

Integrated Water Resource Management in the Red River Basin - Problems and Cooperation Opportunity

Nguyen Van Diep¹, Nguyen Hong Khanh², Nguyen Minh Son²,
Nguyen Van Hanh³, Patrick Huntjens⁴

¹ Institute of Mechanics (IMECH, Vietnam)

² Institute of Environmental Technology (IET, Vietnam)

³ Vietnam Institute for Water Resources Research (VIWRR)

⁴ University of Osnabruck (UOS, Germany)

1 Introduction about the Red River basin [5, 10]

The Red River basin is among the largest river basins in the World. It is located in the North and North-East of Vietnam, between 20⁰⁰N and 25³⁰N, and 100⁰⁰E and 107¹⁰E. The basin stretches across 3 countries, including China, Laos and Vietnam (Figure 1). Its total area is approximately 169,020 km², of which 81,240 km² (48%) in China's territory, 1,100km² (0.65%) in Laos and 86,660km² (51.35%) in Vietnam. Adminis-



Fig. 1 Red River basin

tratively, the Red River basin covers 26 provinces and cities in the northern region of Vietnam, including the cities of Hanoi and Hai Phong, and the provinces of Ha Tay, Ha Nam, Nam Dinh, Ninh Binh, Hai Duong, Hung Yen, Thai Binh, Bac Kan, Bac Ninh, Bac Giang, Vinh Phuc, Phu Tho, Thai Nguyen, Tuyen Quang, Ha Giang, Lao Cai, Yen Bai, Lai Chau, Son La, Hoa Binh, Cao Bang, Lang Son, Quang Ninh and Dien Bien, with a total population of about 28 million of people.

Annual rainfall strongly varies from place to place in a range of 700-4,800 mm/year (700-2,100 in Chinese part and 1,200-4,800 mm/year in Vietnamese part). About 80% of rainfall occurs in summer (May-October).

The hydrological regime in the Red River system is characterized by the two distinguished seasons: rainy season from May to October and dry season from November to April of the following year. The flood season lasts from June to October, while the low flow season: from November to May of the following year. The total flow volume of the Red River system (including Thai Binh River system, which is located in the lowland part of the northern region of Vietnam and linked with the Red River system) is estimated of about 135.7 km³/year, of which 82.9 km³ (61%) is produced in Vietnam's territory. Flows through the Basin are unevenly distributed in space and time, typically causing water shortages in the dry season and floods and water-logging in the rainy season.

The total groundwater reserve in Vietnam's part of the Basin is about 18,219 billion m³ (equivalent to a flow of 577.4 m³/s).

Among 86,660 km² of the total natural area of Vietnam covered by the Red River basin, the agricultural land occupies about 1,874,100 ha and forestry land occupies 2,570,775 ha. Potential area for future agriculture and forestry development is estimated of about 3,919,500 ha.

The Red - Thai Binh River delta and midland area, including Hanoi capital and many cities and towns is an economic and political center of Vietnam. The road system here is well developed. It includes 12 national roads of 1,200 km long, 2,300 km of provincial roads and 4,500 km of district roads. There is a well developed concentrated irrigation system in the Basin, which includes 10,800 km of irrigation canal, 9,300 km of drainage canal, 3,828 irrigation sluices, 4,300 drainage sluices, 3,212 irrigation pumps, 3,220 drainage pumps, 3,500 km of dykes for river and sea, and 2,266 sluices under dykes. The dyke system is constructed for the protection of an area of 14,425 km², of which agricultural land is 8,793 km².

2 Main issues [4, 5, 7, 10]

2.1 Flooding

Big floods in the Red river often occur in July and August. The Red - Thai Binh river delta is too low in altitude and all the delta area with the infrastructure systems in it are at 3-5 m lower than flood level (5-7 m lower than the highest flood level, recorded in August 1971). Floods are the biggest threat to the life and property of people, as well as the biggest constraint to various developments in this area. To reduce the damages caused by floods, for short-term and long-term flood prevention and control in the Red - Thai Binh River system, the followings measures are taken:

- Strengthening dike systems;
- Clearing river flows for flood discharge;
- Building reservoirs in upstream areas of big rivers to reduce floods;
- Diverting and retaining floods;
- Reforesting in the watersheds; and
- Intensifying dike protection and management.

