10 Mangrove Dependency and the Livelihoods of Coastal Communities in Thailand

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Abstract

From 1961 to 1996, Thailand lost 50–60% of its mangrove forests, mainly because of conversion to shrimp aquaculture. The speed and scale of deforestation have affected many coastal communities. This chapter highlights the importance of mangroves to four case study villages. Households depend directly on mangrove forests for fish and wood collection and/or benefit indirectly from the mangroves' support to coastal fisheries. Mangrove loss therefore affects the decision of households to look for outside employment. In response to deforestation, female household members allocate more hours to employment relative to mangrove-dependent activities, whereas males allocate fewer hours to outside work. Awareness of community conservation efforts and of the environmental damage imposed by shrimp farms also motivates households to participate in replanting activities. Efforts to control mangrove deforestation and promote community-based management of remaining mangrove forests, as well as replanting, would help to mitigate some of the worst impacts on coastal villages. By developing institutions to support local community management, the government of Thailand could help avoid excessive mangrove deforestation and conflicts over uses. Such a framework could also provide important lessons in coastal resource management for other countries in South-east Asia and elsewhere.

Introduction: Shrimp Farm Expansion and Mangrove Loss in Thailand

The issue of coastal land conversion for commercial shrimp farming is a highly controversial topic in Thailand. Frozen shrimp are a major export product of Thailand, earning more than US$1.6 billion each year, and the government has been keen to expand these exports (Tokrisna, 1998; Barbier and Sathirathai, 2004). Yet, the expansion of shrimp exports has caused much devastation to Thailand's coastline and has affected other commercial sectors, such as fisheries.

Thailand's coastline is vast, stretching for 2815 km, of which 1878 km are on the Gulf of Thailand and 937 km on the Andaman Sea (Indian Ocean) (Kaosa-ard and Pednekar, 1998). In recent decades, the expansion of intensive shrimp farming in the coastal areas of southern Thailand has led to rapid conversion of mangroves (Barbier and Sathirathai, 2004). Between 1961 and 1996, Thailand lost around 20,500 km^2 of mangrove forests, or about 56% of the original area, mainly because of shrimp aquaculture and other coastal developments (Charuppat and Charuppat, 1997). Estimates of the

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amount of mangrove conversion caused by shrimp farming vary, but recent studies suggest that up to 65% of Thailand's mangroves have been lost to shrimp farm conversion since 1975 (Dierberg and Kiattisimkul, 1996; Charuppat and Charuppat, 1997; Aksornkoae and Tokrisna, 2004). The rate of mangrove deforestation slowed in the 1990s, but in the mid-1990s the annual loss was estimated to be around 3000 ha/year (Sathirathai, 1998).

Although mangrove conversion for aquaculture began in Thailand as early as 1974, the boom in intensive shrimp farming through mangrove clearing took off in 1985 when the increasing demand for shrimp in Japan pushed up the border-equivalent price to $100/kg (Barbier and Sathirathai, 2004). For example, from 1981 to 1985 in Thailand, annual shrimp production through aquaculture was around 15,000 t, but by 1991 it had risen to over 162,000 t and by 1994 to over 264,000 t (Kaosa-ard and Pednekar, 1998).

Shrimp farm area expanded from 31,906 to 66,027 ha from 1983 to 1996. However, much of the semi-intensive and intensive shrimp farming in Thailand is short-term and 'unsustainable', that is, poor water quality and disease problems mean that yields decline rapidly and farms are routinely abandoned after 5–6 years of production (Flaherty and Karnjanakesorn, 1995; Dierberg and Kiattisimkul, 1996; Tokrisna, 1998; Vandergeest *et al*., 1999).

Although shrimp farm expansion has slowed in recent years, unsustainable production methods and lack of know-how have meant that more expansion still takes place every year simply to replace unproductive and abandoned farms. In provinces close to Bangkok, such as Chanthaburi, mangrove areas have been devastated by shrimp farm developments (Raine, 1994). More recently, Thailand's shrimp output has been maintained by the expansion of shrimp-farming activities to the southern and eastern parts of the Gulf of Thailand, and across to the Andaman Sea coast (Flaherty and Karnjanakesorn, 1995; Sathirathai, 1998; Vandergeest *et al*., 1999).

Moreover, conversion of mangroves to shrimp farms is irreversible. Without careful ecosystem restoration and manual replanting efforts, mangroves do not regenerate even in abandoned shrimp farm areas. In Thailand, most of the estimated 11,000 ha or more of replanted areas between 1991 and 1995 have been on previously unvegetated tidal mudflats (Lewis *et al*., 2000). Currently, in Thailand, there is no legal requirement that shrimp farm owners invest in replanting and restoring mangroves once farming operations have ceased and the ponds are abandoned.

Much of the financial investment in coastal shrimp farms is from wealthy individual investors and business enterprises from outside of the local community (Flaherty and Karnjanakesorn, 1995; Goss *et al*., 2000, 2001). Although some hiring of local labour occurs, it is reported that many shrimp farm owners in coastal areas have hired Burmese workers, as their wage rates are much lower.

