PLANNING THE USE OF FISH FOR FOOD SECURITY IN SOLOMON ISLANDS

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Cover photo: Tuna on sale at a fish market in Gizo, Solomon Islands. CTSP is working with fishermen and local communities to ensure the sustainability of fish stocks and related livelihoods.

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ABBREVIATIONS AND ACRONYMS

ADB	Asia Development Bank
CTI	Coral Triangle Initiative
CTSP	Coral Triangle Support Partnership
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GEF	Global Environment Facility
HIES	Household Income and Expenditure Survey
NGO	Non-Government Organization
RPOA	Regional Plan of Action
USAID	United States Agency for International Development
WCPFC	Western and central Pacific Fisheries Commission
WHO	World Health Organization
WQFA	World Fish Qualitative Assessment

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EXECUTIVE SUMMARY

This study provides an insight into the changing demand for fish in the Solomon Islands over the next 20 years. It supports US CTI Indicator 3 — "*Number of policies, laws, agreements, or regulations promoting sustainable natural resource management and conservation that are implemented as a result of USG assistance*".[1]

The study's findings will help to inform the development and implementation of suitable policies, capacities, and alternative livelihoods to accommodate the projected growth in fish demand. It aims to identify where future imbalances may occur between fish supply and demand in Solomon Islands, as well as opportunities to address these imbalances in ways that are resilient to natural disasters, social and political instability, and the uncertainties of climate change.

Currently, nearshore subsistence fishing meets 60 percent of consumption needs, with fish accounting for about 94 percent of consumed animal protein in Solomon Islands. The nation is a net exporter of fish, and the country generated almost US$ 28.0 million in fish export revenues in 2005, principally from tuna. Aquaculture is not a traditional practice in Solomon Islands due to the highly productive reefs.

The AsiaFish model was applied to generate possible future scenarios for fish supply and demand in Solomon Islands during the period 2010 to 2030. Past and future drivers of change affecting the role of fish for food security were identified through expert elicitation, and used to establish a range of scenarios for future fish production and demand in Solomon Islands.

The model projects that fishery outputs, exports, and consumption will grow slowly over the next 20 years. Current consumption levels of fish are already below estimated minimum nutritional requirements. Fish consumption is not expected to keep pace with population growth, leading to a decline in per capita consumption of fish.

This publication presents the following recommendations for enhancing the use for fish for food security in Solomon Islands: 1) it is essential for the government to invest in measures to enhance the productivity of the domestic fisheries sector; 2) aquaculture should be promoted as a source of fish for food and potential export revenues; 3) it may be important to explore other potential sources of animal protein; 4) it will be important for the government to ensure a healthy macroeconomic environment, as lower income growth tends to reduce fish consumption and output.

[1] See Appendix IV for the US CTI Results Framework

1. INTRODUCTION

Fishing and farming of aquatic resources are a vital part of rural livelihoods within the Coral Triangle region, and are at the core of subsistence and market-oriented economies. The Coral Triangle encompasses six archipelago nations — Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands, and Timor-Leste — whose coastal areas are inhabited by an estimated 150 million people (Hoegh-Guldberg *et al.* 2009). Fish availability has a significant impact on livelihoods and human wellbeing throughout the region via dietary protein intake; contribution to household incomes; value addition along fish supply chains; and the generation of economic growth, as indicated by contributions to gross domestic product (GDP), foreign exchange earnings, and government tax income. However, sustainable harvesting of fish resources is not only an important livelihood and economic concern, but also interacts critically with threats to the overall health of marine ecosystems in a region endowed with high biodiversity.

The Coral Triangle's 132,000 km coastline harbors 76 percent of the world's reef-building coral species, 37 percent of coral reef fish species and 50 percent of the global supply of tuna (Hoegh-Guldberg *et al.* 2009). This rich biodiversity is threatened by unsustainable fishing practices, sedimentation, and water pollution from coastal development, as well as by the impacts of climate change, including elevated water temperatures, sea level rise, coral bleaching, and ocean acidification.

An estimated 2 million artisanal fishers depend on the region's coastal reefs and mangroves for subsistence and income. Commercial fisheries provide US$ 3 billion annually to the six Coral Triangle nations (Hoegh-Guldberg *et al.* 2009). High dependence on the fisheries sector, combined with unequal income distribution, market and institutional constraints, rapid population growth, and environmental degradation, accentuate the need for improved policy and planning to maintain the vital role of fisheries in providing future food security for the Coral Triangle nations.

Fishing in Asia and the Pacific region experienced unprecedented growth during the second half of the twentieth century due to capacity increases, technological modernization of vessels, expansion of trawl fisheries, and a global shift in fishing effort from temperate to tropical zones. The Asia and Pacific region is now one of the most heavily fished in the world (Lymer *et al.* 2008). Evidence of over-exploitation is increasingly apparent, including vessels remaining in port due to reduced fishing opportunities, declining quality of catch, and conflicts between industrial and small-scale sectors (Lymer *et al.* 2008). These trends threaten food security, as well as the employment and income opportunities that fishing provides. At the same time, high population densities and growth rates in coastal areas will result in even greater demand for fish in the future.

The critical role of fisheries is recognized by the Coral Triangle Initiative (CTI), a multilateral collaboration established in 2009 between the six nations. This partnership aims to address threats to the marine, coastal and all island ecosystems within the Coral Triangle region, through accelerated and collaborative action, taking into consideration multi-stakeholder participation in all six Coral Triangle nations. Supported by international partners—including the Asian Development Bank (ADB), Global Environment Facility (GEF), and the United States Agency for International Development (USAID)—the CTI aims to adopt a Regional Plan of Action (RPOA) to conserve and sustainably manage coastal and marine resources within the Coral Triangle region.

This study addresses Target 2 of Goal 2 of the RPOA that proposes a new collaborative Sustainable Coastal Fisheries and Poverty Reduction Initiative (COASTFISH) designed to apply an ecosystem-based fisheries management approach to improve the incomes, livelihoods, and food security for millions of people living in targeted coastal communities by 2020.

This study provides an insight into the changing demand for fish in Solomon Islands over the next 20 years. The results establish a framework for the future development of the COASTFISH initiative, and will help to inform the development and implementation of suitable policies, capacities, and alternative livelihoods to accommodate the projected growth in fish demand. This study also supports the target of developing COASTFISH investment plans for each country that defines and costs a set of strategic activities identified through a range of studies, including on fisheries status, enterprise, industry growth, and market analysis. The Coral Triangle nations have developed, or are in the process of revising, National Plans of Action within the context of a broader Regional Plan of Action. This study identifies supply and demand trends within the fisheries sector of the Solomon Islands, as well as potential drivers of change, that are highly relevant to meeting a number of CTI targets. CTI's success at promoting evidence-based decision-making within an enabling regulatory framework and policy environment is critical if fish are to continue making a significant contribution to food security in this region for the foreseeable future.

