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Livelihood impacts of water policy changes: evidence from a coastal area of the Mekong river delta

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Abstract

The coastal zone of the Mekong river delta has experienced rapid economic and environmental changes during the last decade. Given the nature of the environment and the level of dependence on the natural resources base, policies for land and water were very influential in this process. The emphasis on rice created an imperative to control saline intrusion, which was realized through the construction of major engineering works over an extended period (1994–2000). The inertia built up by this process led to a divergence between policy and practice, and adversely affected the livelihoods of fishers and of those farmers who live on aquaculture. This prompted the government to rethink the rice-focus policy, in favor of a land and water policy for balanced rice and aquaculture production. This paper describes an analytical process, which was adopted to explore the feasibility of adopting the new policy for the balanced development of both rice and shrimp production and discusses the impact of the new policy on farmers' livelihoods.

Keywords: Participatory rural appraisal; Rice production; Rural livelihoods; Salinity control; Shrimp aquaculture; Water-policy changes

1. Introduction

In this paper we present a case study from the coastal zone of the Mekong river delta in Vietnam. This paper examines how policies for land and water became divergent in the context of the rapidly changing social and economic environment during the 1990s. Livelihood impacts are explored on the basis of Participatory Rural Appraisals (PRAs) (Cornwell, 2000) conducted with different wealth groups at different times corresponding to two distinct phases. Phase I (1996–2000) reflects the original policy to maximize rice production in the region. The policy divergence became most pronounced after 1998 when adverse impacts on livelihoods began to provoke popular pressure for change. Phase II (2001–2003) reflects the new policy for the balanced development of rice and shrimp production. This followed a rapid process of policy review by using information technologies to support the screening of alternatives. The analytical process, which relied on GIS-linked hydraulic and salinity modeling and dialogs with local governments/policymakers to support policy changes, is fully described in the paper.

2. The study setting

The Ca Mau peninsula, which lies at the extreme southern tip of the Mekong delta in Vietnam, is a much modified environment. The natural vegetation has been almost entirely cleared and replaced by a landscape of cultivated fields and ponds, while the natural network of tidal creeks has been modified and extended so that a dense network of artificial waterways now exists throughout the region. Environmental change has been rapid, particularly since the 1990s when the *doi moi*[1] policy introduced an agenda of agriculture-led growth. Given the nature of the deltaic environment and the emphasis on rice production as the engine of growth, policies for both land and water have been equally influential in this process. The peninsula lies entirely within the zone of saline intrusion, which extends up to 50 km inland during the dry season, thus limiting traditional rice production to only one rainy season crop (June–November). In order to promote intensification of rice production, a plan was devised to build a series of coastal embankments and tidal sluices. This paper concerns, in particular, the Bac Lieu province (Figure 1), which covers approximately 160,000 hectares in the Quan Lo Phung Hiep water-control project. The first sluice of the project became operational in 1994 and the area protected from saltwater intrusion gradually expanded westwards as successive sluices were completed up to 2000. Within the protected area, the duration of freshwater conditions was extended in line with the policy to promote double or triple cropping of rice. Figure 1 illustrates this process by showing the position of the 7 dS m^{-1} isohaline for February, the end of the rice crop in the dry season.

The policy can be criticized (with the benefit of hindsight) for suffering the same faults identified by Hori (2000) in a review of development planning throughout the lower Mekong basin. It failed to recognize the diversity of livelihoods of the population within the project area and did not give adequate consideration to the environmental impact. In particular, the importance of fisheries and aquaculture was neglected. The problem was exacerbated by the presence of extensive deposits of acid sulfate soils (ASS), particularly in the western part of the project area. Changes in the chemistry of water due to excavation of canals (Minh *et al*., 1997; Tuong *et al*., 1998, 2003) and exploitation of fallow land for agriculture (Xuan, 1993) then resulted in reduced aquatic biodiversity, including fish and shrimps (Chairuddin *et al*., 1990), which constitute important protein sources as well as an income source for the rural poor.

[1] *Doi moi* can be translated as “renovation” and is commonly used to describe the move from a centrally planned command economy to a market economy with accompanying democratization of social relations.