However, the implementation of these measures requires a comprehensive data and information set, as well as the advanced modelling technologies, which are inadequate in Vietnam.

Besides, flash floods often occur in the upstream regions of the Red River basin. They cause massive losses of human life and immense damages. The tools for flash flood forecasting and warning are currently lacking in Vietnam.

2.2 Reservoir system regulation

Reservoir system in the Red River basin plays very important role in socio-economic development of Vietnam. The major reservoirs include:

- Thac Ba reservoir, with the following main features: high water level: 59 m, total storage: 3.6 billion m³, flood regulation storage: 0.45 billion m³, installed capacity: 120 MW;

- Hoa Binh reservoir - the biggest in Vietnam at present. Its main features are: high water level: 120 m, total storage: 9.45 billion m³, flood regulation storage: 5.6 billion m³, installed capacity: 1920 MW;
- Tuyen Quang reservoir, being completed. Its main features are: high water level: 123 m, total storage: 2.3 billion m³, flood regulation storage 1 – 1.5 billion m³, installed capacity: 342 MW;
- Son La reservoir, being constructed and planned to be completed in 2010. Its main features are: high water level: 217 m, total storage: 9.26 billion m³, flood regulation storage 5.5 billion m³, installed capacity 2400 MW.

Besides, some other reservoirs are under designing process. It is evident that the problem of multiple use and management of reservoirs in the Red River basin is important and actual for Vietnam.

2.3 Droughts

The droughts occur frequently in the Red River basin. During dry seasons, many areas suffer serious shortage of water that affects the economic activities, including the water supply for domestic use to local people. Water shortage leads to saline intrusion and causes constraints to waterway navigation. In 2004, the water shortage became ever worse as water level in the Red river at Hanoi station was lower than the alarming level (1.97m). In the dry season of 2005, the water level in the Red river is brought down to the lowest level of the past 100 years, i.e. 1.58m at Hanoi station.

2.4 Water pollution

Many river segments and lakes in the Red River basin are being polluted with concentrations of most of the environmental parameters exceeded Vietnamese standards. According to the data collected during the last few years, the impact to Red river water, caused by the socio-economic development, particularly by the domestic and industrial waste water from the upstream area and from urban/industrial areas in the Northern Vietnam, such as Thai Nguyen, Vinh Phuc, Hanoi, Nam Dinh, Hai Phong, Thai Binh..., increases, that makes the Red river water became worse and worse. Some river segments in the Basin, such as Red, Cau, Day, Nhue and Thuong... are polluted at a large scale. The pollution of surface water impacts to the ground water in Hanoi. The content of NH₄ in the

water supplied to all 3 water supply factories in Hanoi (before treatment) for example is 2-8 times exceeded Vietnamese standards.

2.5 Multiple water use

The rate of average water demand of sectors on 9 main river basins in Vietnam is shown in the figure 2. In general, the water demand of agriculture's sector is highest (74% in 2001 and 56% in 2020); the water demand of industry's sector will be raised dramatically (from 1% in 2001 to 16% in 2020). Thus, the problem of sectoral integration for sustainable water use is urgent issue in the Red River basin.