Fish production and consumption are relatively high among Solomon Island's population of 520,000 people (SPC 2008). Human settlements are distributed throughout the country's 990 islands, and distances between them are substantial. Markets and infrastructure are restricted due to the absence of economies of scale. Nearshore subsistence fishing meets 60 percent of consumption needs (Bell *et al.* 2009). Foreign fleets, on the other hand, dominate commercial deep-sea fishing, with catches primarily targeted for export. Fish remains the major source of animal protein and micronutrients for the population. Income from fish and other marine products sold primarily in local markets also provide indirect benefits, generating revenues to purchase other foods, goods, and services. Bell *et al.* (2009) argue that this high dependence on fish should not be interpreted as a lack of development, but rather as an indication of "subsistence affluence".

While many Pacific nations are expected to meet the national requirements of fish for food security, Papua New Guinea and Solomon Islands are considered exceptions (Bell *et al.* 2009). Contributing factors include population growth and development, travel time to and from fishing grounds, fishing access rights, as well as external factors such as fuel prices (Bell *et al.* 2009). Other factors, including the impact of climate change on stocks and fishing grounds, may also have a significant influence. To support planning for food security by the national government, it is vital that the precise factors influencing fish supply and demand in Solomon Islands are better understood.

This study aims to identify where future imbalances may occur between fish supply and demand in Solomon Islands, as well as opportunities to address these imbalances in ways that are resilient to natural disasters, social and political instability, and the uncertainties of climate change. The expert elicitation process conducted as part of this study revealed that governance as well as institutional and policy measures that bring about changes in fisheries management at local, national, and regional levels will play an important role in ensuring continued and equitable access to fish for food security in Solomon Islands.

1.1 Objectives of the study

The primary objectives of this study are to:

- Forecast the quantity of fish catch required by Solomon Islands in 2030 to (a) meet World Health Organization (WHO) recommended per capita fish consumption and (b) maintain current consumption, disaggregated by urban and rural groups.[2]

- Analyze scenarios for future fish supply and demand in Solomon Islands, disaggregated by major fish categories and production systems, and considering impacts of trade and price elasticities.

- Identify major policy options for addressing the likely dietary "fish gap" for rural and urban consumers, and options for managing demand and reducing pressure on highly-biodiverse coastal resource systems that are threatened by over-exploitation.

- Enable science-based fisheries management, coastal conservation, and food security policies that are based on robust statistical models and enhance the pro-poor benefits of these policies.

- Contribute to the government of Solomon Islands' CTI National Plan of Action, specifically to enhance strategic actions under the COASTFISH investment plan.

This study addresses the question of how much fish will be needed to meet demand in Solomon Islands over the next 20 years, as well as the projected capacity of the country to satisfy this demand given current resources, effort, and capacity. This information is a critical step towards developing policies that will enable the national government to plan to meet increased demand for fish through:

- more productive yet ecologically sustainable coastal fisheries;

- increased production from sustainable aquaculture; or

- the development of alternative (non-fish) sources of protein.

It is imperative that trade-offs between these alternative strategies are considered during the development and establishment of fisheries strategies in Solomon Islands.

[2] The original intention of the study was to disaggregate fish consumption by fish category and income/ expenditure groups. However, the data from the Household Income and Expenditure Survey (HIES) 2005/06 of the Solomon Islands National Statistical Office were not available in an appropriate form for the modeling required by this study.

2. METHODOLOY

2.1 Conceptual approach

This study applies the AsiaFish model (Dey *et al.* 2004) to generate possible future scenarios for fish supply and demand in Solomon Islands during the period 2010 to 2030. The AsiaFish model is a tool for evaluating the impacts of policies and exogenous shocks in the fisheries sector of an economy. It is a multi-market model that captures the interaction of producers, consumers, and foreign agents, and is capable of generating disaggregated results for fish production, consumption, prices, and trade. The model was initially developed for nine countries in Asia: Bangladesh, China, India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, and Vietnam. It has also been used extensively to analyze the impacts of changes in productivity, fishing effort, incomes, urbanization, export prices, and trade policy (Dey *et al.* 2008, 2007, 2005; Briones 2007; Rodriguez and Garcia 2008; Rodriguez *et al.* 2005).

In the current application to Solomon Islands, the model focused on potential patterns in fish harvest, consumption, and trade in the country. The study also extends the model to account for the possible trends in fish consumption of rural and urban population groups. The model is used to evaluate various scenarios that account for trade demands in five major commodity groups (four different types of tuna and “other fish”, which includes both reef fish and invertebrates), categorized according to the data currently available. Further disaggregation was not possible due to the current categorization of fish products in national statistics, as well as the small scale of some commodity groups that were not conducive to robust modeling.

The model is based on an empirical analysis of current rates of supply and demand for fish derived from published data and available national-level datasets, the pressure this puts on coastal resource systems (status of fish stocks, reefs, and environmental demands of aquaculture) and projections of future demand based on the number of people consuming fish in rural and urban areas. The empirical analysis was supported by an exploratory qualitative assessment (hereafter referred to as the WorldFish Qualitative Assessment, WFQA 2010) to address gaps in national data, such as issues of gender and fisheries-related livelihoods, the role of fish in food security at the household level and fish consumption preferences, based on a well-being approach (Weeratunge *et al.* forthcoming).

2.2 Methods

The methods used in the study include:

1. A review of published literature and grey literature (including technical reports, policy papers, position statement, etc), as well as analysis of available national datasets that quantify fisheries and aquaculture production (Ministry of Fisheries and Aquatic Resources; Household Income and Expenditure Survey of Solomon Islands Statistics Office); import and export statistics; household expenditure on fish; food balance data; and data on dietary preferences, employment, livelihoods, and gender issues.

2. Expert elicitation of past and future drivers of change affecting the role of fish for food security in the context of socio-economic, political, and ecological changes within the country conducted using a strategic tool for scenario building. Twelve experts from

government, research institutions, regional organizations, and NGOs in Solomon Islands responded to an e-mail survey, based on a structured questionnaire with several open-ended questions. Their responses were part of the scenario analysis process based on the QUESTFISH approach (Badjeck *et al.* 2010a, 2010b). Expert proposals to improve access to fish for food security in light of these trends and drivers were taken into account in the recommendations.

3. Econometric modeling, following the AsiaFish model approach and structure, was used to disaggregate demand by fish category and wealth group, interacting with demographic projections, poverty trends, trends in regional and global trade, and projected changes in diets and prices to evaluate likely future supply and demand in Solomon Islands.

4. A qualitative assessment (WFQA 2010) was conducted to provide insights into gaps in national level data. The qualitative assessment used an indicative sample (38 respondents) of households (with different livelihood portfolios) and consumers in two villages in the Western Province, as well as Gizo and Honiara towns during a 10-day study visit to Solomon Islands in March 2010. This provided an exploratory, preliminary analysis of the role of fisheries in rural livelihoods and food security; local trade and market linkages; the gender division of labor within the livelihood system; and gendered fish consumption preferences.

