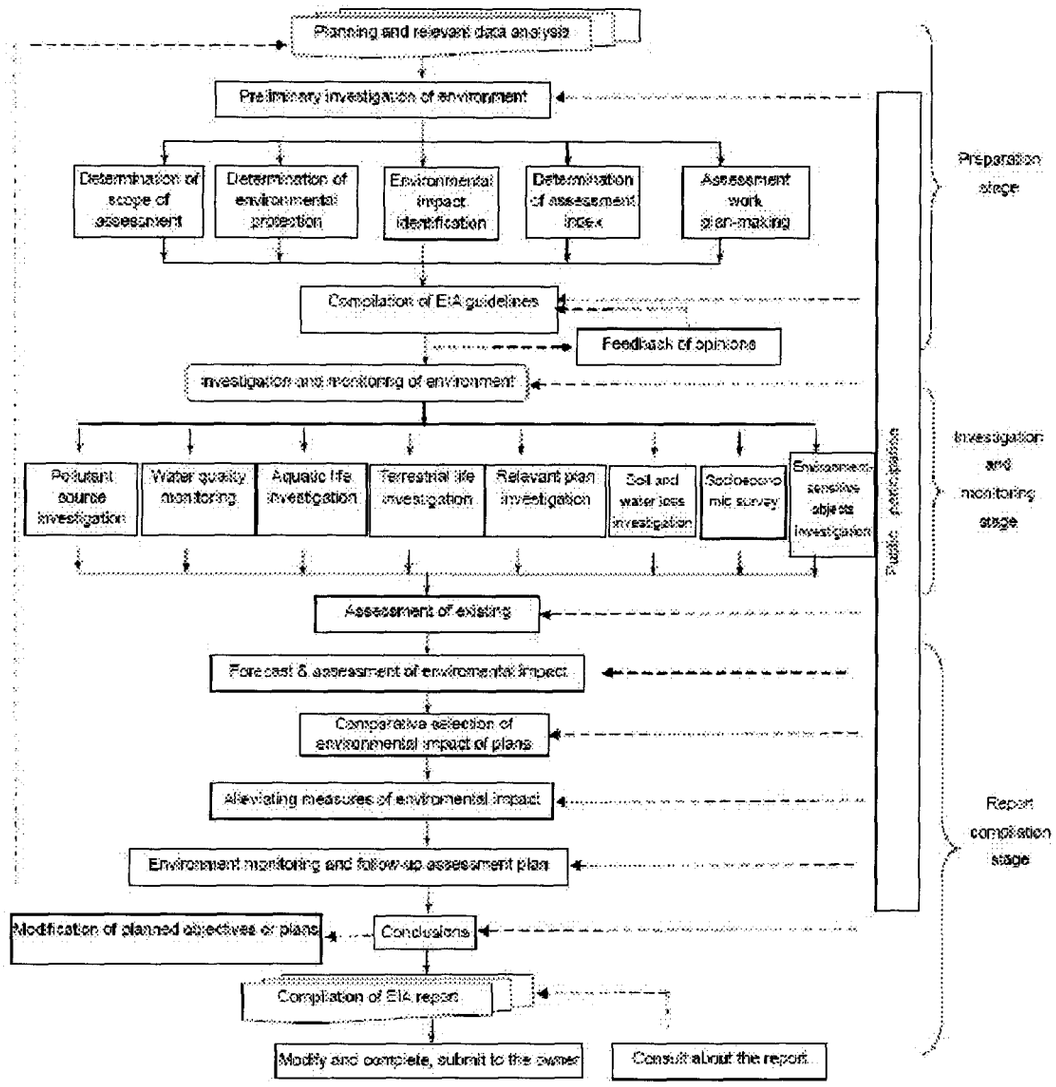


**Figure 1.7-1 Procedure of environmental impact assessment for hydropower development in the upper reaches of Ayeyawady River**

# 2 Project Overview and Analysis

## 2.1 Project type

The hydropower development in upper reaches of Ayeyawady River is an energy project of hydro-electrical power, which is the Type A project categorized by the *Environmental Assessment Guideline* by Asia Development Bank.

## 2.2 Planned scope of hydropower development

(1) Planned scope

The river reach scope of the hydropower development is in Ayeyawady River basin above Myitkyina, geologically between north latitude 25°40' ~ 28°50' and east longitude 97°26' ~ 98°47' as is shown in Attached Figure 1.

Ayeyawady River basin above Myitkyina is divided into the east and west sources. The east source Enmaynua River is 353km long in total, which is the major source of Ayeyawady River, with basin area about 24 200 $km^2$ (including 4 200$km^2$ basin area in China), natural fall about 1010m. Malinka River, the west source, is originated from the northern mountain area of Myanmar, the southern foot of Himalayas. It has three sources, in the left, in the middle and in the right respectively. Its total length is 375km, basin area about 23 000 $km^2$, natural fall about 4470m. The upper drainage basin area of Ayeyawady River is about 47 300 $km^2$ (including 4 200$km^2$ basin area in China).