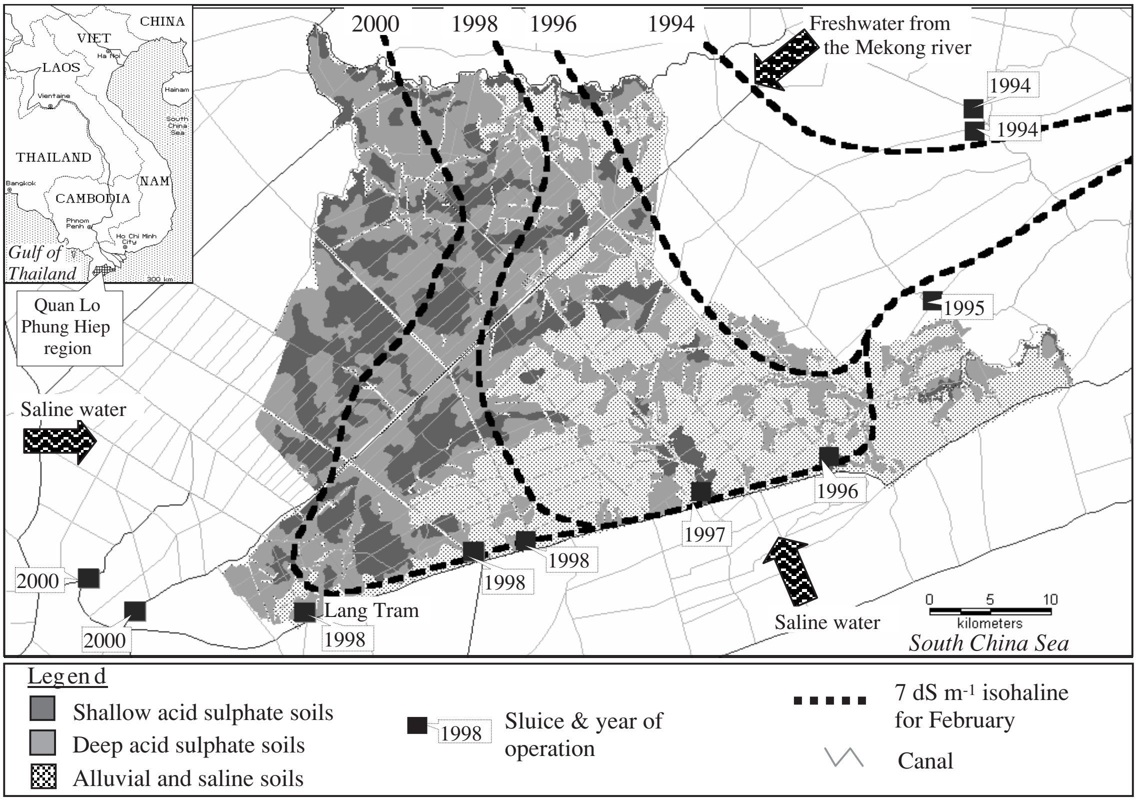

Fig. 1. Location map (inset), soil map, and 7 dS m^{-1} February isohalines for 1994, 1996, 1998 and 2000 of the study site (shaded area). The soil map is compiled from Ve (1988) and IRMC (2000). For simplicity of presentation, alluvial and saline soils are grouped together.

Nevertheless, the original policy was that these problem soils would be developed for rice farming. However, as the freshwater zone spread gradually westwards the local economy was undergoing rapid change. Profitability of the rice crop fell sharply and, at the same time, aquaculture was experiencing a dramatic boom fuelled by technical innovations and the high local and export price of tiger shrimp (*Penaeus monodon*). Traditional extensive systems of shrimp production based on natural recruitment of shrimp larvae were being replaced by semi-intensive monoculture production systems (Brennan *et al.*, 2000). By 1998, tiger shrimp culture was widespread in the western part of the project area (Figure 2) and this was consistent with the official policy[2] adopted in that year, which explicitly encouraged production for export using more intensive methods. Despite the apparent success and popularity of shrimp farming and its endorsement in the 2001–2006 Fisheries Five Year Plan, tidal sluices continued to be built and the freshwater zone continued to spread westwards (Figure 1).

When the supply of brackish water required for shrimp production was cut off, many farmers were forced to abandon aquaculture and to convert to less-profitable rice farming. Some shrimp farmers resisted and attempted to maintain favorable conditions by blocking secondary canals and pumping

[2] Decision on the ratification of the program of developing the export of aquatic products up to 2006. Government Decision No.21, 1998.

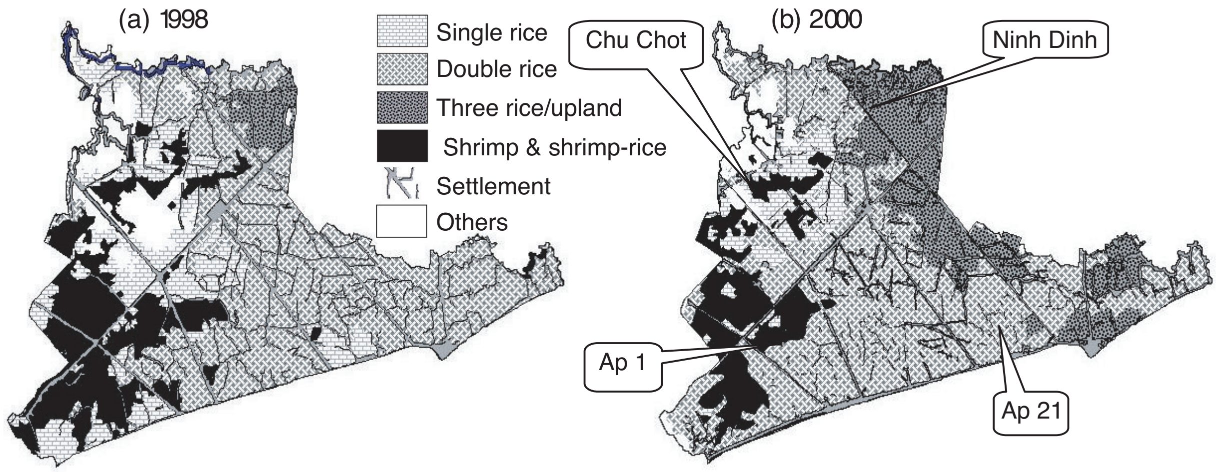

Fig. 2. Land use in the study area for (a) 1998 and (b) 2000. Locations of four surveyed representative hamlets are shown in (b) (Tuong *et al*., 2003).

