VIETNAM-NETHERLANDS PARTNERSHIP
"WATER FOR FOOD & ECOSYSTEMS"

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Ministry of Agriculture and Rural Development (MARD)

agriculture, nature and food quality

The Netherlands Ministry of Agriculture, Nature and Food Quality (LNV)

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BACKGROUND, SCOPE, AND OBJECTIVES OF WFE STRATEGY

1.1 The Vietnam-Netherlands Partnership on Water for Food & Ecosystems was established as a follow-up to the FAO/Netherlands conference on water for food and ecosystems in The Hague in January 2005. This conference discussed the progress made and lessons learnt on sustainable water management for food and ecosystems. At a follow-up meeting in October 2006, the Vietnam Ministry of Agriculture and Rural Development (MARD) and the Netherlands Ministry of Agriculture, Nature, and Food Quality (LNV) agreed to implement the Vietnam-Netherlands Water Partnership on Water for Food & Ecosystems (WFE). The two ministries agreed to an 18-month preparation period (from July 2007 to December 2008) to develop a framework strategy for the partnership. IUCN, the International Union for Conservation of Nature in Vietnam, was asked to coordinate and facilitate the preparation process.

1.2 This strategy identifies the key issues and outlines the institutional arrangements for the implementation of the WFE approach in Vietnam. It is based on extensive stakeholder consultations and ten case studies. Summaries of these case studies are annexed in Section 5. It also benefits from research that IUCN has conducted on wetlands management in the Mekong Delta and the value of mangroves in diversifying livelihoods and both mitigating and buffering the effects of climate change.

1.3 The WFE Partnership reflects a shared concern over the need to find a balance between the needs for food production and the sustainability of the natural resource base in Vietnam at a time of rapid economic growth, industrialization, and urbanization. The 2006-2010 Socio-Economic Development Plan (SEDP) calls for the development of pathways that balance economic growth, social equity, and environmental sustainability. MARD has initiated new rural development strategies that are in line with the SEDP approach and identify agriculture and rural development options that respond to Vietnam's emerging challenges and opportunities.

1.4 The WFE Partnership proposes innovative ways to manage water resources that balance agricultural production while securing the integrity of water-dependent ecosystems. The partnership is informed by the global Water for Food & Ecosystems Programme, which promotes an ecosystems approach to agricultural production. This will in turn provide a basis for improved synergies between agriculture and aquatic ecosystems, the two largest water users in Vietnam, within an Integrated Water Resources Management (IWRM) framework.

1.5 The principles of IWRM have been introduced in Vietnam through the establishment of pilot River Basin Organizations (RBOs) and the National Water Resources Council. However, while good in theory, those bodies face many difficulties and IWRM is far from being operational. In practice, there has been little progress in implementing IWRM because of institutional and policy constraints.

1.6 The WFE Partnership addresses the interactions between water resources use, food production, and ecosystem sustainability in ways that are complementary to IWRM. This is done by examining WFE interactions at local levels and focusing on innovative water management practices to achieve a more sustainable balance between food production and conservation of aquatic ecosystems. The partnership aims to document good practices and recommend appropriate solutions to address the seemingly unsolvable conflicts between sectors.

1.7 The case studies conducted under the partnership show that there are already many examples of cross-sectoral collaboration on the ground. Stakeholders at all levels expressed their interest in and need for such collaboration. The case studies also highlight factors that constrain progress. The strategy focuses on actions that need to be taken to address these constraints.

1.8 The WFE strategy aims to create an institutional and operational framework through which different sectors can collaborate to achieve IWRM. It will support the development and implementation of integrated policies, strategies, and programmes that address the complex challenges of sustainable development, poverty eradication, and food security. The strategy aims to achieve these objectives through two interrelated processes:

1. Establish an institutional mechanism by which ministries, departments, researchers, and NGOs can engage in cross-sectoral collaboration at national, provincial, and district levels.
2. Build capacity to implement WFE approaches in policy, planning, and water management through the application of innovative tools and methods.

To this end, the WFE strategy calls for:

1. Institutionalization of a cross-sectoral and inter-ministerial dialogue, as was established in the first phase of the WFE Partnership through the formation of a WFE Steering Committee and WFE Working Group. Sectors to be included are agriculture, environment, fisheries, forestry, industry, and energy at the national level and corresponding provincial departments, Provincial People's Committees, and irrigation and water utility companies.
2. Application of innovative cross-sectoral water use and management methods through the deployment of action-oriented research and pilot schemes on WFE issues that draw expertise and resources from different national and international partners. Section 3 outlines the priority WFE issues to be addressed based on the results and recommendations of the case studies.

1. OVERVIEW OF VIETNAM WATER RESOURCES AND RELATION TO FOOD AND ECOSYSTEMS

2.1 Vietnam has a land area of 331,690 km^2 with a population of 84.1 million (2008) and population density of 242 people/km^2. Vietnam is a big exporter of agricultural produce (rice, coffee, rubber, pepper, cashew, etc.). Agriculture not only contributes to the increasing GDP, food security, and poverty reduction, but is also considered to contribute to social stability.

2.2 Water resources availability in Vietnam is moderate by international standards. Annual runoff is 830-840 billion m^3, of which only 320-325 billion m^3 are generated inside the country. However, water distribution is uneven in both space and time: 75-80% of annual runoff is concentrated in 3-4 months of the rainy season while runoff during three months of the dry season accounts for only 5-8% of the annual total. Therefore, seasonal water shortages, droughts, and water logging frequently occur in much of the country at some time during the year.

2.3 Increasing competition for reliable water resources constrains economic growth. Demands for water resources are growing rapidly, not just for extraction and sectoral consumption, but also for increasing hydropower generation to meet the expanding economy and growing population. The extraction of groundwater is increasing in both rural and urban areas. In some areas groundwater levels are falling dramatically resulting in land subsidence and damage to infrastructure. Some groundwater sources have elevated levels of arsenic.

2.4 Vietnam has achieved remarkable economic growth and poverty reduction over the last 20 years. However, this growth has included less positive changes, such as high rural-urban migration that places a heavy pressure on the country's dilapidated infrastructure and fragile natural resources base. In particular, rapid economic growth has led to unregulated consumption of water resources.

2.5 Agriculture and aquaculture in particular have undergone a profound transformation and intensification process with major implications for water use:

1. Until the 1990s Vietnam was a predominant rice-growing country. With the goal of attaining food self-sufficiency, the government's strategy was to deploy water resources and irrigation development toward the expansion and intensification of rice production and export of production surplus.
2. The rapid development of irrigation, combined with the control of salinity and acid sulphate hazards, have led to large-scale land reclamation. On the one hand, increases in water resources development and irrigation have greatly facilitated crop production and created the basis for increased rice production. On the other hand, this has significantly

transformed traditional agro-ecosystems (e.g., floating rice, one crop a year) into intensified production systems (e.g., 2-3 crops a year, rice-prawn systems, deforestation).

3. Today, agricultural diversification is the predominant government strategy (e.g., upland cash crops such as coffee, cocoa, rubber, and pepper and fresh, brackish and marine aquaculture). This is imposing new demands on water management systems in terms of water quantity and quality. No clear strategies are in place to meet these new demands.
4. At the same time, the demands from other sectors (e.g., domestic, industry, tourism) have boomed. Plagued by a rapid increase of water pollution, poor sanitation, and inadequate state response, this has led to serious ecosystem degradation. The interrelations between water, agriculture, and ecosystems did not feature in the 1998 Water Law, and the 2008 Vietnam Water Sector Review only referred to them in passing (http://www.vnwatersectorreview.com).
5. Hydropower reservoirs benefit downstream water users through their flow-regulation function. However, to meet electricity peak demands, the daily operation of large dams has caused profound water-level fluctuations downstream, even to the extent of eliminating minimum river flows.

2.6 Water as a limited natural resource and economic good has not always been recognized and as a result the protection and management of water resources has not been given adequate attention. The 1996 Water Sector Review identified the major problems and policy options but very few of those have been acted upon.

2.7 Vietnam's water sector faces major challenges, including increased competition for heavily committed freshwater resources; increased pollution of rivers from industrial, municipal, and agricultural sources; and increasingly severe and frequent natural disasters affecting more and more people. Groundwater is being extracted at unsustainable rates; few water service providers are financially viable; much of the existing water management infrastructure is in poor shape and needs to be replaced; and most agricultural land is under irrigation with diminishing opportunities for increasing production. Furthermore, the provision of basic water services has not kept pace with economic growth, leaving one-third of the population without adequate water supplies and two-thirds without adequate sanitation.

2.8 Many irrigation systems suffer from low efficiency, and the performance of irrigation management companies is poor. Non-irrigation uses of water in rural production are neglected. Water shortages occur frequently during the dry season, and saltwater intrusion is advancing into coastal plains and delta areas, limiting opportunities for extraction of water for agricultural, domestic, and industrial uses. Regional, seasonal, and annual variations in water supply are likely to become more extreme because of climate change. Surface and groundwater pollution is emerging as a problem in many river basins because of population growth and rapid industrialization.

2.9 Since 1995, Vietnam has made substantial progress in terms of policy and legislation in support of IWRM. These include: passage of the Law on Water Resources in 1998; establishment of the Ministry of Natural Resources and Environment (MONRE) in 2002; establishment of the National Water Resources Council (NWRC) as the water sector apex body chaired by the Deputy Prime Minister; and adoption of "sustainability" concepts in the National Strategy for Environmental Protection, Agenda 21, National Water Resources Strategy (NWRS), Water Law, and Law on Environmental Protection.