## 2.3 Hydropower development mission and scale

According to the characteristics of Ayeyawady River basin above Myitkyina and the requirement of the national economy of Myanmar on river development, the mission of the planned drainage basin development is power generation while controlling flood and improving shipping along the lower reaches and irrigation conditions.

The cascade development at Ayeyawady River basin above Myitkyina is of 18 400 MW total installed capacity with annual power generation 99.11 billion kW · h.

## 2.4 Hydropower development scheme and cascade arrangement

### 2.4.1 Principle of determination of hydropower development schemes

According to the development requirements and tasks of upstream of Ayeyawady River, combined with the characteristics of local culture and geographical environment, and based on the prerequisite that Chibwe of Maykha River is or is little submerged and Putao and its plains of Malikha River may not be submerged, the local eco-environment should be well reserved while the water energy resources are exploited at large. The following principles shall be considered for cascade development of watershed:

(1) Comprehensive utilization should be taken as the objective of cascade development and due consideration should be given to the requirements for flood control, irrigation and water supply of this area and the downstream to promote development of domestic economy and society of Myanmar.

(2) Considering that there are undulate chains of mountains and piles of mountain peaks, there is neither large-scale basic establishment nor populous cities along both banks, and population and cultivated land are few, cascade development should take high dam construction as main type to obtain larger reservoir capacity and maximize overall economic efficiency providing that topography and geology conditions of watercourse and technical conditions of dam design permit.

(3) Attention should be paid to protection of river reaches with centralized population and cultivated land. Cascade development planning is based on the principle of non-flooding or little flooding. In layout of cascades, consideration should be given to eco-environment sensitive regions in the planning scope.

(4) Reservoirs with larger regulation capacity should be possibly built in the cascade layout to elevate guaranteed output and power quality of downstream cascade stations

and the comprehensive use of the area downstream of the planning reaches could be achieved.

(5) Cascade water levels of river should be linked reasonably for full utilization of waterpower resources of the river.

### 2.4.2 Hydropower development programming

According to the principles of hydropower development programming, the hydropower planning lists Myitkyina City of Ayeyawady River, Myistone at confluence of Maykha River and Malikha River and significant towns Chibwe and Kaunglanhpu along Maykha River as control points, divides Maykha River and Ayeyawady River into three sections for research of cascade schemes, i.e. section from border between China and Myanmar to Kaunglanhpur, section from Kaunglanhpur to Chibwe and section from Chibwe to Myitkyina, and forms the treatment and development scheme with trunk streams above Maykha River and Ayeyawady River as main line. Furthermore, the hydropower planning takes Malikha River as main branch, Man Nansai, Machanbow and Laza along both banks of Malikha River as control points, and divides Malikha River into four sections for research on cascade development, i.e. section above Man Nansai, section from Man Nansai to Machanbow, section from Machanbow to Laza, and section from Laza to Myitsone.

(1) Maykha River and Ayeyawady River

Maykha River is the main source of Ayeyawady River, and flows to Myistone from north to south, as a whole, along the west side of Gaoligong Mountains and then flows into Ayeyawady River. The canyon is the main landform unit along both banks of the river, with development of gullies and branches.

1) Section from border between China and Myanmar to Kaunglanhpur:

The section from border between China and Myanmar to Kaunglanhpur is the upstream section of Maykha River, with the length 122km, drop height 477m and average gradient 3.9‰. This section belongs to the landform of medium, high mountains. The elevation of

mountain peaks is 1800 ~ 4000m. From the border between China and Myanmar, it flows in a direction of northwest-west. When it comes to Renam, it further flows in a direction of southeast. The river has a high drop with narrow valley shaped in V and steep bank slope. There are two large branches flows into this section: one is Nam Tamai River on the right bank of Maykha River with an area of 309km$^2$ and a length of about 137km, converging with Maykha River at Renam; the other is Ahkyang River on the left bank of Maykha River with an area of 2155km$^2$ and a length of about 94km, converging with Maykha River at Kaunglanhpu, namely about 84km upstream of Renam.

Cascade development programming of this section is: Yenan (1010m, normal water level, hereinafter)—Kaunglanhpu (875m). Refer to Figure 2.4-1 for development scheme of the section from border between China and Myanmar to Kaunglanhpu.