brackish water into their fields, but this created conflict with rice farmers, who depended on freshwater to irrigate their fields. The conflict reached a peak in February 2001 when shrimp farmers destroyed a major dam at the Lang Tram sluice (location given in Figure 1) to let salt water flow into the region. This event prompted the government to reexamine the original policy of emphasizing rice production and to explore alternative land use plans that would accommodate shrimp cultivation in the western part while maintaining the areas of intensive rice production in the eastern part. An urgent question raised by the local authorities was how to operate the sluice system to simultaneously maintain both brackish and freshwater conditions in different parts of the project area. A review of alternatives was conducted following an Analytical Process to support Water Policy Changes (APWPC). In this paper we will describe this process, which was adopted to support a policy review, and the impacts on livelihoods from 1996 to 2002 of different wealth groups in the study area, in particular the poor, based on the PRA.

3. Analytical process to support water-policy changes

In general, the APWPC comprises three main steps: (i) participatory land-use investigation, (ii) water modeling and (iii) selecting a water-management scenario, and implementing and monitoring impacts. The main steps in this process are depicted in Figure 3.

Step 1: Delineating land use zones and determining water-quality requirement

Land-use zoning was carried out by consulting with the provincial authorities, local stakeholders and national scientists. Six zones were delineated (Figure 4), and their corresponding land uses and cropping calendars determined (Figure 5), taking into account farmers' preferences, soil characteristics and the "expected" water quality. The proposed land uses vary from two shrimp crops in the western part to three rice/upland crops in the eastern part (Figure 4). In between are transitional zones with two rice crops, or one shrimp crop in the dry season followed by one rice crop in the rainy season.

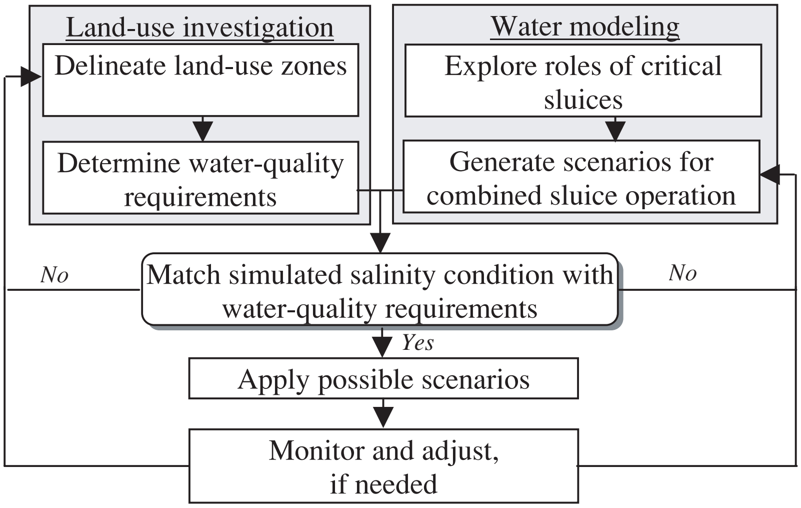

Fig. 3. The Analytical Process to support Water Policy Changes (APSWPC).

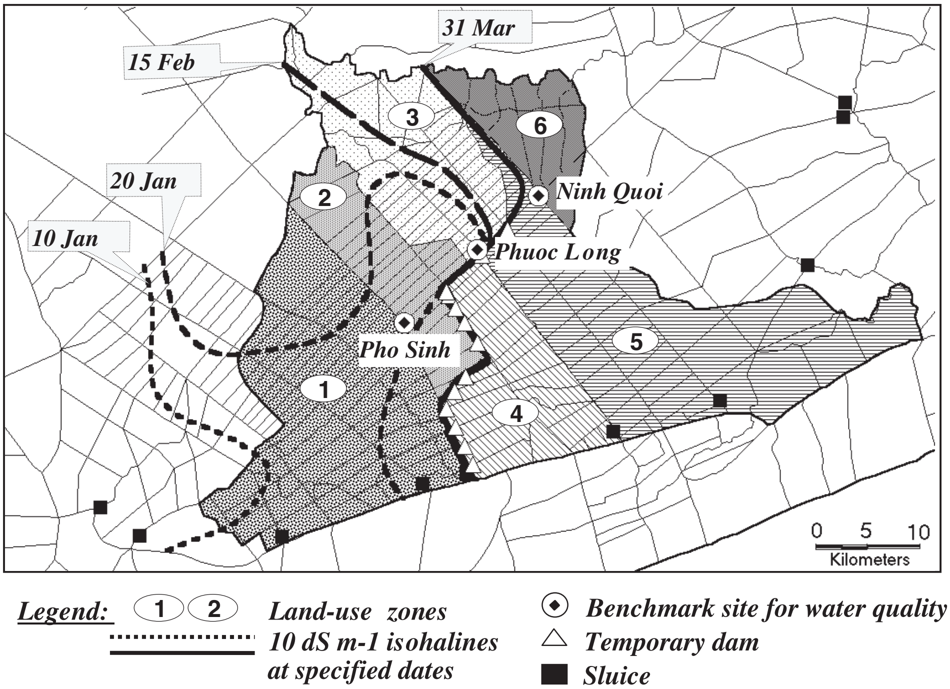

Fig. 4. Land-use zones, benchmark sites and isohalines for Scenario C (see Table 1).