Ill-defined property rights have accelerated the rapid conversion of mangroves to shrimp farms in Thailand. Historically, this has been a common problem for all forested areas in Thailand (Feder *et al*., 1988; Thomson *et al*., 1992; Feeny, 2002). Although the state, through the Royal Forestry Department, ostensibly owns and controls mangrove areas, in practice they are *de facto* open-access areas on to which anyone can encroach. This has had three effects on mangrove deforestation attributable to shrimp farms. First, the open-access conditions have allowed illegal occupation of mangrove areas for establishing shrimp farms in response to the rising prices and profits from shrimp aquaculture (Barbier and Sathirathai, 2004). Second, insecure property rights in cleared forest areas have been associated with underinvestment in land quality and farm productivity (Feder and Onchan, 1987; Feder *et al*., 1988; Thomson *et al*., 1992). The lack of tenure security for shrimp farms in southern Thailand also appears to be a major factor in the lack of investment in improving productivity and adopting better aquaculture methods, leading to more mangrove areas being cleared than necessary (Barbier and Sathirathai, 2004). Third, several studies

have pointed out how open-access forest lands are more vulnerable to rapid deforestation and conversion to agricultural and other commercial uses as the development of roads and the highway network makes these lands more 'accessible' (Cropper *et al*., 1999; Feeny, 2002).

Despite the lack of secure property rights and frequently illegal occupation of mangrove areas, owners have an incentive to register their shrimp farms with the Department of Fisheries. In doing so, they become eligible for the preferential subsidies for key production inputs, such as shrimp larvae, chemicals and machinery, and for preferential commercial loans for land clearing and pond establishment (Tokrisna, 1998; Barbier and Sathirathai, 2004). Such subsidies inflate artificially the commercial profitability of shrimp farming, thus leading to more mangrove conversion, even though estimates of the economic returns to shrimp aquaculture in Thailand suggest that such conversion is not always justified (Sathirathai and Barbier, 2001). Combined with insecure property rights, the subsidies also put further emphasis on shrimp aquaculture as a commercial activity for short-term exploitative financial gains rather than as a long-term sustainable activity.

Case Study in Four Coastal Villages

A case study of the labour allocation decisions of rural households from four representative villages illustrates the importance of mangroves to the livelihoods of coastal communities in Thailand. The four case study villages are Ban Khlong Khut and Ban Gong Khong in Nakhon Si Thammarat Province on the Gulf of Thailand, and Ban Sam Chong Tai and Ban Bang Pat in Phang-nga Province on the Andaman Sea (see Fig. 10.1). Further background details on these case study villages can be found in Aksornkoae *et al.* (2004).

These four villages have experienced rates of mangrove loss similar to those which have occurred nationally in Thailand. Such mangrove deforestation has had important, albeit varying, impacts on the livelihoods of villagers. Some households in these four communities derive their income and subsistence directly from mangrove forests, in terms of fish collection, wood products and firewood. Other households benefit indirectly from the protection and support the mangroves give to coastal fisheries. A few engage in aquaculture.

A randomly stratified survey at the four village study sites was conducted during April and July 2000. Interviews with the heads of the households were conducted by trained enumerators speaking the local language under the supervision of a team of Thailand-based researchers, using a pretested survey designed by the author. Pretesting of the questionnaires was conducted in February 2000. The first stage of the survey was conducted in Phang-nga from 17 to 23 April 2000. The second stage of the survey, in Nakhon Si Thammarat, was carried out from 2 to 8 July 2000.

The survey gathered information on household involvement in outside employment and important household characteristics such as age, education, household composition, number of children, debt and size of landholding, and various production/income characteristics. The survey also collected detailed information on the mangrove-based activities of households, including the area of mangrove used by the household for such activities. Details on household labour allocation were also obtained to establish whether the household was undertaking other activities that were not dependent on mangroves.

Ban Sam Chong Tai and Ban Bang Pat are located on Phang-nga Bay, the former having only poor road access and consisting mainly of traditional fishing households that also collect many products from the mangroves. Ban Bang Pat is quite different. This village is located on the main highway and is highly commercialized and relatively modern. Although the villagers here still engage in coastal fishing, they generally do less traditional collection from the mangrove areas. Some female villagers also conduct various agricultural activities, including tending any rubber plantations owned by the household. The Nakhon Si Thammarat villages, Ban