The study was carried out in collaboration with national agencies within the Solomon Islands, particularly the Ministry of Fisheries and Marine Resources and the Solomon Islands National Statistics Office.

The remainder of this report is organized as follows:

Section 3 provides an overview of the fisheries sector in Solomon Islands. It contextualizes fisheries production within the predominantly subsistence-oriented livelihood system of rural households, and discusses trends in the production, consumption, and international trade of fish in the country.

Section 4 describes the structure, dataset, and key assumptions of the econometric model.

Section 5 discusses the methods and results of the scenario analysis based on expert elicitation.

Section 6 presents the results of simulating future outcomes for fisheries supply and demand for a number of scenarios derived from the expert elicitation.

Section 7 presents the policy implications of the study and provides recommendations.

3. OVERVIEW OF FISHERIES IN SOLOMON ISLANDS

Solomon Islands is characterized by a dual economy with a subsistence rural sector, and a cash sector dependent on primary export commodities such as timber, tuna, copra[3], and cocoa (JICA 2010). The overall GDP growth rates for 2007 and 2008 were 10 percent and 6.4 percent respectively, reversing the negative trend of (-) 14.3 percent in 2000 following ethnic tensions during the 1990s. Around 75 percent of the labor force in the country is engaged in an agricultural sector that contributed slightly more than 30 percent to GDP between 2000 and 2007. While the economy appears to be undergoing a transformation process with an emphasis on cash (JICA 2010), the downturn in growth that accompanied recent ethnic tensions has shifted a considerable sector of the population back into subsistence. The poverty rate, according to the Headcount Index, was estimated at 22.7 percent for the country as a whole, ranging from 13.6 percent in provincial urban areas, 18.8 percent in rural areas and 32.2 percent in Honiara (UNDP 2008). However, food poverty was lower at 10.6 percent nationally, ranging from 0.8 percent in provincial urban areas, 2.6 percent in Honiara to 8.7 percent in rural areas (UNDP 2008). Poverty also varied by province with the highest proportion of poor households and population found in Choiseul, Malaita, Makira, and Temotu (UNDP 2008).

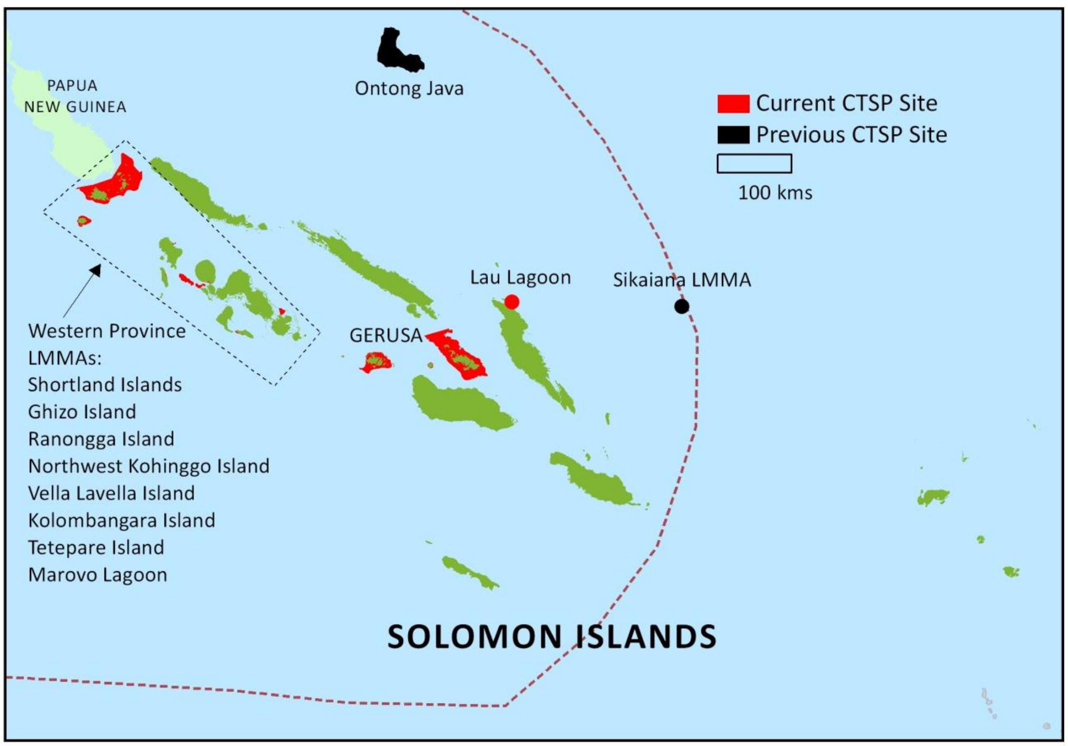

Figure 1: Map of Solomon Islands (Source: CTSP/The Nature Conservancy, 2010).

[3] Copra is the dried meat, or kernel, of the coconut. Coconut oil is traditionally extracted by grating or grinding copra, then boiling it in water. Nowadays, the process of coconut oil extraction is done by crushing copra to produce coconut oil (70 percent); the by-product is known as copra cake or copra meal (30 percent).

Solomon Islands' half a million inhabitants are heavily dependent on fishing. At the macro level, fisheries value added contributed about 7.3 percent of GDP from 2003 to 2006 (SI-NSO 2008). Fisheries are also a valuable source of foreign exchange. Information from the World Trade Organization (2009) suggested that fishery products accounted for 19.4 percent of the total export revenues of the country from 2000 to 2007. Apart from its contribution to output and foreign exchange earnings, fish and fish products are also important food sources for the population. The most recent Household Income and Expenditure Survey (HIES) (SI-NSO, 2006) indicated that fish (including shellfish and canned fish) accounted for about 14.5 percent of household food expenditure. This equates to approximately 73.5 percent of total expenditures on meat.[4]

3.1 Gender and fisheries-related livelihoods

With its high contribution to GDP, fisheries are a vital employment sector in the country. In 1999 an estimated 3,367 people were engaged in paid work in the fisheries sector, amounting to 12.1 percent of total paid employment in Solomon Islands. Of these paid employees, 12.8 percent were women (SI-NSO 1999); however, this figure does not include post-harvesting activities such as fish processing and trading, in which substantial numbers of women are engaged. While disaggregated data for the fishing sector is not available, 65 percent of paid employment in the retail trade outside stores (i.e., in open markets) is carried out by women (SI-NSO 1999). However, it is significant that two-thirds of the adult population and three-quarters of women in Solomon Islands do not participate in any formal, paid employment (AUSAID 2008). Consequently formal statistics conceal the critical importance of subsistence fisheries, with approximately 83 percent of households engaged in some form of fishing activity in 2004 (Gillet 2009).