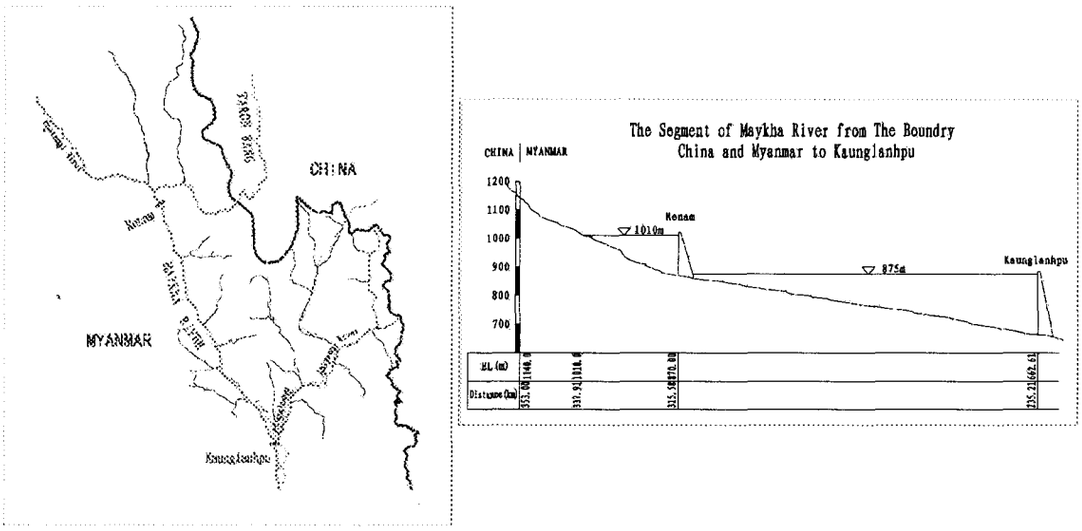


**Figure 2.4-1 Schematic diagram of the section from border between China and Myanmar to Kaunglanhpu**

2) Section from Kaunglanhpu to Chibwe

The section from Kaunglanhpu to Chibwe is the middle section of Maykha River with the length about 125km, drop height 412m and average gradient 3.3‰. It is of medium mountain and valley. The elevation of mountain peaks is 800~2600m. The river straightly flows from north to south with narrow valley shaped in V and steep bank slope. It features

few residents and cultivated land distribution in the mountainous area along both banks and low flooding loss. The cascade arrangement of this river reach is mainly based on such factors as geographic and geologic conditions. Two alternatives are preliminarily determined for this section: 3 cascade development on Pisa (665m) to Wutsok (525m) to Chibwe (400m), and 2 cascade development on Larkhin (665m) to Chibwe (450m) namely:

Scheme 1: Pisa (665m) to Wutsok (525m) to Chibwe (400m)

Scheme 2: Larkhin (665m) to Chibwe (450m)

Refer to Figure 2.4-2 for alternatives of development of section from Kaunglanhpu to Chibwe of Maykha River.

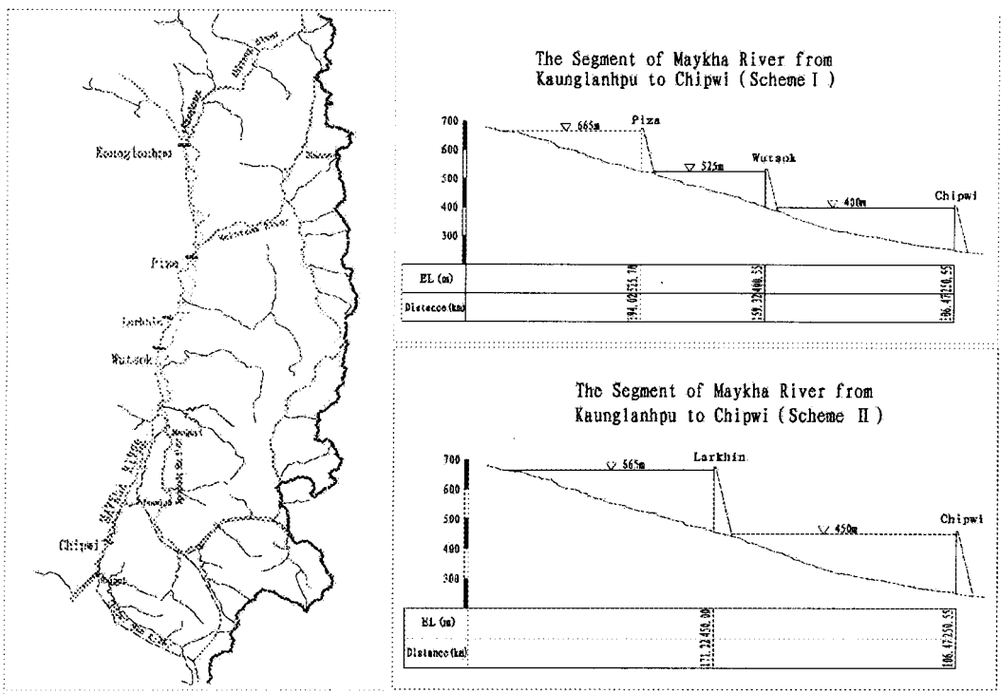


**Figure 2.4-2 Schematic diagram of alternatives of development of section from Kaunglanhpu to Chibwe of Maykha River**

3) Section from Chibwe of Maykha River to Myitkyina of Ayeyawady River and section from Laza of Malikha River to Myitsone:

① Section from Chibwe of Maykha River to Myitkyina of Ayeyawady River

The section from Chibwe of Maykha River to Myistone is the downstream section of Maykha River with the length about 112km, drop height 119m and average gradient 1.06‰. It is of medium-sized mountain and hill. The elevation of mountain peaks is 300~1200m. The river flows from south to west and winds NWW at Lakai with wide valley shaped in V and developed gullies. The elevation of the first bank slope is mostly 300~800m and gentle locally, with developed terraces. It features few residents, no distribution of important flooding loss both banks.