Shrimp farming requires water salinity exceeding 10 dS m^{-1}, while the upper salinity limit for rice is 7.6 dS m^{-1}. As a simplification, we used 10 dS m^{-1} as the required threshold for both shrimp and rice. The monthly salinity requirements for different zones are shown in Figure 5. Three benchmark sites were identified along the arterial Phung Hiep canal (Figure 4). At Pho Sinh, water salinity before mid-January should be < 10 dS m^{-1} for rice growing in zone 2 and > 10 dS m^{-1} thereafter until the end of the

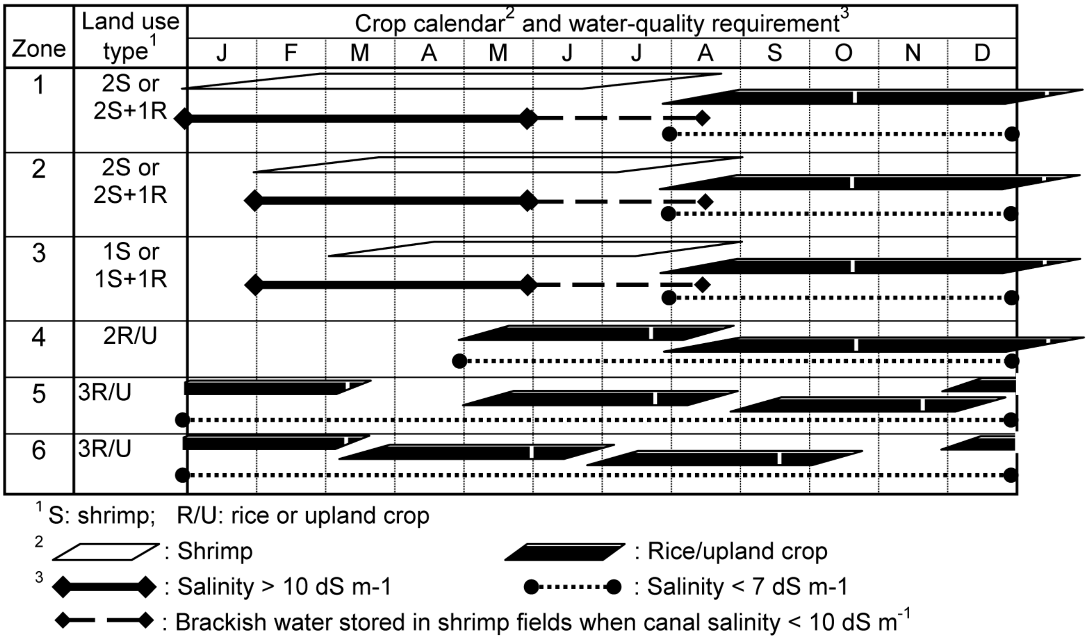

Fig. 5. Land use, cropping calendar and salinity requirement in different zones. Locations of zones are given in Figure 4.

dry season, to allow for two crops of shrimp in zones 1 and 2. At Phuoc Long, water salinity should be > 10 dS m^{-1} from mid-February until the end of the dry season for at least one shrimp crop in zone 3, but should fall below 10 dS m^{-1} from July to January for wet season rice in zones 3 and 4. At Ninh Quoi, water salinity should be < 10 dS m^{-1} throughout the year to allow up to three rice/upland crops per year in zones 5 and 6.

Step 2: Exploring roles of critical sluices and generating scenarios for sluice operation

In this study, the validated VRSAP model (Khue, 1986; NEDECO, 1992; ESSA *et al.*, 1992; KOICA & KARICO, 2000; Dong, 2000; Hoanh *et al.*, 2001) was used to analyze the effects of sluice operation on salinity conditions, using the canal network data and boundary conditions of 2000. We mapped the movement of the simulated 10 dS m^{-1} isohaline to understand the role of different sluices on salinity distribution. Some examples are shown in Figure 6.

If all sluices were closed, the 10 dS m^{-1} isohaline on 31 March would be west of the study area (line 1, Figure 6). If the Lang Tram sluice was opened, the 10 dS m^{-1} isohaline would move progressively eastward the longer the sluice is kept open (lines 2 and 3, Figure 6). However, at the same time as the Lang Tram sluice is open, opening the Ho Phong sluice at low tide to drain water out of the study area would curtail the eastward advance of the salinity boundary caused by opening the Lang Tram sluice (line 3 vs line 4, Figure 6). This is because drainage at Ho Phong would induce more freshwater to flow from the Mekong river into the study area through the arterial Phung Hiep canal.

Using the knowledge gathered from such modeling exercises, we formulated a number of scenarios comprising different combinations of sluice operation: (a) opening all the sluices to the west of Ho Phong to allow salinity intrusion; (b) opening the Ho Phong sluice at low tide to curtail excessive salinity intrusion to zones 4, 5 and 6; and (c) adjusting the opening duration of each sluice to control the