Available estimates reveal that 50 percent of all women and 90 percent of all men in Solomon Islands participate in small-scale fishing activities (Gillet 2009). Defining part-time and full-time fishing, as well as the boundary between the two, is difficult given the absence of informal economic activities in labor force surveys. Rural communities account for 84 percent of the total population of Solomon Islands (SPC 2008). The majority of households have at least one member who fishes for household consumption and/or supplementary income, depending on day-to-day needs (Gillet 2009). Thus engagement in fishing needs to be contextualized within the broader livelihood system of the country.

The rural livelihood system in Solomon Islands consists of two core components that provide essential food — gardening and fishing — combined with activities that provide cash incomes such as copra production, logging, carving, weaving, shell money[5] production and state or private sector employment. The qualitative assessment indicated that rural households in the two study villages of the Western Province are self-sufficient in staple crops such as cassava, sweet potatoes, yams, and bananas (WFQA 2010). This is also confirmed by a study by Aswani and Furusawa (2007) in five villages in the Western Province where 79-100 percent of respondents indicated that they had sufficient food to eat every day. The contribution of fish to the diet is in part dependent on the number of days a week that the household engages in fishing, and the availability of fish. For example, households in a village located close to a productive reef in the Western Province spent twice as

[4] Meat refers to consumption of meat and meat products, poultry and fish (including shellfish).

[5] Shell money is a traditional currency used as bride wealth, compensation, and for trading purposes in Melanesian societies. It is exchanged in the form of bead necklaces and mostly used now for ritual purposes and ornamentation. The main production center for shell money in Solomon Islands is the Province of Malaita.

many days and times-per-day fishing than households with less access to reef resources, e.g., those close to a smaller reef (WFQA 2010). Gardening is predominantly a women's activity but is supported by male household members in coastal communities in the Western Province (Schwarz *et al.* 2007, Prange *et al.* 2009, WFQA 2010). However, women are estimated to spend three times as much time as men in gardening, and women's work is considered informal (JICA 2010). Around 71 percent of women and 51 percent of men are engaged in subsistence agriculture overall in Solomon Islands (SI-NSO 2007).

Fishing, on the other hand, is a predominantly male activity (90 percent of men) with at least one female household member (50 percent of women) engaged in fishing (JICA 2010). However, there can be significant variations among provinces and villages (Ramofafia *et al.* 2007, Prange *et al.* 2009; Boso and Schwarz 2009). Women are engaged in trading of garden and fish products, including cooked food, as well as weaving, production of shell money, and employment in industrial fish processing plants. In the main fish canning factory in Noro, 80 percent of the 500 workers are women (NZAID 2009). In many fishing communities men are involved in logging, fish trading, and stone and wood carving as well as other employment such as running small businesses (such as grocery stores, fuel depots, copra mills) and pastors. Home-based tasks, such as household chores, child care, gathering firewood and fetching water are largely women's work while house repair and maintenance, canoe building and repair, and cutting firewood (except firewood collection from mangroves) (Boso and Schwarz 2009), are predominantly male tasks (WFQA 2010).

In rural Solomon Islands the gender division of labor in fisheries is bounded to some extent by space — men fish in the reefs and offshore, while women and children predominantly fish the nearshore zone on reefs close to villages, lagoons, and mangroves. Men are also engaged in diving and spear fishing; women glean for invertebrates and harvest mangrove fruit and seaweed (Weint and Aswani 2006; Schwarz *et al.* 2007; Molea and Vuki 2008; Boso and Schwarz 2009; WFQA 2010). Mariculture activities conducted by both men and women in some Western Province villages include farming giant clams and corals (Prange *et al.* 2009) and both women and men can be engaged in the cultivation of seaweed. In terms of fishing assets, the qualitative assessment in the Western Province showed that men predominate in canoe ownership; however, some women own canoes and others access canoes of kin (WFQA 21010). Both men and women own their fishing lines and hooks, although men tend to own a larger number of lines. Ownership of fishing spears, engines, nets, boats, sails, and diving gear (masks and fins) is largely confined to men. Some women own swimming goggles and use these for gleaning (WFQA 2010).

The pursuit of rural livelihoods is influenced by the institutional and governance context of natural resources on which these livelihoods are dependent. Land tenure is customary in Solomon Islands, with 88 percent of the land owned by tribes. Land is held along the patriline in some villages and the matriline in others (JICA 2010), however women are often only nominal owners even in the case of matrilineal inheritance, with decision-making over land transactions and access exercised by male tribal members (JICA 2010). A Western Province case study illustrated that reef ownership is usually tribal with access provided to both men and women (Prange *et al.* 2009). However, tenure over marine resources and governance systems are complex, in some places dominated by chiefs and "big men," and often with women and youth having little voice in decision-making (Vunisea 2008). Thus, gender relations and disparities play a significant role in fisheries-related rural livelihoods, access to marine and coastal resources, as well as decision-making around resource use.

3.2 Fish catch and production

Fish output in Solomon Islands grew at an average annual rate of 4.8 percent from 1991 to 2006 (Table 1).[6] However, this period was marked by a sharp decline in fish output (approximately 63.4 percent) in 2000, attributed to ethnic tensions beginning in the late 1990s (Pinca *et al.* 2009).[7] Excluding the year 2000 from the analysis suggests that average annual growth over this period would have been a robust 9.4 percent. However, this estimate should also be interpreted with care as the relatively rapid growth of fish catch (15.2 percent p.a.) from 2001 to 2006 represents the partial recovery of the fisheries sector following the events of 2000. The impacts of these events were still felt as late as 2006, when aggregate fish output remained at levels (39,454 metric tons) that were less than three-quarters of 1999 output (53,810 metric tons).

Table 1: Fish catch and production of Solomon Islands, 1991-2006. Source: FAO FishStat.

Item	Capture	Aquaculture[1]	Total
Fish production (mt)			
1999	53,809.6	13.0	53,822.6
2000	19,229.3	15.0	19,244.3
2006	39,354.0	-	39,354.0
Growth of production (%)			
1991-2006	4.8	nc[2]	4.8
1991-2006 (excluding 2000)	9.4	nc[2]	9.4
1991-1999	5.5	12.0	5.5
2001-2006	15.2	nc[2]	15.2

1. Excludes seaweed

2. Aquaculture output was zero as of 2002

Except for seaweed, aquaculture production in Solomon Islands is limited, with some farming of giant clams and corals for the aquarium trade. Aquaculture outputs were reported in the 1980s and 1990s (e.g., *Macrobrachium* and *Penaied* prawn) but production was very low relative to capture fisheries, never exceeding one percent of total fish production. Aquaculture is not a traditional practice in Solomon Islands due to the highly productive reefs (Pinca *et al.* 2009). Perceived constraints to aquaculture development include unstable governance and lack of an aquaculture policy; issues of land tenure and land access; limited technical and business skills; limited access to information and services; limited infrastructure and private investment; and geographical barriers that limit transportation between production centers and markets (SPC 2009). Aquaculture production peaked in 2000-2001 (approx. 15 metric tons), and there has been no production since 2002 except seaweed and small-scale mariculture of corals and clams. Seaweed production also declined sharply following the 2007 tsunami, and has only recently been revived.