② Section from Malinka River Laza to Myistone

Laza is the backwater end of the Myistone reservoir. The length of the section from Laza to Myistone is 119km, drop height 120m, average gradient 1‰. The valley of this section shows a "U" shape with relatively straight riverway and developed gully. The elevation of the first bank slope is mostly 300~800m. The terrain of both banks of the lower estuary is relatively gentle. It features few residents, backward economy, no distribution of minerals and low flooding loss on both banks.

③ Section from Ayeyawady RiverMyistone to Myitkyina

The section from Ayeyawady RiverMyistone to Myitkyina is about 45km, drop height 7m, average gradient 0.16‰. This section is of transition zone from mountain area to plain, featuring alluvial plain in slow basin, most ground elevation lower than 300m. The overall flow of the river goes from the south to the southwest. The valley gradually becomes wide and the terrain of both banks gradually becomes lower, with terrace developed, to Myitkyina ground elevation 140~150m.

Planning Report of Hydropower Development in Nmaihka River, Malikha River and Myitsone of Ayeyawady River, Myanmar in Dec. 2007 proposes the following schemes of river reach development by taking into consideration of power generation, flood control and shipping etc.

Scheme I: Myistone（230m）(Ayeyawady River)

Scheme II: Myistone（180m）- Majiangyang（230m）(Enmaynua River)

Myistone（180m）－Sawan（230m）（Malinka River）

In Aug. 2009, CDC made supplementary analysis on normal water level, dead water level, and scale of installed capacity, based on the latest terrain paper and the calculated relationship between water level and flow according to the extended series of documents in the recent 2 years. In Oct. the same year, the Feasibility Report of Myistone Hydropower station of Myanmar Hydropower Project, which compiled and completed by CDC and recommends normal water level 245m and installed capacity 6000MW, was reviewed by HydroChina Engineering Consulting Com. Ltd,.

To summarize, the development scheme finally formed for this river reach is: Myistone（245m）（Ayeyawady River）.

(2) Malinka River

The overall flow direction of Malinka River goes from the north of Myanmar through Putao Basin to the south and enters Ayeyawady River at Myistone along the west of Kachin mountain area. According to the geological characteristics of the river and the development conditions, it is divided into four sections for planning study.

1) Section above Man Nansai

Man Nansai is located at the confluence of NamKiu River, the main source of Malinka River, and the branch NamYin River, controlling basin area 1379km$^2$, average flow for many years 140m$^3$/s, river length 59.5km, drop height 4127m, average gradient 69‰. This section features middle and high gorge valley terrain, hill top elevation of both banks 1500~5000m, extremely large river drop height, torrential flow, high and steep valley. The drop height of this section accounts for 92.3% of the total drop height of Malinka River, but the catchment area only accounts for 6% of the drainage basin area of Malinka River, with few runoff produced. In order to maintain the current ecology of this section and retain some natural sections, the plan does not consider arranging cascade development at this section.

2) Section from Man Nansai to Machanbow

This section is about 22km long, with drop height 102m, average gradient 4.6‰. It flows through the boundless and fertile Putao Plain, with relatively slow and wide terrain, elevation 370~460m, slow flow, many branches. Putao Plain has a dense population with firm economic foundation. If dam is built at this section, large loss may be caused by drowning, which will produce unfavorable influence to the economy, society and the ecological environment. Therefore, the plan does not consider arranging cascade development at this section.

3) Section from Machanbow to Laza

This section is about 171km long, with drop height 120m, average gradient 0.7‰. This section is of middle and lower mountain valley terrain, hill top elevation 500~1200m, with zigzag flowing course, relatively wide valley, wide and slow bank slope. Some are of gorges, suitable for dyke-dam development. With not drowning Nongkai and Machanbow as the principle, this section adopts Laza (370m) grade-I development method, joining Myistone cascade with its upper reach.

According to the above mentioned river reach division and the planned hydropower cascade development scheme, the following two schemes are formed for the cascade arrangement of the hydropower development of the upstream of Ayeyawady River:

(1) Scheme I (grade 7 development)

Enmaynua River, Ayeyawady River: Yenan( 1010m )—Kaunglanhpur( 875m )—Pisa( 665m ) —Wutsok ( 525m ) —Chibwe ( 400m ) —Myistone ( 245m )

Malinka River: Laza ( 370m )

(2) Scheme II (grade 6 development)

Enmaynua River, Ayeyawady River: Yenan ( 1010m ) —Kaunglanhpur ( 875m ) —Larkhin ( 665m ) —Chibwe ( 450m ) —Myistone ( 245m )

Malinka River: Laza ( 370m )

The cascade layout of the hydropower development scheme of Ayeyawady River basin above Myitkyina is shown in the attached figures 3, vertical sectional schematic in attached figures 4 and major technical indexes in Table 2.4-1 and 2.4-2.

### 2.4.3 Recommended scheme for hydropower development

The plan recommends scheme I for the Cascade Development of Ayeyawady River basin above Myitkyina after analyzing and comparing the comprehensive utilization profits, engineering technical condition and engineering economic indexes, namely:

Enmaynua River , Ayeyawady River: Yenan ( 1010m ) —Kaunglanhpur ( 875m ) —Pisa ( 665m ) —Wutsok ( 525m ) —Chibwe ( 400m ) —Myistone ( 245m )

Malinka River: Laza ( 370m )

The recommended scheme for the cascade development of Ayeyawady River basin above Myitkyina is of 18400MW total installed capacity and 99.11 billion kW · h annual energy output.

