WISDOM

PROJECT PORTFOLIO

Water-related Information System
for the sustainable development
of the Mekong Delta

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1. THE PROJECT

GENERAL PROJECT INTRODUCTION

Key Issues and Challenges in the Mekong Delta

The Mekong Delta is formed by the nine arms of the Mekong River, which all drain into the South China Sea. It comprises an area of 40,000 km^2 and offers natural resources for over 17 million inhabitants living in 13 of the 58 provinces of Vietnam (Figure 1).

Frequent floods and droughts, limited availability of drinking water, increasing water pollution, and loss of species and habitats, such as the decrease of mangrove ecosystems, all have negative effects on people's lives. Strong population pressure and the first impacts of climate change pose increasing challenges for the population of this fast developing region, and hence for the planning authorities in the delta.

Though people have adapted for centuries to seasonal flooding in the delta, they are facing numerous challenges which are constantly intensifying. Amongst them are an increase in the number of extreme floods, expanded drought periods, accelerating water pollution, sea level rise induced saltwater intrusion and soil salinization leading to a decrease in agricultural yields and to an expected increase in tropical storms, and, generally, strong population and economic growth leading to more pressure on natural resources and the livelihood of the population.

National and regional authorities face the problem of ensuring the sustainable management of land and water resources in the Mekong Delta. Thus, a key aspect for planning authorities is the generation and distribution of water–related information for the delta.

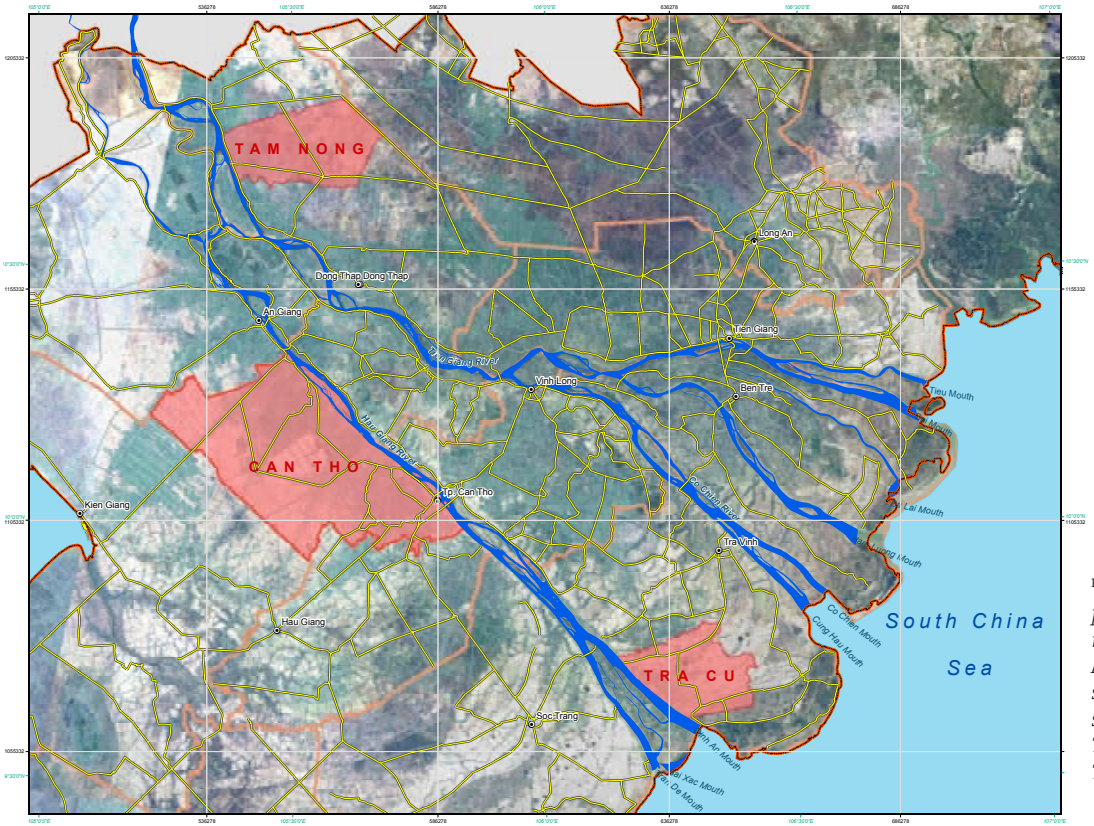

Fig. 1 *WISDOM project area: zoom in on central Mekong Delta to show selected study sites – Can Tho, Tam Nong and Tra Cu*

Introduction to the WISDOM project

WISDOM is a bilateral, multidisciplinary research project involving Germany and Vietnam (Figure 2). The German side is funded by the German Ministry of Education and Research, BMBF, the Vietnamese side by the respective counterpart, MOST. The main project goal is to design and implement a comprehensive information system tool which supports regional government agencies in the Mekong Delta in their planning processes to develop the region and adapt to climate change.

In the first project phase (2007 – 2010) a prototypical Water- and Land-Information System was developed. Information System is a technical term describing a knowledge cluster built up from different research fields within the project plus a physically existing web-based information system. In the WISDOM Information System, data and information from project disciplines like hydrology, geochemistry, socio-economics, geography, and earth observation are constantly integrated.