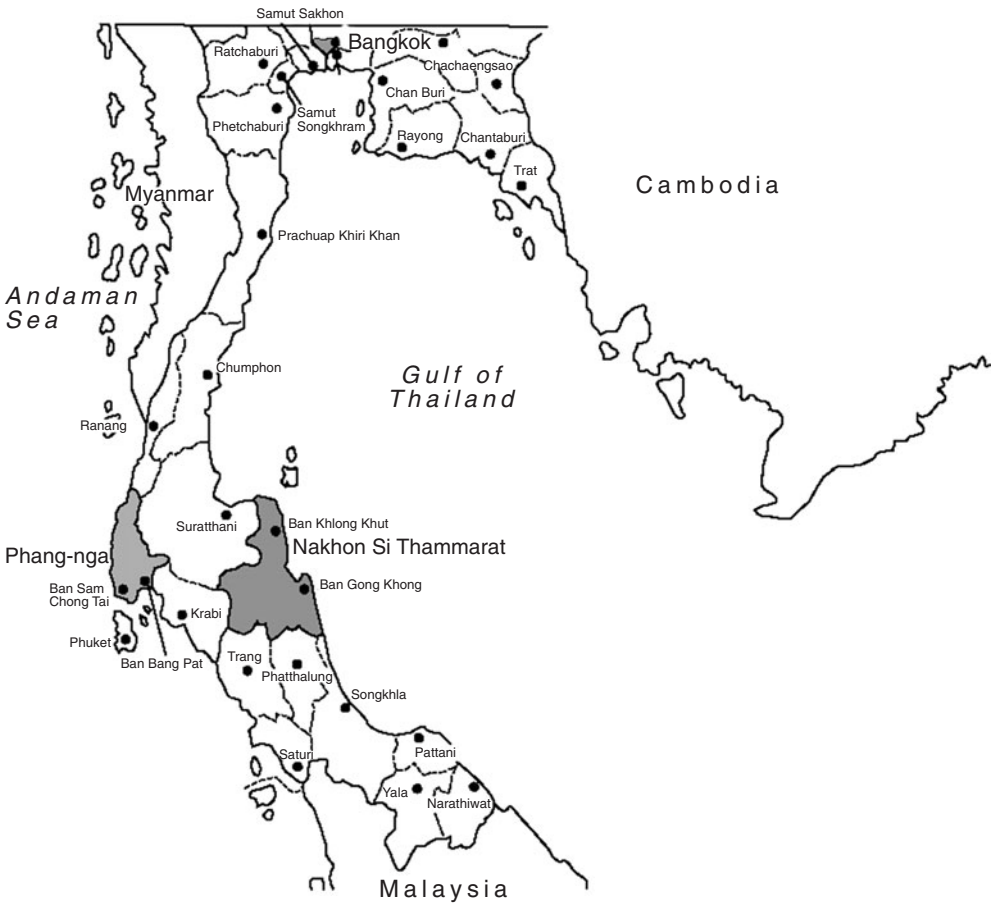

Fig. 10.1. Case study villages, Thailand (from Barbier and Sathirathai, 2004).

Gong Khong and Ban Khlong Khut, have relatively high levels of urbanization and commercialization. As both villages are located on the coast, fishing is still a major activity for many households. Villagers in Ban Gong Khong still engage in traditional collection activities from the mangrove areas, but households in Ban Khlong Khut do much less collection. In Ban Khlong Khut, some households have their own shrimp ponds, which occupy much of the female labour of the household. A large percentage of household members in both villages in Nakhon Si Thammarat turn to outside employment. The main source of employment for female villagers is at nearby factories, whereas male villagers often work on commercial shrimp farms owned by outsiders.

The mangrove areas in Ban Sam Chong Tai have been degraded mainly because of forest concessions. According to Thai law, forest concessionaires are required to replant but, in reality, reforestation has never taken place. Although the forests have not been completely cleared, extensive damage has occurred in many of the forest areas. In Ban Bang Pat, the mangrove forests were first cleared by tin-mining concessions. These activities not only destroyed the forests but also created extensive water pollution in the area. After the prices of tin fell drastically, coupled with the severe decline of mangroves, a Cabinet resolution on 23 July 1991 abolished tin mining in mangrove forests throughout Thailand. However, the unintended consequence was that the forests

became open-access areas and became susceptible to conversion to shrimp farming, which is the current threat to the mangroves near Ban Bang Pat.

Mangrove areas in Nakhon Si Thammarat have decreased by as much as 53,811 ha, or 87.93%, from 1961 to 1996 (Charuppat and Charuppat, 1997). This mangrove loss was much higher than the deforestation level of 19,742 ha, or 33.56%, in Phang-nga over the same period. At present in Phang-nga, 38,138 ha of mangrove area still remain compared with only 7,389 ha in Nakhon Si Thammarat.

In Ban Sam Chong Tai village, the local community is very active in the conservation of mangroves. They consider an area of around 60 ha, which is legally owned by the state, as their own community forest. These villagers are small-scale fishermen, who, when questioned during our survey, expressed knowledge that their local mangrove areas serve as breeding grounds and fry nurseries for coastal fisheries. In Ban Bang Pat, the local community also participates actively in the replanting of mangroves, but less so than in Ban Sam Chong Tai. The replanting projects in Ban Bang Pat were not initiated originally by the community but by outside non-governmental organizations (NGOs). The situation is similar in the two villages surveyed in Nakhon Si Thammarat, where local replanting schemes were initiated by NGOs or by the Royal Forestry Department.

The survey of the four villages elicited from households their allocation of male and female labour to their main income-producing and other activities, as well as key socioeconomic characteristics. Information on the employment of male and female labour in work outside of the household also included wage rates and detailed time allocations. In total, 201 households were surveyed, although two households reported no direct or indirect income-producing activities that depended on mangroves and were excluded from the sample, leaving a total of 199 households. Of the latter households, 61 reported having at least one male member undertaking outside employment, and 33 have at least one female member participating in paid outside work.

Table 10.1 provides a brief set of summary statistics for the entire sample and shows that 32 households were involved in offshore fishing but did not collect mangrove products, 61 households were involved in direct-use collection activities only and 104 households did a combination of both. From those three groups, the collect-only group had the greatest percentage of households devoting time to outside employment (49% of males and 32% of females). The households involved in both activities had the lowest percentages participating in outside employment (males 17%, females 7%). As might be expected, the need to supplement income in households involved only in collection activities is paramount. This result is reinforced by the figures for percentage of income that is mangrove-based. The households that are solely involved in collection activities have the lowest proportion of mangrove-dependent income. At the other end of the scale, for those households involved in both direct and indirect mangrove-based activities, almost all of their income comes from these activities.