### 2.4.4 Arrangement of cascade power station

(1) Yenan cascade

1) Development method

Dam-type method is adopted for Yenan cascade. The planned normal water level is 1010.0m, with check flood level 1013.77m, corresponding total reservoir capacity 1.237 billion $m^3$, and installed capacity 1200MW.

2) Layout of hydroproject

Yenan cascade dam site is located at about 2.3km downstream of the Nantamai River estuary, the branch of Enmaynua River, about 84km away from the downstream Kaunglanhpur dam site. According to the terrain of the dam site area, the scheme for the layout of the hydroproject is dam arranged in main riverbed, and initially selected dam type is concrete faced rock-fill dam, spillway and emptying tunnel set at left bank, bank-type power station at the right bank.

**Table 2.4-1** **Main Technical Index Table of each Cascade Development Scheme of the Upper Drainage Basin of Ayeyawady River Myitkyina ( Scheme I, recommended scheme)**

| River | Unit | Enmaynua River | | | | | Malinka River | Ayeyawady River | Total |
|---|---|---|---|---|---|---|---|---|---|
| Subproject | | Yenan | Kaunglanhpur | Pisa | Wutsok | Chibwe400 | Laza | Myistone | |
| Geological location | | Kachin · Putao County | Kachin · Putao County | Kachin · Myitkyina County | Kachin · Myitkyina County | Kachin · Myitkyina County | Kachin · Myitkyina County | Kachin · Myitkyina County | |
| Dam-site location | | Lower reaches of Nantamai River confluence 2.3km | Lower reaches of Ahkyang River confluence 1km | Lower reaches of MekhRame River confluence 3.2km | Upstream of Ngawchahg Hka River confluence 16.4km | Upstream of Chibwe 10-12km | Lower reaches of Ranka River confluence 4.6km | Lower reaches of Myistone River confluence 7km | |
| Distance to Myistone confluence | km | 315.6 | 231.1 | 194 | 159.3 | 106.5 | 114.2 | -7 | |
| Drainage basin area | $km^2$ | 11123 | 14655 | 16689 | 18225 | 21734 | 15291 | 47300 | |
| Average flow for many years | $m^3/s$ | 950 | 1300 | 1490 | 1610 | 1880 | 1560 | 5020 | |
| Average water amount for many years | 100 million $m^3$ | 302 | 415 | 472 | 512 | 598 | 495 | 1585 | |
| Development method | | Dam | Dam | Dam | Dam | Dam | Dam | Dam | |
| Normal water level | m | 1010 | 875 | 665 | 525 | 400 | 370 | 245 | |
| Normal water level corresponding water surface area | $km^2$ | 22.9 | 35.59 | 10.53 | 20.09 | 39.81 | 285.48 | 404.83 | 819.23 |
| Dead water level | m | 980 | 825 | 635 | 500 | 365 | 340 | 230 | |
| Total reservoir capacity | 100 million $m^3$ | 12.37 | 31.72 | 5.35 | 3.21 | 19.39 | 123.28 | 132.82 | 328.14 |
| Effective reservoir capacity | 100 million $m^3$ | 5.78 | 15.26 | 2.29 | 1.13 | 8.1 | 57.85 | 45.03 | 135.44 |
| Reservoir capacity coefficient | % | 1.91 | 3.68 | 0.49 | 0.22 | 1.35 | 11.69 | 2.8 | |

**Table 2.4-1** **Main Technical Index Table of each Cascade Development Scheme of the Upper Drainage Basin of Ayeyawady River Myitkyina ( Scheme I, recommended scheme)**

| River | Unit | Enmaynua River | | | | | Malinka River | Ayeyawady River | Total |
|---|---|---|---|---|---|---|---|---|---|
| Subproject | | Yenan | Kaunglanhpur | Pisa | Wutsok | Chibwe400 | Laza | Myistone | |
| Geological location | | Kachin · Putao County | Kachin · Putao County | Kachin · Myitkyina County | Kachin · Myitkyina County | Kachin · Myitkyina County | Kachin · Myitkyina County | Kachin · Myitkyina County | |
| Dam-site location | | Lower reaches of Nantamai River confluence 2.3km | Lower reaches of Ahkyang River confluence 1km | Lower reaches of MekhRame River confluence 3.2km | Upstream of Ngawchahg Hka River confluence 16.4km | Upstream of Chibwe 10-12km | Lower reaches of Ranka River confluence 4.6km | Lower reaches of Myistone River confluence 7km | |
| Adjusting performance | | Annual adjustment | Annual adjustment | Daily adjustment | Daily adjustment | Annual adjustment | Annual adjustment | Annual adjustment | |
| Max. dam height | m | 159 | 223 | 153 | 141 | 192 | 128 | 139.5 | |
| Length of dam axis | m | 500 | 576 | 312 | 434 | 820 | 481 | 1310 | |
| Design head | m | 122.6 | 192 | 120.7 | 103.6 | 174 | 97.9 | 155.3 | |
| Installed capacity | MW | 1200 | 2700 | 2000 | 1800 | 2800 | 1900 | 6000 | 18400 |
| Guaranteed output (combined) | MW | 258.4 | 687.7 | 512.3 | 475.2 | 677.3 | 623.9 | 1722 | 4956.8 |
| Annual energy output (combined) | 100 million kW·h | 66.5 | 147.3 | 110.8 | 101.4 | 152.1 | 104.4 | 308.6 | 991.1 |
| Utilization hours (combined) | h | 5542 | 5456 | 5540 | 5633 | 5432 | 5495 | 5144 | |
| Basic earthquake intensity | Degree | Ⅷ | Ⅷ | Ⅷ | Ⅷ | Ⅷ | Ⅷ | Ⅷ | |
| Total construction period | Year month | 7·8 | 8·2 | 8·5 | 8·5 | 8·1 | 8·5 | 8·0 | |