Fig. 2 *WISDOM project group at WISDOM II Kickoff Meeting in Ho Chi Minh City*

The potential user is not only able to visualize all this information but can use it to analyze special Mekong Delta related questions as well.

In the second project phase (2010 – 2013) the project network comprises seven German and eight Vietnamese research institutions, six German small- and medium-size enterprises as well as eleven associated partners. There are two major goals for this second phase. First, there is the challenge to answer numerous research questions related to climate change as well as land and water management, which is being addressed by numerous senior scientists as well as 14 PhD students in research topics from disciplines such as environmental science, remote sensing, GIS, hydrologic modelling, socio-economics, climate change resilience and adaptation, etc. Secondly, the WISDOM Information System is to be implemented in Vietnam. Capacity building activities are carried out jointly by project partners, stakeholder and users to achieve sustainable knowledge dissemination as well as the long-term use of the system.

This brochure introduces the research activities which are part of the WISDOM project. Detailed project information can also be found on the bilingual (English/ Vietnamese) WISDOM web page: www.wisdom.caf.dlr.de

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THE WISDOM INFORMATION SYSTEM

Key characteristics of the WISDOM Information System

The WISDOM Information System communicates researchers' findings from different domains to local decision makers. The system enables an integrated view of interdisciplinary information products, which supports sound decision making as key environmental issues can be regarded from different points of view (Figure 3). Furthermore, the system, which is available online, assures that none of the results generated over the six years of the project are lost. All geodata, map products, research reports, additional literature, legal document databases, institutional databases, image galleries, etc. are available to a broad audience beyond the end of the project.

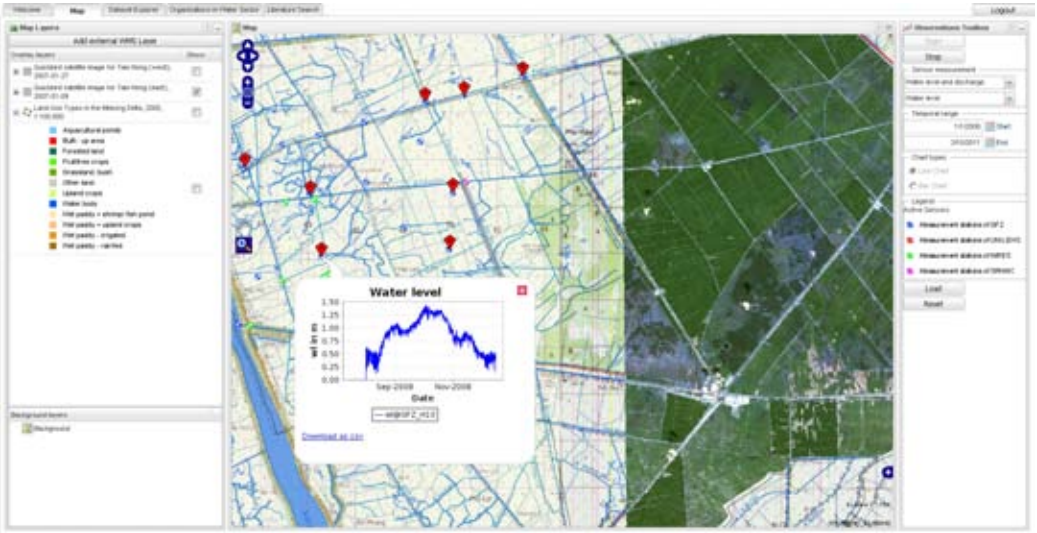

Fig. 3 *Snapshot of the WISDOM Information System User Interface – zoom in on Tam Nong area with hydrological measuring stations (red dots) and a chart showing the measured water level*

What is the technical backbone of the WISDOM Information System?

Fig. 4 *Multi-disciplinary data sources form the input for the WISDOM Information System*

The WISDOM Information System is the central access point for all WISDOM data products generated by the project's partners (Figure 4). The WISDOM Information System is a web-based Geographic Information System with data ingestion and operational data processing capabilities which follow widely-agreed international standards. The focus is on employing open-source technologies in order to satisfy current Vietnamese government IT strategies, reduce installation costs and permit further adaptations to meet necessary project requirements. The implemented client-server technology with components consisting of a spatial database, a Java web application and several services can be installed at multiple locations. According to the project-wide data standard developed in the beginning of the project, the data integration process is fully automated to enable partners to import or update their data easily. After data ingestion the WISDOM Information System provides a set of functions for data querying and visualization in a web-based application. The main idea is that combining historical and near-real-time data from different science fields will facilitate user analysis of water related question (for example, "How does

the current inundation situation differ from past flood events or from different flooding scenarios from hydrological modelling?"). End users can directly access the functions of the WISDOM Information System via the Internet using standard browser software. In addition, the implementation of services compliant with OGC (Open Geospatial Consortium) standards provides access to WISDOM components and data even for those using non-WISDOM software. Because of this compliance with open standards the WISDOM Information System can integrate new data sources easily and play a major role in establishing a Vietnamese spatial data infrastructure.

How can the success of the WISDOM Information System be ensured?

