Strategies and Options for Increasing and Sustaining Fisheries and Aquaculture Production to Benefit Poorer Households in Asia

The WorldFish Center

APPENDICES

Appendices available on CD

Appendix 1

NATIONAL PROJECT TEAM COMPOSITION FOR THE NINE DMCS, ADB-RETA 5945

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Appendix 2

Appendix 2, Table 1 Summary of Fisheries Laws and Regulations in the Selected Countries

Country	Formal rules	Informal rules	Level of enforcement
Bangladesh	– Four sets of formal laws – Law prohibits collecting of hilsha juveniles	- At grass-root level, especially in the hill tribe area where there are informal rules	– Insufficient enforcement – Corruption
China	– Renewal of land contract system in 1994/95 Fisheries Law (2000) – No-catch season has enhanced fishery resources since 1995 – MOA revised the regulation for issuing fish license, fry and fingerling collection in 1997 – Free market of aquatic products have gradually emerged in China since mid-1980s – Agriculture law (1993) – Fisheries law (1986, amended in 2000) – Marine environmental protection law (1982) – Agricultural technology extension law (1993) – Reproduction and preservation of aquatic resources, issued by the state council in 1979 – Regulation on no-catch season (1995, amended in 1998), issued by MOA – Regulation on reservoir safety and preservation of aquatic resources (1979), issued by state council – Protection zone for young fish (1981) issued by state council – Transportation safety in fishing port waters (1989), issued by state council – Protection of aquatic wild animals (1993), issued by MOA – Management of marine fishing vessels (1983), MOA – Resolution on further accelerating the development of fisheries (1997), state councils – Water pollution prevention law (1994, amended in 1996) – Fishing license (1989, amended in 1997), MOA – Provision of fishmeal production (1984), MOA – Management of fry and fingerling (1992, amended in 1997), MOA – Regulation on verification of pedigree and high quality varieties of aquatic species (1993), MOA – Management of frozen fish and cold storage firms (1979), State Fisheries Bureau – Regulation on wholesale wet market (1996), MOA, and State Industry and Commerce Administration – Regulation on restricted marine fishing intensity (1997)	- Locally specific and limited formal acceptance	- Most effective in the centralized administration

Country	Formal rules	Informal rules	Level of enforcement
India	– Wildlife Protection Act (1972) – Prevention of Food Adulteration Act (1954) – Fishery Act – Maritime Zone Act (1975) – All maritime states have similar laws for fishing and other related activities – Environmental Protection Act (1986) – Land Reform Act (1997) – Court Directive to establish a Coastal Zone Management Authority – The Supreme Court of India has banned intensive shrimp farming within 500 meters from coast. Extensive and improved extensive production systems are allowed. – Constitution of Aquaculture Authority to issue license for traditional and improve traditional aquaculture within CRZ (1997) – GOI Notification (2002) on the use of certain chemicals.	- Not recognized in the formal institutions	– Due to vast magnitude, institutional and authority systems are under the open access regime – Poor enforcement of laws and regulations
Indonesia	– Constitution of Indonesia (1945) – Fisheries Act (1985) or Act No.9 (1985) deals with many aspects of fisheries – Act No. 5 (1983) deals with EEZ of UNCLOS – Regulation No. 15 (1984) provides detailed regulations on fishing activities in the EEZ – Regulation No. 15 (1990) deals with licensing, fish business – Regulation No. 46 (1993) deals with allocation of fees to the central and provincial governments. Currently the GOI is drafting government regulation on fishery resource management and fisheries infrastructure on the basis of Act No.9 (1985) – Ministry Decree No. 473 (1985) total allowable catch in IEEZ – Ministry Decree No. 475 (1985) on permit for persons and foreign legal entities engaged in fishing in IEEZ – Ministry Decree No. 476 (1985) on the reporting requirements for fishing vessels permitted to fish in IEEZ – Ministry Decree No. 477(1985) on the fishing fees imposed on foreign persons or legal entities with further amendments by the Minister Decree No. 438 of 1986 and no. 477 of 1988 – Ministry Decree No. 277 (1986) on fishing permits in Indonesian waters and EEZ	- Traditional fisheries management or indigenous knowledge such as Sasi, Panglima Laut, Lubuk Larangan, Lebak Lebung, Maawu Dfanau, Ikan Larangan, I kan Diniatkan, Suaka Perikanan, etc.	- Fairly effective in the local and specific conditions

Country	Formal rules	Informal rules	Level of enforcement
Indonesia (continued)	–Agriculture Ministerial Decree No. 607 (1976) on coastal fishing zones – Agriculture Ministerial Decree No. 608 (1976) on fishing zones of the government-owned company's vessels – Presidential Decree No. 39 (1980) on banning all trawlers from waters off Java and Sumatra – Presidential Instruction No. 11 (1982) on extending the trawl ban throughout Indonesia –Government Regulation No. 20 (1990) concerning water pollution control – Act No. 24 (1992) concerning spatial planning – Act No. 4 (1982) concerning the management of environment – Government Regulation No. 19 (1994) concerning the management of dangerous and poisonous wastes – Agriculture Ministerial Decree No. 2 (1995) concerning the technical guidelines for analysis of the environmental impact of the agriculture activities and business – Agriculture Ministerial Decree No. 752 (1994) concerning the technical guidelines for effort of environmental management and monitoring of the agriculture activities and businesses (This decree requires environmenta management and monitoring plans for a farm that cultivates shrimps on a pond area of 5 ha - < 50 ha adopting semi-intensive production intensities with a processing unit or intensive production intensities) – Autonomy Act No. 22 (1999) providing greater authority to provincial and district governments in managing and conserving marine resources (0-4 nautical miles managed by district government, 4-12 miles by provincial government, and > 12 miles by the central government) – Act No. 11 (1974) concerning irrigation – Government Regulation No. 22 (1982) concerning water resource utilization control – Government Regulation No.20 (1990) concerning water pollution control – Act No. 24 (1992) concerning the management of dangerous and poisonous wastes – Presidential Decree No. 39 (1980) concerning trawl ban – Presidential Decree No. 23 (1982) concerning the development of mariculture in Indonesian waters – Agriculture Ministerial Decree No. 473 (1982) concerning the guidelines for the implementation of the development of mariculture in Indonesian waters – Presidential Decree No. 18 (1984) concerning the project on nucleus estate and small holders system in brackishwater pond culture		

Country	Formal rules	Informal rules	Level of enforcement
Malaysia	– The Malaysian Constitution – National Land Code (1965) – Town and Country Planning Act (1974, amended in 1994) – Land Conservation Act (1960) – Fisheries Act (1963, amended 1985) – Fisheries Act (1993) (amendment) – Fisheries Development Authority Act (LKIM) (1971) – Fisheries Ordinance (1909) – Fisheries (Maritime) Regulation (1967) – The Fisheries Regulations (1964) – Fisheries (Maritime) Regulation (Sarawak) (1976) – Fisheries (prohibition of Methods of Fishing) Regulation (1980) – Fisheries (Licensing of local fishing vessels) Regulations (1985) – Fisheries (Conservative and culture of cockles) Regulations (1964) – Fisheries (Marine culture system) Regulations (1990) – Fisheries (Prohibition of Import, etc. of Fish) – Fisheries (Prohibited areas) Rantau Abang Regulations (1991) – Marine Parks and Marine Reserves Order (1994) – Fisheries (Prohibited area) Regulations (1994) – Fisheries (Closed season for the catching of grouper fry) Regulation (1996) – Fisheries (Prohibited fishing methods for the catching of grouper fry) Regulation (1996) – Fisheries (Control of endangered species of fish) Regulation (1999) – Fishermen Association Act (1971, revised in 1978 and 1999) – Merchant Shipping Ordinance (1952) – Merchant Shipping Ordinance (1960) (Sabah) – Merchant Shipping Ordinance (1960) (Sarawak) aiming to control pollution from shipping – Environmental Quality Act (1974, amended in 1985) – Environmental Quality (prescribed activities) (Environmental Impact Assessment Order (1987) providing guidelines on EIA for fisheries) – National Forestry Act (1984, amended 1993) – Mineral Development Act (1994) – Continental Shelf Act (1966) – Promotion of Investment Act (1986)	- Insignificant informal and customary laws exist.	- Effective, as people\ are aware of resources; and there are other more attractive alternatives for livelihoods in terms of income.

Country	Formal rules	Informal rules	Level of enforcement
Philippines	– There are laws prohibiting commercial encroachment and the use of illegal fishing methods. – Comprehensive Agrarian Reform Law (CARL)(1987) - the provision for a 5-hectare retention limit to land ownership is waived on fish ponds and other aquaculture activities, but there is an exception to the general rule on retention limits. – The Local Government Code (LGC)(1991) extending the limits of the municipal waters to 15 km from the shoreline, thus prohibiting commercial fishers to fish in this 15-km limit – Agriculture and Fisheries Modernization Act (AFMA)(1997) – The Philippines Fisheries Code (PFC)(1998) – The AFMA and Fisheries Code are closely related; the AFMA prescribes the urgent measures the government should undertake, while the Fisheries code consolidates all fisheries laws, explicitly providing for the development, management and conservation of the fisheries and aquatic resources, integrating all pertinent laws thereto.	– On the use of artisanal fishing gear such as distance from the entrance of fish corrals, limited number of fish corrals, new owners' permission from the existing owners, and removal of gill net – The informal rules depend on the area.	- Integration of law enforcement is a problem. - Revision of laws should be made after 5 years of implementation.
Sri Lanka	– No new shrimp farming is allowed in the North Western Provinces (NWP), but can be extended to new areas on the basis of zonal plan – Fisheries and Aquatic Resources Act (1996) principal legal instrument, issued based on historical laws and ordinances such as Chank Fisheries Act, Pearl Fisheries Ordinance and the Whaling Ordinance. Under this Act, 23 regulations have been imposed. – Fisheries and Aquatic Resources Act (1996), under which Fish Products (Exports) Regulations (1998) were issued – Coast Conservation Act (1981), initiating coast protection and survey and coastal zone management programs – The Fauna and Flora Protection Act (1949, last amended in 1993) indicating protected fish species and the establishment of marine reserves – National Environment Act (amended 1988) – Forest Act (last amended in 1979) – The Fishermen's Pension and Social Security Benefit Scheme (1990) – Marine Pollution Prevention Act	– Informal and customary laws specific to socioeconomic and geographic conditions exist.	– MOFAR limits its role to planner, facilitator, advisor, and promoter, rather than direct implementer. At present, it plays contradictory roles.

Country	Formal rules	Informal rules	Level of enforcement
Thailand	– Constitution of the Kingdom of Thailand (1997) – Forest Act (1941) – Forest Reserve Act (1992) – Local Administration Act (1914) – Public Administration Act (1991) – Fisheries Act (1947, amended in 1985) – Wild Animal Protection and Reserve Act (1992) – Provincial Administrative Organization Act (1997) – Sub-district Council and Sub-district Administrative Organization Act (1994) – Enhancement and Conservation of National Environmental Act (1992) – Land Code (1965) – Civil and Commercial Code – Navigation in Thai Water Act (1913) – Decentralization of Public Administration Act (1999) – Several other regulations on fisheries and aquaculture	– Informal and customary laws in specific areas take priority over formal laws. – Many fishing communities manage their own resources, and are supported by law.	– Effectiveness is subject to compromise between formal and informal laws. Evidences of violation are visible.
Vietnam	– Constitution of Vietnam (1992) stating that provinces and cities are directly under the central authority – Declaration of its territorial waters, contiguous zones, EEZ and continental shelf on 12 May 1997 – Ordinance on the Conservation and Development of Marine Resources (1989) – Many Decisions, Resolutions and Decrees issued by the Vietnamese Government and MOF to guide activities in the fisheries sector	- There exists a long-standing, traditional set of informal laws, to which the formal laws needs to adjust.	– Effectiveness is still questionable. – There are levels of compromise and negotiation based on family relationships.

Appendix 2, Table 2 Land Tenure and Water-use Rights in the Selected Countries

Country	Rights and characteristics	Institutional involvement	Formal and legal support	Informal support
Bangladesh	- Fishery resources except ponds in private land are state property.	– MOL and district administration – DOF under the MOFL – Ministry of Establishment leases out large waterbodies and oversees enforcement of laws.	- Ministry of Establishment used to assign fishing rights to individuals, but now to co-operatives.	- Local communities provide informal supports in conjunction with NGOs and international donors.
China	– Land remains collectively owned. – Policy-makers design user rights to encourage farmers to invest in agriculture. – Joint ownership is encouraged in aquaculture. In general, the village has ownership of fish ponds and rent them out to individual farm households, from which the village collects rent and fees.	- Local and central governments	- Laws support collective ownership of land.	- Limited informal supports
India	– Rivers are common property; reservoirs are state property; ponds and tanks, if natural, are common property, but if man-made on private lands are private property; estuaries are mostly open access; floodplain lakes are mostly state property. – State Fisheries Departments lease ponds and tanks to co-operatives. – Aquaculture is largely practiced in private waterbodies and leased public waterbodies.	– State DOF – Irrigation Department and State DOF – FFDA and private owners	– Laws guarantee the specified rights.	– The informal supports of rights are disappearing.
Indonesia	– All waterbodies are publicly owned. – Within 0-4 miles, fisheries are under the responsibility of local government. – Coastal areas 4-12 miles from shore are under provincial government; areas beyond 12 miles are under the central government.	- Local, provincial and central governments - MOMAF	- Rights guaranteed by law	- Rights supported by informal structures
Malaysia	- All water surfaces, except on the private lands, are state owned.	- DOF	- Rights guaranteed by law	- Rights supported by informal structures

Country	Rights and characteristics	Institutional involvement	Formal and legal support	Informal support
Philippines	- Mostly inland and coastal waterbodies are publicly owned, except some in private hands.	- LGUs - DA-BFAR	- Rights guaranteed by law	- Rights supported by informal structures
Sri Lanka	– Fishers have inherited rights – License for fishing is required – Consumer rights for food safety recognized – Fishing right of inland fishers in irrigation reservoir is protected and safeguarded in consultation with authorities concerned.	- DOFAR	- Traditional fishing rights of coastal fishers are protected.	- Informal supports are limited to the local communities.
Thailand	– Waterbodies are publicly owned, except in private hands. – A small fee is collected for water usage for capture fisheries – The government under the asset capitalization scheme plans to lease out to aquaculture (shellfish sea ranching and cage aquaculture) for a minimum of 3 years.	– Department of Land – Department of Water Transports – Department of Fisheries – Royal Forest Department	- Rights guaranteed by law, e.g., Land Code, Fisheries Act, and others	– Communities play a role in allocating use rights to cage aquaculture, and location of stationary gears. – Informal allocations are strongly protected by communities.
Vietnam	- Water surface and land, in principle, are state-owned. User rights are assigned, can be transferred, renewed, and inherited. Use rights in agriculture involve long-term contracts (25-50 years). - Capture fisheries resources are public access, but fishers (both small and large-scale) need registration.	- Land Registration Office - Ministry of Environment and Natural Resources - Contract to use resources is done at village or district levels. - Provincial Fishery Resources Protection Office of the MOF monitors public property.	- There are laws specifying land rights classification, and other laws with specific rights to the resources.	- There are limited supports of rights by informal arrangements.