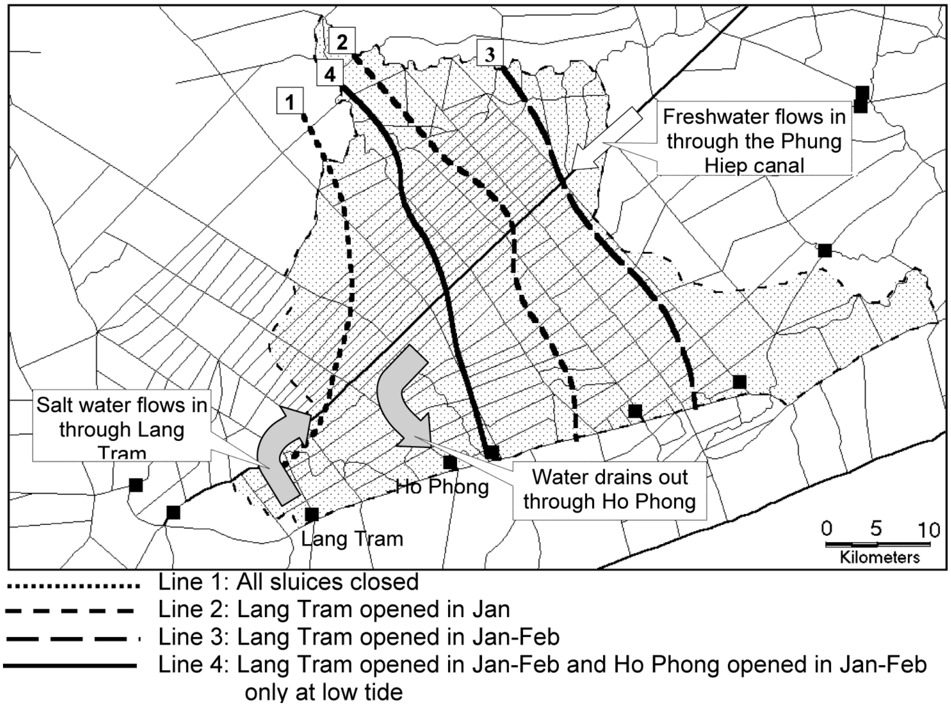

Fig. 6. Flow directions and 10 dS m^{-1} isohalines on 31 March under different sluice operation scenarios.

movement of the salinity boundary. Table 1 shows examples of three such scenarios and the simulated salinity for certain critical dates at the three benchmark points. Simulated values that do not satisfy the thresholds are printed in bold in shaded cells. For example, for scenario A in Table 1, the Lang Tram sluice is left open to allow two-way flows in January and February for the intake of saline water, then closed in March and April to maintain the salinity boundary at suitable limits, and opened again at low tide in May and June to drain out excess rainwater and acid water from ASS. At the same time, the Ho Phong sluice is opened at low tide in January to drain out freshwater and control the salinity boundary, then closed from February to April to maintain the salinity boundary, and reopened at low tide in May and June for the same purpose as for the Lang Tram sluice.

Step 3: Selecting a water-management scenario, implementing, monitoring and adjusting

The sluice operation scenarios explored were assessed to see if the resulting salinity distributions satisfied the water-quality requirements. This was first done by comparing the simulated salinity values at the three benchmarks with the required thresholds at critical dates. Scenario A in Table 1 would not meet the water-quality requirement in January, February and March. Scenario B would also not be acceptable in January, while Scenario C would satisfy the requirements at all three benchmarks. Second, the results of the promising scenario were transferred to the GIS to generate isohalines to see if the spatial distribution of salinity would correspond with the land-use zones. The analysis helps reveal situations where the salinity requirements at benchmarks are met, but the spatial distribution of salinity would still be unsatisfactory. For example, with Scenario C, there is still the possibility that brackish

Table 1. Three simulated scenarios of sluice operation and water salinity at benchmark sites.

Sluice	Operation mode[1] in each month						Salinity ($dS\ m^{-1}$) at benchmark sites on critical dates			
	Jan.	Feb.	Mar.	Apr.	May	June	Date	Pho Sinh	Phuoc Long	Ninh Quoi
Scenario A										
Lang Tram	O_2	O_2	C	C	O_o	O_o	10 Jan	**12 [<*10*]**	10 [<*10*]	0 [<*10*]
Ho Phong	O_o	C	C	C	O_o	O_o	20 Jan	13 [>10]	12 [>10]	8 [<*10*]
							15 Feb	27 [>*10*]	27 [>*10*]	**23 [<*10*]**
							31 Mar	33 [>*10*]	27 [>*10*]	**23 [<*10*]**
Scenario B										
Lang Tram	O_2	C	C	C	O_o	O_o	10 Jan	6 [<*10*]	2 [<*10*]	0 [<*10*]
Ho Phong	O_o	C	C	C	O_o	O_o	20 Jan	**6 [>10]**	**2 [>10]**	0 [<*10*]
							15 Feb	27 [>*10*]	21 [>*10*]	8 [<*10*]
							31 Mar	37 [>*10*]	25 [>*10*]	8 [<*10*]
Scenario C										
Lang Tram	O_i	C	C	C	O_o	O_o	10 Jan	6 [<*10*]	2 [<*10*]	0 [<*10*]
Ho Phong	O_o	O_o	C	C	O_o	O_o	20 Jan	12 [>10]	10 [<10]	0 [<*10*]
							15 Feb	21 [>*10*]	19 [>*10*]	10 [<*10*]
							31 Mar	40 [>*10*]	31 [>*10*]	10 [<*10*]

[1] O_2: Opened for two-way flow C: Closed
O_o: Opened at low tide for drainage O_i: Opened at high tide for saline water intake

water could flow from zones 1, 2 and 3 into zones 4 and 5 via the small canals. This could be rectified by building a series of small temporary dams in the dry season along the border between these zones (Figure 4). The figure also shows that the salinity distribution, as delineated by the 10 $dS\ m^{-1}$ isohalines on 15 February and 31 March, would comply with the requirements of zones 4 and 5 if these dams were in place. Without these dams, the 10 $dS\ m^{-1}$ isohaline on 31 March would traverse zones 4 and 5 similarly to line 3 in Figure 6.