Building both capacity and acceptance are important tasks extending beyond the technical development of an information system. There have been several activities, still ongoing, between DLR and VNU-ITP (the Information Technology Park of the Vietnam National University) and including all other partners in

Fig. 5 *Technical User Training Workshop*

Fig. 6 *Stakeholder Meeting in Can Tho City*

Germany and Vietnam to jointly design, build, develop, and ensure maintenance of the system in Vietnam. Several training sessions (Figure 5) covering all aspects of information system design as well as geodata management provide the background for internal project collaboration. Further activities to ensure the final successful implementation of the WISDOM Information System include defining a sound operator concept enabling Vietnamese stakeholders and scientists to continuously fill the system with further information and maintain system operation. Frequent exchanges with stakeholders (Figure 6) at different administrative levels clear the path for the final acceptance and further development of this planning tool.

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2. RESEARCH ACTIVITIES

REMOTE SENSING PRODUCTS IN WISDOM

Using earth observation based on satellite imagery is a cost effective way to map large areas of the earth's surface (Figure 7) while at the same time monitoring the dynamics over time. Satellite-based imaging sensors visualize the surface in spectral ranges beyond what the human eye can see. So-called passive sensors measure reflected sunlight in the optical and infrared regions of the electromagnetic spectrum. Active sensors utilize their own source of radiation, for example in the microwave range, to measure the signals reflected back to the sensor, and since clouds, fog and rain are transparent to microwaves, a radar sensor can see through clouds.

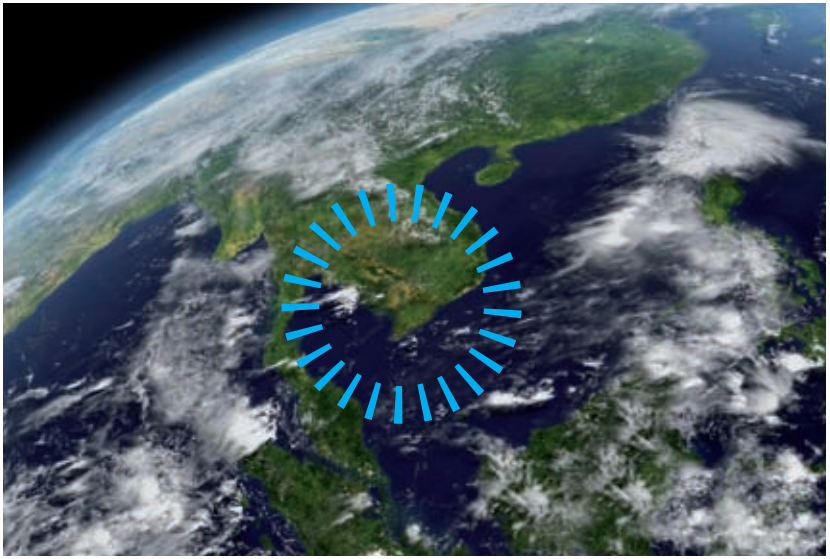

Fig. 7 *The Mekong Delta is the focus area of the WISDOM project*

Remote sensing product generation

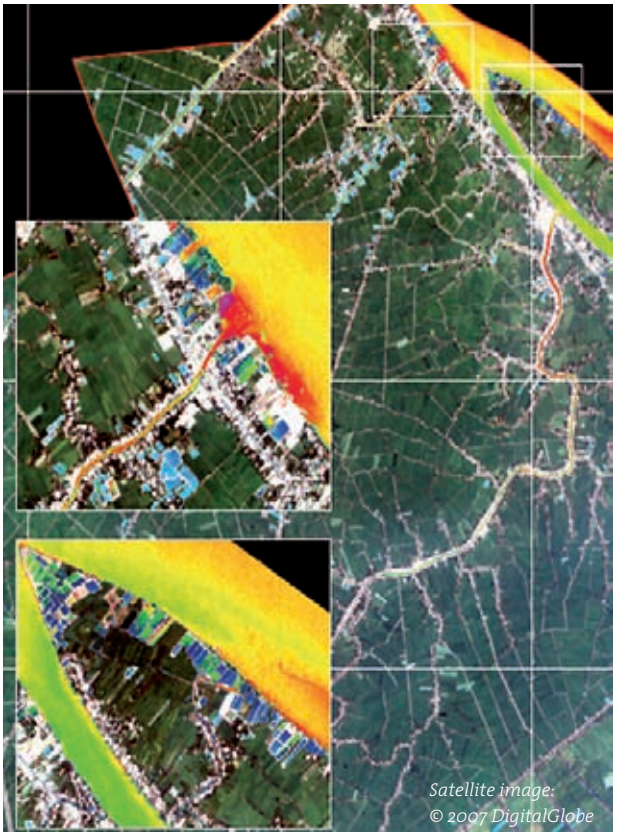

Fig. 8 *Sediment concentration maps derived from optical remote sensing data – zoom in on river channel in the north of Can Tho province running into a main river arm of the Mekong*