Table 10.2 reports similar data by village. An interesting pattern also emerges here, in that the villages in Nakhon Si Thammarat have a lower proportion of income coming from mangrove-based activities and a higher percentage of households working in outside employment. Households in Phang-nga, on the other hand, obtain a much higher percentage of their income from mangrove-related activities and engage in less outside employment, with the majority of households choosing to devote their time to both direct collection and indirect mangrove production activities.

Table 10.3 summarizes by village the household male and female labour allocation, in terms of average hours per year, for mangrove-dependent activities, agriculture, replanting and outside employment. For all villages surveyed, collection of fish (mainly shellfish and crabs) from the mangrove swamps and coastal fishing are the principal sources of mangrove-dependent employment for male and female labour. Across the entire 199 surveyed households, both male

Table 10.1. Summary statistics for outside employment by household type.

	Fish only (n = 32)		Collect only (n = 63)		Fish and collect (n = 104)	
	Male	Female	Male	Female	Male	Female
Number (n)	12	6	31	20	18	7
(% of total)	(38)	(19)	(49)	(32)	(17)	(7)
Mangrove-dependent income share of total income (%)	82		75		93	

Table 10.2. Summary statistics for outside employment by village.

	Phang-nga				Nakhon Si Thammarat			
	Ban Sam Chong Tai (n = 55)		Ban Bang Pat (n = 41)		Ban Gong Khong (n = 52)		Ban Khlong Khut (n = 51)	
	M	F	M	F	M	F	M	F
Number (n)	8	4	7	7	31	12	15	10
(% of total)	(15)	(7)	(17)	(17)	(60)	(23)	(29)	(20)
Mangrove-dependent income share of total income (%)	95		89		66		83	
Fish only	1		5		3		23	
Collect only	19		3		34		7	
Fish and collect	35		33		15		21	

M, male; F, female.

and female household members devote a substantial number of hours each year to mangrove-dependent activities. This is not surprising, given that, in the sample, mangrove-based income accounts on average for 83% of all household income, with a relatively small deviation across households.

Mangrove-based activities appear to require more male than female household labour. The exceptions are that females spend more time making shrimp paste in Ban Sam Chong Tai and in producing dried fish in Ban Gong Khong. However, as Table 10.3 indicates, these two activities do not require a considerable amount of labour compared with the other mangrove-dependent activities conducted by the households. In the two Phang-nga villages, households allocate on average almost three times as many male hours as female hours per year to all mangrove-dependent fishing and collection activities. In the Nakhon Si Thammarat villages, the ratio of total male to female hours spent per year on these activities is around 3.7 for Ban Gong Khong and 4.3 for Ban Khlong Khut. On average across all four villages, males spend over three times as many hours on mangrove-dependent activities as females.

In contrast, females spend proportionately much more of their time in outside employment relative to mangrove-based activities. Across all households, the ratio of the average hours in outside employment to hours in all mangrove-based activities ranges from 41% to 74% for females, whereas the ratio for males ranges from 11% to 28%. The difference between males and females is even more striking when comparing average labour allocation rates for only those households whose members participate in outside work. In all four villages, for those house-

Table 10.3. Summary statistics for labour allocation, by village (average hours per year).

Activity	Phang-nga				Nakhon Si Thammarat			
	Ban Sam Chong Tai (n = 55)		Ban Bang Pat (n = 41)		Ban Gong Khong (n = 52)		Ban Khlong Khut (n = 51)	
	Male	Female	Male	Female	Male	Female	Male	Female
Wood collection	5.18	0.84	3.76	0.05	10.67	4.41	10.57	0.76
Fuelwood and charcoal	5.82	0	0	0	3.96	2.56	0	0.47
Fish collection	610.85	218.89	125.73	110.41	1367.73	386.88	324.02	35.22
Shrimp paste	28.87	123.35	23.27	2.93	4.35	4.73	0	0
Dried fish	0	0	0	0	9.81	12.23	1.73	1.12
All collection	650.73	343.07	152.76	113.39	1396.51	410.82	336.31	37.57
Coastal fishing	783.20	194.09	965.20	279.73	857.50	195.69	2231.98	520.27
Aquaculture	37.07	12.75	19.46	14.66	0	4.65	19.96	47.65
All fishing	820.27	206.84	984.66	294.39	857.50	200.35	2251.94	567.92
All mangrove-based activities	1471.00	549.91	1137.41	407.78	2254.01	611.16	2588.25	605.49
Agriculture	0	0	0	35.12	452.69	253.15	82.37	33.02
Replanting mangroves	22.69	14.07	18.94	9.43	61.69	18.77	2.37	0.31
Outside work[a]	157.56	225.64	176.66	301.68	621.67	361.52	541.67	393.41
(% of mangrove-based hours)[b]	(11)	(41)	(16)	(74)	(28)	(59)	(21)	(65)
Adjusted outside work[c]	1083.25	3102.50	1034.71	1767.00	1042.81	1566.58	1841.67	2006.40
(% of mangrove-based hours)[b]	(130)	–	(86)	(542)	(61)	(155)	(59)	(490)

[a] Hours in outside employment averaged across all households.
[b] Ratio of average hours in outside employment to average hours in all mangrove-based activities.
[c] Hours in outside employment averaged across households whose members participate in such work.

holds reporting individuals engaged in outside work, the total number of average hours per year spent in outside employment by females exceeds that of males.