Appendix 2, Table 3 Co-management, Community based Management, and Decentralization in the Selected Countries

Country	Decentralization policy	Co-management practices	Community-based management practices
Bangladesh	– No laws, but there are local government bodies at the union level. – There are co-operatives dealing with local matters.	- Co-management models are being tested with cooperations from donors, governmental and non governmental organizations.	- Community-based fisheries management models are being tested, similar situation to that in the co-management practices.
China	- Still under centralization policy		- Community-based fisheries management is practiced informally at the local level.
India	– Laws and Constitution (1993) guarantee decentralization policy. – Indication that small tank management by the local authority is a success story	- A few cases available	- A few cases available
Indonesia	– For the past five years the national development has shifted from the centralized to decentralized system, formalized in the National Act (1999 and 2000) – giving the local government more autonomy in managing its resources. – Central and local governments have mandates to develop rural aquaculture including formulation of aquaculture development policies and strategies, technologies and management ability.	- Co-management practices in a form of waste management in aquaculture, i.e., the operation of inlet and outlet canals, incoming and drainage water	– Traditional community-based system of fisheries management such as Sasi, Panglima Laut, etc. – Set of practices guiding shares of the catch between crew members and its owners, captain and master fishers
Malaysia	- Being explored	- Co-management practices are implicitly available	- Traditional community-based management is practiced to a limited extent.
Philippines	– The Local Government Code (1991) devolves a significant portion of the functions of the national agencies such as DA-BFAR to the Municipal Government, i.e., the management, development, exploitation and protection of the fisheries and aquatic resources. – Local governments manage the coast up to 15 km from shore; the remainder is under the jurisdiction of the DA-BFAR, the Coast Guard, and the Navy.	– Co-management works at different levels of implementation. – There are composite teams in co-management practices including local government units, coast guards, DA-BFAR and fisher communities.	– The community-based management and co-management practices are considered interdependent. – These two practices fit well with the decentralization policy and the creation of local management councils. – Civil society organization is developing its roles.

Country	Decentralization policy	Co-management practices	Community-based management practices
Sri Lanka	- Not currently practiced	- MOFAR upon using the Fisheries and Aquatic Resources Act designate areas for fisheries management, including designating fisheries committees of registered fishers in the fisheries management area. The tasks are to assist fishers with management programs, fishing inputs, social infrastructure, or other activities approved by the DG. The minister can order the merging of fisheries committees.	- Traditional and community-based fisheries management practices exist.
Thailand	– The Kingdom's Constitution stresses local administration of natural resources. – There are laws on the decentralization of public administration authority, e.g., decentralization laws of 1999.	– Co-management models are being tested. – Application in fisheries is limited in a few communities; there is no extensive network.	- Traditional and community-based fisheries management practices exist. There is a more extensive network of these practices than the co-management.
Vietnam	- Decentralization of public administration is not currently available, however; the policies direction is to provide support to local fisheries communities to establish their local fisheries management plans.	– Not yet officially approved by the Central Government, but already applied in several coastal areas under different styles – The Model is rather effective, especially in resource protection. – Support is provided by international donors such as DANIDA, CIDA, UNDP, FAO, WB, WFC, ADB, JICA. – Ministry of Fisheries is trying to bring the concept into the Fisheries Law.	- Research and development to support the concept of CBM have been carried out at selected sites.

Appendix 2, Table 4 Roles of Local Organizations, Private Sector and NGOs in the Selected Countries

Country	Local organization	Private sector	NGOs
Bangladesh	- Registered Fisher Organizations have their exclusive rights to auction the use of waterbodies.	- Increasingly involved, especially in aquaculture, seafood export and mechanized fishing boats, and trade.	- NGOs play dominant roles in all aspects of fisheries management.
China	– The 5-year plan indicates the promotion of incentives for farmers and local government to invest in agriculture. – Fishery Bureau at each level administratively manages the wholesale market of aquatic products. – Industry and commercial administration supervise commercial transactions of the wholesale market.	- The private sector increasingly plays important role in fisheries and aquaculture investment.	- NGO role is limited.
India	– There is an establishment of fisheries industrial estate at the local level. – Local co-operatives are given water-use lease at the highest priority.	– Private sector involved in marketing, transportation, storage, processing, credit facilitation, quality controls and inspection services – Strong controls from the government and communities exercised, especially with respect to environmental issues	– NGOs provide education and training. – NGOs focus on social and environmental issues, not on the technical aspects of fisheries.
Indonesia	The following are active in fishing and marketing activities: – Fish Farmers' Cooperatives – Fish-farmer Groups – Women Groups of Fish- farmers – Youth Fish Farmers – Joint Aquaculture Groups (KUB) – Muslim Boarding Schools	– Private associations and federations are a collection of scholars and business people who give advice to the government regarding fisheries trade and other related fisheries issues; these associations include Association of Indonesia Fisheries Scholars (ISPIKANI), Federation of Indonesian Fisheries Entrepreneurs (GAPPINDO), Association of Indonesian Fishers (HNSI), Federation of Indonesian Fisheries Cooperatives (IKPI), National Fisheries Society (MPN). – The private sector plays a dominant role in fisheries. – The private sector supplies information concerning aquaculture development for businesses, undertakes construction of aquaculture facilities.	- NGOs play some roles in fisheries management

Country	Local organization	Private sector	NGOs
Malaysia	- Fishers' associations at the area (Area Fishers' Association - AFA), (State Fishers' Association – SFA) and federal levels (NEKMAT)	– Private sector investment in aquaculture emphasized in national plans, medium and large-scale companies or entities to venture into large-scale fish culture, production of feed and seed – Private sector dominating fish business from production to retail – Trade associations, both privately and publicly supported, protect business interests (e.g., Marine Product Association, Ipoh Wholesale Merchant's Club, KL Fish wholesalers' Association). Oligopolistic tendencies have been noted.	- NGOs play some roles in fisheries management.
Philippines	– Local government units are very strong in fisheries management. – Aquatic Resources Management Council (1995) at all levels (village to national) still follows the policies of the government.	– The private sector is strong in fisheries trade and joint ventures. – The private sector is considered dominant in the fisheries sector. – The Philippine Fisheries Development Authority is working in close co-operation with the private sector. – DA-BFAR works in strong partnership with the private sector.	– NGOs are heavily involved in fisheries management; work with government, in contrast to past opposition (partly owing to the shift to democracy). – The NGOs work as committee, and they are open to government involvement. – The role of NGOs is limited to small communities and significant when there are conflicts.

Country	Local organization	Private sector	NGOs
Sri Lanka	– A handful of co-operatives with three-tier structure, primary societies, secondary unions and an apex federation. There are 943 village-level fisheries cooperatives societies. – Fisheries Co-operative Banks, and high performance fisheries co-operative societies ready to be elevated to fisheries co-operative banks – Local communities involved with private sector in shrimp out-growers – Local government bodies and MOFAR to develop village-level fish landing sites for facilities management – Fishers' organizations and cooperatives will be assisted and encouraged in implementing village level projects.	– The fishing industry has always been dominated by the private sector (including fishers). – Every fishing household that owns a fishing craft is treated as a small business entity. – The private sector takes lead in aquaculture development under facilitation and guidelines of the MOFAR. – The private sector is supported and encouraged in new aquaculture activities. – The private sector and local communities are encouraged participate in aquaculture activities with BOI incentives. – The private sector is encouraged to produce ornamental fish with research inputs from the National Aquatic Resources Research Development Agency (NARA) and the National Aquaculture Development Authority (NAQDA). – The private sector is in partnership with CFHC to operate shore facilities and invest in shore facilities. – Policy in December 2002 encouraged local and foreign investment in 5 zones, including fishery investment.	- No correct record on NGOs, but there are several NGOs that solely, partially or potentially concerned with the fisheries sector. They provide services to unfortunate group of fishers. They are for example Sarvoday, Sanasa, Seva Lanka Foundation, national Fisheries Solidarity, Social Mobilization Foundation, Small Fishers' Foundation.
Thailand	- Local organizations play increasingly dominant roles in managing fisheries resources, supported and promoted by the government.	- Marketing and trade promotion is mostly carried out by the private sector, while the government plays a role as facilitator and gives other support.	– NGOs work closely with the communities, especially in small-scale capture fisheries. In aquaculture, NGOs play less of a role.
Vietnam	– There are 28 coastal provinces and cities having fisheries departments and two others having Department of Agriculture and Rural Development. – People's Committee and People's Council of the provinces consider and approve the strategies and plans. - People's Committee exists in all levels of public administration. – Based on traditional relationship – Women and youth groups	– The private sector plays a dominant role; is more effective. The public sector controls only the processing activities for exporting. – Investment is huge, so only the government and big corporations can be involved in it. – The Nau and Vua system is the assemble system where middlemen collect from producers, store and distribute to retail outlets.	- NGOs exist but their roles are limited to specific localities and topics.

Appendix 2, Table 5 International Involvement in Fisheries in the Selected Countries

Country	Technical advice	Financial support	Aquaculture joint investment	Marine fisheries joint-venture	Deep-sea fisheries joint-venture
Bangladesh	- WorldFish Center and other international donors	- Grameen Bank, which was initiated by the UNDP and now is an autonomous institute	- Feed investment from oversea investors	- Mainly in fisheries processing activities	- Not developed
China	- WorldFish Center and other donors	- The Five-year Plan indicates further opening of the agricultural sector including fisheries to foreign investment and improving the efficiency of foreign capital use in the agricultural sector.	- Joint investment, especially on feed	- Joint-venture business in its EEZ is supported by laws, but it is not economical, mostly joint-venture with other countries in their EEZ or international waters.	- Joint-venture business with Sri Lanka for using landing facilities
India	- WB (shrimp and fish project), WorldFish Center, UNDP, DANIDA, ODA (UK – post harvest), ODA (Japan), FAO (HACCP)	- Financial support given by international donors	- There are joint ventures in aquaculture, especially in feed, hatchery and shrimp farming. - They are legally endorsed.	- There are joint ventures with Thailand, and Korea in India's EEZ.	- Not developed
Indonesia	- Indonesia receives technical advice in fisheries management from international donors such as WorldFish Center.	- Indonesia receives financial support from international donors.	- There are joint ventures in aquaculture with other countries.	- There are marine fisheries joint ventures with other countries.	- Not yet developed

Country	Technical advice	Financial support	Aquaculture joint investment	Marine fisheries joint-venture	Deep-sea fisheries joint-venture
Malaysia	- WFC - SEAFDEC	-SEAFDEC	- With neighboring countries	- With neighboring countries	- Not yet developed
Philippines	- Sharing of technical advice with other countries and with international organizations such as WFC, WWF, FAO, etc.	- The Philippines receives financial support from international donors such as ADB, WB, USAID.	- There are joint ventures in aquaculture, especially in feed, seaweed. - Philippine expertise, especially in seaweed	- Joint ventures with neighboring countries, especially with Indonesia in both EEZs, and with other countries in the South Pacific	- Joint ventures in deep-sea fisheries exist.
Sri Lanka	- WFC, FAO and donor agencies	- FAO and donor agencies	- Possible with local joint investment depending on agreements - Foreign investors in aquaculture are supported and encouraged.	- EEZ is closed to foreign vessels, but use of fish landings facilities is allowed. - Marine surveillance system is collaborated with foreign or local organizations in a cost-effective way.	- Joint venture with China for tuna fishing in international waters - Sri Lanka government cooperates with the international community in preventing Illegal, unreported and unregulated (IUU) fisheries.
Thailand	- Thailand has received technical advice from many international organizations such as WFC, WWF and others, and it has provided the same to other neighboring countries.	- Thailand has received financial support from many international organizations, and it has provided the same to other neighboring countries.	- Thailand has invested in aquaculture and other industries in neighboring and other countries.	- Thailand has agreed to fisheries joint ventures with other countries.	- Thailand has developed deep-sea fisheries with other countries, and also practiced on its own.
Vietnam	- Many international donors support aquaculture development, such as WB, WFC, DANIDA, ADB, UNDP, EU.	- Many international donors provide financial support in fisheries management such as ADB.	- Aquaculture feed is not well developed in Vietnam; it is imported or produced jointly with foreign companies.	- Vietnam has developed fisheries joint ventures with other countries.	- Vietnam has developed deep sea fisheries with other countries.

Appendix 3

Source of data on the demand side

Data were obtained from national/regional household consumption/expenditure surveys conducted either by the project or respective statistics offices of partner countries (Table 1). Specifically, the study utilized the information on fish consumption by species or types contained in respective datasets. Five partner countries out of nine used secondary sources, namely: China, Indonesia, Malaysia, the Philippines and Sri Lanka. The remaining four countries (Bangladesh, India, Thailand and Vietnam) conducted own primary surveys because fish species dissaggregation was not available in their national household expenditure surveys. All data sets used in this demand study were fairly recent (1999-2002) except those for Sri Lanka, which went back to 1996. In some cases where prices of the fish species/types included in the study were not available in the expenditure survey, complimentary data sets from separate national surveys were used. For example, in the case of the Philippines, fish prices were taken from the Consumer Price Index Survey (CPIS) of the National Statistics Office.