The German Aerospace Center (DLR) in close cooperation with the University of Würzburg is synergistically utilizing passive and active satellite imagery from a variety of sensors to derive land cover and land use information at different spatial scales for the entire Mekong Basin and the Mekong Delta, and at especially high scales for priority areas. Such information products have been generated for different periods over recent decades, allowing an analysis of changes in the investigated areas. They are valuable input for detecting natural changes, for example, those caused by floods and storms, and understanding the adaptation strategies of the population over recent decades, like urbanization or agricultural intensification. The team of Würzburg-DLR and the EOMAP company in cooperation with the GIS and Remote Sensing Research Center (VAST-GIRS) are utilizing active radar imagery and passive optical images, respectively, to continuously map inundated areas in the Mekong Basin and Delta to obtain time series of so-called water masks which trace the flooding occurring primarily during the wet seasons (Figure 9). EOMAP has high expertise in the derivation of water quality maps from satellite images

Vietnam - Mekong Delta - Seasonal Inundation

1:200.000

Rainy season - August 21, 2009

Dry season - March 09, 2009

Legend

Classification and basic information

- Provincial boundary
- City
- Normal water level
- Inundated area

Interpretation

The Mekong Delta is affected by seasonal flooding between July and December with its peak between late September and the end of October. The map shows the inundated areas during rainy and dry season derived from TerraSAR-X imagery using FLOODMASK software.

Scale / Reference System

0 3 6 9 12 km

Scale 1:200,000

N

Reference coordinate system:		Geographic coord. info:
Projection:	UTM Zone 48 N	Geographic (DMS)
Spheroid:	WGS 84	WGS 84
Datum:	WGS 84	WGS 84

Data Sources

Background Image © True Marple, Unearthed Outdoors, LLC

TerraSAR-X data © German Aerospace Center (DLR), 2007

River network © Sub National Institute for Agricultural Planning and Projection (Sub-NIAPP), 2000

City location data © Southern Institute of Water Resources Research (SIWRR)

Map Info

Image processing and map creation by DLR

Derivation of flooded water areas from TerraSAR-X

Map created December 2010 by WISDOM

German Remote Sensing Data Center
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Fig. 9 *Inundation map of Northern Mekong Delta for rainy season 2009 (left) and for dry season 2009 (right), derived from radar remote sensing data*

and monitors sediment and chlorophyll concentrations in the rivers (Figure 8) and coastal zones of the Mekong Delta. With active remote sensing the soil at the earth surface is penetrated to some extent, which makes it possible to extract information about it. Vienna University is utilizing this technology to monitor soil moisture content in the Mekong Basin. Satellite data are furthermore used to investigate and map in detail priority ecosystems like mangrove swamps (Figure 10) and to monitor the growth of cultivated plants, in particular rice, to derive crop prediction models. High resolution satellite imagery is also used for generating topographic information about the location of houses, road networks and industrial areas.

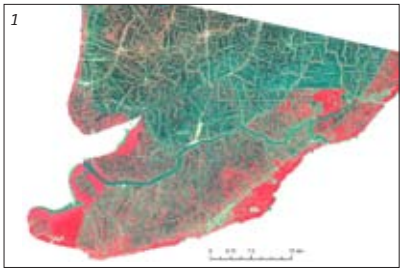
Fig. 10 *Data sources and results of remote sensing analyses of the southern tip of the Mekong Delta*

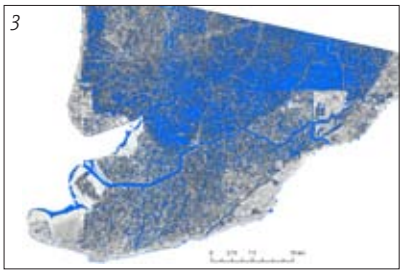
1 — Optical remote sensing image of February 2010 (Satellite image: © Spot Image)

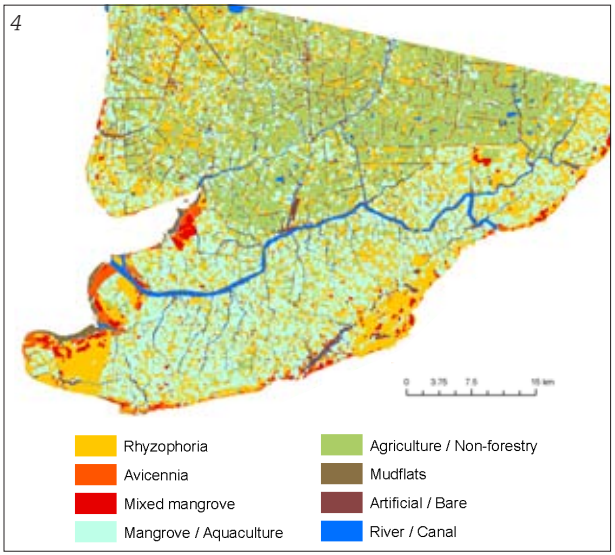
2 — Radar remote sensing image of February 2010 (Satellite image: © DLR)

3 — Inundation map derived from radar remote sensing image

4 — Mangrove distribution and land use map generated from radar and optical remote sensing imagery







Higher value information products

All these products are an integral part of the WISDOM Information System and provide a powerful information source for monitoring, investigating and understanding the properties of the earth's surface. They also constitute important input data for further analysis and processing. Combining and merging these data with other types of information also allows for the generation of higher value information products (Figure 11). Inundation and soil moisture maps as well as land cover monitoring products are major inputs for developing and calibrating robust models for flood prediction. Analysis of land cover and land use changes together with socio-economic statistical data helps to reveal the adaptation strategies of the local population

and the impacts of climate change. Topographic information derived from high resolution satellite images combined with vulnerability calculations at the household level enables the derivation of such products as flood vulnerability maps. Time series of inundation maps are utilized to derive information about regularly inundated areas and to discriminate them from hazardously flooded areas. With that knowledge, flood information products can be generated as high-level reports providing information for populated places, infrastructure, or areas with different land cover types affected by hazardous flooding, for example.