**Table 2.4-2 Main Technical Index Table of each Cascade Development Scheme of the Upper Drainage Basin of Ayeyawady River Myitkyina (scheme II, for comparison)**

| River | Unit | Enmaynua River | | | | Malinka River | Ayeyawady River | Total |
|---|---|---|---|---|---|---|---|---|
| Subproject | | Yenan | Kaunglanhpur | Larkhin | Chibwe450 | Laza | Myistone | |
| Geological location | | Kachin · Putao County | Kachin · Putao County | Kachin · Myitkyina County | Kachin · Myitkyina County | Kachin · Myitkyina County | Kachin · Myitkyina County | |
| Dam-site location | | Lower reaches of Nantamai River confluence 2.3km | Lower reaches of Ahkyang River confluence 1km | Lower reaches of MekhRame River confluence 22.9km | Upstream of Chibwe 10-12km | Lower reaches of Ranka River confluence 4.6km | Lower reaches of Myistone River confluence 7km | |
| Distance to Myistone confluence | km | 315.6 | 231.1 | 171 | 106.5 | 114.2 | -7 | |
| Drainage basin area | $km^2$ | 11123 | 14655 | 17072 | 21734 | 15291 | 47300 | |
| Average flow for many years | $m^3/s$ | 950 | 1300 | 1520 | 1880 | 1560 | 5020 | |
| Average water amount for many years | 100 million $m^3$ | 302 | 415 | 483 | 598 | 495 | 1585 | |
| Development method | | Dam | Dam | Dam | Dam | Dam | Dam | |
| Normal water level | m | 1010 | 875 | 665 | 450 | 370 | 245 | |
| Normal water level corresponding water surface area | $km^2$ | 22.9 | 35.59 | 38.84 | 33.49 | 285.48 | 404.83 | 821.13 |
| Dead water level | m | 980 | 825 | 635 | 410 | 340 | 230 | |
| Total reservoir capacity | 100 million $m^3$ | 12.37 | 31.72 | 11.35 | 36.71 | 123.28 | 132.82 | 348.3 |
| Effective reservoir capacity | 100 million $m^3$ | 5.78 | 15.26 | 3.13 | 14.07 | 57.85 | 45.03 | 141.1 |
| Reservoir capacity coefficient | % | 1.91 | 3.68 | 0.65 | 2.35 | 11.69 | 2.8 | |
| Adjusting performance | | Annual adjustment | Annual adjustment | Annual adjustment | Annual adjustment | Annual adjustment | Annual adjustment | |

**Table 2.4-2 Main Technical Index Table of each Cascade Development Scheme of the Upper Drainage Basin of Ayeyawady River Myitkyina (scheme II, for comparison)**

| River | Unit | Enmaynua River | | | | Malinka River | Ayeyawady River | Total |
|---|---|---|---|---|---|---|---|---|
| Subproject | | Yenan | Kaunglanhpur | Larkhin | Chibwe450 | Laza | Myistone | |
| Geological location | | Kachin · Putao County | Kachin · Putao County | Kachin · Myitkyina County | Kachin · Myitkyina County | Kachin · Myitkyina County | Kachin · Myitkyina County | |
| Dam-site location | | Lower reaches of Nantamai River confluence 2.3km | Lower reaches of Ahkyang River confluence 1km | Lower reaches of MekhRame River confluence 22.9km | Upstream of Chibwe 10-12km | Lower reaches of Ranka River confluence 4.6km | Lower reaches of Myistone River confluence 7km | |
| Max. dam height | m | 159 | 223 | 225 | 240 | 128 | 139.5 | |
| Length of dam axis | m | 500 | 576 | 764 | 1119 | 481 | 1310 | |
| Design head | m | 122.6 | 192 | 181.5 | 129 | 97.9 | 155.3 | |
| Installed capacity | MW | 1200 | 2700 | 3200 | 3800 | 1900 | 6000 | 18800.0 |
| Guaranteed output (combined) | MW | 258.4 | 687.7 | 788 | 1042.8 | 623.9 | 1722 | 5122.8 |
| Annual energy output (combined) | 100 million kW·h | 66.5 | 147.3 | 173.8 | 207.8 | 104.4 | 308.6 | 1008.4 |
| Utilization hours (combined) | h | 5542 | 5456 | 5431 | 5468 | 5495 | 5144 | |
| Basic earthquake intensity | Degree | Ⅷ | Ⅷ | Ⅷ | Ⅷ | Ⅷ | Ⅷ | |
| Total construction period | Year month | 7·8 | 8·2 | 8·10 | 9·0 | 8·5 | 8·0 | |