2.10 These reforms represent important milestones toward the adoption of a multi-sectoral and integrated approach to water resources management. However, progress has been limited due to a focus on sectoral water allocations and their synchronization based on a simple summation of water demand by sector, and on meeting cumulative demands with the available water supply. But as with most approaches to IWRM, no serious attention has been paid to the efficiency of water use by sector. In other words, it is a non-integrated approach to water management. The

WFE approach, by contrast, focuses on how different sectors can share water over space and time, thereby adding greatly to the value per drop. WFE addresses:

1. Sectoral water use and management techniques.
2. Water interactions between up- and downstream sectors with a focus on the interdependencies of water in- and outflows (i.e., multiple uses of water by multiple sectors).
3. Promotion of innovative water use and management techniques within sectors that: enhance water use efficiency; improve water quantity and quality interactions between sectors by accounting for other sectors' water needs; and facilitate multiple water use through the exploitation of between-sector water use synergies.

The focus of WFE is thus on improving sectoral water uses in terms of productivity, efficiency, and sustainability, and thereby alleviating pressures on limited water resources.

2.11 Despite the reforms cited above, the water sector in Vietnam is characterized by a fragmented policy and institutional framework, with a multiplicity of policies and a history of poor coordination among ministries. There are particular concerns over the responsibilities for river basin planning and IWRM. Links to wider national poverty reduction, economic development, and institutional reform programs are also poorly developed, so that the full developmental impacts of better water management are often not realized.

2.12 At the same time, the government provides substantial investment funds for irrigation, flood protection, and hydropower development. National poverty reduction programs, such as Program 135 and the Rural Water Supply and Sanitation Program (RWSSP), also include large investments in water services. There have been several reform initiatives, including establishment of RBOs, introduction of participatory irrigation management (PIM), and development of provincial water strategies. But those actions have been limited in scale and have not been adopted nation-wide.

2.13 The government is acutely aware that Vietnam's natural resource base is highly susceptible to the impacts of climate change such as rising sea levels, more frequent typhoons and accompanying storm surges, increased river peak flows and flood risks, and higher incidence and severity of drought. In December 2008, the government approved the National Target Program to Respond to Climate Change (NTPRCC), which requires all sectors and ministries to develop action plans on climate change adaptation and mitigation. MARD has issued a framework climate change action plan for the period 2008-2010.

2.14 The WFE Partnership case studies in the Mekong Delta, Tam Giang-Cau Hai Lagoon, and the Red River Delta show the critical importance of WFE interactions for sustainable water resources management. For example, the case studies showed that there are beneficial interactions between fresh water (rice) agriculture, brackish aquaculture, and nature conservation that are currently not exploited but could provide substantial benefits if managed from a multiple use perspective. Specifically, drainage water from rice agriculture can be highly beneficial for the management of the brackish water zone, in particular for the maintenance of stable levels of salt concentration and overall water circulation. Those two water quality issues are essential for the productivity of aquaculture. Similarly, within the aquaculture sector, innovative techniques that are geared toward the sustainable waste management and disease control (through polyculture of multiple species and/or engagement of mangrove regeneration as biological water filters) can sustain aquaculture production while maintaining water quality standards and providing a regenerative environment for coastal forests. Currently, such innovations are being implemented on small and isolated scale and primarily as a response to declining productivity of intensive aquaculture. The potential benefit for the sector to improve its environmental and economic performance is very high.

2.15 Vietnam's coastal zones are vulnerable to the combined effects of rising sea levels, increased typhoon-driven storm surges, and higher river peak flows. However, those sensitivities

provide new opportunities, especially for the agriculture-aquaculture-environment interactions. In particular the brackish zones can be expected to increase in the future, with seasonal fluctuations that may provide additional opportunities for aquaculture. Regeneration of mangrove/coastal forest areas may become instrumental in protecting against storm surges and water quality services to the brackish water environment. There is thus an opportunity to explicitly engage freshwater agriculture-brackish aquaculture and brackish/salt water WFE interactions as part of an integrated climate change adaptation strategy similar to the Dutch "room for the river" policy.

2. WFE ISSUES FOR SUSTAINABLE AND PRODUCTIVE WATER RESOURCES DEVELOPMENT AND MANAGEMENT

3.1 The WFE issues presented in this section focus on fostering innovative water use and management practices by forging of cross-sectoral synergies in water-related interdependencies. They are primarily derived from the results of the case studies summarized in Section 5.

A. Fresh-brackish-saline aquatic environments: interactions among agriculture, aquaculture, and environment in coastal areas and deltas

3.2 The vast coastal zone and deltas of Vietnam are characterized by highly dynamic interactions between the fresh, brackish, and saline aquatic agro-ecosystems. The WFE Partnership case studies examined these interactions in three different settings (Red River Delta, Tam Giang-Cau Hai Lagoon, and Mekong Delta). These case studies yielded remarkable similarities in terms of findings and recommendations.

3.3 Development strategies of the past 15 years have achieved remarkable production gains in agriculture and aquaculture but did not take into account water quantity and quality interactions. During this period, the water management domains and aquatic environments were transformed to meet the needs of a single sector. This has had major negative impacts on the aquatic environments, and in particular coastal/marine ecosystems. Increasingly, fresh water shortage and salt water intrusion, water logging during the rainy season, elevated salt concentrations in brackish environments, water stagnation, and water pollution are hampering the productive capacity of agriculture and aquaculture.

3.4 The WFE approach is geared toward improving water use interactions between the sectors and reducing the negative impacts on the aquatic environment. The goal is to regenerate a healthy aquatic environment while sustaining production through an integrated and cross-sectoral approach that exploits the potential of positive synergies between sectors. For the coastal zones, it is essential to acknowledge the key role fresh water plays in the management and maintenance of the brackish environment as an intermediate aquatic coastal zone in terms of:

1. Maintaining optimal levels of brackishness (in terms of salinity concentrations and fluctuations) favorable for brackish aquaculture/fisheries and coastal/marine ecosystems.
2. Maintaining an adequate refreshment rate of brackish water (e.g., securing a basic fresh water in- and outflow and water circulation rate).

3.5 The maintenance of this multifunctional hydrological regime of fresh-brackish-saline aquatic environments is critical for the coastal agro-ecosystems, and will become increasingly so in light of the climate change scenarios. The basic hydrological criteria to be maintained are:

1. Basic fresh water in- and outflow, and tidal and seasonal interactions with saline water intrusion from the sea.
2. Adequate levels of brackish salinity both in terms of concentration and seasonal/tidal fluctuations.
3. Basic refreshment rate (minimal water circulation) that enables the flushing out of organic and inorganic waste to sea.

4. Dynamic sedimentation regime and flow that does not obstruct water circulation and interaction with the sea.

3.6 The agro-ecological system of the fresh-brackish-saline coastal environments (see Fig. 1) provides three distinct agro-ecological services that can be managed through a WFE approach to maximize the services and benefits they have to offer. These are:

1. Irrigated agricultural food production (especially rice) of the fresh water zone, distinguishing permanent irrigated areas (zone I) and fresh water flood plain areas (zone II) in combination and integration with fresh water aquaculture/fisheries;
2. Aquaculture/fisheries in the brackish area (zone III);
3. Preservation and regeneration of saline/brackish coastal ecosystems, in particular mangrove forests (zone IV).

To optimize these sub-systems for food production and water regulation, cross-sectoral water management plans need to be developed. These plans will:

- Optimize the food production services within these sub-systems taking into account water management constraints (in terms of water quantity and quality) derived from the interdependencies between the sub-systems.
- Capitalize on the water synergies from cross-sectoral water interdependencies to optimize the water regulation and ecosystem services of the coastal agro-ecosystem at large.

These require sectoral innovation and cross-sectoral collaboration in the following six domains:

3.7 #**1. Freshwater irrigated (rice) agriculture (zones I-II):**

- Explicitly acknowledge the multiple benefits fresh water management has to provide for: irrigated rice agriculture, fresh and brackish aquatic environment and aquaculture; and water retention and salt intrusion.
- Internalize this knowledge and these multiple benefits into integrated and innovative water management plans and techniques.