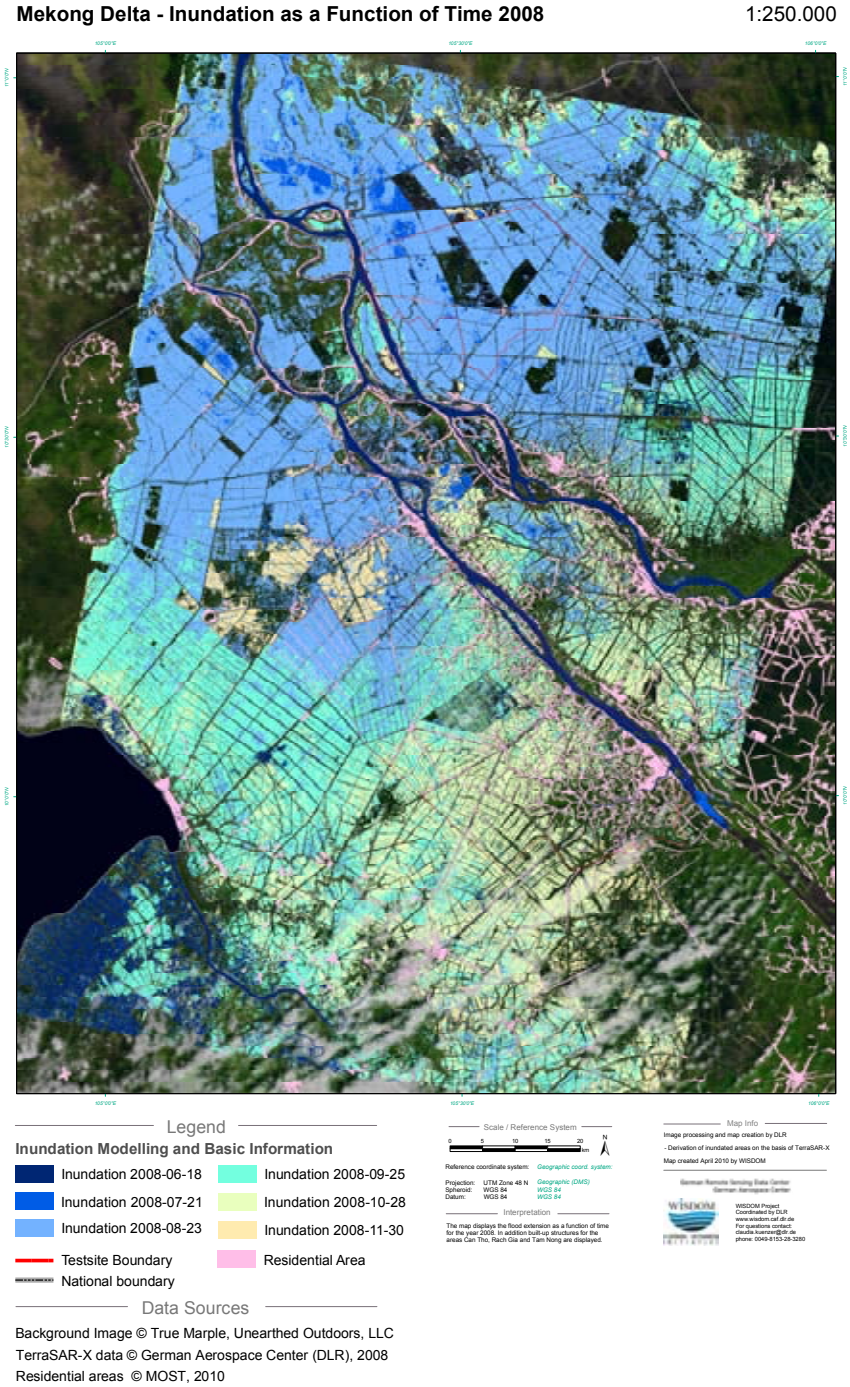


Fig. 11 *Monitoring of inundation as a function of time (flood season 2008): colour changes from light blue to light yellow depict the growing extent of the flood in the observed area*

Sustainable information generation

Fig. 12 *Advice from local nature reserve guide during field trip in the Mekong Delta*

Sustainable generation of such information products only becomes feasible after the development of adaptable and preferably automated methods of satellite data analysis which enable the continuous derivation of products with predictable and acceptable accuracy. In order to accomplish this, products are constantly validated in the field (Figures 12, 13) and calibrated accordingly. Of utmost importance, however, is securing continuous future satellite data acquisition. While especially high resolution data are costly, most other data utilized for resource monitoring in WISDOM are continuously available at relatively low cost.