However, males clearly receive higher wages for outside work than females. For the 32 households whose female members participated in outside employment, the average hourly wage received was 22.8 baht ($0.57/h).[1] For the 60 households whose male members participated in outside work, the average hourly wage received was 44.5 baht/h ($1.11/h).

Mangrove Loss and Labour Allocation in the Case Study Villages

The above case study survey of four coastal villages is ideal for analysing the impacts of mangrove loss on labour allocation decisions in several respects. First, the livelihoods of the surveyed households from these villages clearly depend on the surrounding mangrove ecosystems (Aksornkoae *et al.*, 2004). Second, although a few households in these four villages also engage in agriculture, the main alternative to mangrove-dependent activities is employment as wage earners outside of the household. Thus, any depletion or degradation of local mangrove forests will affect the income earned by villagers from mangrove-dependent activities and influence their decision to seek outside employment.

Using a three-step Heckman selection model, Barbier (2004) estimates the total effect of a change in mangrove area on the supply of labour to outside employment by mangrove-dependent households in the survey.[2] The results are reported in Table 10.4 in terms of both marginal effects (a 1 ha change in mangrove area) and elasticities (a 1% change in mangrove area). Two interesting findings emerge from the analysis.

First, both males and females appear to have 'backward-bending' supply curves with respect to the number of hours spent in outside employment, implying that higher wages lead to income effects that are greater than the substitution effects. The result is that, as males and females receive higher wages for outside employment, the total number of hours that they spend engaged in such work actually declines. Such a negative 'own-wage effect' is also found in other 'household outside employment' studies in developing countries (Rosenzweig, 1980; Hernández-Licona, 1997), and is consistent with the situation where households receive low market wages yet their minimum subjective requirement of income for subsistence cannot be achieved without outside employment. It is very likely that these conditions hold for the mangrove-dependent households surveyed in coastal Thailand.

Second, a change in mangrove area may affect the amount of labour supplied to outside employment in two ways: through a direct effect on hours worked and through an indirect impact on hours worked via the wage rate. Table 10.4 indicates that there is a direct effect of a change in mangrove area on the number of hours worked in outside employment for females, but not for males. Instead, mangrove changes influence the labour supplied by males for outside work indirectly through influencing the 'own-wage effect' described above and a 'cross-wage effect' via female wages. The latter effect indicates the extent to which males adjust their hours devoted to outside

[1] The exchange rate at the time of the survey (July 2000) was 40 baht = US$1.

[2] Applying standard ordinary least squares (OLS) regression analysis to estimate this relationship would yield biased parameter estimates, since an OLS regression cannot take into account the censored nature of the labour allocation decision of the mangrove-dependent household. Although the household always engages in some form of mangrove-based activity, it may not participate in outside employment. This means in turn that the market wage rate and the amount of hours in paid work will be observed only if the household decides to participate in outside employment; if the household decides not to undertake outside work, no wages or hours worked will be observed. To avoid sample selection bias arising from this participation decision, a standard approach adopted in the off-farm labour supply literature is to use a three-step Heckman procedure for conditioning the estimations of wages and hours supplied (for further discussion, see Abdulai and Delgado, 1999; Barbier, 2004).

Table 10.4. The effect of a change in mangrove area on the supply of outside labour (from Barbier, 2004).

	Indirect effect		Indirect effect	
	Direct effect	(via male wages)	(via female wages)	Total effect
Males				
Marginal effects	–	0.13	−0.09	0.04
Elasticities (%)	–	2.30	−1.60	0.70
Females				
Marginal effects	0.26	–	−0.35	−0.09
Elasticities (%)	5.36	–	−7.25	−1.88

employment as the wage paid to female household members for outside work changes. Both of these indirect wage effects of changes in mangrove area are therefore shown in Table 10.4, and the sum of these two effects equals the total effect of a change in mangrove area on labour supply by males. In contrast, only the own-wage indirect effect is significant in affecting the hours worked in outside jobs by females. As shown in Table 10.4, the latter indirect effect plus the direct impact of a change in mangrove area equal the total effect of a change in natural capital on female labour supply to outside employment.

The results reported in Table 10.4 suggest that, for the surveyed mangrove-dependent households, the dominant impacts of a loss of natural capital on the supply of both male and female labour to outside employment arise through indirect own-wage effects. Because mangrove loss leads to a reduction in the wages that females will receive from outside employment, the result is that females will increase the hours they work. In contrast, mangrove deforestation increases the wages that males receive from casual work and, as a result, they will work fewer hours in such employment.

Thus, the total effect of a loss in mangrove area is to reduce the supply of male labour to outside employment but to increase the supply of female members. Across the 199 surveyed households, a 1% decline in the local mangrove forests will cause the number of hours that males work in outside employment to decline by 0.7% while increasing the number of hours worked by females by 1.88%. Given the large losses in mangrove forests that have occurred at the two case study sites, such deforestation clearly has had a significant impact on the allocation of household labour in these coastal communities.