Econometric approaches to demand estimation

The purpose of this section is to present a spectrum of creative, innovative and interesting approaches used by researchers to analyze the demand for fish and other marine products. Empirical studies pertaining to seafood demand and preferences articulation are selectively reviewed to illustrate concepts and highlight research applications. A brief review of the theory of demand is presented to trace the evolution of different models used in food demand analysis.

Demand functions can be indirectly derived either from utility maximization (which yields a Marshallian demand specification) or through expenditure minimization (the dual version of the former, which yields a Hicksian compensated demand function). Both formulations can be used for empirical investigations of demand models using single-equation or system approaches. Earlier demand models often used the single-equation approach, but later empirical studies were focused on the system approach, a technique pioneered by Stone in 1954. Although the demand system that Stone developed was consistent with the assumptions of neoclassical demand theory, the model restricts the nature of the relationship of the goods included in the system by assuming that the underlying preference ordering was additive. This implies that the marginal utility provided by the consumption of one commodity is independent of the consumption of the other goods; hence, all commodities are treated as substitutes and inferior goods are excluded. Early versions of system models are the Rotherdam model (Theil 1965), the S-branch model (Brown and Heien 1972) and the translog demand model (Christensen et al. 1975).

Deaton and Muellbauer (1980) recently extended empirical research on demand systems by developing and estimating the almost ideal demand system (AIDS). The demand system for the AIDS model was derived, by using the duality theory, from an optimal expenditure function defined as the minimum expenditure necessary to attain a specific level of utility at given prices.

Appendix 3, Table 1 Summary of Consumption Data Sources for the Selected Countries

Country	Type of Data	Year	Coverage	Sample size (households)	Data Source
Bangladesh	Primary	1999	9 districts Rural inland Rural coastal Urban	810	Own survey
China	Panel Secondary	1997 and 2001	Nationwide (20% of total national sample)	49,508	National Statistics Bureau (Household Expenditure Survey)
India	Primary	2002	6 out of 18 states where fish is consumed	591	Own survey
Indonesia	Secondary	1999	Nationwide (All 26 provinces)	61,482	Central Bureau of Statistics (Socioeconomic National Survey)
Malaysia	Secondary	2000	Nationwide (All 13 states)	9,198	National Statistics Bureau (Household Expenditure Survey)
Philippines	Secondary	2000	Nationwide (All 16 regions)	39,615	National Statistics Office (Family Income and Expenditure Survey)
Thailand	Primary	1999-2002	10 inland provinces 5 coastal provinces	456 (4 rounds)	Own survey
Sri Lanka	Secondary	1996	Nationwide	19,752	Department of Census and Statistics (Household Income and Expenditure Survey
Vietnam	Primary	2002	13 out of 62 provinces	780 (4 rounds)	Own survey

This model was claimed to be more advantageous than its forerunners owing to the following reasons: (1) it gives an arbitrary first-order approximation to any demand system; (2) it satisfies the axioms of choice exactly; (3) it aggregates perfectly over consumers; (4) it has a functional form that is consistent with micro-level household budget data; (5) it is simple to estimate in its linear approximate form; and (6) it can be used to test the homogeneity and symmetry of demand parameters. In addition, although Deaton and Muellbauer did not mention it, the AIDS is indirectly non-negative, allowing consumption of one commodity to affect the marginal utility of another commodity; whereas the linear expenditure system (LES) is directly additive, implying independent marginal utilities. Thus, the AIDS, in addition to the listed desirable properties, does not impose the severe substitution limitations implied by additive demand models such as the LES (Blanciforti and Green 1983).

Blanciforti and Green (1983) empirically compared the results generated by a simplified linear approximation of the AIDS and the LES models. One of their findings suggested that many commodities classified as luxury goods in the LES (income elasticities greater than one) become necessities in the AIDS model (income elasticities less than one). Specifically, the AIDS possesses a property showing that the values of income elasticities are lower for necessities as their budget shares decreases (the reverse is true for the LES). Thus, the AIDS was found to be an attractive system for analyzing the demand for food commodities. However, the AIDS model requires a large number of parameters to be estimated, and this imposes constraints on the sample size.

The AIDS model is specified as follows:

$$Wi = \alpha i + \sum j \; \gamma ij \log Pj + \beta i \log \{X/P\} \ldots\ldots\ldots(1)$$

where:
Wi is the share in expenditure of the good i
Pj is the price of the good j
X is the income of the ith household

P is a price deflator of the income variable defined as follows:

$$\log P = \alpha o + \sum k \; \alpha k \log Pk + ½ \sum j \sum k \; \gamma kj \log Pk \log Pj \ldots\ldots\ldots(2)$$

Use of the price index defined in equation (2) often raises empirical difficulties, especially when aggregate annual time-series data are used on it (Green and Alston 1990; Moschini 1995). One of the main reasons for the popularity of the AIDS model is that the price deflator P in equation (2) can be replaced by an index that will allow the estimation of a linear demand system. If prices are highly collinear (as they often are), then P may be approximately proportional to P*, i.e., P≈P*. Deaton and Muellbauer (1980) suggest replacing P in the AIDS model by the Stone price index P* defined as:

$$\log P^* = \sum_k W_k \log P_k \ldots\ldots\ldots(3)$$

The model that uses the Stone's price index is called the "linear approximate AIDS or LA/AIDS model. The LA/AIDS model has been used extensively in demand analysis, which includes the works of Blanciforti and Green (1983), Eales and Unnevehr (1988) and Moschini (1995).

The occurrence of zero observations is one of the most pressing issues in applied demand

analysis and other microeconometric applications (Shonkwiler and Yen 1999). At the same time, the fact that the observed budget shares cannot take on negative values means that the dependent variable is censored. The problem of censored dependent variable was first recognized by Tobin (1958), who showed that the use of ordinary least squares (OLS) estimation for such model results in biased and inconsistent estimates. To address the problem, Tobin proposed a maximum likelihood (ML) estimation using the Tobit model. This technique is easy to carry out in the case of the single-equation demand estimation. However, the problem becomes more complex in the case of the system demand model that consists of a set of demand relations interrelated through both the error structure and the cross-equation restrictions.

Whereas theoretical literature exists for systems of equations with limited dependent variables (Amemiya 1974; Lee and Pitt 1986; 1987; Wales and Woodland 1983), direct ML estimation of these models remains difficult when censoring occurs in multiple equations because of the need to evaluate multiple integrals in the likelihood function (Shonkwiler and Yen 1999). Heien and Wessells (1990) argued that it is possible to estimate models of this type by maximum likelihood, but such procedures generally are computationally prohibitive. Heien and Wessells (1990) provide a comprehensive survey of the studies concerning the non-negativity constraint or the problem of censored dependent variables.

Heckman (1979) proposed a two-step estimation procedure for the system of equations with limited dependent variables, which was popularized by Heien and Wessells (1990) through the use of inverse Mills ratio (IMR) in demand model estimation. The IMR is added in the model as a selectivity regressor (derived from probit estimation in an earlier step) to remove the sample selection bias created by a significant number of zero consumption in the data set. The demand system is then estimated using the seemingly unrelated regression (SUR) in the second step, hence the name Heckman two-step procedure. The first step involves a probit regression to compute for the probability that a given household will consume the commodity in question. The decision to consume is modeled as a dichotomous choice problem, i.e., Cih = $f(P_{ih}, D_h)$ where C_{ih} is 1 if the $_h$th household consumes that $_i$th food item, and 0 if otherwise; P_h is a vector of prices for the $_h$th household and D_h is a vector of the demographic variables. This regression is then used to compute the inverse Mills ratio (IMR) for each consuming household. The IMR ratios for the $_h$th households that consume and do not consume the $_i$th good are given by equations 4 and 5, respectively:

for C=1: $IMR = \psi(P_{ih}, D_h) / \Psi(P_{ih}, D_h)$.....(4)

for C=0: $IMR = \psi(P_{ih}, D_h) / \Psi(P_{ih}, D_h)]$…….....(5)

where ψ and Ψ are the density and cumulative probability functions, respectively.

The IMR is used as an instrument that incorporates the censored latent variable in the second-stage estimation of the demand relations. Heien and Wessells (1990) compared the results generated by the censored model (with IMR) and the uncensored model. The authors concluded that the censored model provided substantially improved results in terms of goodness of fit and the conformity of price elasticities with prior expectation.

In spite of the popularity and extensive applications of the Heien and Wessells (HW) model (e.g, Gao and Spreen 1994; Gao et al. 1996; Han and Wahl 1998; Heien and Durham 1991; Nayga 1995, 1996, 1998; Park et al. 1996; Salvanes and DeVoretz 1997; Wang et al. 1996; and Wellman 1992), Shonkwiler and Yen (1999) criticized the model and claimed that "there is internal inconsistency in this model". In addition, the authors proposed an alternative consistent two-step estimation (CTS) procedure for systems of equations with limited dependent variables and conducted a Monte Carlo simulation to investigate and compare the performance of the CTS and the censored model proposed by Heien and Wessells (1990). Shonkwiler and Yen (1999) concluded that the CTS performed well, compared to the HW procedure. The authors added that although their CTS model only considered a three-equation linear system in the simulation, an application of the methodology to the case of multiple and/or nonlinear equations (e.g., a "theoretically plausible" demand system) would be equally straightforward. Another problem arising because of zero consumption is that of missing prices. In order to estimate a complete system, prices must be available for all items consumed by all households.

However, for households not consuming a particular item, there will be no data on the price of that item. The usual procedure employed is to estimate the missing price by performing a regression on the price of the item from those households that did consume it. Therefore, regional dummies, seasonal dummies and income are included as regressors in this model. The model is then used to estimate the missing price for those households that did not consume that particular item. The properties of estimates using price data obtained in this manner were discussed by Dagenais (1973), and Gourieroux and Monfort (1981). However, it should be pointed out that these properties hold only for non-censored variables.

Likewise, it has been recognized that food demand is influenced by the age structure of the population and various other demographic factors as cited by Heien and Wessells (1990). The AIDS or LA/AIDS models can be modified by incorporating demographic variables in the budget share equations of the AIDS model as follows: $\alpha j = \rho jo + \sum m\ \rho jm\ dm$, where dm is the mth demographic variable. This method of incorporating demographic variables in the AIDS model is known as translation (Heien and Wessells 1990). The other widely used technique is demographic scaling. Translation preserves the linearity of the system, whereas scaling is a highly non-linear specification (Pollak and Wales 1981).

Model and estimation procedure for the study

A multi-stage budgeting framework[1] was used to model the fish consumption behavior of Asian households similar to the approach employed by Dey (2000b), who built on the framework used by Deaton and Muellbauer (1980), Blundell et al. (1993) and Heien and Wessels (1990). This approach made use of the concept of Strotz (1957) who extended the idea of exhaustive expenditure to stages. In the first stage, the consumer is assumed to allocate expenditures to broad groups of commodities and then, in the second stage, to further allocate expenditures within each of the broad groups to smaller groups. This process can continue, but for most empirical analyses, it has been limited to two stages requiring the condition of weak separability - that is, the condition ordering of goods on the independence of marginal utilities

[1] Detailed discussions of multi-stage budgeting framework are found in Thomas (1987); Blundell et al. (1993); Mustapha et al. (1994); Fan et al. (1995); Gao et al. (1996); and Tiffin and Tiffin (1999).

of goods within one group from consumption of the goods in other groups.

This approach was used to address a common problem in the empirical estimation of the AIDS models, which requires a sizeable system of demand equations in light of the wide variety of consumption goods jointly purchased by households. The full demand system containing all these commodities warrants a large amount of own-price and cross-price parameters that are impractical to estimate, given the limited sample size. A solution forwarded in the literature is to estimate the model in stages, whereby expenditures on goods belonging to various food categories are estimated sequentially. In this study, a three-stage budgeting framework was adopted to enable the specification of a fish demand system in the final stage that is species-specific, while keeping the size of the demand system manageable.

Expenditure functions (for food and subsequently for fish) were specified at the initial stages of the model, while the quadratic extension of the Deaton and Muellbauer's linear approximate AIDS model (1980), hereafter referred to as the QUAIDS model, was formulated in the final stage. The food expenditure function shows how households, given their total per-household incomes, allocate their budget to food and non-food commodities. The fish expenditure function shows how the fish budget of a household is affected by the prices of various types of food commodities, such as cereal, fish, meat, beverages, fruit and vegetables. In the final stage, the QUAIDS model was specified to estimate the parameters of the demand system needed in the computation of elasticities for various fish types in light of the household fish budget.

The QUAIDS model used in this study assumes that fish is weakly separable[2] from all the other categories of food commodities, such as cereals, fruits/vegetables, meat and beverages. The weak separability assumption of the direct utility function over various groups of commodities is necessary to satisfy the condition for estimating the AIDS model in a multi-stage budgeting framework. This procedure suggests that price aggregation in a partitioned utility function is possible only if either of the following conditions is satisfied: (a) the utility function is strongly separable (block additive form) or (b) it is homothetically separable. In this study, the second condition was supposed to allow the specification of a fish demand system that is independent of the other food commodities cited.

In the first stage, the food expenditure function (FD) is expressed as:

FD= f(PF, PNF, Y,Z)……..…….....……(6)

where: FD is the per capita food expenditure; PF is the household-specific price index for food; PNF is the household-specific price index of non-food prices; Y is a vector of per-household income expressed in linear and quadratic forms; and Z is a vector of household characteristics.

The price index for food (PF) is computed as the geometric mean of food prices ($\Sigma wj \ lnPj$), where wj is the share in the total food expenditure of the jth food commodity and Pj is the price of the jth commodity. The price index for non-food commodities (PNF) was included in the model to take into account the *income effect* component of the change in non-food price index. Further, it is assumed that the *substitution effect* between food and non-food commodities is negligible.

[2] For further discussions on separable utility functions in the multi-stage budgeting framework, please refer to Brown and Heien (1972); Eales and Unnevehr (1988); Yen and Roe (1989); Gao et al. (1996); Jorgenson et al. (1988); and Michalek and Keyzer (1992).

The income variable Y is included in the model both in linear and squared forms. The quadratic term was included to capture the possible non-linearity in the food expenditure behavior of households with respect to income. The variable Zi is a vector of household characteristics, which is represented by a dummy variable for urban areas, the number of children in the household and household size.