Fig. 13 *Joint field data collection in the Mekong Delta*

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WATER QUANTITY PRODUCTS IN WISDOM

Flood monitoring and modelling

Fig. 14 *Tam Nong hydrological measuring stations in operation*

Within WISDOM, the Hydrology Section of the GFZ, the German Research Centre for Geosciences, develops monitoring stations for water level, suspended sediment concentrations, and other water quality related parameters like temperature, pH-value and electric conductivity (Figure 14). The aim of the stations and the monitoring scheme implemented in a test area in the Tam Nong district (Dong Thap province in the Plain of Reeds in the Mekong Delta) is the quantitative monitoring

of the inundation dynamics in the flood season in both the channels and the floodplain. The second aspect —the floodplain— is a novelty, as floodplain processes are hardly ever monitored worldwide, despite their high relevance in various areas like agriculture, flood management and mitigation planning, and hydrodynamic modeling. The stations are designed to operate autonomously without external power supply and frequent control. GFZ also develops prototype river buoys equipped with GPS for continuously recording water level and water movement (Figure 15). This novel inland monitoring technique provides solutions for large inland water bodies where standard monitoring is difficult. It also offers additional monitoring options like movement velocities and flow direction changes. Within the project frame of WISDOM the data are used for detailed calibration of hydrodynamic models of the investigation areas in Tam Nong and the whole Mekong Delta downstream of Kratie in Cambodia, thus including the Tonle Sap lake system. The latter models were developed in close cooperation with SIWRR, the Southern Institute of Water Resources Research. These models will in turn be used for planning tasks which include planning flood defense structures and the operation of sluice gates and pumps, as well as for a first time quantification of nutrients carried in flood sediment which enter fields on the floodplains.

Fig. 15 *Deployment of turbidity sensors and GPS buoys in Tam Nong*

Water quantity, quality and the WISDOM Information System

Fig. 16 *Result of extended Mekong Delta modelling of inundation and expected sea level rise of 45 cm for the year 2000 (including Tonle Sap Lake, Cambodia)*

The ground based observations of water extent, water level and suspended sediment concentration can be combined with the earth observation data provided by DLR-Würzburg and EOMAP to derive maps showing inundation and spatially suspended sediment concentrations. This combination constitutes the most encompassing data set on inundation dynamics ever compiled: comparatively accurate, high temporal resolution ground based data combined with the wide spatial coverage of earth observation data are a valuable resource for researchers and practitioners in the field of water resources and flood management. The data collected and the results of hydrodynamic simulations for the investigation area and the whole Mekong Delta (Figure 16) will be fed into the WISDOM Information System and thus will be available for further use. Through the WISDOM Information System the water quantity data can be combined with the water quality data collected by UNU-EHS and INRES (Institute of Crop Science and Resource Conservation) to assess general water quality in the delta and possible pollution sources and pathways.

Designed for and with Vietnamese partners – basis for sustainability

By feeding the collected data and simulation results into the WISDOM Information System their availability for a wider scientific, administrative and public audience is ensured. The technical development of the stations was based on local conditions and available materials. Accordingly, long term use and adaptability of the stations themselves along with the technology can be granted. Knowledge building was promoted by involving staff from the Vietnamese Inland Water Authority (VIWA) in station design and operation, as well as by hiring local people to take care of the stations (Figure 17). This furthers public acceptability as well as public discourse on water quantity and quality issues.

Fig. 17 *Local farmer watches over hydrological measuring stations in the Northern Mekong Delta*

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IN SITU WATER QUALITY SAMPLING IN WISDOM

In situ water quality monitoring and modelling

Fig. 18 *Local farmer sprays pesticides on his rice field*

Water quality monitoring activities within WISDOM contribute to the sustainable development of the Mekong Delta through the generation, assessment, forecasting and dissemination of information on water pollution by pesticides and endocrine disruptors (EDs, hormone like substances).

Specifically, UNU-EHS is systematically surveying pesticide use and management by local farmers in two case study sites which are representative of the agricultural landscape of the delta. The aims are to identify the most important pathways for pesticide residue transport, to monitor pesticide residue concentrations in water discharging from fields and in surface waters of the Mekong Delta (Figure 18), to develop suggestions for mitigation measures, to model the fate of recently used pesticides in surface waters, and to develop different scenarios for the assessment of suggested mitigation measures through modeling. INRES has established an analytical method in Vietnam to identify hormone like substances. Their concentration has been monitored in rural and urban areas for one year in order to identify both background concentrations as well as hot spots of endocrine disruptor release into the aqueous environment (for example, waste water from various industries, pig farms, and human waste water from Can Tho City).

Activities for sustainable use of results

Fig. 19 *Water Sampling at Tien River (one of the main Mekong river arms)*

Time series of pesticide and endocrine disruptor concentrations will be available at two case study sites at several sampling points and will be ingested as spatial data into the WISDOM Information System. The data will be available for the user on demand as customized output in the form of tables, graphs or, in case of modeling results, as animated maps. The results of the mitigation assessment via modeling will be provided as a decision support flowchart or manual.