These scenarios were given to the water-management authorities in the Bac Lieu province to guide the actual sluice operations from 2001 onwards, which have achieved the objective of accommodating the needs of both shrimp and rice farmers, as will be presented in the next section of this paper. Water quality has been monitored at benchmark sites and daily data have been transmitted to the sluice-management agency for timely adjusting of the sluice operation schedule if water quality does not vary within the limits as expected. At the same time, a dense water-quality monitoring network has been established and operated to provide salinity and pH data for the whole Quan Lo Phung Hiep region. These data are essential for the revision of land use and the water management scenario after the dry season, the critical period for shrimp production, in each year.

4. Investigation of livelihood impacts

To access the impact of water-policy changes on the livelihoods of local people, in particular poor groups, we carried out two PRAs in the Bac Lieu province, the first in December 2000–January 2001 and the second in January 2003. The PRA was undertaken in seven sample hamlets stratified across the province. Each hamlet represents one of seven sampling zones, defined by its surface-water salinity and soil type. A participatory wealth-ranking exercise was undertaken to identify clusters of stakeholders that were similar in more than household income, i.e. also in other production factors such as land use, soil and water conditions. Altogether 33 groups of Very Poor, Poor, Average, and Wealthy (or Rich) stakeholders participated in the PRA. Those classified as either “Poor” or “Very Poor” represented 29–59% of households across all hamlets.

Changes in livelihood strategies as a result of changes within the natural-resource asset base can be measured as livelihood outcomes, such as increased income, increased well-being, reduced vulnerability, improved food security and more sustainable use of natural resources (Carney, 1998). For simplicity, we present changes in household income for each stakeholder group within four representative hamlets (Figure 2(b)): Ninh Dinh hamlet (zone 6) and Hamlet (Ap, in Vietnamese) 21 (zone 5) both lie within the freshwater zone and have mainly three rice/upland crops, and Chu Chot hamlet (zone 2) and Hamlet 1 (zone 1) both lie within the saline water zone and have double shrimp or shrimp plus rice crops.

Since the “Very Poor” group did not exist in all of the four hamlets, we have focused on changes in household income of the “Poor” and “Average” groups within each representative hamlet. The purpose of the investigation was to show the relative changes in household income of these groups in two phases: Phase I: 1996–2000, under the original policy to intensify rice production; and Phase II: 2001–2003, after the water policy had been changed to allow both shrimp and rice production in the region.

5. Results and analysis

5.1 Impacts of water-policy changes in freshwater zones

On the nonacid soils in the eastern part of the study area, which includes Ninh Dinh hamlet and Hamlet 21 (Figures 1 and 2(b)), farmers’ livelihoods improved over time in both Phase I and Phase II as water became less saline and salinity was controlled at a level suitable for agricultural production (Table 2). This was clearly associated with the intensification of rice cropping and crop diversification under freshwater conditions. The average groups, being able to grow two or even three rice/upland crops (Figure 2(b)), converted this increased production into increased income, in particular after 2000 in Hamlet 21 where the effects of flooding and waterlogging in the rainy season were minor.

The “Poor” group in Ninh Dinh hamlet reported that they no longer received income directly from rice production in Phase II (Table 2). Rice yield was affected by saline water from the nearby shrimp area in the summer–autumn and spring–summer seasons. This salinity has been slightly higher in the last 2 years and has caused difficulties in farming for this group, since their farms are usually located in the depression areas. However, with an increase in the cropping intensification over the region, poor households in both hamlets were able to increase their income by selling labor (off-farm activities of the “Poor” group of Ninh Dinh and Hamlet 21 in Table 2) to meet the increased demand for farm labor within the rice production by the wealthier households.

However, a negative impact in these freshwater zones has been the effect of changes in water quality on capture fisheries. Opportunities to make money from catching and selling wild fish from the canals have declined due to a decline in the number and species of fish available. As a result, contributions to

Table 2. Income level during 1996–2002 (expressed as % of income in 1996) of average and poor groups at four representative hamlets.