In the second stage, the fish expenditure function (FS) is expressed as:

FS = f(P, FD, Z)…….....……(7)

where: FS is the per capita fish expenditure;
P is a vector of prices for different food categories such as cereals, meat, fish, vegetables, etc.; FD* is a vector of predicted food expenditure from stage 1, in linear and quadratic forms; and Z is the same vector of household characteristics used in equation 1.

The QUAIDS model for various fish types is specified in the third stage as a system of equations where the budget share of each fish type (Wi) is expressed as a function of fish prices, fish expenditures and demographic characteristics of a household. The demand system is expressed as follows:

Wi = f(PF, FS*/P*, Z, IMRi)…….....……..…(8)

where: Wi is the share of an individual fish type in total fish expenditure; PF is the vector of prices for different fish types i; FS* is a vector of predicted fish expenditure from stage 2, in linear and quadratic forms; P* is a household specific Stone price index for fish and is used as a deflator for fish expenditure; Z is the vector of household characteristics; and IMRi is the inverse Mill's ratio for the specific fish type i.

To achieve the QUAIDS specification, the quadratic term for the fish expenditure variable is added to the linear approximate AIDS model (LA-AIDS) as an explanatory variable (Dey 2000b; Blundell et al. 1993; Dickens et al. 1993; and Meenakshi and Ray 1999). The QUAIDS specification was used in this study to capture the non-linearity in consumption behavior of households for goods exhibiting threshold levels such as food commodities. At the same time, it relaxes the restriction imposed by linear demand functions regarding the allocation of marginal expenditures among commodities to be the same in rich and poor households (Beach and Holt 2001). Such an assumption limits the classification of goods into either necessities or luxuries and denies the possibility that some goods may be luxuries at a low level of income and necessities at a higher level of income. This type of consumption behavior may be observed in the case of high-valued fish and other marine products such as prawn, oysters and crabs. Also, the computation of demand and income elasticities by income classes, i.e., low, medium and high income, is facilitated under the QUAIDS specification, since only one set of demand parameters needs to be estimated for the global sample. Subsequently, the demand elasticities by income group can be computed by simply varying the level of income in the elasticity formula.

The use of the Stone price[3] index as a deflator for the fish expenditure variable in the model allows the empirical approximation of the non-linear AIDS model of Deaton and Muellbauer (with translog price index) to be linearly estimated. It has the following formula: $\ln P^* = \Sigma_i w_i \ln P_i$. The Stone index is particularly useful in AIDS models with other sources of non-linearities (Moschini

1995); hence, it is suitable to the QUAIDS model used in this study.

The inverse Mills ratios[4] (IMRs) are also incorporated in the model to correct for the possible bias created by the presence of zero consumption for certain fish types (Heckman, 1979). Zero consumption results when households report no consumption due either to abstention or corner solution in the household's utility maximization problem. Corner solution results when consumers cannot afford to pay the price of certain fish types given their budget (i.e., shrimp and other high-value fish types) while abstention may be due to non-preference or infrequent purchases. Both cases render the share in expenditure W_i to zero. In this paper, correction of the sample selection bias created by the presence of numerous zero consumption of certain fish types in the dataset requires either the use of the Heckman two-step procedure (1979) in estimating the inverse Mills ratios for the various fish types or the Tobit model in the estimation of the fish expenditure function (equation 2).

To ensure that the specification of the QUAIDS model will conform to the theory of optimal consumption (i.e., that the consumer is a utility maximizer), three restrictions on the parameters of the model need to be satisfied. These restrictions are: (1) the homogeneity condition (i.e., consumers react only to real prices and income); (2) the additivity condition (i.e., all the budget shares w_i add up to 1); and (3) the symmetry condition (i.e., the cross effects of a change in the price of a certain fish type on the demand for another fish type are equal). At the same time, due to the quadratic nature of the demand functions, the symmetry restriction also requires that the ratio of the income coefficients must all be equal to a constant, implying that the relative effects of the linear and squared income terms in the demand equations must be the same for all fish types.

The additivity property of the QUAIDS model implies a singular variance-covariance matrix for the error terms of the model when all the n demand functions are estimated jointly. To impose this restriction, the last equation in the model is simply deleted to avoid the singularity problem in the estimation of the model parameters. Then, the parameters of the omitted demand equation are calculated by substituting the estimated parameters of the n-1 equations in the formula of the additivity restrictions. The parameter estimates of the whole model are invariant with respect to the demand function that is deleted from the system (Pollack and Wales 1981). To estimate the parameters of the QUAIDS model, the iterative seemingly unrelated regression (ITSUR) method of the SYSNLIN (non-linear systems) procedure of SAS (Statistical Analysis System 1984) was employed.

Based on the parameter estimates of the QUAIDS model, the price elasticities for the different fish types are estimated as follows:

$$\xi_{ij} = (b_{ij} / w_i) - \{c_{1i} + 2c_{2i} \mathrm{Ln}(FS)\} (w_j/w_i) - k_{ij} \quad (9)$$

where: k_{ij} is the Knonecker delta that is equal to 1 for own-price elasticity and zero for cross-price elasticity; w_i is the consumption share of the i^{th} fish type; and b_i and c_i are parameter estimates of the QUAIDS model.

[3] For further discussions on the use of Stone price index in AIDS models, please refer to Swamy and Binswanger (1983); Green and Alston (1990); Pashardes (1993); Buse (1994); and Hahn (1994).

The above formula yields the uncompensated price elasticity (ξ_{ij}). The compensated (Hicksian) elasticity is computed using the Slutsky equation in elasticity form, i.e.,

$$\xi_{ij}^{H} = \xi_{ij} + w_j \, \eta_i \quad \text{...(10)}$$

where: ξ_{ij}^{H} stand for Hicksian elasticity, while η_i is the fish expenditure elasticity of the individual fish type and is given by the formula:

$$\eta_i = (c_{1i} + 2c_{2i}\, \text{Ln(FS)/wi}) + 1 \quad \text{..........................(11)}$$

The income elasticity η_i^{Y} for a specific fish species is computed as the joint product of food expenditure elasticity η^{FD} from stage 1, fish expenditure elasticity η^{FS} with respect to food from stage 2, and fish expenditure elasticity for the individual fish type, i.e.,

$$\eta_i^{Y} = (\eta^{FD})\,(\eta^{FS})\,(\eta_i) \quad \text{....................................(12)}$$

Theoretical framework for supply response

Studies on multi-products and joint inputs supply response for agriculture abound in the literature (see Just et al. 1983; Shumway 1983; Shumway et al., 1987; Ball 1988; and Ball et al. 1997). These studies used the duality theory by formulating a profit or revenue function and then deriving the output supply and input demand functions indirectly by applying the Hotelling's lemma. The main advantage of the dual approach, as compared to direct estimation of the supply function, is that the state of production technology can be implicitly derived from the former.

Not many aquaculture supply response studies per se are available in the literature. Studies by Anderson (1985) and Ye and Beddington (1996) focused on the interaction between aquaculture and marine capture fisheries. However, because the production process in aquaculture, which involves greater control of environmental factors, is approximately similar to crop production, the duality approach in modeling fishery supply response appears to be appropriate. For capture fisheries, the bioeconomic models were traditionally used to specify the production relationship between aggregate industry or individual species output (total catch) and aggregate input that is normally expressed as fishing effort (Clark and Munro 1980; Sampson, 1992; Tai and Heaps 1996; and Pascoe and Mardle 1999). However, the aggregate production function that is often used in the literature to relate total catch to fishing effort and resource abundance invariably has a very restrictive Cobb-Douglas functional form. In addition, the fishing effort variable used in the production function combines a myriad of inputs such as vessels, labor, fuel, fishing gears and others into a composite index. Thus, fishing effort is an abstract concept that is difficult to understand.

In recent years, several studies in marine capture fisheries applied the duality approach as an alternative to bioeconomic models in estimating the supply response functions. These studies used either a profit function approach (for example, Squires 1987, 1988; Dupont 1991; Salvanes and Squires 1995; and Alam et al. 2002) or a revenue function specification (Kirkley and Strand 1988; Squires and Kirkley 1991, 1996; Thunberg 1995; and Diop and Kazmierczak 1996). The dual approach has the advantage because it obviates the abstract concepts of fishing effort and provides direct and specific knowledge on individual inputs and outputs.

[4] For further discussion on zero consumption, refer to Keen 1986; Shonkwiler and Yen 1999, and Perali and Chavas 2000. Also, further discussions on the use of IMR in censored demand functions can be found in Cheng and Capps 1988; Heien and Wessels (1990), Heien and Durham (1991), and Byrne et al. 1996.

The above review of literature seems to point to the fact that the use of the dual approach is appropriate in modeling both the aquaculture and capture fisheries supply response. This approach is followed in this study.

The normalized quadratic profit function, often applied to joint agricultural production (e.g., Shumway et al. 1987; and Ball et al. 1997) is used to derive the output supply and input demand equations for the estimation of the fish supply response in Asia. Given the netput vector (where positive and negative netputs denote quantities of outputs and inputs, respectively), the researchers arbitrarily select an element as a numeraire good and denote its price as Pnum and its quantity as Qnum. Let i, j ∈ A and k, l ∈ V, where A denotes a set of non-numeraire netputs while V denotes a set of conditioning variables (consisting of fixed inputs and are taken as exogenous). The stochastic specification of the normalized quadratic profit function is represented as:

$$\pi^* = \alpha_0 + \sum_i \alpha_i P_i^* + \sum_k \gamma_{0k} v_k + \frac{1}{2}\sum_i \sum_j \alpha_{ij} P_i^* P_j^* + \sum_i \sum_k \gamma_{ik} P_i^* v_k + \frac{1}{2}\sum_k \sum_l \gamma_{kl} v_k v_l + \sum_i \varepsilon_i P_i^* + \varepsilon \quad \ldots\ldots(1)$$

where π^* is normalized profit, the α's and γ's are parameters of the model, $P_i^* = P_i/Pnum$ is the normalized price of the i^{th} netput with P_i as the producer price, V_k is the k^{th} conditioning variable, and ε is the error term. Applying the envelope theorem, the netput supply QA_i are the price derivatives of the profit function as follows:

$$QA_i = \alpha_{0i} + \sum_j \alpha P_j^* + \sum_k \gamma_{ik} v_k + \varepsilon \quad \ldots\ldots(2)$$

Note that if $QA_i < 0$, then the netput i is an input. Supply response to price changes, expressed in terms of own-price and cross-price elasticities, can be readily computed from (2).

To derive the supply function of the numeraire commodity, multiply the expression in (1) by Pnum to obtain the nominal profit, then differentiate with respect to Pnum to yield:

$$Qnum = \alpha_0 + \sum_k \alpha_{0k} v_k + \frac{1}{2}\sum_i \sum_j \alpha_{ij} P_i^* P_j^* + \frac{1}{2}\sum_k \sum_l \gamma_{kl} v_k v_l + \varepsilon \quad \ldots\ldots(3)$$

The derivation of the supply function from a profit function entails certain restrictions on the former. A profit function is homogenous in terms of prices, and should have equal cross-price derivatives. Therefore, the supply parameters must comply with the homogeneity and symmetry restrictions[5]. In the present specification, the homogeneity restriction has been incorporated by normalization while the symmetry restriction can be implemented by imposing $\alpha_{ij} = \alpha_{ji}$ during the estimation of (2). Note that equation (2) needs to be estimated separately for each fishery production category for all the nine countries using Zellner's Seemingly Unrelated Regression (SUR) technique.

The data used in the supply response estimation come from two main sources. For almost all of the selected DMCs in the study except Indonesia, data from secondary sources such as published statistics and reports from relevant government agencies, official statistical databases, and other published research reports form the backbone of the data set used. In some countries where secondary data are unavailable for some of the model variables, primary data from surveys

[5] A profit function should also satisfy the convexity and monotonicity restrictions. Implementing these restrictions is possible (e.g., Lang 2001), but the procedure is highly technical and is not intuitively appealing.

conducted by researchers were used. The sources of data used in the study are provided in Table 3. It should be noted that in many DMCs where time-series data were used in the estimation of the fish supply response model, sufficient lengths of the data series were unavailable, thereby affecting the degree of freedom in the estimation. In these cases, the time series data were disaggregated by locations or regions in order to construct a data panel with a larger sample size. It should also be noted that the supply estimation faced considerable data constraints, much more so than the demand estimation. In some instances, entire categories were omitted from the statistical estimation process. Where this was unavoidable, elasticities were imputed by modeling convention, i.e., based on literature review and expert judgment.