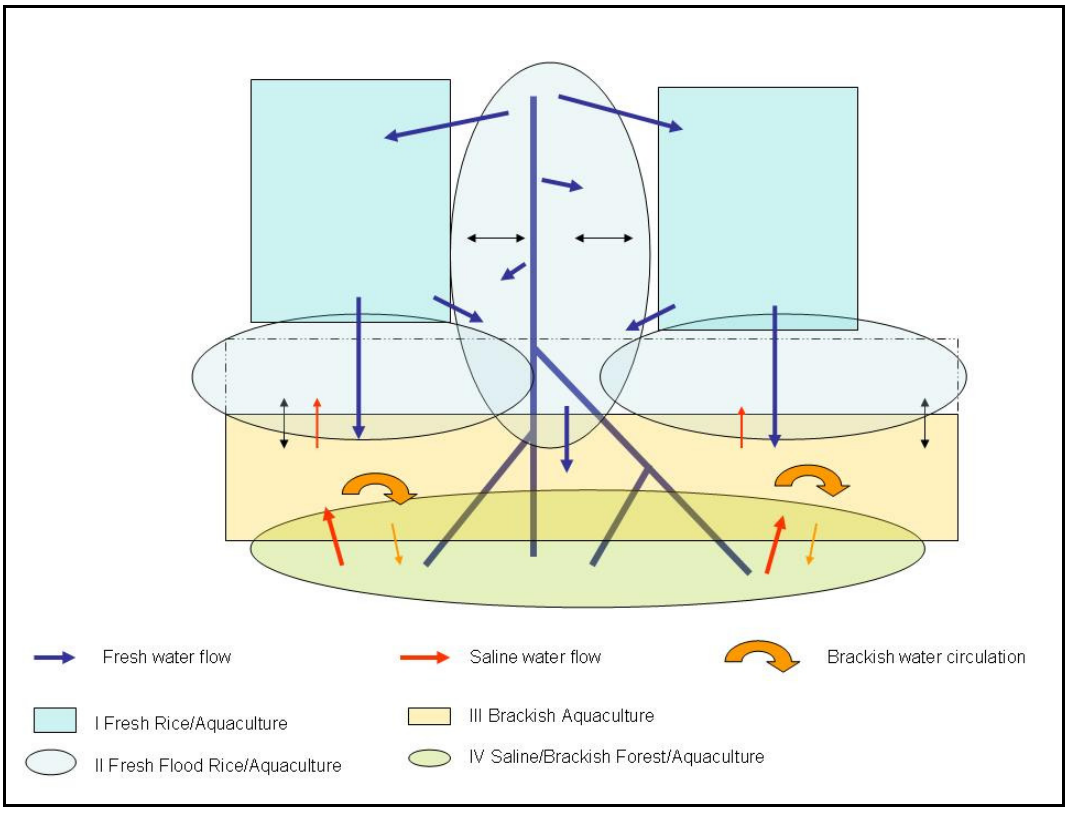

Fig. 1: Coastal Agro-ecosystems in Vietnam

3.8 #**2. Drainage management**

The fresh water drainage effluent from irrigated rice agriculture provides a dual service in regulating salinity levels in the brackish water zone and enhancing water circulation and refreshment of the brackish water. Both elements are critical factors for the maintenance of the aquatic environment and aquaculture productivity. At present, drainage flows from irrigated agriculture are not yet managed to enhance these benefits, whereas multiple drainage outflow points are present that can be optimized through integrated and cross-sectoral management (e.g., Xuan Thuy). Integrated management would include the following elements:

- Develop an integrated water and drainage management plan for irrigated rice systems that optimizes the drainage water outflow management (in quantity, timing, and locality) to enhance the brackish aquatic environment in terms of salinity levels and water circulation/refreshment.
- Ensure minimum water quality standards of drainage effluent from irrigated rice through the promotion and implementation of integrated pest management (IPM) practices, so that chemical and fertilizer contamination is kept at minimal levels and do damage the aquaculture and forest ecosystems of the brackish and coastal zones.
- Incorporate aquaculture as a user of fresh (drainage) water in integrated water management plans by acknowledging and targeting their beneficial (drainage) water uses, and by devising specific management practices and fees for aquaculture within or bordering irrigation systems.

3.9 #**3. Aquaculture in the brackish buffer (zone III)**

Stimulate the development and implementation of a multiple and diverse aquaculture strategy for brackish aquatic (buffer) zones that is geared to optimizing aquaculture production while respecting and maintaining the hydrological characteristics of these aquatic zones. As exemplified by the case of Tam Giang-Cau Hai, over-intensification of monoculture pond techniques has led to production declines due to salinity, water circulation and waste/disease management problems that are nurtured by non-favorable alterations of the hydrological and aquatic environment. A WFE aquaculture strategy for the brackish zone that is geared towards restoring the hydrological and aquatic environment should comprise the following elements:

- Diversified and multifaceted aquaculture strategy comprising intensive, semi-intensive, and extensive aquaculture practices that can be extended over brackish buffer zones.
- Further development of aquaculture practices that are non-obtrusive to water flows and water circulation in brackish zone (i.e., less flow-obstructing ponding).
- Further development of poly- and multiple culture practices (within ponds or in sequential ponds) that are less damaging to aquatic environments in terms of aquaculture waste and water quality while maintaining high rates of productivity.
- Enhancing the productivity of extensive aquaculture practices (such as clams) through active seedling culture and release, and common pool management practices.
- Research and development in sequential multiple ponding systems that can stimulate mangrove re-generation as has been initiated by MARD's Research Institute for Aquaculture 2 in HCMC.
- Development and implementation of aquaculture wastewater management and disposal strategies to minimize the risk of disease transmission.

3.10 #**4. Conservation and regeneration in coastal forest ecosystems (zone IV)**

Develop a nature conservation and regeneration strategy in integration with aquaculture/fisheries strategies for the brackish buffer zone that exploits synergies between the two systems. There is a need to:

- Devise comprehensive extensive aquaculture and fisheries management practices and plans for interface of nature-buffer zones; implement strict limits on exploitation.
- Invest in regeneration and expanded production of extensive aquaculture and fisheries through a combination of seedling culture and release practices in forest zones.
- Develop combined aquaculture-reforestation practices that can boost sustainable aquaculture practices in brackish buffer zones, while accelerating reforestation (on aquaculture waste disposal) to reinforce coastal defenses against climate change impacts.

3.11 #**5. Multiple use rice-aquaculture irrigation systems in the Mekong Delta**

The brackish zone in the Mekong Delta is very dynamic with irrigated agriculture and fresh water aquaculture dominant in the wet season and brackish water aquaculture dominant in the dry season. From an ecological and climate change point of view, it is important to preserve this dynamic fresh-brackish water system. Land use and water management practices in the delta are complex due to the dual functions of fresh water irrigated rice and fresh water aquaculture (which are dominant in the wet season and minor in the dry season) and brackish aquaculture (which is dominant in the dry season and minor in the wet season.) The key aspect in this system is the dual management of fresh and brackish water flows through the network of canals. Fresh/salt water management needs to account for:

- Dual purpose of water management (dominantly fresh water-agriculture in the wet, dominantly brackish water-aquaculture in the dry season) that accommodates minority uses (brackish water-aquaculture in the wet, and freshwater-rice in the dry season). Management should strengthen this alternate character of fresh-brackish water flows rather than try to separate them into two separate systems of water diversion that will block seasonally alternating water flows and land uses.
- Management of brackish drainage effluent from intensive aquaculture is critical. This requires a specific management strategy that allows for the disposal of brackish effluent to the sea without contaminating fresh water systems or brackish aquaculture uses (disease contamination).
- Fresh and brackish aquaculture solid waste may form nutrient rich sediments for re-use in fresh water agriculture that can boost production and minimize the need for inorganic fertilizer use. Research is needed to optimize cross-fertilization between agriculture and aquaculture both as neighboring production systems and seasonally sequential systems on the same plot.

3.12 #**6. Climate change adaptation for the coastal zones and inland wetlands**

Climate change scenarios for the coastal zones in Vietnam foresee three main threats: higher seawater levels; larger and more frequent storm surges fed by typhoons; and an increase in high intensity rainfall events accompanied by higher river peak flows and flood events.

All three effects will impact the coastal zones by increasing the dynamic fresh-brackish-salt water interfaces, especially as larger storms and higher intensity rainfall are expected to occur more or less simultaneously. For the coastal zones this means that the flood retention capacity of fresh water floods (along the major river floodplains) and brackish water floods (in the deltas and lagoons) needs to be strengthened. Although this may threaten coastal ecosystems, it also offers opportunities. As is evident from the case studies, the coastal fresh-brackish-salt water interfaces provide enormous potential for agriculture, aquaculture, and natural resource conservation. A WFE-informed climate change adaptation strategy could be developed based on enhancing the flood retention capacity of fresh and brackish water ecosystems and optimizing the geography of agriculture and aquaculture production in these zones. Such a strategy would consist of three components:

1. Strengthen coastal defense systems by conserving and regenerating mangrove and coastal forests, particularly to mitigate the effect of storm surges. This is to be accompanied by an

integrated management strategy for semi-intensive mangrove-filtered aquaculture and extensive aquaculture in the immediate salt-brackish zones of the coastal forests.

2. Manage the brackish zone, which will seasonally swell and shrink, accompanied by management of brackish aquaculture to foster the seasonally dynamic character of the brackish zone and enhance the water storage/retention capacity of the brackish flood zones.
3. Manage the fresh water zones, where rice and fresh water aquaculture thrive. Attention should be given to enhancing the fresh floodwater retention capacity in the river floodplains and to drainage management of the brackish zone and brackish aquaculture. Within agriculture, this strategy needs a dual component:
    a. Increase the flood retention capacity of irrigated rice within areas protected from floods (e.g., by dykes) accompanied by an integrated drainage management plan.
    b. Develop multi-purpose floodplain agriculture-aquaculture systems (i.e., non-flood protected areas) that can accommodate freshwater floods, i.e., "room for the river." This will require developments in flood-rice varieties and systems, as well as communal flood plain aquaculture management.