From 1990 to 2006, fish harvests in Solomon Islands were dominated by skipjack and yellowfin tuna (Table 2), with these two species accounting for about 71.0 percent of total fish catch. There have been noticeable changes in the distribution of fish in recent years. The clearest indication of this is the decline in the share of skipjack tuna in favor of yellowfin tuna and miscellaneous marine fish.

6 More in-depth discussions of fishing in the Solomon Islands can be found in Gillet (2009) and Pinca et al. (2009).

7 The ethnic tensions of the late 1990s and early 2000s had an impact on many aspects of everyday life and overall development, beyond the fisheries sector. Interested readers may consult MDPAC (2007).

Table 2: Disaggregation of the SI fish catch, 1990-2006, %. Source: FAO FishStat

Species	Species share on total fish catch (%)			
	1990-1999	2000-2005	2006	1990-2006
Tuna				
Skipjack	59.02	46.63	47.15	55.56
Yellowfin	13.44	19.18	26.59	15.45
Big-eye	2.20	3.96	0.63	2.52
Other tuna	0.14	0.48	-	0.21
Marine fishes, not elsewhere included[1]	23.28	28.66	25.41	24.62
Other fish	1.92	1.09	0.21	1.64

1. As classified by FAO

3.3 Trade in fish

Solomon Islands is a net exporter of fish. The country generated almost US$28.0 million in fish export revenues in 2005 (see Table 3). The volume and value of fish exports also grew at robust rates between 1990 and 2005. The slower growth of export value relative to export volume suggests that, on average, prices of fish exports have been declining over time. Fish imports, both in volume and value, grew at a rapid pace over the same period. However, total import volume is currently very small relative to fish exports.

Table 3: Aggregate SI trade in fish, 1990-2005. Source: FAO FishStat

Fish trade	Exports	Imports
Volume (2005, tons)	20,748.0	284.0
Value (2005, US$'000)	27,987.0	496.0
Implicit price (US$'000 /ton)	1.3	1.7
Average growth rate (%, 1991-2005)		
Volume	9.0	75.0
Value	6.7	44.5

The composition of exports reflects the dominance of tuna in the fish catch of the country. In terms of volume and value, fresh and processed tuna accounted for more than 90 percent of total fish exports (see Table 4). While skipjack tuna had the largest share of total exports, the contribution of yellowfin tuna in 2005 was substantially higher compared to 1990-2005.

The composition of imports, in terms of fish species, was more evenly distributed compared to exports. However, the majority of imports — 75.8 percent of total value from 1990 to 2005 — consisted of processed fish. The share of processed fish on total imports for 2005 was also noticeably larger compared to the average for 1990 to 2005 (Table 4).

Table 4: Composition of SI international trade in fish, 1990-2005, %. Source: FAO FishStat

Species	Volume		Value	
	1990-2005	2005	1990-2005	2005
Exports				
Tuna	94.1	94.9	90.4	90.5
Skipjack	0	0	0	0
Frozen	74.5	68.3	44	39.7
prepared or preserved	13.1	3.1	32.7	9.7
Smoked	1.4	0	3.2	0
Yellowfin tuna	0	0	0	0
Frozen	3.1	11.8	2.9	8.9
Other tunas	2	11.7	7.7	32.1
Sea-cucumber, dried, salted or in brine	1	0.7	3.9	2.7
Others	4.9	4.4	5.7	6.8
Total	100	100	100	100
Imports				
Tunas nei*, prepared or preserved	15.8	34.2	18.1	30.8
Fish nei*, prepared or preserved	18.2	-	21.7	-
Mackerels nei*, frozen	18.8	-	9.9	-
Mackerels nei*, prepared or preserved	6.6	16.9	7.1	18.5
Miscel. marine fishes, salted or in brine, nei*	8.4	-	5.9	-
Others	32.2	48.9	37.3	50.6
Total	100.0	100.0	100.0	100.0
Memo: Processed** fish	67.0	91.9	75.8	88.7

* nei = not elsewhere included

** Processed: all except frozen and fresh or chilled categories

The trade in reef fish and larger pelagics within domestic markets remains predominantly local, remaining within islands or transported by dugout canoe or boats with outboard motors to the nearest small urban center, according to the cash needs of households (WFQA 2010). The qualitative assessment revealed that value chains are short, with producers selling directly to consumers in most cases and sometimes engaging in barter for other food items. Women sell cooked fish in local markets — these are mostly small reef fish — which they or their husbands catch or buy from other fishers. Collectors who buy from a number of fishers are predominantly male; they transport or arrange transport by public boat to urban markets such as the capital Honiara, and engage in retail sales themselves (WFQA 2010). Wholesalers are absent from the market chain. Both women and men are engaged in fish trading in local markets, while men dominate the sale of reef fish in Honiara market. However, in the Honiara market women predominate among traders of mollusks and crustaceans (such as mangrove crabs and clams), as well as trash fish from the tuna trawlers (WFQA 2010). Fish in local markets, including small urban centers such as Gizo in the Western Province, is sold by the piece (larger fish) or in heaps (smaller fish); fish is weighed and sold by the kilogram in Honiara. Prices ranged from SI$ 2[8] for a heap of small trevally to SI$ 60 for a grouper in Gizo in March 2010. During the same period, in Honiara where around 10-20 traders of reef fish engage in retail trade, a pound of reef fish (price does not vary according to species) fetched from SI$ 15-18, depending primarily on the transportation distance (WFQA 2010). Traders in Honiara source their fish from Guadalcanal, Florida Islands, Maru, Russel Island, Isabel, Malaita and Gizo. The transportation distances vary from 1.5 hours to 2 days. Lindley (2007) estimated that 245 metric tons of fish reach Honiara market from outlying rural areas annually. The share of value is approximately 33 percent to the fisher and 40 percent to the trader; transport, ice, market fees and other transaction costs amount to around 27 percent (WFQA 2010).

8 US$ 1.00 = SI$ 8.05 (31 May 2010)

3.4 Fish consumption

No official (annual) data on fish consumption are collected in Solomon Islands on a regular basis. Hence, the data presented in this report were drawn mostly from surveys and various independent studies.