Appendix 3, Table 2 Summary of Production Data Sources in the Selected Countries

Country / Production System	Primary Source	Secondary Source
Bangladesh		
Inland Capture; Marine/Brackishwater Aquaculture		Fisheries Statistical Yearbook of Bangladesh, Department of Fisheries
Inland/Freshwater Aquaculture	Surveys 1998, 2002, and 2003	
China	Department of Fisheries, China	Chinese Fisheries Statistic Yearbook, Fisheries Bureau; Chinese Price Information Centre Database
India		Handbook on Fisheries Statistics, Ministry of Agriculture; Reports from various states, Fertilizer Statistics, Fertilizer Association of India; Agriculture Prices in India; Government Economic Survey reports
Indonesia	Surveys 2001, 2002	
Malaysia		
Marine Capture		Annual Fisheries Statistics, Department of Fisheries; Consumer Price Index, Department of Statistics; previous research surveys
Aquaculture	Survey 2000	Annual Fisheries Statistics, Department of Fisheries; Consumer Price Index, Department of Statistics
Philippines	Family Income and Expenditure Survey (FIES) 2000	National Statistics Office
Sri Lanka		Reports from Statistical Unit of the Ministry of Fisheries and Aquatic Resources
Thailand		Fisheries Statistics, Department of Fisheries
Vietnam	Survey 2002	

Appendix 3, Table 3 Supply Parameter Estimates by Production System and Fish Type in Nine DMCs

Appendix 3, Table 3.A.1 Supply Parameters for Inland Cultured Fish, Bangladesh

Variable	Major carp (tonne/ha)	Other carp (tonne/ha)	Tilapia (tonne/ha)	Pangas (tonne/ha)	Labour (day/ha)	Stock (No. fglg/ha)	Feed (kg/ha)
Intercept	-304.67	-329.59	-253.36	-4659.7	496.84	74340.5	-5,594.08
Major carp	3.619	4.511**	-0.533	-3.891	-0.466	0.588	3.304
Other carp	4.511**	1.201	2.488*	-4.631***	0.270	0.107	4.886
Tilapia	-0.533	2.488*	4.478***	-0.874	2.317***	0.274*	2.679
Pangas	-3.891	-4.631***	-0.875	6.340***	1.726	-0.258	1.994
Labor	0.470	-0.270	-2.317***	-1.726	-2.377***	0.620	-0.762
Stock	-0.588	-0.107	-0.274*	0.258	0.620	-100.70*	-9.889
Feed	-3.304	-4.886	-2.679	-1.994	-0.762	-9.889	-73.216
Inverse mill ratio	1405.34	1,171.04	583.29	7,940.41	-	-	9,884.36

Appendix 3, Table 3.A.2 Supply Parameters for Inland Captured Fish, Bangladesh

Variable	Carps (tonne/ha)	Live fish (tonne/ha)
Intercept	3,495.923	30.369
Carps	177.680	-30.191
Live fish	-30.191	82.435***

Appendix 3, Table 3.A.3 Supply Parameters for Brackishwater Cultured Shrimp, Bangladesh

Variable	Shrimp (tonne/ha)	Stock (No. fglg/ha)	Feed (kg/ha)	Fertilizer (kg/ha)	Lime (kg/ha)
Intercept	79.195	22,928.460	-69.164	54.629	-0.762
Shrimp	1.902*	24.389	1.493***	-1.149*	0.012
Stock	-24.389	-11,638.600	-51.790	-33.254	0.215
Feed	-1.493***	-51.790	-76.270***	-6.871	-0.333
Fertilizer	1.149**	-33.254	-6.871	-25.841	0.321
Lime	-0.012	0.215	-0.333	0.321	-0.003
Emb. Cost	0.003	1.763***	0.000	0.000	0.000
Bam. Cost	0.006	-4.345*	-0.004	-0.002	0.000
Box	0.001	-0.900	0.005	0.007*	0.000
Inverse mill ratio	-	-	150.840	75.297	-

*** Significant at 1% level, ** significant at 5% level, * significant at 10% level

Appendix 3, Table 3.B.1 Supply Parameter for Marine Captured Fish, Malaysia

Price	Low value fish	High value fish	Low value crustaceans	High value crustaceans	Mollusks	Others
Constant	13,072 (1.277)	66,329 (3.912)*	30,294 (2.949)*	25,670 (2.469)*	61,826 (3.501)*	0.20945E+06 (5.013)*
Low-value fish	10,769 (0.2640)	-5,070 (-0.4521)	-5,844.8 (-1.085)	2,980.3 (1.006)	23,592 (1.815)	-20,089 (-0.1197)
High-value fish	-5,070 (-0.4521)	25,953 (2.219)*	542.09 (0.1001)	-2,228.9 (-0.6605)	-10,256 (-0.7190)	42,934 (0.9009)
Low-value crustaceans	-5,844.8 (-1.085)	542.09 (0.1001)	611.01 (0.1484)	2,468.3 (1.393)	-1,105.8 (-0.1612)	-29,082 (-1.258)
High-value crustaceans	2,980.3 (1.006)	-2,228.9 (-0.6605)	2,468.3 (1.393)	576.34 (0.2969)	-3,523.3 (-0.8205)	47,747 (2.367)*
Mollusks	23,592 (1.815)	-10,256 (-0.7190)	-1,105.8 (-0.1612)	-3,523.3 (-0.8205)	15,981 (0.6995)	-8,165.3 (-0.1502)
Others	-20,089 (-0.1197)	42,934 (0.9009)	-29,082 (-1.258)	47,747 (2.367)*	-8,165.3 (-0.1502)	-0.6872E+07 (-3.821)*
Aggregate catch per unit effort	0.11046E+06 (6.670)*	-32,536 (-0.9993)	-99,810 (-5.060)*	-61,936 (-3.350)*	-48,333 (-1.634)	-0.1839E+06 (-3.333)*

Figures in parentheses are asymptotic t-values, and * denotes significance at 5% level.

Appendix 3, Table 3.B.2 Supply Parameters for Brackishwater Aquaculture Fish, Malaysia

Variable	High-value fish	High-value crustacean	Mollusks	Tilapia	Feed
Constant	389.29 (1.11)	143.40 (0.29)	-975.43 (-0.58)	630.98* (2.30)	0.60 (0.66)
High-value fish price	82.93 (0.919)	-173.59* (-2.10)	38.33 (0.28)	51.94 (0.79)	0.45* (2.40)
High-value crustacean price	-173.59* (-2.10)	168.51 (1.22)	192.92 (1.51)	-187.98* (-2.42)	-0.35 (-1.39)
Mollusks price	38.33 (0.28)	192.92 (1.51)	-311.44 (-1.19)	81.12 (0.81)	-0.19 (-0.69)
Tilapia price	51.94 (0.79)	-187.98* (-2.42)	81.12 (0.81)	54.29 (0.58)	-0.80 (-1.44)
Feed price	0.45* (2.40)	-0.35 (-1.40)	-0.19 (-0.58)	-0.80 (-1.44)	891.63 (1.61)
Area of pond (ha)	0.073 (0.83)	-0.040 (-0.45)	6.21* (7.35)	0.047 (0.77)	-0.0008* (-5.09)
Area of cage (m^2)	0.008* (8.11)	0.007* (7.37)	0.046* (4.71)	-0.0005 (-0.70)	-0.000004* (-2.18)

Figures in parentheses are asymptotic t-values, and * denotes significance at 5% level.

Appendix 3Table 3.B.3 Supply Parameters for Freshwater Aquaculture Fish, Malaysia

Variable	Low-value fish	Tilapia	Feed
Constant	-1,063.3 (-0.31)	-983.31 (-0.40)	85,872 (1.05)
Low-value fish price	-126.03 (-0.16)	780.64 (0.88)	1,013.4 (0.13)
Tilapia price	197.51 (0.15)	-126.03 (-0.16)	2,214.8 (0.19)
Feed price	2214.8 (0.19)	1013.4 (0.13)	-2,34120 (-0.89)
Area of pond (ha)	1.92* (3.42)	0.63 (1.56)	-27.89* (-2.09)
Area of cage (m^2)	0.069* (3.03)	0.036* (2.23)	0.79 (1.47)

Figures in parentheses are asymptotic t-values, and * denotes significance at 5% level.

Appendix 3, Table 3.C.1 Supply Parameters for Municipal Captured Fish, Philippines

Variable	Capture fish	Shells	Oil	Labor
Intercept	-588.9880	55.3633	-25.2633	-15.9876
Price of capture fish	7.4469	6.4895	12.7622	1.2885
Price of shell fish	6.4895	5.7886	1.2885	90.8700*
Price of oil	-12.7622	-4.3290	-3.1642	-42.1828
Price of labor	-4.3290	-90.8700*	-42.1828	20.4137
Urbanity	74.2417	-73.4408	2.2691	92.6463
Education	374.4910**	101.0384**	17.4397**	18.0263
Household size	93.3599	-1.9575	2.3863	4.7135

Note: Parameter estimates for municipal capture fishery using FIES 2000 (NSO)

Appendix 3, Table 3.C.2 Supply Parameters for Aquaculture Fish, Philippines

Variable	Aquaculture fish	Mussel & oyster	Fertilizer	Labor
Intercept	-576.4710	17.1286	-356.1360	17.0901
Price of aquaculture fish	16.8974	-9.6385	-55.1058	2.3261
Price of mussel & oysters	-9.6385	-1.7953	2.3261	-7.5761
Price of fertilizer	55.1058	-20.9878	-4.4905	35.3575
Price of labor	-20.9878	7.5761	35.3575	-7.9811
Urbanity	171.5906	16.9783	-75.8257	1.0331
Education	162.9895**	-2.4655	136.8812**	23.0925**
Household size	86.4690	0.6735	28.2064	-2.7686

Note: Parameter estimates for the aquaculture sector using FIES 2000 (NSO)

Appendix 3, Table 3.D.1 Supply Parameters for Marine Captured Fish, Thailand

Price	Indo-Pacific Mackerel	Shrimp	Squid	Crab	High Value Fish	Low Value Fish	Process	Diesel
Constant	-5508**	1263	-6299***	-928***	-772	-37945***	-4207**	-52050**
Indo-Pacific Mackerel	8.26	13.19	47.64**	-19.15**	-20.97	-17.88	-101.9**	-75.07
Shrimp	13.192	-12.604	1.992	6.105**	0.780	0.413	37.76**	-62.031
Squid	47.65**	1.99	3.16	-7.39	-2.33	-58.94	37.24	-192.2**
Crab	-19.15**	6.105**	-7.39	5.16	-1.47	56.11**	-10.87	66.52**
High-value fish	-20.97	0.78	-2.33	-1.47	12.34	100.0***	-19.44	118.2**
Low-value Fish	-17.88	0.41	-58.94	56.11**	100.04***	386.79	318.4***	-870.08
Process	-101.9**	37.762**	37.241	-10.87	-19.443	318.4***	-255.9***	-69.145
Diesel	75.07	62.03	192.18**	-66.52**	-118.22**	870.09	69.15	-1296.77
Research	-0.08	-0.12	0.05	0.04	-0.01	1.63**	-0.61***	-3.34**
Area	55.92***	63.49***	52.81***	25.30***	18.10***	443.9***	101.4***	-126.60
Year	2.79**	-0.63	3.16***	0.47***	0.40	19.06***	2.14**	27.05**

Note: ** and *** denote significant at 5% and 1% levels, respectively.

Appendix 3, Table 3.D.2 Supply Parameters for Coastal Aquaculture Fish, Thailand

	Shrimp	Mollusks	Shrimp feed	High-value feed	Shrimp fingerling	Mollusks fingerling
Constant	-0.1559***	0.03363*	-0.4017***	0.02445	-10.58***	0.15937
Shrimp	0.9E-5	0.5E-04	-0.6E-04	0.8E-04	-0.021***	0.00106
Fish	0.5E-04	-8.6E-4***	-0.0002	1.4E-04	0.0060	-0.0109**
Shrimp feed	0.6E-04	2.07E-4	0.00025	-0.3E-04	0.2387**	0.053**
High-value feed	-0.8E-04	-0.00014	-0.0047	-6.6E-04	0.11613	0.0402
Shrimp fingerling	0.0217***	-0.00606	0.15287	-0.0067	-6.219	-2.5750
Mollusks fingerling	-0.00106	0.01096**	-3.9227	-0.0891	-599.79**	-17.78
Year	0.8E-04***	-1.7E-05*	0.0002***	-1.2E-5	0.0054***	-0.0001
Research & Development Investment	-5.8E-06**	5.0E-06***	-1.7E-5***	5.0E-6**	-0.0009***	0.9E-04
Rain	-1.5E-07	8.00E-08	-4E-07	3.45E-09	-1E-5	8.0E-06**
Dissolved oxygen	-7E-06	9.4E-5	3.2E-4	0.2E-4	-0.0243**	0.00479*
Dummy	-2.01E-4	-5.84E-4***	-8.8E-4	-5.6E-4***	0.048**	0.0060

Note: ** and *** denote significant at 5% and 1% levels, respectively.

Appendix 3, Table 3.D.3 Supply Parameters for Freshwater Aquaculture Fish, Thailand

	Tilapia	Silver barb	Catfish	Snakehead	Prawn	High-value fish	Low-value fish	Processed	Herbivore feed	Carnivore feed
Constant	-2.127	-26.8***	0.000	-6.797	-0.116	-0.951	25.31***	-4.111	-68.84***	5.029
Tilapia	0.276	-0.33**	0.001	-0.092	-0.06***	0.056**	-0.027	0.044	0.032	0.084
Silver Barb	-0.33**	0.674***	0.000	-0.239*	0.039*	-0.009	-0.059	0.054	0.284	-0.144
Catfish	0.001	0.000	0.000	0.000	0.000***	0.000	0.000	0.002***	0.005	-0.003
Snake Head	-0.092	-0.239*	0.000	0.351***	0.049***	-0.031	-0.041	-0.049	-0.372	0.106
Prawn	-0.06***	0.039*	-3E-4***	0.049***	-0.012	-0.019*	-0.059***	-0.023*	-0.017	-0.044***
High-value fish	0.056**	-0.009	0.000	-0.031	-0.019*	0.026	0.216***	0.062***	-0.035	0.104***
Low-value fish	-0.027	-0.059	0.000	-0.041	-0.059***	0.216***	-0.520***	-0.177***	-0.915***	-0.323**
Processed fish	0.044	0.054	0.002***	-0.049	-0.023*	0.062***	-0.177***	0.069	0.030	-0.077
Herbivore feed	-0.032	-0.284	-0.005	0.372	0.017	0.035	0.915***	-0.030	-6.529	3.733***
Carnivore feed	-0.084	0.144	0.003	-0.106	0.044***	-0.104***	0.323**	0.077	2.587	-1.406**
Year	0.001	0.014***	0.000	0.003	0.000	0.000	-0.013***	0.002	0.035***	-0.002
Region	0.011	0.008	2E-4***	0.019	0.001	-0.030***	0.015	0.021*	-0.025	-0.011
Area	0.000***	0.000***	0.000	0.000*	0.000***	0.000	0.000	0.000	0.000	0.000
Dummy	0.007	0.008	0.000	-0.011	0.020	0.118***	-0.154	-0.031	0.011	0.010

Note: *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

Appendix 3, Table 3.E.1 Supply Parameters for Cultured Carp, Vietnam

	Carp	Seed	Feed	Labor
Constant	897.49	0.16	-1,973.00	193.14
Carp	4.8524*	0.0003	11.01	-3.76
Seed	-0.0003	0.0001	-0.03	0.0007
Feed	-11.01	-0.03	650.62	9.31
Labor	3.76	0.0007	9.31	1.01
Farm area	-1,098.8**	0.05	3,112.17	-207.04
Household size	0.09	0.00	0.072	0.003

Note: * and ** denote significance at 5% and 1% levels, respectively.