3.13 Increased flood retention behind dykes and the development of flood-rice varieties and floodplain aquaculture in areas exposed to flooding, could reinvigorate natural ecosystems. As flood peaks rise and minimum water levels fall, the role of wetlands in acting as sponges will become increasingly important in adapting to climate change. The huge cost of destroying riparian wetlands was shown by the Yangtze flooding in 1998, which killed 3,500 people and caused hundreds of millions of dollars of damage. Over the past 20 years virtually all of the Mekong Delta's natural wetlands have been destroyed by the construction of dikes and canals to allow irrigated rice production. As the role of wetlands in buffering flood events and allowing the dispersal of sediment, nutrients, and biodiversity becomes increasingly important, a long-term objective is to develop a land-use plan to "re-wild" parts of the Mekong Delta, as is being done in the Yangtze and Mississippi river systems.

3.14 The use of natural or re-constructed wetlands as natural treatment systems for wastewater with high nutrient loading or chemical pollutants, including heavy metals, should be investigated as part of the strategy. In other countries wetlands have been shown to be highly effective for this purpose because of the speed with which contaminants are absorbed and in most cases broken down in wetland ecosystems. The potential contribution of wetlands to reduce the nutrient and chemical waste (including antibiotics and hormones) from aquaculture is particularly important because of growing food safety concerns about aquaculture in Vietnam and the potential negative impact on international exports, especially to the increasingly safety conscious EU and US markets.

3.15 This ecosystem-based approach to climate change adaptation can be extended to the mangroves and coastal forests of the Mekong Delta. The IUCN-coordinated Mangroves for the Future (MFF) initiative promotes this approach in the countries hardest hit by the 2004 tsunami and Vietnam will join in January 2010 (http://www.mangrovesforthefuture.org). MARD and MONRE will co-chair the MFF Vietnam component. MFF is aligned with MARD's Climate Change Adaptation and Mitigation Action Plan and the NTPRCC.

B. Wastewater use in irrigated agriculture: aligning multiple uses and services of water and irrigation infrastructure to meet the needs of urban-agricultural water users

3.16 Irrigation infrastructure and water management practices in peri-urban areas provide multiple functions that go beyond the management of water for agriculture alone (e.g., Bac Duong case study). These include: irrigated agriculture; urban drainage; and urban and industrial wastewater disposal. As urban drainage and wastewater effluent are frequently valuable additional water resources for agricultural use, there is a need to manage these multiple functions in an integrated and safe manner.

3.17 Urban and industrial wastewater will grow significantly over the next decades driven by economic growth and urbanization, especially around large urban centers. Wastewater flows already constitute a significant source of water in peri-urban watersheds, especially during the dry season and irrigated agriculture is already a large user of wastewater. This use of wastewater in agriculture needs to be formally recognized in policy and planning in order to put in place water management practices that safeguard consumer and farmer health.

3.18 Provided that minimum safety standards are met, the use of wastewater in irrigated agriculture can help dispose of wastewater safely. To meet these standards, primary water treatment may still be required, but this is much less costly than full treatment. Properly managed, agricultural wastewater use can therefore be part of an affordable water management system. It can also bring substantial benefits to agriculture by providing cheap and reliable additional water resources; supplying a free source of nutrients, and reducing the need for additional fertilizers.

3.19 An agricultural wastewater-use strategy is needed to secure these benefits. The strategy should recognize the de facto use of wastewater in agriculture with the aim of establishing a well-regulated wastewater management system that capitalizes on the role of agriculture in helping to address urban and industrial wastewater management problems.

3.20 Strict regulations need to be put in place and enforced to ensure that heavy metals (e.g., Pb, Cr), chemical pollution, and pathogens do not threaten farmer safety and consumer health. And farmers need training to ensure safe use of wastewater in agriculture, in particular in relation to pathogenic contamination; and reduce fertilizer use to make optimal use of high nutrient loads in wastewater.

3.21 An integrated wastewater treatment and disposal strategy needs to be developed and applied in heavily urbanized and industrialized zones where irrigated agriculture is present. This strategy should encompass the following elements: heavy metal pollution minimization at source; industrial wastewater collection and partial treatment to meet minimal standards; and strict separation of solid waste collection and disposal from wastewater. The standards for agricultural wastewater treatment and use should comply with the international wastewater and food safety standards established by WHO and FAO.

3.22 Policies should acknowledge the use of irrigation infrastructure for irrigation, urban drainage, and wastewater use, thereby providing an enabling environment for irrigation companies and agriculture, environment, industry and urban planning sectors at district and provincial level to coordinate planning and investment strategies.

3.23 Additional research and monitoring should be conducted to the present use of wastewater in rice and upland crops to understand the current threats to the environment and to food safety and to improve farmer training and wastewater use in agriculture.

C. Multiple use systems for enhanced food security and livelihoods diversification

3.24 The case studies undertaken in the first phase of the WFE Partnership demonstrated the widespread incidence of the use of water management systems for multiple uses. This includes the combination of irrigated agriculture, aquaculture, and other water uses, but is a phenomenon that is particularly widespread in relation to water management within villages, where it brings multiple benefits. The existing patterns of multiple use systems (MUS) in rural communities improves productivity, enhances food security, provides major opportunities for livelihood diversification and provides a framework for the integrated management of water supplies and human and animal organic wastes. It shifts the analysis of the economic viability of domestic water supply systems from being focused only on health and time saving benefits to being a direct asset in small, home-based production. Where the MUS approach is integrated with organic waste disposal, it also provides a way to address the growing problem of environmental health in Vietnam, where the unhygienic disposal of these waste products is a major hazard.

3.25 The focus on approaches to systematize and enhance these benefits is in close alignment with emerging government policies for rural development, which emphasize livelihood diversification and the development of rural enterprises. The local-level private sector is a major stakeholder in the development of rural water supply and sanitation facilities and in the production and marketing of domestic-based produce. The pilot activities in this cluster will develop local-level public-private partnerships whereby local communities are linked to local entrepreneurs to efficiently extend services and develop and market new produce opportunities.

3.26 It is consequently proposed that the next phase of the WFE Partnership include a component that focuses on village-level integrated water and sanitation management. These activities will focus on productive uses of domestic water, linked to sanitation and livestock waste management that will provide nutrient recycling (e.g., ecological sanitation, composting), reduce environmental impacts of waste discharges, improve human, animal and environmental health, and could facilitate new production options (e.g., high-value vegetables, fruits, flowers). These opportunities reflect the wider changes in the rural economy that result from increasing market connectivity and changes in consumption patterns in urban areas and international markets.

3.27 The 2005 National Rural Water Supply and Sanitation Review (NRWSSR) demonstrated the significance of the use of domestic water for production purposes and the key role of the private sector in constructing water supply systems and providing services in rural areas. Rural water supplies are often used to irrigate vegetables, fruits, and other high value (and nutritionally important) products in home gardens. They are also essential for livestock, which is an important factor in livelihood diversification and poverty reduction. Water is also essential for many forms of crop processing and other home-based livelihood activities that can add value and diversify incomes.

3.28 The NRWSSR also identified the need for the extension of sanitation services and the safe disposal of animal wastes (especially pigs, cattle and buffaloes) in rural communities. These organic wastes are both a major health risk and a vital source of nutrients for agriculture. The piloting of options such as ecological sanitation and improved composting (both of which have been tested in Vietnam with some success) will provide the twin benefits of reducing the environmental and health impacts of organic waste disposal and providing a natural and low-cost source of nutrients for domestic-based food and other agricultural produces.

3.29 The activities undertaken in the next phase of the WFE on MUS can be relatively small-scale, working at a single village level. It is proposed that they should be established in a number of sites around the country, with preference initially given to sites with good levels of market access. These pilots will establish the modalities for such approaches, which can then be extended to more remote sites where levels of market access and private sector development are limited.

3.30 The goal of the pilot projects is to work with communities to develop more effective and sustainable management systems for water supply and organic waste disposal that create new livelihood opportunities, improve the reliability and diversity of food supplies, make more efficient use of water supplies and ensure the hygienic disposal of waste products, including the recycling of nutrients whenever possible. The project details would depend on consultations and planning with local communities and would reflect the realities of market conditions and access in each locality. Links to existing government programmes, especially the National Target Programme on Rural Water Supply and Sanitation, should be established so as to ensure conformity with existing policies and provide a means through which successful experiences can be replicated.

3. WFE IMPLEMENTATION STRATEGY

4.1 The following recommendations are drawn from the Vietnam-Netherlands WFE Partnership, which identified options for and constraints on a better alignment and integration of multiple water uses across agriculture, aquaculture, and aquatic ecosystems.

4.2 This strategy identifies numerous opportunities to optimize water use for irrigated rice and aquaculture production without further reducing the quantity and quality of water needed to

sustain aquatic ecosystems. With the appropriate pre-treatment, for example, irrigated rice can help filter urban wastewater, thereby contributing to environmental protection.

4.3 The strategy identifies three major themes in which innovations in water management across agriculture, aquaculture, and conservation can be applied. These are: integrated management of fresh, brackish, and saline water in coastal areas; use of urban wastewater in peri-urban agriculture; and development of MUS to enhance rural food security and livelihoods.

4.4 Of these three focal themes, the integrated management of fresh, brackish, and saline water in coastal areas is the broadest and most complex and has been split into six sub-themes. These are: irrigated rice; drainage; brackish aquaculture; conservation of coastal forests; mixed rice-aquaculture; and climate change adaptation with a focus on mangroves and inland wetlands. Within each domain, a set of objectives have been defined. The climate change adaptation sub-theme is of special interest given Vietnam's vulnerability to climate change and the need to rebuild the resilience of its already degraded ecosystems.