Mangrove Dependency and Participation in Conservation Efforts

Barbier *et al*. (2004) test the hypothesis that the degree of mangrove dependency is a major causative factor in the active participation of households from the four case study villages in conservation efforts. The hypothesis is that, once households realize that as mangrove area declines they will experience impacts on their livelihoods leading to income losses, they will participate in the replanting of mangroves. Whether households choose to be involved in mangrove conservation is also likely to vary with their characteristics and location, land ownership and tenure considerations, awareness of and attitudes towards community conservation efforts – including the replanting programmes sponsored by non-governmental organizations (NGOs) and some international organizations, and with concerns over the threat of the environmental effects of shrimp farms. In addition, the decision to participate in mangrove conservation may vary between male and female members of the household.

As indicated in Table 10.3, all mangrove-dependent households in the four case study villages allocate some time to replanting

activities. However, the average hours per year spent replanting vary considerably across the villages. Males generally spend more time replanting than females. Barbier *et al*. (2004) depict a mangrove-dependent household's choice of whether or not to participate in mangrove conservation as a binary decision, which can be empirically estimated through a bivariate probit estimation for household males and females. The regression results are depicted in Table 10.5.

The results show that the male decision to participate is mostly influenced by household awareness of community conservation efforts and use rules, as shown by the positive coefficient and highest marginal probability. The degree of mangrove-dependent income is the second-most important positive influence, with a marginal probability of 0.28. The household's awareness of the environmental impact of shrimp farming is the other significant variable in the male equation. The positive coefficient value and marginal probability of 0.13 suggest that males from households that are aware of the negative environmental impact of shrimp farms are more likely to participate in replanting.

For females, the degree of dependence of the household on mangrove-based income is significant at the 10% level and is the most important variable influencing its participation. Distance to the mangroves from the household is the next most important influence. The negative coefficient suggests that females from households that live increasing distances from the mangroves are less likely to participate in replanting. The area of mangrove used by the household is also important in the female decision. The result suggests that females from households that collect and fish in larger mangrove areas are less likely to participate in conservation. This might reflect that the household recognizes that smaller mangrove areas require more replanting effort. The number of children under 6 years of age, as might be expected, also influences the female decision to participate. The household awareness of community conservation and use rules positively affects female participation in replanting.

Finally, the variable ρ (1,2) measures the degree to which a household determines simultaneously, or jointly, whether males and females should participate in mangrove conservation. This variable is positive and significant, suggesting that the participation decision is determined jointly.

Conclusions and Policy Implications

Drawing on a case study of four coastal villages surveyed in Thailand, this chapter has shown that continuing mangrove deforestation not only has a significant impact on the allocation of household labour in Thai coastal villages that traditionally exploit these forests but also affects the intra-household division of labour. In response to such deforestation, for those households whose members participate in some outside work, females will continue to allocate more hours to such employment relative to mangrove-dependent activities, whereas males will allocate fewer hours to such work. One might also expect other mangrove-dependent households to send their non-working females out to look for outside employment.

Two concerns arise from this intra-household allocation of labour in response to mangrove deforestation. First, for the households in the case study survey, the average hourly wage received by females ($0.57) is barely half that received by males ($1.11). If the households require income from outside employment to meet overall needs, then they may fall short of their outside income target if the households increasingly rely on female members to participate in such employment. Even if the households do achieve their target by supplying more female labour to outside work, there may be an impact on other non-income activities important to the welfare of the household that are traditionally undertaken by females, such as child rearing, food preparation, care of the elderly and house cleaning. Secondly, the decline in the number of hours spent by males in outside employment accompanying deforestation presumably means that the males will be more productively employed at the margin in mangrove-based activities. If this is the case, household income from these activities

Table 10.5. Male and female participation in mangrove replanting efforts (from Barbier *et al*., 2004).

Variable	Males			Females		
	Coeff.	t-ratio	Marginal prob.	Coeff.	t-ratio	Marginal prob.
Constant	−2.4374	−2.4800	−0.6146	−1.9948	−1.6098	0.2741
Mangrove-dependent income as a proportion of total income	1.1070	1.9772	0.2792	1.5465	1.7843	−0.2125
Area of mangrove used by household (ha)	−0.0002	−0.1428	0.0000	−0.0057	−2.2296	0.0008
If household is aware of community conservation efforts and use rules (AWARE, 1; otherwise, 0)	1.1357	4.3000	0.2864	0.8765	2.6493	−0.1204
If household believes shrimp farming has a negative environmental impact (ATSFARM, 1; otherwise, 0)	0.5012	1.6316	0.1264	0.8173	1.4319	−0.1123
Average age of household members	0.0131	0.7055	0.0033	−0.0093	−0.6093	0.0013
Number of children < 6	−0.0308	−0.1129	−0.0078	−0.6560	−2.5976	0.0901
Number of children 6–12	0.1048	0.5644	0.0264	−0.1447	−0.7812	0.0199
Distance of household to mangroves	−0.0307	−1.4999	−0.0077	−0.0484	−2.1469	−0.0066
Average years of male education	0.0043	0.0982	0.0011			
Number of adult males in household	0.2142	1.3659	0.0540			
If any household males participate in outside employment (DM, 1; otherwise, 0)	0.1334	0.4194	0.0336			
Average years of female education				0.0412	0.5620	−0.0057
Number of adult females in household				0.0369	0.2810	−0.0051
If any household females participate in outside employment (DF, 1; otherwise, 0)				0.2451	0.4069	−0.0337
ρ (1,2)	0.6817	4.2975				