In addition, supporting documents on sampling (Figure 19), sample processing and analysis will be available. Overview documents on pesticide and endocrine disruptor concentrations and data processing schemes for the on-demand preparation of

figures from the database will be provided. The georeferenced data on water quality will be linked with results generated at the same sites, for example on hydrology in Dong Thap or on domestic water use in rural Can Tho. The thematic cluster on water quality in the WISDOM Information System will establish a link to all results and data with water quality relevance.

In terms of a contribution to the sustainable development of the Mekong Delta, UNU-EHS and INRES are actively involved in capacity building activities and are in continuous dialog with relevant stakeholders in the delta. To analyze endocrine disruptors, INRES partnered with the ITB (Institute of Tropical Biology) in Ho Chi Minh City and organized a two-day workshop on endocrine disruptors with hands-on training for the representatives from Departments of Natural Resources and Environment (DONRE) in Ho Chi Minh City, Can Tho, Hau Giang, Dong, and Nai, from the Department of Science and Technology (DOST) Binh Duong, from Can Tho and An Giang Universities and from the ITB and SIWRR (Southern Institute of Water Resources Research) research institutes. Pesticide monitoring is carried out in cooperation with the Central Laboratory at Can Tho University and in frequent consultation with members of DONRE and the Departments of Agriculture and Rural Development (DARD) from Can Tho and Dong Thap. The results were discussed on a regular basis in meetings and workshops. Additionally, UNU-EHS and INRES contribute with the academic education of four Vietnamese PhD students.

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VULNERABILITY ASSESSMENT IN WISDOM

Objectives

The objective of this work package is to conduct vulnerability and risk assessments for water-related hazards in the Mekong Delta and to evaluate resulting adaptation options. Vulnerability related information as well as assessment and evaluation guidelines are fed into the WISDOM Information System. In order to allow for proactive integrated water resources management, there is great need to understand how vulnerabilities to water-related hazards emerge and how they

Fig. 20 *Marginal settlement with high flood exposure, Can Tho*

Fig. 21 *Adaptation to high flood levels in the Northern Mekong Delta*

differ among various socio-economic groups as well as with respect to different types of hazards, such as floods (Figure 20), salinization, water scarcity, storms and river bank erosion. Based on this knowledge, different strategies for adaptation are evaluated in collaboration with relevant stakeholder groups in Vietnam and the development of innovative adaptation strategies integrating formal and informal mechanisms is promoted (Figure 21). In order to capture the different biophysical and socio-economic settings within the Mekong Delta, rural and urban profiles are compared among the case study provinces Dong Thap (rural, prone to annual flooding), Can Tho (urban and peri-urban, tidal and urban flooding) and Tra Vinh (rural, salinization and coastal storms).

Products for the WISDOM Information System

The vulnerability assessment contributes a variety of data sets to the WISDOM Information System combining assessment findings from social as well as engineering sciences. Based on in-depth interviews and a household survey in three case study areas (covering roughly 1400 households), vulnerability profiles are developed which are represented in schematic figures highlighting archetype vulnerability pathways as well as in maps showing the spatial distribution of the main vulnerability parameters, hence allowing for the identification of vulnerability hotspots and priority areas for action (Figure 22). Based on hydrological modelling, flood hazard maps will be generated and combined with physical asset and vulnerability maps to derive flood loss maps and aggregated risk maps. This cascading combination of data sets and maps allows the user of the WISDOM Information System to access information at various levels of aggregation (ranging from single components such as

Fig. 22 *Participatory vulnerability assessment with local farmers, Tra Vinh Province*

the map of one particular vulnerability parameter in one specific case study area all the way to the comprehensive and aggregated risk maps which merge physical hazard scenarios with socio-economic vulnerabilities).

On the basis of the knowledge generated through these assessment techniques, a comprehensive (digital) handbook with quality criteria for different adaptation options is being developed. In addition, checklists are provided which compare the advantages and disadvantages of different adaptation options (for example, the erection of a dyke system vs. resettlement for a given community) and which help to assess the feasibility of potential options.

Sustainability of the products

In order to encourage sustainable use of the products generated, an iterative process of needs assessment and joint method development with partners from the political as well as scientific communities in Vietnam and particularly the Mekong Delta has been ongoing since 2008. This ensures relevance as well as political support and the continued application of the assessments developed. This exchange will even intensify as the project advances and more and more results of ongoing assessments will become available and used to devise implementation measures and to support decision making. The most important formats for fostering this exchange are meetings with the relevant planning agencies, expert workshops, joint science seminars with partners from academia, and joint field campaigns, all of which remain an important basis of this work.

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SOCIO-ECONOMIC RESEARCH IN WISDOM

Fields of socio-economic research in WISDOM

The socio-economic research addresses the specific challenges, policies and practices of water resources management in Vietnam and, more precisely, in the Mekong Delta.

With regard to the specific challenges, statistical data on socio-economic transformation processes are being collected. Data analysis focuses on the impact of processes like economic growth, urbanization, industrialization and modernization, on water usage and consumption patterns, as well as on water quality. Moreover, local adaptation strategies and related changes in the specific water-related livelihoods of the Mekong Delta population are examined (Figure 23).