4.5 By design, this strategy does not include information about the location, timing, and details of project activities since these would emerge from negotiations between MARD, LNV, and other relevant stakeholders. Priority themes are given in Section 3.

4.6 Implementation of this strategy would build on the results and relationships that the WFE Partnership has already established. This implies the on-going involvement of MARD, MONRE, Ministry of Industry and Trade (MOIT), Ministry of Transportation (MOT), Ministry of Health (MOH), Ministry of Construction (MOC), and Electricity of Vietnam (EVN) as well as NGOs, businesses, academic and research centres, and civil society. It is strongly recommended that the WFE Steering Committee and WFE Working Group, which have served as effective mechanisms to promote inter-sectoral discussion and information sharing, be further institutionalised and charged with the implementation of this strategy.

4.7 MARD would be responsible for leading the implementation of this strategy. Its principal duty would be to coordinate and supervise other ministries and agencies in the development and implementation of priority projects identified in this strategy. Other ministries and agencies, according to their mandates, would be responsible for participating in project design and leading implementation of specific projects components.

4.8 Many of the proposed activities would require the active participation of provincial and sub-provincial stakeholders, notably the provincial authorities. In a follow-up phase, membership of the partnership is therefore likely to expand significantly in those provinces where the WFE strategy is being implemented.

4.9 It is recommended that implementation of this strategy focus on pilot areas selected by MARD in consultation with relevant stakeholders. The WFE Partnership used case studies to identify issues and opportunities for WFE in Vietnam and develop this strategy. In implementing this strategy, the focus should be on hands-on exercises to test WFE methods in pilot areas and to apply innovative cross-sectoral multiple use water management techniques.

4.10 As weak inter-ministerial coordination is the single greatest weaknesses of IWRM, and by implication WFE, in Vietnam, it may be necessary to have an outside organization assist MARD in engaging partners and serve as the secretariat of the WFE Steering Committee and WFE Working Group. This was the role that IUCN played in the first phase.

4. ANNEX: CASE STUDIES

Title	Implementing organization	Lead
1. Integrated and Sustainable Use of Water Resources in Xuan Thuy National Park, Nam Dinh Province	Vietnam Academy for Water Resources (VAWR)	Dr. Nguyen Tung Phong
2. Sustainable Use of Water Resources for Maintaining Ecosystems of Xuan Thuy National Park	VAWR	Dr. Nguyen Tung Phong
3. Potential Use of Waste Water for Irrigation to Alleviate Water Pollution While Assuring Sustainable and Safe Agriculture (North Duong River Irrigation Scheme, Hanoi and Bac Ninh Province)	Department of Water Resources (DWR)	Dr. Bui Cong Quang
4. Impact of Participatory Irrigation Management to Local Communities and Environment in Hop Tien Commune, Dong Hy District, Thai Nguyen Province	DWR	Tran Van Dat
5. Impact of Rural Water Supply System to Livelihood and Environment in Nam Hong Commune, Nam Truc District, Nam Dinh Province	DWR	Vu Van Hai
6. Application of Economic Water Valuation for Devising a Multiple Use Operational Strategy for Hoa Binh Dam, Hoa Binh Hydropower Dam and Command Area, Hoa Binh Province	Water Resources University (WRU)	Dr. Le Dinh Thanh; Dr. Pham Thi Huong Lan
7. Toward Better Use and Management of Water Resources for Aquaculture and Agriculture Production in Dai Hoa Loc and Binh Thoi Communes, Binh Dai District, Ben Tre Province	Department of Aquaculture (DOA)	Nguyen Thi Minh
8. Sustainable Use and Management of Water Resources for Aquaculture in Binh Dai District, Ben Tre Province	DOA	Nguyen Thi Minh
9. Economic Analysis and Environment Impact Assessment of Water-based Economic Activities in Tam Giang-Cau Hai Lagoon, Thua Thien Hue Province	Hue College of Economics (HCE)	Dr. Mai Van Xuan
10. National-Level Review of Policies and Issues in Relation to Water-Food-Ecosystem Interaction	National Institute for Science and Technology Policy and Strategy Studies (NISTPASS)	Dr. Bach Tan Sinh

1. Integrated and Sustainable Use of Water Resources for Maintaining Ecosystems of Xuan Thuy National Park

The study aims to provide recommendations for devising a water and natural resources management strategy for the Red River estuary around Xuan Thuy National Park, Nam Dinh Province, focused on: maintaining and fostering the park's ecosystem; providing services to food production systems (e.g., agriculture, fisheries, aquaculture) in and around the park that are non-intrusive to ecological integrity; and reviewing environmental issues in terms of water resources.

Research context and summary

Xuan Thuy National Park covers 7,100 ha on the Ba Lat estuary of the Red River, with an 8,000 ha buffer zone. A UNESCO biosphere reserve and Ramsar site, it consists primarily of wetland and mangrove ecosystems and is an important stop for international migratory birds. Aquaculture and agricultural production sustain people living in the 5-commune buffer zone, but such activities impact the water regime and quality in the park. The local population and associated economic activities have been on the rise since Vietnam's 1986 switch to a more market-oriented economy, resulting in the clearing of mangrove forests for shrimp and oyster farming, wild bird trapping and livestock grazing inside the core area.

Major findings

- Interfering with drainage system can have unintended consequences. The construction of a weir across Vop River in 1986, for example, led to a rapid increase in salinity and large-scale mangrove mortality. It was demolished in 2002, but the river has now been encroached upon and has never recovered.
- Clearing mangroves to make shrimp ponds has unexpectedly led to loss of many species of birds and reptiles.
- Xuan Thuy's core preservation area suffered a dramatic reduction from 1,400 ha in 1986 to 400 ha in 1998, as shrimp farming grew from 400 to 2,700 ha over that period. The reduction is tied to the period of rapid economic growth after *doi moi*, illustrating the link between economic policy and land use that is likely to be especially significant given the rapid short-term income shrimp farming generates.
- Despite its Ramsar status, Xuan Thuy is essentially open access, with oyster, shrimp and livestock farming occurring in the core zone.
- The Red River Delta is among the world's most densely populated rural regions. That density results in mass dumping of household, industrial and agricultural waste into waterways, and researchers have questioned the carrying capacity of the delta. Today, 36% of the labor force is employed in the "marine economy," which is the major off-farm income generator.
- The Hoa Binh dam has allowed double or triple rice cropping, a huge contribution to food security and export earnings. Irrigation now consumes 90% of the Red River's discharge. Only 70% of the irrigated area is operational because of poor maintenance, implying that small improvements in irrigation efficiency could yield big improvements in water availability downstream.

Major conclusions and recommendations

Technical recommendations

- A study of the bridge that replaced the Vop River dam should be conducted to ensure that it allows a flow regime sufficient to restore the ecosystem there.
- Stations should be set up to monitor indicators like water level, flow and quality.
- The operation schedule of sluices should match with crop and pesticide use calendars to minimize water pollution.

Management and institutional recommendations

- The Xuan Thuy management unit should receive professional skills training.
- Rural handicrafts, ecotourism and other replacement income sources should be developed to take pressure off wetlands and marine resources.
- Environment protection law enforcement must be strengthened and environmental education activities are needed for the community.

2. Sustainable Use of Water Resources in Xuan Thuy National Park, Nam Dinh Province

The study aims to propose initial measures to manage water resources and quality, and the natural environment in and around Xuan Thuy National Park, Nam Dinh Province, as part of an ecosystems approach to administering water for multiple economic purposes, including agriculture, aquaculture, ecotourism and other livelihoods. Such a system would harmonize those human uses with the water flow requirements of local ecosystems, with a local term goal of establishing balanced and sustainable management of the region's water resources.

Research context and summary

Same as previous case study.

Major findings

- Agriculture and aquaculture are the primary income generators in the densely populated buffer zone communes. Farming contributes 40% of income in the area with an additional 10% from animal husbandry, and marine economic activities responsible for another 36%.
- Most irrigation and drainage structures in the five buffer zone communes were built before the construction of Hoa Binh hydropower plant and the recent expansion of agricultural and aquaculture land. Disrepair, accumulated sediment and intentionally blocked canals have left the system running at 70% of its design capacity. It fails to meet current and projected water supply needs, but the cost of upgrades and new construction makes them infeasible in the immediate future.
- Lack of integrated planning between district and commune people's committees has led to a laissez-faire management environment where individuals can clear mangrove forests without consulting a larger, regional plan. As a result, mangroves have been eliminated or reduced to a fraction of their former area in some places.
- Samples of water for domestic use showed higher than permissible levels of some indicators of pollution. Indicators were within the acceptable range for agricultural and aquaculture water, but salinity was excessive.
- Sedimentation from upstream Vop River starkly reduces fresh water flow into the core zone, particularly in the dry season, and changes the biological system in certain areas of the park.

Major conclusions and recommendations

- Public awareness campaigns should be run to education local farmers about the proper operation of hydraulic works, including limiting canal blockage, participating in dredging, repairing canals and reducing wastewater discharge.
- Dredging and widening the Vop River could restore its original ecosystem.
- Further study is needed on saline water intrusion and river sedimentation. Continuing water quality assessments should be taken at different times, including during the application of pesticides in the buffer zone, and should measure a greater number of indicators for more comprehensive water quality assessment.
- Recommended long-term actions include: developing environmentally friendly alternate livelihoods, strengthening the role and capacity of the community in participatory management with special focus on women and the poor, and building capacity of local management and law enforcement agencies.