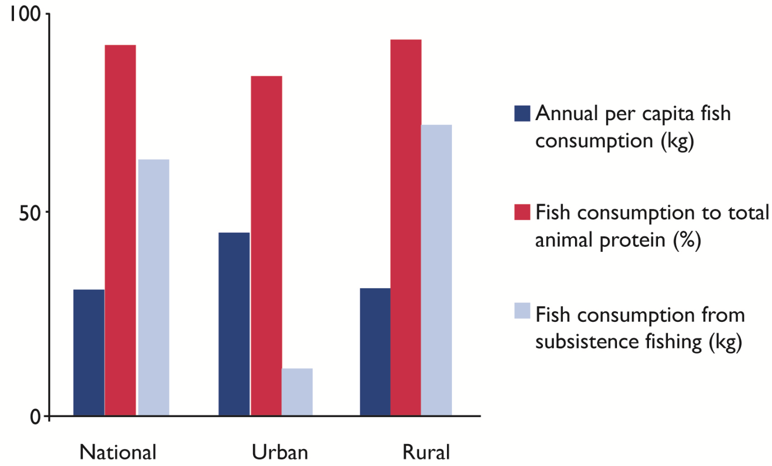

Figure 2: Selected indicators for fish consumption in the SI

Information on fish consumption for Solomon Islands, calculated using data from the 1991 HIES (Figure 2), suggest that:

- Fish is an important component of the diets of the people in the country. This is especially true for rural households where fish accounted for about 94 percent of the consumption of animal protein. However, households in rural areas consumed significantly less fish (in terms of total quantity per household) compared to their counterparts in urban areas.

- Food security is a bigger concern in rural areas. Per capita fish consumption for rural households (31.2 kg per year) was below the estimated 34-37 kg of fish required for good nutrition (Bell *et al.* 2009). This is particularly critical given that fish account for almost all animal protein consumption in rural areas.

- Subsistence fishing provides the main source of protein in rural areas. Consequently rural households are more vulnerable to the effects of resource overexploitation and the destruction of local fish habitats.

Table 5: Per capita expenditure on fish across provinces (2005/2006

Province	# HH	Population	HH Size	Per capita ($SBD) Purchased	Own consumption	Total	Value share of purchased fish in total fish consumption %
Total	86735	534856.2	6.2	192.41	197.26	389.68	49
Choiseul	5056	31347.2	6.2	85.59	273.92	359.51	24
Western	13650	81900	6	188.61	288.95	477.56	39
Isabel	4614	23531.4	5.1	104.09	303.37	407.46	26
Central	4209	24412.2	5.8	148.32	437.03	585.36	25
Rennell-Bellona	672	4435.2	6.6	204.73	291.73	496.46	41
Guadalcanal	14611	84743.8	5.8	200.37	195.27	395.64	51
Malaita	22115	141536	6.4	111.67	156.29	267.96	42
Makira-Ulawa	7524	50410.8	6.7	79.80	147.26	227.07	35
Temotu	4300	23650	5.5	80.46	166.07	246.53	33
Honiara	9984	68889.6	6.9	567.47	60.03	627.50	90

Based on the 2005/6 HIES, processed fish, particularly Second Grade Taiyo, dominated household expenditures on fish (Figure 3). Other key fish groups are tuna/bonito and reef fish.

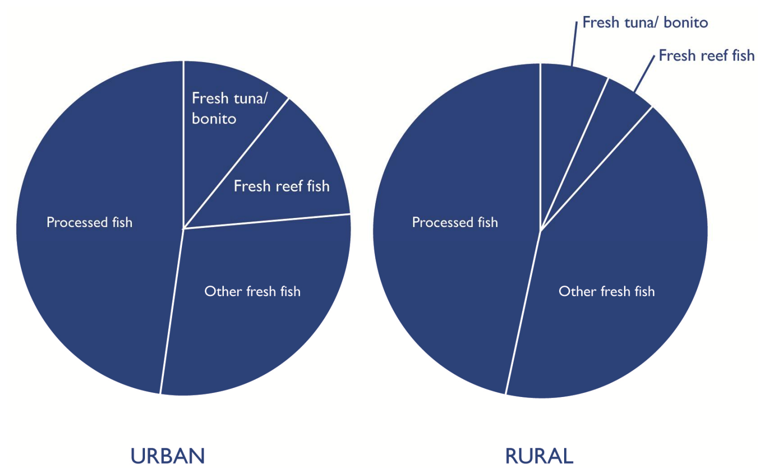

Figure 3: Distribution of household expenditures on fish, 2005, %

There are three important points to note about the data shown in Figure 2.

1. The heavy reliance on subsistence fishing is indicative of the possible underestimation of fish catch in the country.

2. The quantities reported by Bell *et al.* (2009) may also underestimate fish consumption in the country. In a recent survey of four sites in Solomon Islands, per capita consumption of fresh fish ranged from 98.6 to 110.9 kg per year (Pinca *et al.* 2009)[9], about three to four times larger than the quantities reported by Bell *et al.*

3. There is considerable variation in fish consumption throughout the different provinces in Solomon Islands, as indicated by combined per capita expenditure data on caught and purchased fish. There is also a marked difference between provinces in the proportion of fish purchased versus fish obtained through subsistence fishing, with per capita expenditure on fish in Honiara, Central and Rennell-Bellona two to three times greater than in Temotu,

[9] The survey sites were Nggela, Marau, Rarumana and Chubikopi.

Makira-Ulawa and Malaita Provinces (HIES 2005/06) — the latter provinces also coincide with the highest poverty rates in Solomon Islands (UNDP 2008). At the same time, approximately 75 percent of fish consumed in Choiseul, Isabel and Central Provinces are obtained from subsistence fishing, while in Honiara and Guadalcanal Provinces, 90 percent and 51 percent of fish respectively are purchased (HIES 2005/06).

The differences in fish consumption patterns are also evident from the comparative data on expenditure and caloric intake in poorer households (last three deciles of the population) in Honiara, other provincial urban areas and rural areas (Table 6). While expenditure on fish (both caught and purchased) comprises around 20 percent of the total expenditure on food in poorer households in Honiara and other urban areas, fish accounts for only 14 percent of total expenditure in similar status households in the rural areas (UNDP 2008). However, in terms of kilocalories obtained per average expenditure in poorer households, fish comprise 9 percent of kilocalorie consumption in Honiara and rural areas, and 16 percent in other urban areas (UNDP 2008), indicating a higher importance of fish in the diet of poorer households in urban areas other than Honiara. Thus, the disaggregation into urban and rural areas, without taking into account the differences between Honiara and provincial urban areas, distort the analysis from the perspective of caloric intake by poor households. While both sets of households show the same proportion of expenditure on fish in relation to total food expenditure, the proportion of fish caloric intake in provincial urban areas is nearly double that of Honiara. Moreover, there is also a difference in the types of fish consumed; while the highest proportion of expenditure in fish is on low-grade taiyo (canned tuna) and fresh tuna/bonito in urban areas, the highest proportion in rural areas is “other” and reef fish.