Appendix 3, Table 3.E.2 Supply Parameters for Cultured Catfish, Vietnam

	Catfish	Seed	Feed	Labor
Constant	-3,756.59	0.13	-1,791.24	14.75
Catfish	278.80**	-0.0007	14.12	0.70
Seed	0.0007	0.0002	0.005	0.0015
Feed	-14.12*	0.0051	3,820.52	-15.93
Labor	-0.70	0.0015	-15.93	0.57
Household size	0.27	0.00	-0.001	0.0001

Note: * and ** denote significance at 5% and 1% levels, respectively.

Appendix 3, Table 3.E.3 Supply Parameters for Cultured Tilapia, Vietnam

	Tilapia	Seed	Feed	Labor
Constant	-157.39	-0.19	-3,711.28	59.50
Tilapia	11.86*	0.0043	73.72	0.31
Seed	-0.0043	0.0006	0.11	0.0048
Feed	-73.72*	0.11	2,032.52	-7.96
Labor	-0.31	0.0048	-7.96	-1.03
Household size	0.06	0.00	0.018	0.0004

Note: * and ** denote significance at 5% and 1% level,, respectively.

Appendix 3, Table 3.E.4 Supply Parameters for Cultured Shrimp, Vietnam

	Shrimp	Seed	Feed	Labor
Constant	-142.69**	1.52	4,683.74	-35.57
Shrimp	2.88**	-0.002	-6.50	0.06
Seed	0.0023	0.0009	-0.10	0.0001
Feed	6.50*	-0.10	-1,905.51**	13.44
Labor	-0.06	0.0001	13.44	0.26
Household size	-0.01	-0.0001	-0.02	0.0001

Note: * and ** denote significance at 5% and 1% levels, respectively.

Appendix 3, Table 4 Fish Supply and Input Demand Elasticity Estimates by Production System and Fish Type in Nine DMCs

Appendix 3, Table 4.A.1 Elasticities for Inland Cultured Fish, Bangladesh

Price	Major carp	Other carp	Tilapia	Pangas	Labor	Stock	Feed
Major carp	0.275	0.343	-0.041	-0.296	-0.036	0.045	0.251
Other carp	0.002	0.001	0.001	-0.002	0.000	0.000	0.002
Tilapia	-0.003	0.013	0.024	-0.005	0.013	0.002	0.015
Pangas	-0.040	-0.047	-0.009	0.065	0.018	-0.003	0.020
Labor	0.013	-0.008	-0.066	-0.049	-0.067	0.018	-0.022
Stock	-0.041	-0.007	-0.019	0.018	0.043	-6.972	-0.685
Feed	-0.042	-0.062	-0.034	-0.025	-0.010	-0.125	-0.928

Appendix 3, Table 4.A.2 Elasticities for Inland Captured Fish, Bangladesh

Price	Major carp	Live fish
Major carp	0.07	-0.01
Live fish	-0.41	1.12

Appendix 3, Table 4.A.3 Elasticities for Brackishwater Cultured Shrimp, Bangladesh

Price	Shrimp	Stock	Feed	Fertilizer	Lime
Shrimp	0.513	6.576	0.402	-0.310	0.003
Stock	0.000	-0.059	0.000	0.000	0.000
Feed	-0.055	-1.913	-2.817	-0.254	-0.012
Fertilizer	0.049	-1.419	-0.293	-1.102	0.014
Lime	-0.114	2.106	-3.263	3.151	-0.031

Appendix 3, Table 4.B.1 Elasticities for Aquaculture Fish, China

Price	SCCC	GCCC	OFFA	SHRA	OTHA	Feed
SCCC	0.055	0.154	0.003	-0.172	-0.052	0.044
GCCC	0.176	0.044	0.078	-0.126	--0.141	0.029
OFFA	0.006	0.147	0.965	0.349	-1.172	-0.134
SHRA	-0.290	-0.186	0.274	1.882	-1.106	-0.440
OTHA	-0.023	-0.056	-0.246	-0.296	0.393	0.509
Feed	-0.000	-0.000	-0.000	-0.000	-0.000	-0.012

SCCC: silver/common carps; GCCC: grass/crucian carps; OFFA: other aquaculture finfish; SHRA: aquaculture shrimp; OTHA: other aquaculture products; Labor: numeraire

Appendix 3, Table 4.B.2 Elasticities for Captured Fish, China

Price	YC	HT	OFFC	SHRC	OTHC
YC	0.566	0.837	-0.641	1.557	-1.782
HT	0.285	0.518	-0.596	3.556	-3.069
OFFC	-0.138	-0.378	1.465	-1.227	-0.243
SHRC	0.179	1.204	-0.655	4.139	-3.865
OTHC	-0.296	-1.494	-0.187	-5.558	5.268

YC: yellow crocker; HT: hair-tail; OFFC: other finfish; SHRC: shrimp; OTHC: other products

Appendix 3, Table 4.C.1 Elasticities for Aquaculture Fish, India

	Indian major carp	Other freshwater fish	Prawn	Labor	Feed	Fertilizer
Indian major carps	1.560	0.294	-4.032	0.174	0.032	-0.013
Other freshwater fish	0.157	1.716	-0.224	0.254	0.818	0.637
Prawn	-0.645	-0.221	0.727	0.127	0.043	0.171
Wage	-0.046	-0.185	-0.210	-0.746	0.047	0.270
Feed	-0.048	-0.415	-0.417	0.272	-0.872	-0.138
Fertilizer	0.001	-0.088	-0.113	0.107	-0.009	-1.544
Area (ha)	0.731	0.737	0.73	0.717	0.794	0.626

Appendix 3, Table 4.C.2 Elasticities for Marine Captured Fish, India

	Pelagic HV	Pelagic LV	Demersal HV	Demersal LV	Shrimp	Mollusks	Fuel	Labor
Own Price	0.28	0.33	0.45	0.2	0.49	0.28	0.1	0.01
Fuel	-0.06	-0.24	-0.14	-0.37	-0.96	-0.27	-1.1	-0.001
Wage	-0.004	-0.003	-0.01	0.002	0.537	0.576	-0.002	1.08
Coast length (km)	0.44	0.31	0.37	0.53	0.37	0.71	1.08	
Year trend	0.32	0.6	0.03	0.58	1.1	0.28	1.64	

Appendix 3, Table 4.D.1 Elasticities for Marine Captured, Marine Cultured, Inland Captured and Inland Cultured Fish, Indonesia

	Own price elasticity							
	Shrimp	**Tuna**	**Mackerel**	**APF**	**Grouper**	**Snapper**	**Other finfish**	**Fuel**
Marine capture	0.23	0.23	0.03	0.096	0.23	0.23	0.096	0.01

	Grouper	**Fuel**	**Fertilizer**
Marine culture	0.50	0.50	0.50

	Other finfish	**Carp**	**Tilapia**	**Catfish**	**Fuel**
Inland capture	0.098	0.094	0.01	0.0144	0.0100

	Carp	**Tilapia**	**Catfish**	**Fuel**	**Fertilizer**
Inland culture	0.14	0.03	0.004	0.06	0.06

Appendix 3, Table 4.E.1 Elasticities for Marine Captured Fish, Malaysia

	Anchovy	**Low-value fish**	**High-value fish**	**Low-value crustacean**	**High-value crustacean**	**Mollusks**	**Other**
Anchovy	-0.1134	-	-	-	-	-	-
Low-value fish	-	0.1048	-0.0309	-0.1648	0.1101	0.4529	-0.0976
High-value fish	-	-0.1944	0.6234	0.0602	-0.3244	-0.7758	0.8223
Low-value crustacean	-	-0.1371	0.008	0.0415	0.2197	-0.0512	-0.3406
High-value crustacean	-	0.3129	-0.1466	0.7506	0.2297	-0.7297	2.5038
Mollusks	-	0.3341	-0.091	-0.0454	-0.1894	0.4464	-0.0578
Other	-	-0.0189	0.0253	-0.0793	0.1705	-0.0152	-3.2296
Aggregate catch per unit effort	-0.5469	0.3838	-0.0708	-1.0046	-0.8169	0.3313	-0.3193

Elasticities were computed at mean values of variables.

Appendix 3, Table 4.E.2 Elasticities for Brackishwater Aquaculture Fish, Malaysia

	High-value Fish	High-value Crustacean	Mollusks	Tilapia	Feed
High-value fish	1.47	-3.03	0.04	45.41	-3.83
HV Crustacean	-3.31	3.16	0.23	-176.73	3.18
Mollusks	0.60	2.99	-0.30	63.06	1.47
Tilapia	0.85	-3.03	0.08	43.87	6.28
Feed	0.00	0.00	0.00	-0.0006	-6.69

Appendix 3, Table 4.E.3 Elasticities for Freshwater Aquaculture Fish, Malaysia

	Low-value Fish	Tilapia	Feed
Low-value fish	0.13	-0.18	-0.26
Tilapia	-0.05	0.70	-0.07
Feed	0.25	0.26	4.88

Appendix 3, Table 4.F.1 Elasticities for Municipal Captured Fishery, Philippines

Variable	Captured fish	Shell fish	Oil	Labor
Price of captured fish	0.0130	0.0427	1.0013	0.0094
Price of shell fish	0.0236	0.0795	0.2111	1.3869
Price of oil	-0.0067	-0.0086	-0.0747	-0.0928
Price of labor	-0.0218	-1.7324	-9.5935	0.4325

Appendix 3, Table 4.F.2 Elasticities for Aquaculture Fish, Philippines

Variable	Aquaculture fish	Mussel & oyster	Fertilizer	Labor
Price of aquaculture fish	0.1775	-1.3897	-0.7822	0.2525
Price of mussel & oysters	-0.0358	-0.0914	0.0117	-0.2905
Price of fertilizer	0.2662	-1.3919	-0.0293	1.7651
Price of labor	-0.6024	2.9852	1.3715	-2.3672

Appendix 3, Table 4.G.1 Elasticities for Marine Captured Fish, Sri Lanka

	Large pelagic	Small pelagic	Demersal	Other	Fuel	Ice
Large pelagic	0.18	-0.30	0.29	-0.57	-0.02	-0.01
Small pelagic		0.10	-1.14	-0.40	-0.13	-0.01
Demersal			1.18	0.03	-0.05	-0.01
Other				0.72	-0.06	-0.01
Fuel					-0.05	-0.01
Ice						-0.01

Appendix 3, Table 4.G.2 Elasticities for Municipal Captured Fish, Sri Lanka

	Freshwater fish	Ice
Freshwater fish	0.20	-0.01
Ice		-0.05

Appendix 3, Table 4.G.3 Elasticities for Aquaculture Fish, Sri Lanka

	Prawn	Freshwater fish	Feed	Fertilizer	Seed
Prawn	0.40	0.00	0.00	0.00	-0.21
Freshwater fish		0.13	-0.17	-0.12	-0.01
Feed			-0.80	-0.01	-0.01
Fertilizer				-0.80	-0.01
Seed					-0.80

Appendix 3, Table 4.H.1 Elasticities for Marine Captured Fish, Thailand

	Indo-Pacific Mackerel	Shrimp	High-value fish	Low-value fish	Squid	Crab	Processed fish	Fuel
Indo-Pacific Mackerel	0.03	0.05	-0.19	-0.01	0.18	-0.19	-0.30	-0.01
Shrimp	0.17	-0.18	0.03	0.00	0.03	0.22	0.40	-0.03
High-value fish	-0.19	0.01	0.28	0.11	-0.02	-0.04	-0.14	0.05
Low-value fish	-0.03	0.00	0.46	0.08	-0.12	0.28	0.48	-0.07
Squid	0.32	0.01	-0.04	-0.05	0.02	-0.14	0.21	-0.06
Crab	-0.13	0.04	-0.02	0.04	-0.05	0.09	-0.06	0.02
Processed fish	-0.48	0.20	-0.23	0.18	0.19	-0.14	-0.99	-0.01

Appendix 3, Table 4.H.2 Elasticities for Coastal Aquaculture Fish, Thailand

	Shrimp	High-value Mollusks	Low-value Mollusks	Shrimp feed	High-value feed	Shrimp fingerling	High-value fingerling	Low-value Fingerling
Shrimp	0.06	0.53	0.53	-0.21	0.71	-0.8	0.35	0.35
High-value Mollusks	0.04	-1.08	-1.08	-0.08	0.16	0.03	-0.46	-0.46
Low-value Mollusks	0.04	-1.08	-1.08	-0.08	0.16	0.03	-0.46	-0.46
Shrimp feed	0.08	0.37	0.37	0.15	-0.06	1.61	3.23	3.23
High-value feed	-0.01	-0.04	-0.04	-0.38	-0.15	0.11	0.34	0.34
Shrimp fingerling	0.24	-0.10	-0.10	0.82	-0.104	-0.39	-1.46	-1.46
High-value fingerling	-0.0001	0.0018	0.0018	-0.21	0.014	-0.37	-0.10	-0.10
Low -value fingerling	-0.0001	0.0018	0.0018	-0.21	0.014	-0.37	-0.10	-0.10

Appendix 3, Table 4.H.3 Elasticities for Freshwater Aquaculture Fish, Thailand

	Tilapia	Silver barb	Catfish	Snakehead	High-value fish	Low-value fish	Prawn	Processed fish	Carnivore feed	Herbivore feed
Tilapia	0.39	-0.64	1.95	-0.80	0.16	-0.07	-0.69	0.07	0.14	0.02
Silver barb	-0.53	1.50	0.29	-2.40	-0.03	-0.17	0.48	0.10	-0.27	0.16
Catfish	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00	-0.01	0.00
Snakehead	-0.28	-1.02	-1.06	6.72	-0.20	-0.23	1.15	-0.18	0.38	-0.40
High-value fish	-0.61	0.52	-3.09	2.94	-0.39	-1.05	-0.91	-0.26	-0.49	-0.06
Low-value fish	0.13	-0.03	-0.29	-0.44	0.12	0.90	-0.34	0.17	0.27	-0.03
Prawn	-0.03	-0.09	0.27	-0.29	0.51	-1.09	-0.52	-0.24	-0.43	-0.37
Processed fish	0.08	0.13	3.07	-0.53	0.23	-0.57	-0.30	0.14	-0.16	0.02
Carnivore feed	-0.08	0.19	2.78	-0.62	-0.20	0.56	0.32	0.09	-1.54	0.86
Herbivore feed	-0.02	-0.23	-3.58	1.33	0.04	0.97	0.08	-0.02	2.50	-1.33