3. Potential Use of Wastewater for Irrigation to Mitigate Pollution and Assure Sustainable and Safe Agriculture in the Bac Duong Irrigation Scheme, Hanoi and Bac Ninh Province

The case study aims to assist MARD with developing tools to protect rice cultivation against possible negative impacts of irrigation from the heavily polluted Ngu Huyen Khe (NHK) River. It analyzes those impacts and formulates a strategy for addressing farmers' problems with pollution. The selected case study area is the Bac Duong Irrigation Scheme (BDIS) located in the Red River Delta in Bac Ninh Province and Hanoi.

Research context and summary

The case study area encompasses about 62 trade and handicraft villages making diversified products. Major trade and handicraft villages include the Phong Khe paper production, Tam Da

alcohol processing, Da Hoi steel production, Van Mon lead and aluminium casting, Dai Bai copper casting, and Dong Ky furniture production villages.

Untreated wastewater is the main source of water pollution in the study area. Values of BOD_5 and the concentration of suspended solids, coliform and nutrients (N, P) are high, leading to eutrophication in ponds and lakes in the area. Old industrial zones lack adequate waste treatment systems and are significant sources of pollution. New industrial zones, such as Tien Son and Que Vo, have proper waste treatment systems that meet the standards. Strict monitoring and management of their waste treatment systems is required, however, to ensure their continued compliance with legal regulations.

Major findings

- Changes in cropping patterns recently have been introduced, resulting in depletion of soil and water resources.
- Overuse of pesticides, fertilizers and other chemical agents for crop cultivation is leading to infertile, polluted soil. Residuals of chemical inputs leak into water sources and kill aquatic life.
- Heavy metals and other industrial and handicraft village waste are causing water and soil pollution, with negative effects on the quality and quantity of crop and animal products.
- Drinking water supply also is affected by surface water pollution and ground water contamination. Cancer, pleurisy, diarrhea, and skin diseases have occurred in the area, however, no study exists showing a link between cancer and water pollution.
- Much of the sedimentation in canal beds comes from waste matter, leading to soil pollution when dredging and filling.
- Levels of pollution indications vary by season in the NHK River but remain significantly above allowable values. The temporarily improved water quality in the rainy season cannot restore the damage done in the dry season and if pollution-reduction measures are not taken soon, the NHK River will become a dead river.

Major conclusions and recommendations

- Wastewater reuse for irrigation negatively affects rice in nursery periods and up-land crops, but it could be effective for watering rice in later periods.
- Rice fields at canal heads are highly affected by pollution (too much nitrogen, rice leaves are verdant but result in a poor yield).
- Wastewater should be stored for a time (7-10 days) before use for irrigation, but wastewater storage space is difficult to come by.
- Rice product tests are few and insufficient for proper assessment. No specific rice quality standards exist. Concentrations of lead and chromium are rather high in rice product samples. More tests are required to reach a conclusion about health implications.
- Water pollution in the NHK River is serious, especially in the dry season. It is the sole irrigation water source for areas along the river banks in the dry season. Wastewater reuse is the only option for those areas.
- If urgent measures are not taken now, the continued high rate of economic and social development will mean an unabated increase in water pollution in the scheme.

4. Impact of Participatory Irrigation Management on Local Communities and Environment in Hop Tien Commune, Dong Hy District, Thai Nguyen Province

The purpose of the case study is to explore ways to make water resource management

mechanisms, which are traditionally approached as single-purpose management regimes, more integrated, multi-stakeholder based systems. At the irrigation scheme level, water resource management entails irrigation governance and management.

Research context and summary

Hop Tien Commune, Dong Hy District, Thai Nguyen Province is 26 km southeast of Dong Hy District HQ, 33 km from Thai Nguyen City, and 120 km from Hanoi.

The case study analyzes water sources, primarily the Cap Ke dam, used to irrigate Hop Tien Commune, as well as the current irrigation management situation. A participatory approach has been initiated and integrated management should continue with consideration for various interests, such as irrigation, domestic water supply and fisheries. Additionally, the case study focuses on issues of water resource protection to ensure sustainable water resource development in the area.

Major findings

A Hop Tien Commune irrigation team was established in 1994. The team consists of a team leader and 15-20 team members (3-4 members per village) and is tasked with overseeing headworks operation and irrigation water distribution to fields for five villages in the commune.

According to data and surveys by the case study team, the Hop Tien Water User Organization (WUO) has significantly contributed in the following ways:

- Successful operation of irrigation structures within the Cap Ke scheme to supply irrigation water for agricultural production. That irrigation contributes to increased crop yields and food production in the commune, reduced production costs, improved living standards for the local people and greater food security.
- Indirect and/or direct impacts on water resource development and protection, including development and protection of forests, preserved water quality of the reservoir and canals, crop diversification, water loss reduction and water saving.
- Though the WUO depends on the authority of the Commune People's Committee (CPC), farmer participation is increasing, and decisions occasionally are made on a democratic basis.

Major conclusions and recommendations

- The Hop Tien irrigation teams are considered a form of WUO. Despite providing good water supply services, the teams do not operate according to any official methodology. It is necessary to strengthen the irrigation teams under the Participatory Irrigation Management (PIM) development philosophy. Irrigation management capacity building is required for the irrigation teams, as well as for village leaders and staff of Hop Tien CPC.
- The Cap Ke dam and irrigation system contribute significantly to agricultural production, both in terms of increasing crop production (area and yield) and reducing costs and labor. Irrigation also has considerably contributed to poverty reduction in Hop Tien Commune.
- The Hop Tien catchment is facing a low rainfall period, with water sources simultaneously decreasing. It is critical that all water users in the catchment take steps to save water. The Cap Ke dam scheme should increase its intake, canals, and on-canal structures to reduce water loss.
- Cultivation land for a spring rice crop is available if irrigation water is available. If the normal water level of the Cap Ke dam were increased 0.5 m, augmenting its use capacity to 66,000 m^3, the irrigated area would be 80 ha. In order to ensure food security, the rice cultivation area should not be less than 325 ha/year, and average rice yield should not be less than 4.30 tons/ha.
- Water quality in the Cap Ke dam scheme meets Vietnam's Class B standards. However, drinking water should be taken from dug wells, bore wells or the Hop Tien Commune pipe

system. The Cap Ke dam has played an important role in increasing the water table in Hop Tien Commune, providing significant indirect contributions to domestic water use.

- Tea tree cultivation is a good option for increasing crop diversification in Hop Tien. To improve tea production, irrigation water must meet of the species requirements for tea trees even in winter. Winter maize cultivation is also important for Hop Tien farmers.
- Forestry development is critical for water resource protection and management in the Hop Tien catchment because forests can regulate surface water. Forest quality must be improved to gain the full benefit of this effect, through flora diversification beyond Keo and Phan trees. It would be reasonable for local people to head forest management.
- Operation and management (O&M) issues in the Cap Ke dam scheme have not yet been given sufficient attention. There is no O&M budget available, but without improvements in that area, serious degradation of the scheme is imminent.

5. Impact of Rural Water Supply System on Livelihoods and Environment in Nam Hong Commune, Nam Truc District, Nam Dinh Province

The case study aims to assist MARD in assessing the effectiveness of the rural water piping scheme in Nam Hong Commune, Nam Truc District, Nam Dinh Province; and to propose an appropriate model for the locality and for potential replication to other regions in the Red River Delta and neighboring areas.

Research context and summary

The Nam Hong rural water supply pipe scheme is implemented in Bach Tinh village, on the bank of the Red River. It was constructed in August 2004 and became operational in December 2005. The system is managed by a team under the commune People's Committee composed of a unit head, technicians, accountant and cashier, most of who have little relevant training. Heads of hamlets manage pipe systems in their jurisdictions. It was designed with the capacity to provide clean water to all households in the commune: a capacity of 1,120 m^3/household. However, there are only 2,000-3,000 households connected to the system.

Major findings

- Households install water meters at their own expense to use clean, piped water and pay based on meter readings. As a result, a strong reliance on well and rain water remains, especially for non-consumptive uses like washing and hygiene, and 973 households, or 34%, continue to use no piped water.
- There have been some complaints about the expense of the 2,100 VND/m^3 unsubsidized flat rate applied to all water users.
- The management unit lacks a legal mechanism that could grant it more secure authority.
- The water is sourced from surface water of the Red River and pumped to households on a regular schedule, but not all operational steps have been standardized. Additionally, the headwork station has capacity for more water if demand increases, but is not equipped with a back-up generator.
- Samples of water after treatment had indicators of possible hazards all within the Ministry of Public Health's required standards, and indicators in downstream households were equivalent, implying an intact pipeline system with no outside penetration.

Major conclusions and recommendations

- The system in Nam Hong Commune, Nam Truc District, Nam Dinh Province has been providing "good" service to users, but central and provincial agencies should provide technical training courses to strengthen management capacity.