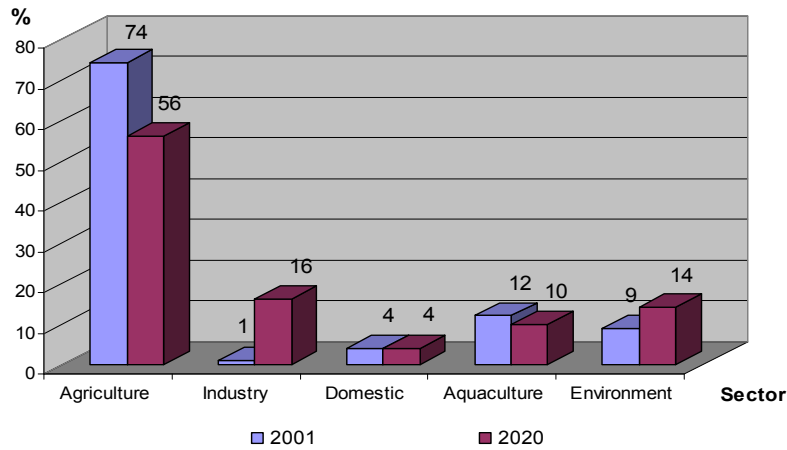


Fig. 2 Water demand of sectors on 9 main river basins (in 2001 and projected for 2020)

2.6 Governance

Almost all aspects of water resources are addressed in the relevant policies, strategies and laws of Vietnam. However, the circulars and under-law documents, which give guidance to implementation of the policies and laws, are still in the development stage. The lack of comprehensive institutional framework has caused losses and failures in water resources management practices in Vietnam. The major issues on the water resources governance can be listed as follows:

- Sub-law documents of the Law on Water Resources are not adequate and comprehensive;

- Mechanisms and tools, especially the economic ones, for implementing the policies on water resources are lacking;
- Information and data on water resources are inadequate and inaccurate; there is a lack of a national database on water resources and the information sharing mechanism;
- Public awareness on the importance of water resources and sustainable water resource use is low. This hinders the participation of the society in the water use and management;
- A suitable model for the integrated Red River basin management has not yet been established and the imbalance in the development of different economic sectors with environmental protection, natural disaster mitigation and poverty reduction remains a critical issue.

2.7 Transboundary issue

The Red River basin is an international one, shared by China, Laos and Vietnam. Many issues arisen from the socio-economic development in different parts of the Basin belonging to all three countries, including the reservoir building and waste discharging from the upstream area, belonging to China, effect more and more severely the downstream areas of Vietnam. Thus, the integrated water management in the Red River basin has to be considered as a transboundary issue, requiring the joint efforts of the three countries. Unfortunately, this topic up to now is not yet appropriately addressed.

In addition, the climate change effects, including the changes in storm intensity and frequency, rainfall patterns and other meteorological characteristics, which could affect much the midland and coastal zones of the Red River basin, should also be addressed. It is evident, that all the above mentioned issues are related to the lack of an integrated approach to the management of the Red River basin.

3 Research activities related to the water resources in the Red River basin [1-3, 6, 8, 9]

Before, the research activities on water resources of the Red and Thai Binh rivers mainly dealt with the irrigation field. The measures proposed then had single-sector character and focused more on the construction of sluices, dams and embankments. Recently, the issues on flood con-

trol and reservoir regulation become more important, as long as there are many threats from these activities to the socio-economic development in the Red River basin. Moreover, the multiple uses of water resources in the Basin are of a great concern in both national and international projects on flood control and reservoir regulation in the Basin. Some important projects implemented recently can be listed below:

- ***National project (KC.08-13) on Scientific Basis for Flood Control in the Red and Thai Binh River Delta, MOST, 2001-2005***

The objectives of this Project are:

- To determine the flood patterns and main factors causing floods in the Red and Thai Binh River delta;
- To develop a scientific basis for flood forecasting and control.

Participated in this Project were: IMECH (responsible), Institute of Geography, Institute of Water Resources Planning, Vietnam Institute of Water Resources Research (VIWRR), Department for Dike Management and the Storm & Flood Control, National Center for Meteor-Hydrological Forecasting.

The activities of this Project are grouped in 3 main work packages:

- Work Package 1: Study on natural and socio-economic factors leading to floods in the Red and Thai Binh River basin. Within this package, a database for flood control in the Basin was constructed;
- Work Package 2: Development and consolidation of forecasting technologies and DSS for flood control;
- Work Package 3: Development of scientific basis for overall solutions on flood control and rescue.