Source of income		Phase I		Phase II			Phase I		Phase II	
	1996	1998	2000	2001	2002	1996	1998	2000	2001	2002
	Ninh Dinh, Average					Ninh Dinh, Poor				
Rice	39	65	89	91	91	5	20	33	-	-
Shrimp	-	-	-	-	-	-	-	-	-	-
Capture fisheries	-	-	-	-	-	10	7	8	-	-
Off-farm	6	-	-	-	-	50	60	67	160	152
Nonfarm	6	-	-	5	8	-	-	-	-	-
Other	50	65	68	86	99	35	47	58	40	65
Total	*100*	*129*	*156*	*182*	*197*	*100*	*133*	*167*	*200*	*217*
	Hamlet 21, Average					Hamlet 21, Poor				
Rice	70	93	233	299	299	10	13	13	24	18
Shrimp	-	-	-	-	-	-	-	-	-	-
Capture fisheries	6	8	6	-	-	10	-	-	-	-
Off-farm	12	16	43	80	80	70	100	100	120	120
Nonfarm	-	-	-	8	8	-	-	-	-	-
Other	12	16	50	12	12	10	13	13	6	12
Total	*100*	*133*	*332*	*399*	*399*	*100*	*125*	*125*	*150*	*150*
	Chu Chot, Average					Chu Chot, Poor				
Rice	2	4	30	86	-	-	4	5	32	-
Shrimp	78	129	136	86	224	-	4	5	96	270
Capture fisheries	-	-	-	11	12	-	-	-	8	6
Off-farm	-	11	-	-	-	50	98	120	-	-
Nonfarm	10	-	-	32	45	50	35	70	24	24
Other	10	-	-	22	18	-	-	-	-	-
Total	*100*	*143*	*166*	*237*	*299*	*100*	*140*	*200*	*160*	*300*
	Hamlet 1, Average					Hamlet 1, Poor				
Rice	11	30	76	-	-	-	11	8	5	-
Shrimp	37	14	-	107	153	-	-	-	20	54
Capture fisheries	-	-	-	15	18	26	-	-	-	-
Off-farm	4	8	8	-	-	46	46	23	-	-
Nonfarm	31	27	25	12	8	-	-	-	-	-
Other	16	20	18	18	24	28	26	20	15	6
Total	*100*	*99*	*126*	*153*	*204*	*100*	*83*	*50*	*40*	*60*

Notes:

- Locations of the surveyed hamlets are shown in Figure 2(b).
- Nonfarm refers to nonfarming activities.
- Off-farm refers to farmer's works as hired labor in other farms.

household income from capture fisheries have declined from approximately 10% to negligible for the "Average" and "Poor" groups. This environmental change may have particularly serious consequences for landless households, who depend more upon open-access aquatic resources than those households with land for economic production.

5.2 Impacts of water-policy changes in saline-water zones

In contrast, a very different situation is seen in Chu Chot hamlet in the northwestern part of the study area (Figure 2(b)), where salinity intrusion during the dry season has persisted (Figure 1), allowing farmers to continue intensive shrimp raising and shrimp-rice farming up to 2000 (Figure 2(b)). During Phase I, poor households benefited from an increased labor demand from shrimp pond owners (off-farm activities, "Chu Chot, Poor" in Table 2). Further trading opportunities in commodities such as ice, powdered lime and oil also became available, enabling these households to supplement their income from nonfarm activities. Innovations in shrimp farming and the expanding export market boosted the income of the average farmers associated with shrimp aquaculture. The income from rice in 2000 and 2001 also increased because of experience gained in rice–shrimp farming techniques. However, in 2002, the income from rice became negligible while the income from shrimp increased significantly. By 2001 in Phase II, there was a shift by poor households into shrimp or rice–shrimp production, with complete conversion to shrimp production in 2002. It is likely that, with the availability of saline water, poor farmers could use their land, mostly located in the fallow area covered by severe ASS, for shrimp culture. Credit facilities and bank loans have also become more readily available, which have enabled poorer households to raise the capital for converting rice fields to shrimp ponds.

In the southwestern part of the study area (Hamlet 1), during Phase I, livelihoods were almost equally dependent on both shrimp on the low-lying ASS and rice on the higher land. The income structure and trends of the three groups in Hamlet 1 show a clear association of the rich group with shrimp cultivation (Table 3), the average group with rice farming (Hamlet 1, "Average" in Table 2) and the poor group with capture fishery or off-farm activities (Hamlet 1, "Poor" in Table 2). The income from shrimp farming declined drastically in 1998 and 2000 when the supply of saline water was cut off in line with the policy at that time (Table 3 and Hamlet 1, "Average" in Table 2). Results from the survey showed that farmers who attempted to change to rice cropping failed because most of the shrimp fields were located in low-lying, shallow ASS. The income for the average group slightly increased over time. This is associated with an increase in their income from rice production as a result of the reduced salinity. The poor group suffered from a reduction in household income since the group's livelihood largely depended in the past on capture fisheries (26% of their income in 1996). Changes in water quality and barriers to fish migration and movement from the sluice closure led to a reduction in the natural fish populations. In 2000, the poor group had to earn their living almost entirely by selling labor (off-farm

Table 3. Income level during 1996–2002 (expressed as % of income in 1996) of the "Rich" group in Hamlet 1. (The "Rich" groups at Ninh Binh, Hamlet 21, and Chu Chot were not presented because they showed the same trends as the "Average" group.)

Source of income	Phase I			Phase II	
	1996	1998	2000	2001	2002
	Hamlet 1, Rich				
Rice	15	24	6	-	-
Shrimp	69	25	4	18	24
Capture fisheries	-	-	-	3	1
Off-farm	-	-	-	-	-
Nonfarm	8	14	5	-	-
Other	8	15	5	3	2
Total	*100*	*77*	*20*	*24*	*26*

activities, Hamlet 1, “Poor” in Table 2). From 2001 in Phase II, shrimp farming has recovered in this area, with the average group even managing to improve upon the 1996 situation due to raising shrimp and pigs, and running a number of small businesses. The poor group has also started to earn income from shrimp farming from their own land since shrimp farming technology and credit facilities have become more widely available. The rich group has yet to recover and return to the 1996 situation (Table 3).