Appendix 3, Table 4.H.4 Elasticities for Inland Captured Fish, Thailand

	Tilapia	Silver barb	Catfish	Snakehead	High-value fish	Low-value fish	Prawn	Fishing effort
Tilapia	0.26	-0.41	2.76	-1.59	0.10	-0.08	-2.59	0.09
Silver barb	-1.18	0.84	-1.22	-2.97	-0.11	-0.04	3.68	0.11
Catfish	13.36	-2.06	0.47	0.02	-0.03	-0.01	-0.08	0.02
Snakehead	-4.65	-3.04	0.01	2.21	-0.14	-0.07	1.76	0.09
High-value fish	0.11	-0.04	-0.01	-0.05	1.01	0.38	0.00	0.04
Low-value fish	-0.19	-0.03	-0.01	-0.05	0.81	0.04	0.00	0.23
Prawn	-284.84	141.67	-1.71	66.17	-0.01	-0.12	0.28	0.01
Fishing effort	-0.28	-0.11	-0.01	-0.09	-0.10	-0.30	0.00	1.86

Appendix 3, Table 4.I.1 Elasticities for Cultured Carp, Vietnam

	Carp	Seed	Feed	Labor
Carp	0.0575	0.2305	0.0910	-0.0311
Seed	0.0000	0.2280	-0.0009	0.0000
Feed	-0.0212	-4.3998	0.8751	0.0125
Labor	0.0889	1.2059	0.1535	0.0166

Appendix 3, Table 4.I.2 Elasticities for Cultured Catfish, Vietnam

	Catfish	Seed	Feed	Labor
Catfish	2.1623	-0.3814	0.0764	0.0038
Seed	0.0001	1.8767	0.0005	0.0002
Feed	-0.0107	0.2678	2.0232	-0.0084
Labor	-0.0090	1.3366	-0.1433	0.0051

Appendix 3, Table 4.I.3 Elasticities for Cultured Tilapia, Vietnam

	Tilapia	Seed	Feed	Labor
Tilapia	0.0979	2.4582	0.4245	0.0018
Seed	-0.0001	1.5275	0.0028	0.0001
Feed	-0.0495	5.3305	0.9514	-0.0037
Labor	-0.0044	4.6808	-0.0786	-0.0102

Appendix 3, Table 4.I.4 Elasticities for Cultured Shrimp, Vietnam

	Shrimp	Seed	Feed	Labor
Shrimp	0.1457	-8.1281	-0.2292	0.0021
Seed	0.0008	20.8933	-0.0248	0.0000
Feed	0.0034	-3.6960	-0.6927	0.0049
Labor	-0.0009	0.0688	0.1371	0.0027

Appendix 4

Appendix 4, Table 1 Supply and Demand Elasticities by Types of Fish in Nine DMCs

Appendix 4, Table 1.A.1 Supply Elasticities by Types of Fish, Bangladesh

Inland culture	
Indian major carp	0.7
Other carp	0.5
Tilapia	0.6
Pangas	0.6
Brackish culture	
Shrimp	0.8
Inland capture	
Indian major carp	0.4
Live fish	0.7
Hilsha	0.5
Freshwater fish	0.5
Marine capture	
High-value marine fish	0.4
Low-value marine fish	0.3

Appendix 4, Table 1.A.2 Demand Elasticities by Types of Fish, Bangladesh

	Demand elasticities			
	Own price		**Expenditure**	
	Rural	**Urban**	**Rural**	**Urban**
Indian major carp	-1.92	-0.65	1.97	1
Other carp	-3.36	-0.19	1.26	0.6
Tilapia	-1.37	-1.27	1.47	-0.25
Pangas	-1.7	-2.58	2.45	2.09
Live fish	-5.2	-0.55	1.29	1
Hilsha	-2.15	-0.77	2.26	1.06
Freshwater fish	-0.6	-0.75	0.97	0.59
Shrimp	-0.93	-0.49	0.99	0.43
High-value marine fish	-7.3	0.23	2.98	0.84
Dried fish	-1	3.29	2.56	0.83

Appendix 4, Table 1.B.1 Supply Elasticities by Types of Fish, China

Aquaculture	
Carp	0.09
Other finfish aquaculture	0.9
Shrimp	1.42
Other fish aquaculture	0.55
Tilapia	0.4
Capture	
Other finfish capture	0
Shrimp	0
Other capture	0

Appendix 4, Table 1.B.2 Demand Elasticities by Types of Fish, China

	Demand elasticities			
	Own price		**Expenditure**	
	Rural	**Urban**	**Rural**	**Urban**
Carp	-1	-0.3	0.9	1
Other finfish	-0.8	-0.5	1	1.1
Shrimp	-0.2	-0.5	1.3	1.5
Other fish	-1.2	-0.5	1	1.3

Appendix 4, Table 1.C.1 Supply Elasticities by Types of Fish, India

Aquaculture	
Indian major carps	1.56
Other freshwater fish	1.716
Prawn	0.727
Marine capture	
Pelagic high-value fish	0.276
Pelagic low-value fish	0.326
Demersal high-value fish	0.454
Demersal low-value fish	0.203
Shrimp	0.494
Mollusks	0.278

Appendix 4, Table 1.C.2 Demand Elasticities by Types of Fish, India

	Demand elasticities	
	Own price	Expenditure
	India	India
Indian major carps	-0.99	1.62
Other freshwater fish	-0.99	1.62
Prawn/Shrimp	-0.99	1.61
Pelagic high-value fish	-0.99	1.62
Pelagic low-value fish	-1.05	1.62
Demersal high-value fish	-0.95	1.62
Demersal low-value fish	-0.88	1.62
Mollusks	-1	1.66

Appendix 4, Table 1.D.1 Supply Elasticities by Types of Fish, Indonesia

Inland culture	
Carp	0.1449
Tilapia	0.025
Catfish	0.0043
Brackish culture	
Shrimp	0.5
Milkfish	0.5
Marine culture	
Grouper	0.5
Inland capture	
Other finfish	0.0975
Carp	0.09353
Tilapia	0.009353
Catfish	0.01446
Marine capture	
Shrimp	0.23
Tuna	0.23
Mackerel	0.03
Assorted pelagic fish	0.096
Grouper	0.23
Snapper	0.23
Other finfish	0.0964

Appendix 4, Table 1.D.2 Demand Elasticities by Types of Fish, Indonesia

	Demand elasticities			
	Own price		Expenditure	
	Rural	Urban	Rural	Urban
Shrimp	-1.2	-1.06	1.8703	1.4916
Tuna	-1.35	-1.45	1.1241	0.6184
Mackerel	-1.35	-1.75	1.026	1.3914
Assorted pelagic fish	-1.56	-1.46	0.6827	0.5213
Grouper	-1.35	-1.45	1.2879	1.2879
Snapper	-1.35	-1.45	1.2879	1.2879
Other finfish	-0.9	-0.9	0.6521	0.6521
Carp	-0.94	-0.9	0.2624	0.2624
Tilapia	-0.94	-0.9	0.4826	0.4826
Catfish	-0.94	-0.9	0.4826	0.4826
Milkfish	-0.94	-0.9	0.9759	0.9759
Dried	-0.92	-0.9	0.6184	0.6184
High-value pelagic fish	-1.85	-1.3	1.4986	1.4986

Appendix 4, Table 1.E.1 Supply Elasticities by Types of Fish, Malaysia

Purse Seine Anchovy	
Anchovy	-0.1134
Marine capture	
Low-value fish	0.1048
High-value fish	0.6234
Low-value crustacean	0.0415
High-value crustacean	0.2297
Mollusks	0.4464
Others	0.2296
Brackish culture	
High-value fish	1.47
High-value crustacean	3.162
Mollusk	-0.305
Tilapia	0.871
Freshwater	
Low-value fish	0.05
Tilapia	0.1795

Appendix 4, Table 1.E.2 Demand Elasticities by Types of Fish, Malaysia

	Demand elasticities			
	Own price		Expenditure	
	Rural	Urban	Rural	Urban
Tilapia	-1.086	-1.062	0.9915	0.9862
Low-value fish	-1.262	-1.35	1.2583	1.2979
High-value fish	-1.25	-1.39	0.4925	0.6512
Crustacean	-1.341	-1.1	0.5206	0.5835
Mollusk	-1.077	-1.28	0.8327	0.8285
Anchovy	-1.25	-1.089	0.931	0.9214
Others			2.1783	2.1889

Appendix 4, Table 1.F.1 Supply Elasticities by Types of Fish, Philippines

Aquaculture	
Oyster	0.8
Carp	0.4
Catfish	0.6
Milkfish	1
Tilapia	0.8
Shrimp	0.8
Other aquaculture	0.4
Other shell fish	0.4
Commercial	
Grouper	0.6
Tuna	0.6
Anchovy	0.6
Roundscad	0.6
Other shell fish	0.6
Squid	0.6
Shrimp	0.6
Other captured fish	0.6
Municipal	
Tuna	0.1
Grouper	0.1
Anchovy	0.1
Roundscad	0.1
Squid	0.1
Other shell fish	0.1
Shrimp	0.1
Milkfish	0.1
Tilapia	0.1
Carp	0.1
Catfish	0.1
Other captured fish	0.1

Appendix 4, Table 1.F.2 Demand Elasticities by Types of Fish, Philippines

	Demand elasticities			
	Own price		Expenditure	
	Rural	Urban	Rural	Urban
Anchovy	-1.249	-1.343	0.70416	0.58675
Milk fish	-1.761	-1.369	0.43422	0.69664
Roundscad	-1.527	-1.5	0.57417	0.58245
Tilapia	-1.661	-1.493	0.47952	0.59086
Shrimp	-0.953	-0.989	1.84999	1.42926
Squid	-1.33	-1.233	1.48804	1.34615
Shell fish	n/a	n/a	1.46592	1.44338
Others	-1.502	-1.657	1.59681	1.90295
Processed fish	-1.426142857	-1.369142857	0.7979	0.70925

Appendix 4, Table 1.G.1 Supply Elasticities by Types of Fish, Sri Lanka

Aquaculture	
Cultured prawn	0.4
Freshwater fish	0.13
Marine capture	
Large pelagic fish	0.18
Small pelagic fish	0.1
Demersal fish	1.18
Other marine fish	0.72
Municipal	
Freshwater fish	0.2

Appendix 4, Table 1.G.2. Demand Elasticities by Types of Fish, Sri Lanka

	Demand elasticities					
	Own price			Expenditure		
	Rural	Urban	Estate	Rural	Urban	Estate
Large pelagic fish	-0.83	-0.83	-0.83	1	1	1
Small pelagic fish	-0.56	-0.56	-0.56	0.99	0.99	0.99
Demersal fish	-1.01	-1.01	-1.01	1	1	1
Other marine fish	-1.01	-1.01	-1.01	1.01	1.01	1.01
Freshwater fish	-1.06	-1.06	-1.06	0.97	0.97	0.97

Appendix 4, Table 1.H.1 Supply Elasticities by Types of Fish, Thailand

Freshwater aquaculture	
Tilapia	0.39
Silver barb	1.5
Catfish	1.08
Snakehead	1.72
High-value freshwater fish	0.5
Low-value freshwater fish	0.9
Prawn	2
Marine culture	
Shrimp (culture)	3.16
High-value marine	1.08
Low-value marine	0.1
Marine capture	
Indo Pacific mackerel	0.03
Shrimp (capture)	0.23
High-value marine fish	0.28
Low-value marine fish	0.08
Cephalopods	0.02
Inland capture	
Tilapia	0.26
Silver barb	0.84
Catfish	0.47
Snakehead	2.21
High-value freshwater fish	1.01
Low-value freshwater fish	0.04
Prawn	0.28

Appendix 4, Table 1.H.2 Demand Elasticities by Types of Fish, Thailand

	Demand elasticities			
	Own price		**Expenditure**	
	Rural	**Urban**	**Rural**	**Urban**
Tilapia	-0.66	-0.66	0.27	0.27
Silver barb	-0.05	-0.05	0.6	0.6
Catfish	-0.9	-0.9	0.71	0.71
Snakehead	-1.1	-1.1	1.47	1.47
Indo Pacific mackerel	-0.8	-0.8	1.34	0.95
Shrimp	-0.29	-1.5	1.64	1.03
Cephalopods	-0.31	-0.8	0.9	0.9
Processed freshwater fish	-1.02	-0.02	1.31	1.31
Processed captured fish	-0.02	-0.02	1.13	1.13
Prawn	-0.65	-0.65	1.03	1.03
High-value fish	0.31	-0.31	1.37	1.37
Low-value fish			1.03	1.02

Appendix 4, Table 1.I.1 Supply Elasticities by Types of Fish, Vietnam

Freshwater aquaculture	
Tilapia	0.0979
Catfish	1.1623
Other freshwater fish	0.0575
Marine culture	
Shrimp	0.1457
Marine capture	
Mollusk	0.4
Squid	0.4
High-value marine fish	0.4
Low-value marine fish	0.1
Anchovy	0.1

Appendix, 4 Table 1.I.2 Demand Elasticities by Types of Fish, Vietnam

	Demand elasticities			
	Own price		**Expenditure**	
	Rural	**Urban**	**Rural**	**Urban**
Catfish	-0.988	-0.988	0.603	0.603
Shrimp	-2.031	-3.031	0.917	0.917
Tilapia	-1.782	-2.782	0.679	0.679
Mollusk	-1.655	-1.655	1.013	1.013
Squid	-0.514	-0.514	0.923	0.923
Low-value marine fish	-1.185	-1.185	0.451	0.451
High-value marine fish	-0.738	-0.738	0.98	0.98
Anchovy	-0.4	-0.4	0.276	0.276
Other freshwater fish	-0.684	-0.684	0.492	0.492
Processed fish			0.176	0.176

Appendix 5.1

Aquaculture—food and livelihoods for the poor in Asia: A brief overview of the issues

Twelve articles printed in the journal *Aquaculture Economics and Management* volume 9 (issue 1 and 2) January 2005 arose as a result of the research work carried out by the WorldFish Center for the project titled "Strategies and Options for Increasing and Sustaining Fisheries and Aquaculture Production to Benefit Poorer Households in Asia."

The full versions of the papers are available from the publisher Taylor and Francis through the website http://www.uaex.edu/cengle/IAAEM/Management/default.htm.