McFadden $R^2 = 0.40$

Log-likelihood ratio statistic = 194.54

Log-likelihood ratio test for homoskedasticity = −21.46

Note: The McFadden R^2 is calculated as $R^2 = 1 - L_{UR}/L_R$, where L_{UR} is the unrestricted maximum likelihood and L_R is the restricted maximum likelihood with all slope coefficients set equal to zero. The log-likelihood ratio statistic is given by $2(L_{UR} - L_R)$ and is asymptotically distributed as an χ^2 random variable. The log-likelihood ratio test for homoskedasticity was computed by $\chi^2 = -2(LR_{HOMO} - LR_{HETO})$, where LR_{HOMO} is the maximum likelihood in the homoskedastic regression and LR_{HETO} is the maximum likelihood in a regression corrected for heteroskedasticity.

should increase. However, as noted above, the loss of mangrove area at the four case study sites has been far from marginal. The large-scale land-use changes that have occurred have already led to substantial losses to the local mangrove forests. Any large, and decidedly non-marginal, losses in the remaining mangrove areas, such as the current threat posed by conversion to commercial shrimp farms, would have devastating consequences for the livelihoods of the mangrove-dependent households. The current mangrove-based collection and fishing activities conducted by these households would be in danger of collapsing, and the amount of time that males spend in such activities would not increase but would decline drastically.

The analysis of the decision by male and female members of mangrove-dependent

households to participate in replanting activities suggests that awareness of community conservation efforts and of the environmental damage imposed by shrimp farms is a powerful motivating force. The degree of dependence of the household on mangrove-based income is also an important factor. However, participation in replanting by females appears to face additional considerations, such as the distance of the household to mangroves, the number of children under 6 in the household and the size of the mangrove area.

The insights from the case study analysis of mangrove-dependent households in Thailand suggest two main policy implications. First, there is an urgent need to address the main institutional failure concerning management of local mangrove resources in coastal areas of Thailand. The present law and formal institutional structures of resource management in Thailand do not allow coastal communities to establish and enforce their local rules effectively. This has an important impact on the ability and willingness of these communities to conserve and protect their local mangrove forests. For example, in Ban Sam Chong Tai village in Phang-nga, the local community is very active in the conservation of mangroves. The community considers an area of around 60 ha as its own community forest, even though it is legally owned by the state and still faces a threat from possible conversion to shrimp farming by outside investors. In the other three surveyed villages, replanting projects were not initiated by the community but by outside NGOs or the Royal Forestry Department. These villagers are less motivated to participate in the replanting schemes and also have less say in the management of the remaining mangrove forests.

A new institutional framework for coastal mangrove management in Thailand that could make a difference to these and other coastal communities might contain the following features (Barbier and Sathirathai, 2004). First, remaining mangrove areas should be designated as conservation (i.e. preservation) and economic zones. Shrimp farming and other extractive commercial uses (e.g. wood concessions) should be restricted to the economic zones only. However, local communities that depend on the collection of forest and fishery products from mangrove forests should be allowed access to both zones, as long as such harvesting activities are conducted on a sustainable basis. Second, the establishment of community mangrove forests should also occur in both the economic and conservation zones. However, the decision to allow such local management efforts should be based on the capability of communities to effectively enforce their local rules and manage the forest sustainably. Moreover, such community rights should not involve full ownership of the forest but be in the form of user rights. Third, the community mangrove forests should be co-managed by the government and local communities. Such effective co-management will require the active participation of existing coastal community organizations, and will allow the representatives of such organizations to have the right to express opinions and make decisions regarding the management plan and regulations related to the use of mangrove resources. Finally, the government must provide technical, educational and financial support to the local community organizations participating in managing the mangrove forests. For example, if only user rights (but not full ownership rights) are granted to local communities, the latter's access to formal credit markets for initiatives such as investment in mangrove conservation and replanting may be restricted. The government may need to provide special lines of credit to support such community-based activities.

A second policy initiative would be to focus on improvements in education and skills training, especially for females. Of the surveyed households, over two-thirds of the households with female members employed in outside work are from the two villages in Nakhon Si Thammarat (see Table 10.2), where the main source of employment is at nearby factories hiring relatively unskilled and young female workers in textiles and other light manufacturing occupations. The very low average female wage rate across all households suggests that outside employment for all females involves few or no skills.

Given the current reliance of mangrove-dependent households on their female members participating in outside employment, and that this reliance will only increase as mangrove deforestation continues, improved education and skills training for young females in the households may be increasingly important for the future income-earning potential and welfare of these households.

References

Abdulai, A. and Delgado, C. (1999) Determinants of non-farm earnings of farm-based husbands and wives in northern Ghana. *American Journal of Agricultural Economics* 81, 117–130.

Aksornkoae, S., Sugunnasil, W. and Sathirathai, S. (2004) Analytical background of the case studies and research sites: ecological, historical and social perspectives. In: Barbier, E.B. and Sathirathai, S. (eds) *Shrimp Farming and Mangrove Loss in Thailand*. Edward Elgar, London, pp. 73–95.