Another branch of research investigates the water policy framework, related sector reforms, and the knowledge production of central and local government agencies. Intensive fieldwork on the implementation of policies and reforms as

Fig. 23 *Rural water supply*

Fig. 24 *Household interview with local farmer*

well as knowledge dissemination and sharing is undertaken. In view of understanding water resources management practices, case studies are carried out in Can Tho City, which is located in the heart of the Mekong Delta. These case studies make it possible to identify the various actors as well as their respective level of engagement and interaction at different scales of operation. Specific attention is given to the interface of state management, private businesses, research organizations, water user groups and, to a certain extent, donors.

There are a number of socio-economic research subprojects, including:

Flood control: planning and implementing dyke systems
Water supply: policy and implementation in rural areas
Water engineering: changing interfaces between water bureaucracies and hydraulic construction businesses
Water research: knowledge production, knowledge assets and regional collaboration
Decentralization and participation: local water management and water user groups
Water legislation: legal framework and law enforcement.

From research findings to presentation

The findings of these empirical studies provide the basis for understanding the institutional complexity and transition of water resources management in Vietnam. Moreover, data and results are provided in the form of tables, organizational flowcharts, maps, pictures and statistics (Figure 25) and are being transferred to the WISDOM Information System. Both visualization of empirical findings in the form of figures and spatial analysis of the data are used to generate new products and knowledge. These enable future users to access a complex set of information on various aspects of water resources management at both national and local administrative levels. In addition, government documents are systematically collected and processed with a

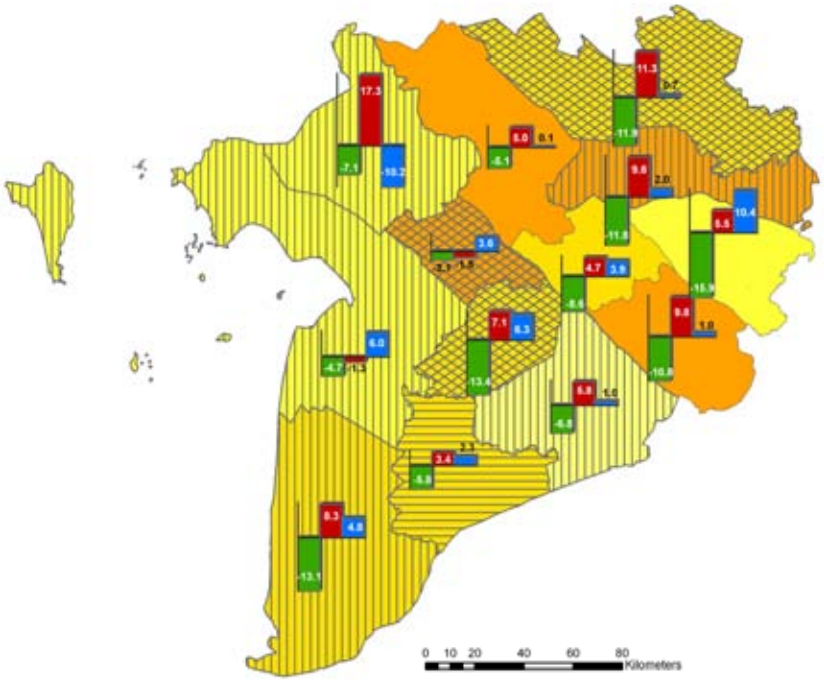

Fig. 25 *Statistics on industrialization in Mekong Delta Provinces*

GDP Percentage of Industry Sector 2007
- 16-20%
- 20-25%
- 25-30%
- 30-40%

Mean Growth Rate of Industry Sector in GDP between 2000-2007
- 0-10%
- 10-15%
- 15-20%
- 20-25%

Percentage Change per Economic Sector in GDP Share from 2000-2007
- in %
- Agriculture
- Industry
- Service

Data Sources:
GSO Vietnam (2009) & Provincial Statistical Offices (2007)

view to developing a comprehensive database on relevant state management and research organizations as well as policy papers and legal documents. This database constitutes the core of the "Yellow Pages" tool of the WISDOM Information System, which aims at bridging institutional boundaries and addressing existing knowledge sharing challenges in the country.

In terms of research output, a series of academic writings are being produced; these include eight PhD theses to be published in the form of books, as well as working papers and journal articles. Publications are in English and Vietnamese and a dissemination strategy, in particular for Vietnam, has been developed. These products also aim at strengthening the linkage necessary for interdisciplinary research and contributing to current scientific debates on IWRM (Integrated Water Resources Management) and sustainable development in Vietnam and beyond.

With regard to knowledge management, a series of capacity building measures are being implemented. In a long-term perspective, a knowledge management training module will be institutionalized at Can Tho University, where local capacity can be systematically developed. Furthermore, stakeholder training for water resources management agencies aims at improving knowledge management practices and facilitating the technical implementation of the WISDOM Information System. The overall objective is to enhance data sharing as well as cross-sector and regional cooperation in an IWRM approach for the sustainable development of the Mekong Delta.

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WP = Work Package

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This brochure introduces the research activities which are part of the WISDOM project. Detailed project information can also be found on the bilingual (English/ Vietnamese) WISDOM web page: www.wisdom.caf.dlr.de

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