The main results achieved in this Project include:

- A comprehensive database for flood control in the Red and Thai Binh River basin has been built;
- A number of hydrological and hydraulic models were consolidated, tested and used for flood forecasting and control. By the demand and evaluation of the Central Committee for Storm and Flood Control,

during the flood season of 2002-2005 years, the short term forecasts made by the IMECH have been used for flood control;

- The main flood control measures (such as reservoir regulations, diversion, retention...) are considered in flood control and management plan.
- ***Decision Support System (DSS) for Ecosystem Upgrading and Flood Control of a Sustainable Development in the Red River System – (FLOCODS, Pilot Phase” 2001-2003, supported by the European Commission.***

The objectives of this Project are:

- To develop main elements a DSS on flood control, including hydrological model for the Red River basin, hydraulic model for the Red River system, dam-break flow model for the Red River and initial socio-economic impact assessment model;
- Development of a visualised module to connect all the above mentioned elements, using advanced techniques, including satellite image processing and GIS;
- Identification of threats from flood, evaluation of their socio-economic impacts and identification of main possible measures for flood controls and ecological sustainability in the Red River basin;
- Contribution to the improvement of the capacity of Vietnam in flood control and ecosystem protection.

The Project was implemented under the coordination of the University of Caen (France) and with the participation of the Institut de Mécanique de Fluids de Toulouse (France), Institut de Recherche pour le Développement (France), Instituto Superior Técnico (Portugal), Laboratório Nacional de Engenharia Civil (Portugal), University of Twente (Netherlands), Institute of Automation of the Chinese Academy of Sciences (China) and Asian Institute of Technology (Thailand). From the Vietnamese side, the Institute of Mechanics (IMECH) and Department of Dyke Management and Flood and Storm Control were involved in the Project implementation.

The main activities of Project were grouped into 6 packages, as follows:

- Work package 1: Geographic and ecosystem background of the Red River system;
- Work package 2: Hydrological background for a generic DSS;
- Work package 3: Hydraulic background for a generic DSS;
- Work package 4: Socio-economic model background of a generic DSS;
- Work package 5 (Transversal work package): Visualised module;
- Work package 6: Pilot DSS.

The first four work packages are to lay the scientific foundation for the pilot DSS. Work package 5, supports all other work packages, based on advanced techniques, such as GIS, computer interface and remote-sensing image processing. Work package 6 is to set up the pilot DSS. It allows initial validation of the pilot system, evaluation of the socio-economic impacts and identification of possible main measures for flood controls, ensuring the ecological sustainability in the Red River system.

As main results of the two above-described projects, some initial database and different models, which can be considered as first elements of a DSS for flood control and management in the Red River basin, have been developed. They include:

- Hydrological model;
- One and quasi-two dimensional hydraulic models;
- Flood forecasting model using a hydrological and one/quasi-two dimensional models;
- Two dimensional hydraulic model;
- Flash flood forecasting model using a hydrological, one and two dimensional models;
- One and two dimensional hydraulic dam and dike break flow model;
- Socio-economic model for evaluating damages caused by flood;
- Pilot DSS linked with the above models (Figure 3).

The Pilot DSS has been used for short term flood forecasting and for evaluating flood protection measures.