5.3 Analysis of livelihood impacts of water-policy changes

Water-policy changes influence poor households located within the coastal region in two main ways. The first has been a direct impact through creating suitable water conditions so that poor households could make the best use of limited resources, including poor-quality agricultural land and limited financial capital. The PRA results from this study showed that, during Phase II of the water-policy changes, poor farmers in the western part of the study area have been able to make use of what was originally deemed “poor-quality” agricultural land on ASS for shrimp production to increase household income. The second has been an indirect impact by creating more demand for off-farm employment, thereby enabling poor households to increase their income by selling labor to wealthier households. However, not all impacts have been positive. Reductions in the opportunities for deriving income from capture fisheries have affected poor households, and landless households may be particularly vulnerable as they lack land for economic production.

This study also indicates that water policy and management should be implemented within an integrated natural-resources management (INRM) framework, including other factors, such as soil characteristics and socioeconomic conditions. A lack of knowledge on the constraints of ASS in successful land use in the western part of the province during Phase I caused difficulty to farmers in that area who tried to improve their livelihoods with an unreliable supply of freshwater and saline water. Moreover, most of the households in this area are poor farmers with limited capital and farming skills in freshwater agricultural cultivation; therefore, they cannot adapt to new production technologies as fast as those in the western part of the study area.

When agricultural production in Vietnam was still low, a “supply-oriented” production system was applied with the attempt to grow as much as possible of all the crops with the highest suitability in every region. However, during the last 10 years, with most agricultural products able to satisfy domestic consumption targets, production has shifted to a “demand-oriented” system that is controlled by markets. The movement of Vietnam from a self-sufficient to a market-oriented production system requires adjustments in water policy both nationally and provincially. With Vietnam already exporting about 4 million tons of rice every year, water policies should be adjusted to support non-rice production systems that are essential to improve people’s livelihoods. Thus, while saline water can be considered a constraint to agricultural production, it can also be considered as a natural resource, in particular in coastal regions where the freshwater supply is limited.

Participatory water management applied using the APWPC in this study is a suitable approach for water-policy changes. This approach is in stark contrast to the top-down approach of central and provincial governments that imposed a land-use plan and corresponding water management on the Quan Lo Phung Hiep region in Phase I. Farmers and local authorities at commune and district levels have an intimate knowledge of local conditions as well as local demand and markets for products. Therefore, the central government needs only to provide a direction in water policy and balance the production at the macro levels (national and regional), and should allow flexible adjustment in water management by lower-level authorities through their consultation with farmers. This policy will help avoid events such as the farmers' protests in Bac Lieu in February 2001.

Lastly, this study justifies the role of information technologies in supporting water-policy settings. Without the help of GIS and water modeling, the water-management authorities were not able to continue using the sluice system that was initially implemented to meet the objective of increasing freshwater supply during Phase I. There were complaints that some sluices with high costs would be useless under the adjusted water policy that allows saline water to intrude into the region. However, these tools have helped in analyzing different scenarios in operating these sluices to satisfy water-quality requirements for the two conflicting objectives of shrimp and rice production. The improvement of communication in the region also helped in sending monitoring data at benchmarks to the water-management agencies in due time. Based on these data, agencies can adjust the daily operation of sluices immediately to ensure that salinity will be maintained within the limits required for shrimp or rice production.

6. Conclusions and policy implications

The Ca Mau peninsula, in general, and the Bac Lieu study area, in particular, have experienced rapid economic and environmental change during the last decade. Given the nature of the deltaic environment and the high level of dependence on the natural-resources base, policies for land and water have been very influential in this process. The emphasis on rice production as the engine of growth created an imperative to control saline intrusion and to convert the environment from a brackish water zone to a freshwater zone. The implementation of this policy was realized through the construction of major engineering works, which took place over an extended period (1994–2000). The inertia built up by this process led to a divergence between policy and practice when, in 1998, the Government of Vietnam began to promote brackish water aquaculture in the region. Government agencies responsible for land and water resources were slow to recognize the adverse impacts on livelihoods resulting from their failure to respond to the changed circumstances, but eventually responded to popular pressure. It then became an urgent necessity to explore the feasibility of adopting a new policy for the balanced development of both rice and shrimp production. This was achieved by following an analytical process using information technologies to support the rapid screening of alternatives. This process was completed within a short time, thus ensuring that the conflicts which arose in 2000 were not repeated in 2001.

The policy shift was a response to popular pressure, but the new policy, as reflected in the designation of rice and shrimp zones (Figure 4), cannot be said to be truly responsive in that it still provides for administrative control of land-use decisions. This approach constrains decentralized decision-making and restricts the freedom of individuals to respond to market opportunities. The existence of the water-management infrastructure and the capabilities of the analytical process described in this paper encourage the belief that it may be possible to adopt and implement a more ambitious policy of multipurpose management, which would be less overtly interventionist and more responsive to the land-use decisions of local people. However, concern still remains on the impacts of the current (and any future) policy on poor people whose livelihood security depends upon open-access aquatic resources. Sluices allow the build-up of an acid reservoir, which may subsequently be released downstream with adverse effects on aquatic life outside the protected area (White *et al.*, 1996) and this concern, therefore, extends to the downstream estuarine zone. It should therefore be noted that there will be tradeoffs between the requirements of different stakeholders, and a degree of regulatory control will still be required.

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