- A fixed water price could ensure financial sustainability but creates an inequitable situation that unfairly burdens poor users, so a fair funding mechanism should be developed and applied.
- Local residents should contribute labor and finances to the construction of clean water supply systems and actively participate in their management. If made aware of the significance of a clean water supply they will be more likely to operate the system effectively, so propaganda and awareness-raising campaigns on the issue are needed.
- The use of appropriate water treatment technologies and facility designs will reduce unnecessary costs. Management teams must devise clear division of labor.
- Community waste collection and treatment systems must be put in place as early as possible to prevent water source pollution from household garbage. Such models should be established immediately in pilot hamlets, to be expanded to other similar communities.

6. Application of Economic Water Valuation for Devising a Multiple Use Operational Strategy for Hoa Binh Hydropower Dam and Control Area, Hoa Binh Province

The study aims to assist MARD in developing, analyzing and selecting models for a multiple-use strategy for the operation and releases of the Hoa Binh hydropower dam. It uses economic valuation as a lens through which to seek to equitably distribute and maximize the value of the water as used in hydropower, agriculture, fishery, navigation, flood control, water supply and environmental systems.

Research context and summary

The Hoa Binh dam is located on the Da River, the largest Red River tributary, in Hoa Binh Province. In addition to electricity generation, since the start of its operation in 1989, the dam has supplemented downstream water flows in the December-April dry season, but those additional flows have been running low in recent years. It serves a flood control function in the wet season. The downstream area is the most heavily populated stretch of the waterway and is a hub for economic activity including agriculture, aquaculture, forestry, tourism and industrial production.

Economic valuation could serve as a powerful tool for devising an Integrated Water Resource Management (IWRM) scheme for the reservoir. Such an analysis can determine and compare the economic value of different water sectors and uses, including ecosystems, and allocate water accordingly. By putting a value on the water consumed by the major sectors in the region and by specifying a minimum discharge needed to maintain the river's basic ecological functions, the study uses a mathematical model to propose a dam operation plan that generates the greatest total economic good across all sectors.

Major findings

- If the dam operates at standard capacity for electricity generation from December to January, insufficient water remains for irrigation and other downstream uses. Inter-sectoral cooperation remains low.
- Consumption of electricity is increasing, and production of energy is still primarily based on hydropower. National electricity use jumped fivefold between 1995 and 2004, and that increase is expected to continue with prolonged industrialization.
- The water level in the Hoa Binh reservoir, responsible for 40% of national energy production, has measured below the minimum acceptable level at certain points in recent years. Inadequate water levels can seriously damage turbines.
- During the dry season of 2005-2006, when Red River levels were recorded at the lowest in 40 years, large vessels could not navigate the waterways and had to rely on longer routes, increasing shipping cost and decreasing product yield.

- Changes in weather and climate patterns mean the dry season is seeing less rainfall on average. The new flow regime governed by the Hoa Binh and other reservoirs also differs significantly from the river's natural flow. It fluctuates depending on electrical production, creating an unstable dry season flow. Shrimp production in Cat Ba-Ba Lat off the Red River Delta has dropped 50% since construction of the dam.
- Recent reservoir construction in China has significantly decreased incoming water flows to Vietnam.
- Models show that the minimum level of downstream water needs to be maintained at 115 m to meet demand. Modeled discharge between 1,100m^3/sec to 1,150m^3/sec is acceptable to satisfy all demands of downstream users but could lead to power loss in the dry season. Balancing scheduled water release and water transfer from dam to inlets and pumping stations can help regulate incoming flows to the reservoir.

Major conclusions and recommendations

- During the dry season, the reservoir needs to maintain a release discharge of at least 800 m^3/sec. During the irrigation stage, discharge should increase to more than 1,100m^3/sec, and priority should be given to food production and security.
- Water resource management offices should be separate from use offices to ensure easier resolution of water conflicts by virtue of an impartial arbiter.
- Upon completion of the Tuyen Quang and Son La dams, a comprehensive study on their internal reservoir operations should be undertaken to assess their impacts on food security, economic interests and ecosystems when operating at the same time as the Hoa Binh dam.
- Sector-specific recommendations include:

  Agriculture
  Study and upgrade current waterworks and irrigation systems to ensure the use of the most water-efficient technology.

  Electricity
  There is an urgent need to develop effective operation procedures, which take minimum requirements for downstream uses into account.

  Navigation
  Studies should be done at selected low-water hotspots to determine the feasibility for river bed trenching to deepen routes. Boats should follow the schedule of dam releases as much as possible, and transport companies should make current water level measurements and warnings available to all vehicles on the river.

  Government ministries
  Fees for water should be charged based on the quality of water services provided. Irrigation and drainage need to be upgraded, and community awareness of saving water should be raised. Annual studies, medium-term forecasting and regular impact assessments should be conducted to gauge water use in the area.

7. Toward Better Use and Management of Water Resources for Aquaculture and Agriculture in Dai Hoa Loc and Binh Thoi Communes, Binh Dai District, Ben Tre Province

The study aims to analyze the conflict over water needs between agricultural irrigation and aquaculture in Dai Hoa Loc and Binh Thoi Communes, Binh Dai District, Ben Tre province. On a dollar-per-drop basis, aquaculture is the higher value activity in the region but cannot serve as the sole income source. The study identifies ways the two production activities affect each other (e.g.,

chemicals from agriculture run into aquaculture water and vice versa) and offers recommendations for adjusting the management scheme to better accommodate both industries.

Research context and summary

Ben Tre's three big estuaries flowing to the sea give the province marine, fresh and brackish water areas with boundaries that change seasonally. Freshwater aquaculture has increased quickly, with an average growth rate of 19% between 2000 and 2006. Intensive catfish farming appeared in 2004, and by 2006 catfish accounted for 62% of freshwater aquaculture. The area for intensive and semi-intensive giant tiger prawn farming increased from 244 to 5,189 ha from 2000 to 2006, and such farming accounts for 88% of marine and brackish aquaculture, and 76% of total aquaculture in the region.

Dai Hoa Loc and Binh Thoi are seaside communes surrounded by big rivers. They are strongly affected by the tide, resulting in good water drainage, but river water is highly salinized during the January-March dry season, causing freshwater shortages. Aquaculture grew from 44,000 ha in 2000 to 67,000 ha in 2006, mostly due to the expansion of freshwater, and particularly catfish, aquaculture. Shrimp farming remains profitable, yielding on average $8,000/crop/ha compared to $400/ha/year for rice.

Major findings

- The irrigation system, which was designed for rice, cannot meet the current demand for water for shrimp farming. The result is the release of untreated wastewater in the canal system, disease spread and mass fish and shrimp kills.
- The system of culture ponds does not meet technical requirements. Further, farmers use prohibited chemicals, and polluted water poses a health risk to local residents.
- Leadership is synchronized from the communal level to the district level. The district government draws on lessons learned when planning aquaculture activities for the coming year and is starting to raise local environmental awareness.
- A structural issue limiting improved water resource management is the extreme fragmentation of land holdings in the Mekong Delta, a hangover from post-war land reforms that is now a major constraint on agricultural production. Also, due to natural conditions, only one rice crop is grown from June to September.
- The main shrimp crop can be raised at high density from February to June, with a sub-crop from June to October.

Major conclusions and recommendations

<u>Planning</u>

- Areas not producing a high agricultural yield should be used for shrimp and rice farming rotations or other species combination farming.

<u>Technology</u>

- One-crop semi-intensive shrimp farming should be done with medium density. Local guidelines on crop patterns should be followed strictly, including releasing shrimp seed at the proper time and refraining from raising a third crop, which can be disease-prone.
- Awareness should be raised about the list of prohibited chemicals and antibiotics, and penalties for their use should be introduced and enforced.

<u>Irrigation</u>

- The existing irrigation system should be repaired and updated for shrimp farming. A new system should be built to satisfy water supply and drainage standards for particular aquaculture forms. Alluvium- and mud-filled channels and ditches need dredging.

8. Use and Management of Water Resources in Aquaculture in Thach Tri Commune, Binh Dai District, Ben Tre Province

The study aims to analyze water use and quality in Thach Tri Commune, Binh Dai District, Ben Tre Province. In a policy context where agriculture is the first priority in district economic development planning, despite a burgeoning aquaculture industry with growing water needs, the case study suggests water-sharing solutions with the objectives of benefiting both food-producing stakeholders and the environment.

Research context and summary

Same as previous case study.

Area and output for aquaculture in coastal Thach Tri Commune is lower than in other communes in the province but are increasing. Thach Tri presently has 441 ha for shrimp culture and 316 ha for semi-intensive culture, producing a shrimp yield of 1,800 tons/year. Saline water stretches far inland during the January-April dry season, when precipitation is low.

Major findings

- Local authorities have not recognized water supply and draining for aquaculture as important or invested in the activities, though they are the most critical determinants of aquaculture success. The irrigation system, which was designed for rice, cannot meet the projected demand for water for shrimp farming. The result is the release of untreated wastewater in the canal system, disease spread and mass fish and shrimp kills.
- Awareness about environmentally friendly tactics and efficient aquaculture techniques is low among the local people. Most farmers lack treatment and sedimentation ponds, and the use of harmful chemicals is widespread.
- There is only one officer from the district aquaculture division responsible for agricultural water use and management in Thach Tri, rendering management and project implementation difficult.
- Fragmented land-use holdings impede the allocation of large, continuous tracts of land for aquaculture. Agriculture and aquaculture lack separate water supplies.