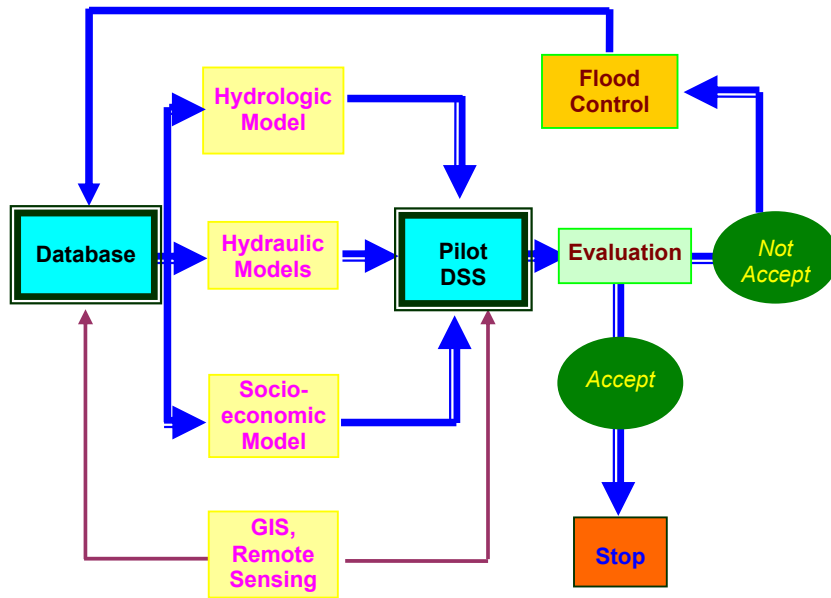


Fig. 3 Pilot DSS for flood control in Red River basin

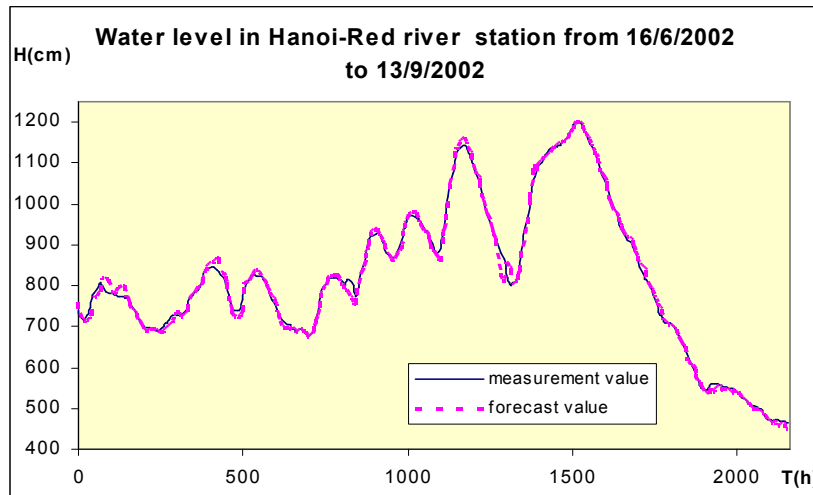


Fig. 4 Predicted and measured water level at Hanoi station, Red river for the 2002-year flood season

Since 2002, the 48 hours - in advance forecasts of the discharge into Hoa Binh reservoir and the water level in Hanoi are undertaken by IMECH for the whole flood season from June 16 to September 15. The forecasting results are acceptable (see Figure 4, as an example), as assessed by the Central Committee for Flood and Storm Prevention.

The 1-D and quasi 2-D_IMECH model were used for evaluating the effectiveness of flood reduction by taking flood protection measures for the floods with frequency of occurrence of 500-year and 1000-year. This requires to evaluate the upstream discharges for the Red River system for extreme floods with frequency of occurrence of 500 and 1000 years, and to evaluate the existing flood control measures (reservoir operation, diversion and detention zones) and the new measure (particularly on building of emergency spillways) to protect these extreme floods. The results of evaluating the effectiveness of flood reduction for 500-year flood of 1996-year shape, with no emergency spillways used, are presented in the Table 1 (Z – water level, Q - water discharge and V – water volume).