(2) Kaunglanhpur cascade

1) Development method

Dam-type method is adopted for Kaunglanhpur cascade. The planned normal water level is 875.0m, with check flood level 880.24m, corresponding total reservoir capacity 3.172 billion $m^3$,and installed capacity 2700MW.

2) Layout of hydroproject

Kauglanhpur cascade dam site is located at 1km from the confluence of the upstream of Enmaynua River and the branch Ahkyang River. According to the terrain of the dam site area, the scheme for the layout of the hydroproject is dam arranged in main riverbed, initially selected dam type is concrete faced rock-fill dam, spillway and emptying tunnel set at left bank, bank-type power station at the right bank.

(3) Pisa cascade

1) Development method

Dam-type method is adopted for Pisa cascade. The planned normal water level is 665.00m, with check flood level 669.56m, corresponding total reservoir capacity 0.535 billion $m^3$, and installed capacity 2000MW.

2) Layout of hydroproject

Pisa dam site is located at the section 0.7~4.0km downstream of Enmaynua River estuary from Mekh Rame River. According to the terrain of the dam site area, the scheme for the layout of the hydroproject is dam arranged in main riverbed, initially selected dam type is concrete faced rock-fill dam, spillway, emptying tunnel and diversion tunnel set at left bank, underground power station at the right bank.

(4) Wutsok cascade

1) Development method

Dam-type method is adopted for Wutsok cascade. The planned normal water level is 525.00m, with check flood level 529.50m, corresponding total reservoir capacity 0.321 billion $m^3$, and installed capacity 1800MW.

2) cascade arrangement

Wutsok dam site is located at the Enmaynua River branch section about 65km upstream of Chibwe, about 210km away from Myitkyina, about 53km away from Chibwe Power Station. According to the terrain of the dam site area, the scheme for the layout of the hydroproject is dam arranged in main riverbed, initially selected dam type is concrete faced rock-fill dam, bank-type power station, emptying tunnel and diversion tunnel set at left bank, spillway at the right bank.

(5) Chibwe cascade

1) Development method

Dam-type development method is adopted in Chibwe cascade. Planned normal water level is 400.0m; check flood level 406.15m, corresponding total reservoir capacity 1.939 billion $m^3$, and installed capacity 2800MW.

2) Cascade arrangement

Chibwe dam site is located at the Enmaynua River branch section about 10~12km of the upsteam of Chibwe, about 106.5km away from the confluence between Enmaynua River and Malinka River, about 140km away from Myitkyina, the capital of Kachin to the south. According to terrain conditions of the dam site, the preliminary layout of hydroproject arranges the dam on main riverbed, and initially selected dam type is concrete faced rock-fill dam, spillway set at left bank, underground power station and bank-type power station and emptying tunnel at the right bank.

(6) Laza cascade

1) Development method

Dam-type method is adopted for Laza cascade. The planned normal water level is 370m, with check flood level 374.55m, corresponding total reservoir capacity 12.328 billion $m^3$, and installed capacity 1900MW.

2) Cascade arrangement

Laza power station dam site is located at the middle and lower reaches of Malinka River, meeting a branch Ranka River at the left bank 4.6km from the upstream of the dam. According to the terrain of the dam site area, the scheme for the layout of the hydroproject is dam arranged in main riverbed, initially selected dam type is concrete faced rock-fill dam, spillway set at right bank, emptying tunnel and bank-type power station at the left bank. The natural terrain is utilized to arrange water-inlet tower at the right bank 8.75km of the dam site upstream. The diversion channel passes through a 1-meter-wide watershed and enters the bank-type power 2.28km of the dam site downstream.

(7) Myistone cascade

1) Development method

Dam-type method is adopted for Myistone cascade. The planned normal water level is 245m, with check flood level 248.26m, corresponding total reservoir capacity 13.282 billion $m^3$, and installed capacity 6000MW.

2) Layout of hydroproject

Myistone dam site is located at the Ayeyawady River branch section 7km downstream of the confluence between Enmaynua Riverand Malinka Rive, about 40km away from Myitkyina to the south. According to the terrain of the dam site area, the scheme for the layout of the hydroproject is dam arranged in main riverbed, initially selected dam type is concrete faced rock-fill dam. No.1 pass and No.4 pass are established with earth core rockfill dam. The west section of No.1 pass is set with spillway dam that is built with flood releasing surface holes and middle holes and diversion bottom holes. The southwest section of No.1 hill is established with water-diversion-type power station. The upstream

and downstream of the dam is built with water retailing cofferdam all year round. The combination of spillway dam diversion bottom hole, flood releasing middle hole and reserved dam body gap is adopted for diversion.