Major conclusions and recommendations

- Irrigation systems need to be restored, built and dredged. Agriculture and aquaculture should have separate water supply and drainage systems.
- Environmental monitoring should be enhanced and more manpower is needed in aquaculture management. Local government should support the creation of a community-based aquaculture area management board.
- Semi-extensive shrimp-rice culture is successful in Thach Tri. Inefficient rice fields should be converted to pangasius or other indigenous species culture. Rotation and integrated culture models should be encouraged.
- Aquaculture sector safety standards should be applied, including stronger inspections of shrimp larvae, feed, drug and other providers.
- Aquaculture should be encouraged to use probiotics for water supply treatment, check seed and feed quality, and limit the use of chemicals.

9. Economic Analysis and Environment Impact Assessment of Water-based Economic Activities in Tam Giang-Cau Hai Lagoon, Thua Thien Hue Province

The study aims to estimate the economic value of the top three income-generating activities on Tam Giang-Cau Hai Lagoon, Thua Thien Hue Province: aquaculture, natural fishing, and rice

farming. It further seeks to assess the environmental impact of those activities on lagoon water quality and biodiversity, to measure the livelihood importance of the activities and to provide recommendations for sustainable management of lagoon resources.

Research context and summary

With a surface area of 21,600 ha and average depth of 1.5 m, Tam Giang-Cau Hai is Southeast Asia's largest coastal lagoon and home to 350,000 people, or a third of the provincial population. Agricultural production employs 55%-60% of the rural labor force, with chemical runoff leaking into the lagoon. Aquaculture is on the rise, and wetland conversion allowed aquaculture area to double to 4,000 ha between 2000 and 2005. Wild fishing is an important source of income for the 1,800 sampan households in the province, and fishermen have been switching from traditional methods to more destructive fishing gear. Those factors, combined with local population growth and the construction of dikes and dams that have interrupted the lagoon's natural hydrology, suggest the need for more sustainable resource use management to avert ecosystem collapse.

Major findings

Aquaculture

- After a period of rapid expansion between 2000 and 2005, when the area of shrimp farms doubled, production stabilized. Intensive shrimp farming burdened farmers with debt after more than 50% of them lost harvests to disease, which triggered a shift toward extensive farming.
- Extensive farming produces less than 50% of the shrimp per unit area of intensive farming, but net income per unit area from extensive farming is higher due to reduced inputs, particularly feed, and much lower disease risk. Statistical analysis shows a 1% increase in stocking density results in a net income drop of up to 1.5%.
- The high disease risk in monoculture has led to a move toward polyculture that combines crab, shrimp, and fish. That method produces high yields with relatively low input costs because the species feed on the leftovers of others, reducing feed costs and resulting in cleaner water. Although polyculture produces fewer individual shrimp, it yields a larger quantity of big shrimps that sell at a higher price per kg.
- Shrimp are mainly marketed in other provinces and for export, depriving shrimp farmers of bargaining power. Crab and fish primarily are sold in Thua Thien Hue at a more stable price. There is evidence that the scale of aquaculture exceeds the lagoon's carrying capacity.

Wild catch

- The fish catch from the lagoon is stable, but numbers are bolstered by an increased level of effort per unit and the adoption of more effective (and destructive) fishing techniques. The number of person-days allocated to fishing activities was the top factor influencing income of fishing households.
- Traditional bamboo and rattan fishing corrals and other structures have disappeared, in favor of electro-fishing and Chinese fish traps that indiscriminately catch fish of all varieties. Those methods have negatively impacted aquatic species reproductive capacity, and tactics like dragnets and rakes have damaged the lagoon bed.
- Large fish have been fished out of existence in the lagoon. Unclear fishing ground boundaries are challenging the local government's capacity to manage lagoon resources.

Rice production

- Integrated Pest Management (IMP) schemes reduce chemical fertilizer use an average of about 200 kg/ha/year, and save farmers cost in pesticides and herbicides. They often incur more labor cost.
- Paddy production is still a subsistence activity, with only about 12% of product sold at market rates. IMP methods are not widely used, and there is still reliance on pesticides.

- The "rice-fish" polyculture model brings a higher return than paddy monoculture. It also reduces fertilizer use and the associated input costs.

Major conclusions and recommendations

Aquaculture

- Households should diversify cultured species, apply appropriate stock density and reduce the use of fresh feed to avoid environmental risks.
- Encourage households not to increase aquaculture area and to adopt proper aquaculture techniques. It is necessary to rearrange aquaculture ponds to allow the construction of suitable canal systems.
- Conduct studies on polyculture models to generate more information on culture techniques, zoning, economic returns and marketing options.

Wild catch

- Restrict and ban destructive fishing practices. Rearrange the system of nets and fish corrals into a more sustainable configuration.
- Local government should allocate fishing ground rights to fishers and communities. Community-based resource management models using a common-pool management approach should be piloted.
- Support local inhabitants in livelihood diversification, and involve fishing households in activities that depend less on lagoon resources.

Rice production

- Local governments should encourage and support local farmers applying IMP methods to increase efficiency and environmental protection.
- More pilot trials and research are needed to back a push for adopting the rice-fish model. Develop simulation models to predict the outcome of policy scenarios.

10. National-level Review of Policies and Issues in Relation to Water-Food-Ecosystems Interaction

The study aims to define the scope and policy context for the development of the WFE approach in Vietnam by assessing the policy, legal, regulatory and institutional environment within which the approach would be implemented. It also was designed to assist with assessing the potential for the replication of management options identified through the WFE case studies.

Research context and summary

Vietnam's total annual runoff of 847 km^3 gives it an abundant but potentially unsustainable level of water volume per capita because 60% of the water it receives comes from international rivers, with rainfall accounting for a much lower proportion. Therefore, many areas are highly dependent on the quality of upstream water sources, which are sometimes in areas over which the government has no jurisdiction. Other challenges Vietnam faces include dependence on surface water resources in upper basin areas, uneven temporal and spatial distribution of rainfall, and degraded water quality. Those issues are becoming more pressing in the face of increased industrial development and a growing population, which have heightened competition for water resources at a time when the impacts of climate change threaten to devastate water-dependent sectors.

Major findings

- Vietnam's surface water is generally of good quality. However, in urban areas, near craft villages, which use outdated technologies, and near industrial production centers it is severely polluted.

- Most water resource projects have been implemented with a focus on specific sectoral issues and with the main funding and expertise coming from foreign countries, two trends that should be reversed.
- The *doi moi* reforms in the mid-1980s transformed agriculture, setting the stage for rapid economic and industrial development. From 1989 to 1991, Vietnam transformed from a net rice importer to one of the world's largest rice exporters and the agricultural sector is now the country's biggest water user.
- Aquaculture has grown significantly in Vietnam and accounts for half the animal protein supply. However, it has caused a loss of mangrove forests and degraded water quality. State fisheries enterprises are inefficient, and fish exploitation and conservation are the responsibility of the same organization.
- Climate change has the potential to lead to more severe seasonal variation and natural disasters, as well as increased salinization of coastal fresh water sources. Vietnam lacks a water saving plan for the dry season.
- Increasing competition for reliable water resources may constrain economic growth and the creation of livelihood opportunities.
- Water governance in Vietnam is trending toward decentralization, which shifts the weight of development planning closer to where resources are used, and toward public-private partnerships. However, competing needs, lack of awareness, increasing demands and institutional inertia have made PIM and other local level management schemes slow to start.
- The concept of ecosystem value is not written into Vietnam's Law on Water Resources. The National Strategy on Water Resources to 2020 fills some of the law's gaps with a stronger focus on IWRM and water for nature. Issues of inadequate data and information sharing, EIA and management capacity hinder implementation of the strategy.
- Lessons learned from WFE case studies include: (1) serious water pollution has significant impacts on food, ecosystem and community; (2) current water management systems at all levels are inadequate for conflict resolution, system improvement and community participation; (3) there is a need to build and strengthen human resources capacity in water management; (4) biodiversity is threatened by domestic and industrial water pollution, dam and infrastructure construction, dredging, destructive fisheries techniques, aquaculture and over-fishing; (5) water sources are becoming limited. Wastewater reuse and saving water are recommended after correcting for negative impacts on human health.

Major conclusions and recommendations

- Though Vietnam has diverse water sources, most research has focused on ground and surface water. More research should be done on using brackish and salt water for fishery development.
- Mechanisms for managing the interaction between water for food and ecosystems should be examined at the local level to find working models for replication in similar localities and to inform possible revision of national policies.
- The ability of MONRE and DONRE to enforce water pollution regulations should be strengthened. Sanctions and incentives for industries and other polluters should be strictly implemented.
- Capacity building is needed on two levels: strengthening the ability of the government organizations to carry out their water resources work more effectively and efficiently, and building capacity for communities to mobilize and participate in IWRM.

- MONRE, through the NWRC and working with other ministries and provinces, should lead a 3-year program of identifying IWRM capacity development needs at all levels and coordinating appropriate activities.
- More focus on river basin planning is needed in developing water resource policies, including creating a mechanism for international cooperation on shared waterways.
- Reuse of treated wastewater is recommended for crop irrigation and fisheries; and crop diversification is recommended as a water saving technique.
- Legal documents have not yet specifically addressed water sharing in general and between agriculture and ecosystems in particular. That gap needs to be filled, and coordination between water using sectors and between such sectors and governing bodies needs improvement.
- Vietnam needs increased investment in research on projected climate change impacts on various sectors in order to propose mitigation and adaptation policies.