Table 1 The effectiveness of flood reduction for 500-year flood of 1996-year shape

Scenario	No Protection measures	Hoa Binh reservoir operation	Hoa Binh reservoir & Day dam operation	All flood protection measures
Z _{max} Hanoi (m)	15.53	14.58	13.97	13.92
Q _{max} Hanoi (m ³ /s)	40,475	31,361	26,071	25,665
Z _{max} Son Tay (m)	18.62	17.34	16.69	16.61
Q _{max} Son Tay (m ³ /s)	49,470	38,632	36,952	35,849
Z _{max} Van Coc (m)			15.43	15.43
Q _{max} Day dam (m ³ /s)			4,190	4,020
Z _{max} Tam Thanh (m)			21.90	21.42
Z _{max} Lap Thach (m)			13.26	18.08
Z _{max} Luong Phu (m)			16.16	18.80
V Day dam (m ³)			1.36 10 ⁹	1.1 10 ⁹
Z _{max} Hoa Binh reservoir (m)		115.60		

- *Multi-Purpose Operation of the Upstream Reservoirs in the Da and Lo Rivers, Ministry of Agriculture and Rural Development, 2005-2007*

The objectives of this Project is to set up the rules for multipurpose operation (flood protection, hydroelectricity production, water supply, environmental protection...) of the upstream reservoirs (including Hoa Binh,

Thac Ba, Tuyen Quang and Son La) in the Da and Lo rivers, for assuring the sustainable development in the Red Rive basin.

VIWRR is responsible for implementing this Project in cooperation with the Institute of Water Resources Planning, IMECH and National Center for Meteor-Hydrological Forecasting.

The Project consists of 5 work packages:

- Work Package 1: Medium term (5 days) hydrological forecasting and its role in reservoir operations;
- Work Package 2: Setting up rules for multipurpose operations of the Thac Ba, Hoa Binh and Tuyen Quang reservoirs for the dam protection and flood safety in the Red River basin;
- Work Package 3: Setting up rules for multipurpose operations of the Thac Ba, Hoa Binh, Tuyen Quang and Son La reservoirs for dam protection and flood safety in the Red River basin;
- Work Package 4: Assessment of river bed changes and their impacts for improving the reservoirs regulation rules;
- Work Package 5: Setting up rules for multipurpose operations of upstream reservoirs in Da and Lo rivers in dry season.

The work packages 1, 2, 4 and 5 have been completed. The rules for multipurpose operations of the 3 reservoirs (including Thac Ba, Hoa Binh and Tuyen Quang) have been adopted by the Government and were used for the flood season of 2007 year. The work package 3 will be completed by the end of the 2007 year, and the rules for multipurpose operations of 4 reservoirs (Thac Ba, Hoa Binh, Tuyen Quang and Son La) will be submitted for approval by the time.

The integrated approach in water resources management has been introduced to Vietnam recently, mainly through the foreign granted projects. There is still no operational model in this field developed, thus, the results achieved are only for increasing knowledge and awareness of some research and management agencies. In 2007, a joint research project on ***Integrated Management of Cau River Basin*** was developed by the Institut National de la Recherche Scientifique (INRS), Canada and Vietnamese Academy of Science and Technology (VAST), for the period 2007-2012. Cau River basin is a sub-basin, covering 5 provinces in the midland area of the Red River basin.

The Institute of Environmental Technology (IET) is the focal agency from Vietnamese side in implementing this Project. The Project aims at strengthening capacity of VAST in the field of river basin management through introducing to VAST the DSS named GIBSI and training of VAST's staffs on water resource research and management at INRS, Quebec, Canada. Some initial test of GIBSI will be carried out for a part of Cau River basin, covering the two upstream provinces, including Thai Nguyen and Bac Kan. In more details, the activities concerning the development of technical tools for water resources management of this Project include:

- Collection, processing and assessment of data and information on Cau River basin;
- Development of database on Cau River basin;
- Exploitation of set of models within GIBSI (hydrological, hydraulic, water quality, erosion/pollution models) for the two upstream provinces (Bac Kan and Thai Nguyen);
- Field survey for additional data/information;
- Development of scenarios to support water-related management;
- Application of DSS for integrated management of the Basin;
- Assessment of the results and perspectives of the system.