## 2.5 Reservoir inundation

The 7-grade hydropower development scheme recommended for the Ayeyawady River has 819.29km$^2$ of inundation area in total under normal water level of the reservoir, where normal water level of Yenan is 1010m, inundation area 22.90km$^2$; and the normal water level and inundation area for Kaunglanhpur, Pisa, Wutsok, Chibwe, Laza and Myistone is respectively 875m, 35.59km$^2$; 665, 10.53km$^2$; 525m, 20.09km$^2$; 400m, 39.81km$^2$; 370m, 285.48km$^2$, 245m, 404.8km$^2$.

When selecting normal water level for cascade power station, reservoir inundation loss is taken full consideration. The planned Myistone cascade considers little inundation of Enmaynua River Chibwe while the Malinka River Laza cascade development considers no inundation of Putao and its plain area (elevation 370~460m). Except Myistone cascade, the other 6 cascade reservoir valleys are of "V" shaped, with few population and arable land in the reservoir area, much forest, without historical relics and mineral resources, so the inundation loss is small and the resettlement issue is insignificant. But the terrace of Myistone cascade reservoir is slow, so the reservoir inundation involves large number of residents to be resettled.

In July 2009, DHPI took the lead to form an investigation team with Kachin government, CPIYN, AWC (Asian World Company) and CDC to carry out the investigation of land acquisition substantial index for building Myistone power station. According to the investigation and statistics, Myistone reservoir will submerge 63 villages in 5 districts of Myitkyina County and Putao County, affecting 11 807 people of 2556 households all together, 205,300m$^2$ of housing area. The farmland and orchards that farmers are cultivating and belong to them account for 7958.7 acres and 6579.8 acres, respectively, with 2835.7 acres of economic trees. There are in total submerged 211 religious

mausoleum, temples, churches, schools and hospitals, occupying 56,700m$^2$.

According to the MOA agreement signed between CPI and DHPI and the relevant requirement of DHPI about resettlement, the principle that the resettlement plan of the hydropower development lives up to is: the living condition of the resettled citizens shall be restored to the original condition and somewhat improved; resettlement area shall be in an area with convenient traffic and relatively sufficient land environment volume and conditions should be created for their future production and living. The initial plan is that relatively centralized resettlement is made by approaching road area or backward from the original place under the circumstance that the resettled residents' willingness is taken into full consideration.

The inundation scope of hydropower development upstream of Ayeyawady River is shown in the attached figure 6.

## 2.6 Progress of hydropower development

According toMOA agreement, Myanmar, it is planned to spend 15 years on developing this valley cascade power station. according to the development condition, pre-phase work foundation and the cascade power station profit, the power stations of Myistone and Chibwe are listed as recent projects to be developed, Wutsok, Pisa, Kaunglanhpur and Laza power stations, which have relatively good development condition and economic indexes, are listed as the second batch of projects to be development, and Yenan power station the third batch.

## 2.7 Overview of recent hydropower stations to be developed

(1) Myitsone Hydropower station

Myistone hydropower station is located at the river reach from Myistone the branch of Ayeyawady River to Myitkyina, 7.0km away from the confluence between Enmaynua River and Malinka River. Besides power generation, the station also has such comprehensive

utilization profit as flood control, improving downstream shipping and irrigation condition. Myistone hydropower station has normal water level 245m, adjustment reservoir 4.50 billion $m^3$, installed capacity 6000MW, annual energy output 30.86 billion kW-h (combined), being the largest controlling key project among the upper branches of Ayeyawady River Myitkyina.

(2) Chibwe Power Station

Chibwe power station is located at the section from Kaunglanhpur, the middle reaches of Enmaynua River, to Chibwe section, 106.5km away downward to the confluence of the two rivers, normal water level 400m, adjusted reservoir 0.81 billion $m^3$, installed capacity 2800MW, annual energy output 15.21 kw-h (combined). Besides power generation, Chibwe power station is in joint regulating with Myistone reservoir. It also has such profits as flood control and improving downstream shipping and irrigation condition, being an important key project of Ayeyawady River Myitkyina.

## 2.8 Coordination analysis of hydropower development plan

The power source development of Myanmar mainly comes from hydropower and the electrical demand of the whole nation is mainly met by hydropower. In order to effectively utilize the rich water resources, Myanmar government actively introduces foreign capital to develop the hydropower resources of the nation and expand power consumption channel abroad. It encourages building out-transmitting hydropower project that has the regional advantage of transmitting power to the neighboring countries to transform its resource advantage into economic advantage, thus promoting the economic development of this nation.

The main mission of this plan focuses on power generation and such comprehensive utilization profits as improving flood control ability, downstream shipping and irrigation conditions. The cascade development scheme recommended in this plan has total installed capacity of 18400MW, and annual energy output 99.11 billion kW-h. The implementation of this plan can reasonably utilize the rich hydropower resources in the planned drainage

basin, which can not only meet the power demand of the national economic and social development of Myanmar, but also has large quantity of power transferred to neighboring countries to gain huge economic profit. Therefore, the implementation of this plan complies with the 30-year-long plan made for Myanmar.