Table 6: Estimated fish expenditure and calorie intake. Principal diary items for lowest three per capita expenditure deciles. Source: UNDP 2008

	Weighted Expenditure per Diary ($SBD)	% of Diary Expenditure	Grossed-up expenditure value	kcal value per 100g	kcal per day per average expenditure
Honiara households					
Tuna/Bonito	$2,140,519	4.00	$2,411,981	204	69.6
Reef fish	$702,368	1.30	$791,442	130	6.5
Other fish	$2,063,599	3.90	$2,325,306	130	19.2
Other tinned fish	$175,190	0.30	$197,407	290	2.6
Second grade taiyo	$3,472,944	6.5	$3,913,385	290	51.9
Fish and chips	$532,190	1.00	$599,683	375	2.9
Total fish per Diary Listed items	$9,086,810		$10,239,204		152.7
Total Food per Diary Listed items	$48,438,946		$54,581,997		1626.9
Share of fish in total food per diary (%)	19		19		9
Provincial Urban Households					
Tuna/Bonito	$433,962	4.28	$474,078	204	149.9
Reef fish	$257,576	2.54	$281,387	130	56.7
Other fish	$375,220	3.70	$409,905	130	82.6
Other tinned fish	$34,253	0.34	$37,420	290	2.42
Second grade taiyo	$693,350	6.84	$757,444	290	48.93
Fish and chips	$112,719	1.11	$123,139	375	7.16
Total fish per Diary Listed items	$1,907,080		$2,083,373		347.7
Total Food per Diary Listed items	$9,328,477		$10,190,816		2194.08
Share of fish in total food per diary (%)	20		20		16
Rural Households					
Tuna/Bonito	$2,994,991	1.90	$3,421,669	204	50.4
Reef fish	$3,593,471	2.30	$4,105,410	130	8.5
Other fish	$8,684,333	5.50	$9,921,535	130	93.1
Other shell fish	$729,639	0.50	$833,586	350	12.6
Second grade taiyo	$3,269,266	2.10	$3,735,017	290	8.4
Crab	$765,283	0.50	$874,308	109	2.6
Total fish per Diary Listed items	$20,036,983		$22,891,525		175.6
Total Food per Diary Listed items	$146,063,553		$166,872,289		1932.3
Share of fish in total food per diary (%)	14		14		9

The qualitative assessment on consumption preferences, conducted in the Western Province as well as Honiara market, indicates higher levels of consumption, especially of reef and “other” fish, than is apparent from the national HIES data. Respondents mentioned over 53 species of fish and around 13 invertebrates and algae in their consumption preferences (WFQA 2010). Among the most preferred species were trevally, snapper, grouper, parrotfish, triggerfish, surgeonfish, emperor and bonito. There was a preference for medium and small reef fish by women and children, with larger reef fish and pelagics preferred by men. Respondents provided a range of reasons for their personal preferences — the most often indicated were taste/flavor, oil content/greasiness, sweetness, softness of meat, large amount of meat and relative lack of bones (WFQA 2010). Men emphasized flavor and sweetness. Women stressed flavor, oil content, softness of meat and relative lack of bones. In outlining perceived fish preferences of men in general in the village (in contrast to personal preferences), men emphasized taste and sweetness, while women referred to amount of meat and ease of capture. In identifying perceived preferences of women in general in the village, men stressed taste and greasiness, while women emphasized taste and ease of capture. In outlining perceived preferences of children, men referred to flavor, sweetness and oil content, while women stressed ease of capture and flavor (WFQA 2010). Thus, while there is some consistency between women’s and men’s perceptions on the qualities of fish that women and children generally prefer, there was inconsistency between men's and women's perceptions on what men generally prefer. What is noteworthy is that the flavor or taste of fish was an important criterion for both men and women in their assessment of other people's preferences, both of women and men. On the other hand, ease of capture emerged as an important criterion for women in assessing the preferences of men, while greasiness was similarly important for men in assessing the preferences of women and children.

While quantities consumed varied greatly from 2-100 fish per week depending on size of the household and the fish, as well as the productivity of the reef, the vast majority of respondents indicated that they ate fish daily or three to four times per week (WFQA 2010). The majority also indicated that men ate the major portion of fish during meals, while substantial minorities said that fish was distributed equally among family members or children were prioritized in intra-household consumption. More men than women indicated that men consumed more, while more women indicated equitable distribution or prioritization of children (WFQA 2010). An overwhelming majority of respondents said they preferred fish and seafood over other meats — they pointed out that they ate chicken once or twice per month at most or not at all, and pork only for special ceremonies, including the minority who expressed a preference for these other meats (WFQA 2010). This is consistent with Aswani and Furusawa's (2007) results that 64-100 percent of respondents in five villages in Western Province indicated that fish was their main source of protein. Chicken was eaten more often by urban respondents.

The vast majority of respondents reported that they ate more fish 10 years ago than now. Reasons included depletion of fish resources, population increase, the impact of the tsunami, lack of a fisher in the household, and increase in vegetable intake (WFQA 2010). The minority who saw no change in fish consumption pointed out that, as in the past, one family member always managed to supply fish for the household. The few who indicated that they ate more fish now than 10 years ago attributed this to changes in technology such as ability to dive in the night, access to fish aggregation devices, health promotion campaigns on the radio, or ease of availability in the market (WFQA 2010).

4. THE SUPPLY AND DEMAND FOR FISH IN SOLOMON ISLANDS: AN APPLICATION OF THE ASIAFISH MODEL

4.1 Structure of the model

The AsiaFish model is designed for generating detailed results on supply, demand, trade, and prices for the fisheries sector.[10] It is a partial equilibrium model that assumes that the quantities and prices of non-fish commodities are determined outside of the system. Despite this, it is flexible enough to evaluate the effects of changes in the environment for non-fish commodities and various socio-economic variables on the fisheries sector.

The general structure of the model is as follows. The domestic supply of a particular fish type is sourced from domestic and foreign agents (imports). This is then allocated among households (consumption), firms (intermediate demand), and foreign agents (exports). The prices of fish types in the domestic market are derived by a series of equilibrium conditions. In other words, these are determined through the interaction of supply and demand.

The model is divided into producer, consumer, and trade cores. The producer core distinguishes between fresh and processed fish output. It also recognizes that fresh fish can come from different domestic sources, such as deep sea and reefs.

In the case of fresh fish, it is assumed that output supplies and input demands are determined jointly within each domestic source. This results in a series of equations in which the quantity of fish outputs and inputs are a function of fish prices, input prices, and technology. Where necessary, the equations may also include non-price determinants of output supply and input demand.

In the case of processed fish, the model assumes that a fixed ratio of fresh fish output is allocated for intermediate use. These then serve as inputs in the production of processed fish. The conversion of inputs to outputs is assumed to follow a fixed proportions technology.