Dey, Madan M. and Mahfuzuddin Ahmed. 2005. "Aquaculture – Food and Livelihoods for the Poor in Asia: a Brief Overview of the Issues" *Aquaculture Economics & Management* 9(1): 1-10.

Abstract
This article does not have an abstract.

Dey, Madan Mohan, Mohammed A. Rab, Ferdinand J. Paraguas, Ramachandra Bhatta, Md. Ferdous Alam, Sonny Koeshendrajana and Mahfuzuddin Ahmed. 2005. "Status and Economics of Freshwater Aquaculture in Selected Countries of Asia" *Aquaculture Economics & Management* 9(1): 11-37.
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Abstract
The paper discusses the status of freshwater aquaculture, and the productivity and cost effectiveness of alternative technologies in the major fish producing countries in Asia, such as Bangladesh, China India, Indonesia, the Philippines, Thailand and Vietnam. The analysis is based on field survey data collected by the WorldFish Center and its partner research institutes, and supplemented by secondary information. The paper adopts descriptive techniques to compare the performance of each technology across the countries in terms of productivity, cost effectiveness and profitability. Results suggest that freshwater fish farming is generally profitable in Asia. The semi-intensive polyculture and monoculture of omnivorous and herbivorous species like carps and tilapia are likely to be more suitable for adoption by the poor farmers in Asia. Although the return from monoculture of carnivorous species such as prawn, snakehead and walking catfish is higher than that from culture of omnivorous and herbivorous species, it appears too capital intensive to be suitable for adoption by the resource poor farmers. The paper also performs econometric analysis to examine the determinants of fish production under polyculture and feed demand for the same. The results of the production function analysis reveal that further use of farm-based feed after a certain level of application cannot increase productivity as the law of diminishing marginal productivity sets in. Feed use is largely determined by the income and ownership status of the farmer. Provision of institutional credit and more secured access to the waterbodies would help poor farmers adopt appropriate aquaculture technologies.

Dey, Madan Mohan, Ferdinand Javien Paraguas, Nartaya Srichantuk, Yuan Xinhua, Ramachandra Bhatta and Le Thi Chau Dung. 2005. "Technical Efficiency of Freshwater Pond Polyculture Production in Selected Asian Countries: Estimation and Implication" *Aquaculture Economics & Management* 9(1): 39-63.
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Abstract
The research documented in this paper estimated the levels and determinants of farm-level technical efficiencies (TE) in freshwater pond polyculture systems in China, India, Thailand and Vietnam. The levels of country-specific TE were estimated for different production intensity levels by estimating stochastic production frontier functions involving the model for technical inefficiency effects. The results were compared with estimates from past studies of aquaculture TE. It was found that yield, input levels and TE increases in line with intensity levels. TE estimates ranged from 42% among extensive farms in Vietnam to 93% among intensive farms in China. For low intensity farms, increased technical efficiency, and the resulting increased productivity, could be achieved by increasing human capital (through effective and efficient training and extension), provision of basic infrastructure (such as roads), easier access to seed supplies, and security of tenure or a well-defined system of land use rights. Increasing technical efficiency and productivity among intensive farms will result more from the continuous development of new technology and cross-country technology transfer. However, the realization of these potential increases in TE depends on governments in these countries continuing to provide adequate support for freshwater aquaculture development.

Dey, Madan M., Mark Prein, A. B. M. Mahfuzul Haque, Parvin Sultana, Nguyen Cong Dan and Nguyen Van Hao. 2005. "Economic Feasibility of Community-Based Fish Culture in Seasonally Flooded Rice Fields in Bangladesh and Vietnam" *Aquaculture Economics & Management* 9(1): 65-88.
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Abstract
During the rainy season in extensive river floodplains and deltaic lowlands, floods lasting several months render the land unavailable for crop production for several months each year. These waters are considerably underutilized in terms of managed aquatic productivity. This raises the opportunity to enclose parts of these annually occurring floodwater areas to produce a crop of specifically stocked aquatic organisms aside from the naturally occurring 'wild' species that are traditionally fished and are not affected by the culture activity, overall resulting in more high-quality, nutrient-dense food production and enhanced farm income for all stakeholders, notably the poor. The WorldFish Center and its national partners recently tested two systems in a community based management approach in Bangladesh and Vietnam: (i) concurrent rice-fish culture in shallower flooded areas, and (ii) alternating rice and fish culture in the deep-flooded areas. Results indicate that community-based fish culture in rice fields is technically feasible, economically viable and socially acceptable. It can increase fish production to about 600 kg/ha/year in shallow flooded areas and up to 1.5 t/ha/year in deep-flooded areas, without reduction in rice yield and wild fish catch. For the overall system and in the trials conducted, an additional income of US$135 per ha in southern Vietnam, and up to US$437 per ha in Bangladesh were achieved, which is an increase of 20%to 85% over the previous profitability. The communities neighboring the trial sites have been adopting the technologies widely.

Dey, Madan Mohan, Mohammed A. Rab, Ferdinand J. Paraguas, Somying Piumsombun, Ramachandra Bhatta, Md Ferdous Alam and Mahfuzuddin Ahmed. 2005. "Fish Consumption and Food Security: a Disaggregated Analysis by Types of Fish and Classes of Consumers in Selected Asian Countries" *Aquaculture Economics & Management* 9(1): 89-111.
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Abstract
This paper discusses fish consumption and preference patterns for fish species by income groups, and by urban/rural divide in Bangladesh, China, India, Indonesia, the Philippines, Thailand, and Vietnam. The analysis is based on primary data collected by the WorldFish Center and its partner institutes by means of a survey of 5,931 households in the selected countries. The FAO database and other published materials were also used to analyze trends in fish consumption. Freshwater fish species constitute a major share in total per capita fish consumption in most of these countries. Pelagic and demersal marine fish are the main contributor to per capita total fish consumption in the countries with longer coastal boundaries (such as Indonesia, the Philippines and Thailand), and in the coastal regions within each country. Results suggest that fish contributes between 15% and 53% of the total animal protein intake in these countries. Fish consumption varies widely with economic position of the households, in terms of both per capita consumption and type of fish species. Per capita fish consumption increases with increase in income. The share of fish protein in total animal protein expenditure is higher for lower income groups, demonstrating their dependence on fish as a source of animal protein. Poor people consume mostly low-price fish and rich people spend a significant portion of their fish budget on expensive fish. Per capita fish consumption is substantially higher in rural areas than in urban areas.

Dey, Madan M., Roehlano M. Briones and Mahfuzzudin Ahmed. 2005. "Disaggregated Analysis of Fish Demand, and Trade in Asia: Baseline Model and Estimation Strategy" *Aquaculture Economics & Management* 9(1): 113-139.
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Abstract
Quantitative modeling of fish supply, demand and trade is a useful tool for analyzing recent structural changes, such as the rapid development of aquaculture. Existing models are, however, limited by their use of highly aggregated fish categories and assumed (rather than estimated) elasticities. This paper outlines an estimation strategy and a multiproduct equilibrium model for disaggregated analysis of fish supply, demand, and trade. The model is composed of a producer, consumer and trade core, and is specified to accommodate special features of the fish sector. The estimation and modeling strategy also address common data problems, such as heterogeneity of fish types, diversity of production categories, and so forth. The model has been applied to nine major fish producers in developing Asia.

Garcia, Yolanda T., Madan Mohan Dey and Sheryl Ma M. Navarez. 2005. "Demand for Fish in the Philippines: a Disaggregated Analysis" *Aquaculture Economics & Management* 9(1): 141-168.

Abstract
This paper sought to establish the fish consumption pattern of Filipino households and estimate the price and income elasticities of fish demand by species, as well as by income groups, i.e., low, middle, and high income. The study used the countrywide Family Income and Expenditure Survey (FIES) for year 2000 of the National Statistics Office, which includes over 39,000 households. A three-stage budgeting framework was used in the analysis, which estimated food and fish expenditure functions in the first and second stages, respectively. In the third stage, a system of demand equations for fish by species was estimated using a quadratic almost ideal demand system (QUAIDS) model. Parameter estimates of the model were corrected through the Heckman procedure to remove the possible bias brought about by zero consumption of certain fish species resulting from nonpreference or infrequent purchases. Results showed that estimated price and income elasticities of demand varied substantially across fish type and across income groups. All 11 fish types included in the study were found to have positive income elasticity for all income levels. Hence, fish in general can be considered normal goods, including processed fish. However, the high-priced fish types generated elasticity values greater than one, which rendered them as luxury food fish. Own-price elasticity, on the other hand, was found to be elastic in most species with values increasing as consumers climbed up the income ladder. This observation, however, was not true in the case of milkfish and tilapia (two most popular species in the country) where price responsiveness of demand was found to be higher among the lower-income groups.

Rodriguez, U-Primo E., Yolanda T. Garcia and Sheryl M. Navarez. 2005. "The Effects of Export Prices on the Demand and Supply for Fish in the Philippines" *Aquaculture Economics & Management* 9(1): 169-194.

Abstract
This paper describes the effects of changes in export prices on Philippine fish demand, supply, prices and trade. The analysis uses a multi-commodity-model of the fisheries sector that is based on the AsiaFish model. The results indicate that higher export prices lead to higher output and exports for the fisheries sector. However, such changes also cause a decline in the domestic consumption of fish.

Li, Luping and Jikun Huang. 2005. "China's Accession to the WTO and Its Implications for the Fishery and Aquaculture Sector" *Aquaculture Economics & Management* 9(1): 195-215.

Abstract
This paper reviews recent developments in China's fishery and aquaculture sectors, as well as the policies affecting rural households in general and fisheries households in particular. It explores how China's policies may change as a result of the nation joining the World Trade Organization (WTO) in December 2001 and the likely impacts of these changes on China's fishery and aquaculture sector. It was found that the domestic fish markets are gradually integrating, suggesting that fish price shifts in one area will affect prices in most parts of the country. It was also found that, compared with the prices of other agricultural commodities, the domestic prices of most aquatic products are well below world prices. This suggests that exports of aquatic products would be able to expand now that the nation has joined the WTO and that fishers would gain from this move.

Dey, Madan M., M. A. Rab, K. M. Jahan, A. Nisapa, A. Kumar and M. Ahmed. 2005. "Food Safety Standards and Regulatory Measures: Implications for Selected Fish Exporting Asian Countries" *Aquaculture Economics & Management* 9(1): 217-236.
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Abstract
Developing Asian countries continue to record an impressive trade surplus in fish products. However, raising consumer concerns about a range of food safety matters and increasingly stringent regulatory standards related to fish product supply pose on-going challenges to the sustained international market access of many developing country suppliers. This paper provides an overview of emerging trade patterns in fish products and the trade regime in which this is occurring. It then reviews the implementation of various food safety standards on fish and seafood exports in the major fish-exporting countries in Asia, and analyzes the costs and benefits of compliance with these standards and regulations in these countries. Results show that, at the factory level, implementation of the standards has significantly increased the cost of processing, and the cost per unit of fish processed is higher for the smaller plants. These economies of scale could exclude small operators in developing countries. Continued competitiveness of small plants would seem to require government policies and support designed to minimize the cost of compliance with international standards.

Katiha, Pradeep K., J. K. Jena, N. G. K. Pillai, Chinmoy Chakraborty and M. M. Dey. 2005. "Inland Aquaculture in India: Past Trend, Present Status and Future Prospects" *Aquaculture Economics & Management* 9(1): 237-264.
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Abstract
In India, inland aquaculture has emerged as a fast-growing enterprise and a viable alternative to the declining capture fisheries. The present paper is an attempt to assess Indian inland aquaculture with respect to its resource base, output trends, systems and activities, yield gaps, adoption and impact on aquaculturists, economics, returns to inputs, investment needs, and future prospects. The paper is largely based on existing literature and observations made as part of an ICAR-WorldFish demand supply project. Indian aquaculture is primarily limited to inland sector and carp-oriented; for that reason, this activity received special attention. Freshwater aquaculture observed tremendous growth in the past 15 years, but immense scope still exists for horizontal expansion and increases in productivity (vertical expansion). This is evidenced by the fact that the average farm fish yield is only one-third of that achieved in farm trials. The difference was mainly due to much higher input use in on-farm trials. Most of the aquaculturists were practicing extensive aquaculture, but aquaculturists with semi-intensive operations benefited most from adoption of technology. The benefit:cost ratios for different systems of aquaculture varied between 1.22 to 1.86. The return to capital was much higher than the return to labor, due to the low labor input. The semi-intensive aquaculture system would receive the greatest return from projected macrolevel investments, followed by extensive and intensive systems. Dedicated efforts are needed to meet the demand for quality fish seed and feed in order to achieve the desired 45% increase in area and greater than 50% increase in productivity. Based on the observations, activities designed to foster inland aquacultural development in India are recommended.

Piumsombun, S., M. A. Rab, M. M. Dey, and M. Srichantuk. 2005. "The Farming Practices and Economics of Aquaculture in Thailand" *Aquaculture Economics & Management* 9(1): 265-287.
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Abstract
The paper reviews freshwater and coastal aquaculture practices in Thailand, and compares the productivity, costs, and benefits across various types of cultivation and various intensities of production. The paper is based on data that were collected in surveys conducted during 1998-2001 by the Department of Fisheries (DOF), Thailand and the WorldFish Center. More than 22% of Thailand's fish supply comes from aquaculture, with coastal aquaculture accounting for more than 88% of this in terms of value. Intensive culture of shrimp is the dominant form of coastal aquaculture, occupying 69% of the area under production. However, in some regions, the average net profit/kg of intensive shrimp culture is negative, and semi-intensive farming, with relatively lower fixed investment and operating costs, delivers the highest rate of return on investment. On the coast, grouper and sea bass are the most important cage-cultivated species, achieving an economic rate of return as high as 92%. In the same environment, culture of mollusks, such as green mussels, oysters, and blood cockles, is widespread. It can also be economically sustainable, with relatively low capital and operating costs. Although the relative share of freshwater aquaculture production is declining, the level of output has been increasing rapidly. While the average production from monoculture of carnivorous species is higher than that from polyculture, the average capital investment and operating costs associated with the former are also higher. The expansion of freshwater polyculture and of mollusk culture in coastal areas would greatly assist poor fish farmers.