Aksornkoae, S. and Tokrisna, R. (2004) Overview of shrimp farming and mangrove loss in Thailand. In: Barbier, E.B. and Sathirathai, S. (eds) *Shrimp Farming and Mangrove Loss in Thailand*. Edward Elgar, London, pp. 37–51.

Barbier, E.B. (2004) *Natural Capital and Labor Allocation: Mangrove-Dependent Households in Thailand*. Department of Economics and Finance, University of Wyoming, Laramie, Wyoming.

Barbier, E.B., Sathirathai, S. (eds) (2004) *Shrimp Farming and Mangrove Loss in Thailand*. Edward Elgar, London.

Barbier, E.B., Cox, M. and Sarntisart, I. (2004) Household use of mangrove and mangrove conservation decisions. In: Barbier, E.B. and Sathirathai, S. (eds) *Shrimp Farming and Mangrove Loss in Thailand*. Edward Elgar, London, pp. 115–130.

Charuppat, T. and Charuppat, J. (1997) *The Use of Landsat-5 (TM) Satellite Images for Tracing the Changes of Mangrove Forest Areas of Thailand*. Royal Forestry Department, Bangkok, Thailand.

Cropper, M., Griffiths, C. and Mani M. (1999) Roads, population pressures, and deforestation in Thailand, 1976–1989. *Land Economics* 75(1), 58–73.

Dierberg, F.E. and Kiattisimkul, W. (1996) Issues, impacts and implications of shrimp aquaculture in Thailand. *Environmental Management* 20(5), 649–666.

Feder, G. and Onchan, T. (1987) Land ownership security and farm investment in Thailand. *American Journal of Agricultural Economics* 69, 311–320.

Feder, G., Onchan, T., Chalamwong, Y. and Hongladarom, C. (1988) Land policies and farm performance in Thailand's forest reserve areas. *Economic Development and Cultural Change* 36(3), 483–501.

Feeny, D. (2002) The co-evolution of property rights regimes for man, land, and forests in Thailand, 1790–1990. In: Richards, J.F. (ed.) *Land, Property and the Environment*. Institute for Contemporary Studies Press, San Francisco, California, pp. 179–221.

Flaherty, M. and Karnjanakesorn, C. (1995) Marine shrimp aquaculture and natural resource degradation in Thailand. *Environmental Management* 19(1), 27–37.

Goss, J., Burch, D. and Rickson, R.E. (2000) Agri-food restructuring and third world transnationals: Thailand, the CP Group and the Global Shrimp Industry. *World Development* 28(3), 513–530.

Goss, J., Skladany, M. and Middendorf, G. (2001) Dialogue: shrimp aquaculture in Thailand: a response to Vandergeest, Flaherty and Miller. *Rural Sociology* 66(3), 451–460.

Hernández-Licona, G. (1997). Oferta laboral familiar y desempleo en México. *Trimestre Económico* (64), 531–568.

Kaosa-ard, M. and Pednekar, S.S. (1998) Background report for the Thai Marine Rehabilitation Plan 1997–2001. Report submitted to the Joint Research Centre of the Commission of the European Community and the Department of Fisheries, Ministry of Agriculture and Cooperatives, Thailand Development Research Institute, Bangkok, Thailand.

Lewis, R.R. III, Erftemeijer, P.L.A., Sayaka, A. and Kethkaew, P. (2000) *Mangrove Rehabilitation after Shrimp Aquaculture: a Case Study in Progress at the Don Sak National Forest Reserves, Surat Thani, Southern Thailand*. Mangrove Forest Management Unit, Surat Thani Regional Forest Office, Royal Forest Department, Surat Thani, Thailand.

Raine, R.M. (1994) Current land use and changes in land use over time in the coastal zone of Chanthaburi Province, Thailand. *Biological Conservation* 67, 201–204.

Rosenzweig, M.R. (1980) Neoclassical theory and the optimizing peasant: an econometric analysis of market family labor supply in a developing country. *Quarterly Journal of Economics* 94, 31–55.

Sathirathai, S. (1998) *Economic Valuation of Mangroves and the Roles of Local Communities in the Conservation of the Resources: Case Study of Surat Thani, South of Thailand*. Final report submitted to the Economy and Environment Program for South-east Asia (EEPSEA), Singapore.

Sathirathai, S. and Barbier, E.B. (2001) Valuing mangrove conservation, southern Thailand. *Contemporary Economic Policy* 19(2), 109–122.

Thomson, J.T., Feeny, D.H. and Oakerson, R.J. (1992) Institutional dynamics: the evolution and dissolution of common property resource management. In: Bromley, D.W. (ed.) *Making the Commons Work: Theory, Practice, and Policy*. Institute for Contemporary Studies Press, San Francisco, California, pp. 129–160.

Tokrisna, R. (1998) The use of economic analysis in support of development and investment decision in Thai aquaculture: with particular reference to marine shrimp culture. A paper submitted to the Food and Agriculture Organization of the United Nations.

Vandergeest, P., Flaherty, M. and Miller, P. (1999) A political ecology of shrimp aquaculture in Thailand. *Rural Sociology* 64(4), 573–596.