It can be said that the Project will give opportunity to the researchers in VAST to strengthen their knowledge through education programme in Canada and learning and exploiting the GIBSI model. Solving specific issues on the Cau River basin management is still in future plan.

4 Opportunity for research cooperation

IMECH, IET and VIWRR are the key Vietnamese organizations participating in the ASEM WATERNET project. They are also the ones, which are responsible and involved in the above mentioned projects on water resources in the Red River basin. The results and experience they have are very important for continuing the research, concerning the water resources management, using integrated approach at river basin scale.

4.1 Focus areas

The development of a DSS for integrated water resources management, especially for multiple uses of the reservoirs (flood control, hydro-power generation, irrigation, water supply, navigation, recreation...) is therefore important for Vietnam, in general, and for the Red River basin, in particular. It is a new and challenged work, not only for the IMECH, IET and VIWRR, but also for all Vietnamese researchers. It requires the participation of different sectors, agencies and individuals under an effective coordination-cooperation mechanism. The international cooperation and assistance are extremely important, particularly in transferring the knowledge and technical tools to Vietnamese counterparts.

On the other hand, the institutional issues concerning the water resources management in the Red River basin should also be solved. This relates to the strengthening of coordination and cooperation among different agencies and stakeholders for integrated water resource management, particularly strengthening of capacity of the Red River Basin Committee, established since 2001, but not yet effectively functioned; improving the policy and legislation on the water resources management; raising public awareness and mobilizing the stakeholders participation in addressing the water related issues in the Basin.

4.2 Red River case-study in ASEM-Waternet project

The Red River case-study would provide input to and need contribution from all work packages of ASEM-Waternet project, including: WP 1 on river basin; WP 2 on water use efficiency in agriculture (e.g. DSS tools for Red river in dry season and optimal allocation of water resources); WP 3 on floods, WP 4 on pollution, and WP 5 on water governance. Knowledge exchange and collaboration between the Red River case-study and others, such as those on the Rhine River basin and the Guadiana River basin, could be promoted. These Basins have similar set of issues with the Red River basin, for example the impact of climate change, sectoral integration, information management, participatory process and transboundary impact. The Rhine River basin and Guadiana River basin are two case-studies in the NeWater-project being considered as a potential counterpart for exchange and collaboration with the Red River basin (www.newater.info), since the objectives and deliverables of NeWater project satisfies the majority of needs identified for the Red river case-study.

There are also opportunities for exchange with the Thai case-study on Bang Pakong River basin, particularly on the linkage between integrated water resources management for the Red River basin and integrated coastal zone management for the Red – Thai Binh River delta, where exist abundant coastal resources, including the Xuan Thuy Ramsar Site at the Red River mouth.

4.3 Proposed project on the Red River basin

Thus, the proposed project for the Red River basin is described below:

Title: DSS for integrated water resources management in the Red River basin.

Objectives:

- Development of comprehensive system of tools for river basin management;
- Guiding the practitioners to apply methods of adaptive management in Red River basin;
- Strengthening of the national and local capacity for the integrated Red River basin management.

Activities:

- Development of an integrated database and information management system for the whole Basin;
- Development and improvement of advanced modelling technologies (hydrological, hydraulic, water quality, socio-economic models);
- Development of advanced modelling technologies for multiple use water resources (for flood control, hydropower, irrigation, navigation, recreation, water supply...);
- Development of DSS for integrated water management in the Red River basin, taking into consideration of climate change scenarios, socio-economic impacts, environmental requirement and the linkage between IWRM and ICZM,
- Strengthening the Red River Basin Management Committee and coordination-cooperation mechanism, particularly between the relevant

local governments, and between governmental management agencies and research institutions;

- Promotion of public awareness on and participatory process in sustainable water use and integrated river basin management;
- Development of human resource through training and education on integrated river basin management;
- Technology transfer and guidance on the implementation of the tools developed to the Red River Basin Management Committee and the functional agency (ies), designated by the Committee.

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