The consumer core represents the behavior of households. It is flexible enough to accommodate a disaggregation by region or social categories. Each region/social category is represented by a typical household and its fish consumption. These figures are then up-scaled to the entire region or social category based on the number of households in each group.

The decision process of the representative households is specified by a three-stage budgeting framework. The first stage determines the demand for food. It assumes that food expenditures depend on the prices of food and non-food products, income and other socio-economic factors. The second stage determines the representative household's demand for fish as a whole. It specifies that fish expenditure is a function of aggregate fish prices, prices of non-fish food prices, real food expenditure, and other factors.

[10] A detailed description of the original model and its equations are presented in Dey *et al.* (2005).

The final stage captures the demands for the different types of fish. This is formulated as a Quadratic Almost Ideal Demand System (QUAIDS) in which the expenditure shares of the different fish types are expressed as a function of fish prices, real fish expenditure, and other socio-economic variables.

The trade core of the model is composed of a series of export supply and import demand equations. It follows the tradition of Applied General Equilibrium (AGE) models that impose the Armington assumption, i.e., domestic and foreign goods (fish types) are treated as differentiated products. The equations suggest that the export supply of a particular fish type is a function of its (a) price in foreign markets relative to domestic markets, and (b) domestic output. On the other hand, the import demand for a particular fish type depends on (a) the price of imports relative to domestic goods, and (b) domestic demand.

4.2 Disaggregation of the model

There are two levels of disaggregation in the model: fish types and household groups. The classification of fish types was driven mostly by the importance of species in the country and by the availability of data. Given these criteria, five distinct fish types were identified for the model: skipjack tuna, yellow fin tuna, big-eye tuna, other tuna, and other fish. The category “other fish” combines all other species (e.g., invertebrates and reef fish) for which detailed information were not available. Households were disaggregated into rural and urban.

4.3 Dataset

Two types of datasets are needed to populate and run the AsiaFish model — a) fish balance sheets and b) extraneous variables and parameters. As one might expect, there is no single source of information for the data requirements of the model. Moreover, information for some variables is not directly available. The following paragraphs describe the effort to assemble a complete and consistent dataset for the application of the model in the Solomon Islands context.

Fish balance sheets

Fish balance sheets contain information on the quantities (or volumes) and values of the sources (supply) and uses (demands) of fish. Constructed for each fish type, the implicit price for each item is the ratio of its value to quantity.

For each fish type, the sources of supply are domestic production (Q) and imports (M). Demand is composed of household consumption (C), exports (X) and intermediate demand (I). The consumption of each fish type is further divided between rural (Cr) and urban (Cu) regions, which are the sum of the fish consumption of the households in each region. Intermediate demand represents the inputs of fresh fish to the production of processed fish. Since the supply and demand sides of the balance sheets must be equal, all the quantities and values must satisfy the accounting identity below.

$$Q + M = Cr + Cu + X + I$$

The biggest challenge in constructing the balance sheets is the absence of a single source for all the information. This implies that adjustments are needed in compiling the data in order to ensure that the basic accounting identity is satisfied. In many instances, detailed data (i.e., by fish type/group) are unavailable. This means that quantities and/or values need to be estimated based on related information and/or by imposing suitable assumptions.

For the quantities of fish, export and import data were obtained from the Food and Agriculture Organization (FAO) FishStat.[11] Production or fish catch data were obtained from two sources; detailed information on tuna comes from the Western and Central Pacific Fisheries Commission (WCPFC, 2008), and for other fish from FAO FishStat. Information on the quantities consumed by households was not directly available. Hence, these variables were constructed such that per capita fish consumption in rural and urban regions reflected the quantities estimated by Bell *et al.* (2009) shown in Figure 1. Given the values for *Q, M, Cr, Cu* and *X*, intermediate demand *I* was calculated using the accounting identity shown earlier.

Disaggregated information on fish values was obtained from various sources. Data on the values of exports and imports were sourced from the FAO FishStat. Expenditures on fish were from the SI-NSO (2006). This was later apportioned among the different fish types and households using unpublished information from the Ministry of Fisheries and Marine Resources of Solomon Islands. Information on the value of fish catch proved to be a challenge as these were not directly available. In the case of tuna, the price was inferred from estimates of the quantity and value of tuna catch in Gillet (2009). This price was later multiplied by quantities from WCPFC and FAO to determine the value of catch to be used in the model. Prices were likewise not available for the fish type "other fish". In this case, the weighted average of the implicit prices of other fish in consumption and exports was used to estimate the value of fish catch. As with quantities, the values of intermediate demands were calculated as a residual.

The outcomes of the exercise discussed above are shown in Table 7. All the quantities and values are for 2005, the most recent year for which the balance sheets could be consistently filled with the available information.

Table 7: Fish balance sheets for Solomon Islands model, 2005

Items	Skipjack Tuna	Yellow fin tuna	Big-eye tuna	Other tuna	Other fish	Processed fish
Quantity (tons)						
Production	22,068.0	14,916.0	2,870.0	534.0	20,184.2	4,931.8
Imports	-	-	-	-	23.0	261.0
Exports	14,162.0	2,486.0	19.0	2.0	116.0	3,271.0
Consumption						
Rural	1,005.3	1,580.5	362.5	67.6	8,097.1	1,234.8
Urban	276.6	434.9	99.8	18.6	1,918.3	687.1
Intermediate demand	6,624.1	10,414.5	2,388.7	445.7	10,075.8	-
Value (US$'000)						
Production	23,839.7	16,113.5	3,100.4	576.9	12,659.6	26,824.5
Imports	-	-	-	-	56.0	440.0
Exports	11,115.0	2,677.0	122.0	8.0	149.0	12,312.0
Consumption						
Rural	877.3	1,379.3	316.4	59.0	4,136.3	11,715.3
Urban	531.1	835.0	191.5	35.7	2,088.7	3,237.2
Intermediate demand	11,316.3	11,222.2	2,470.5	474.1	6,341.6	-

[11] The FAO FishSTAT database contains annual production of fishery commodities and imports and exports of fishery commodities by country and commodities in terms of volume and value for around 245 countries, territories or land areas for the time period 1976-2006

Extraneous variables and model parameters

Additional data requirements include expenditures on various food groups, non-food items, population, and income of the household groups of the model. This information was generally obtained from the HIES 2005/6 and was supplemented by information from other government documents.

The demand, supply, and trade equations of the model require estimates of various parameters. However, lack of data prevented the estimation of any of these parameters. Hence, the current exercise adopted parameters from existing versions of the AsiaFish models.[12] See Appendix I for the key model parameters.

[12] A discussion of the data requirements, estimation methods and values used in existing versions of the AsiaFish model is available from Dey *et al.* (2008).

5. FUTURE SCENARIOS FOR THE FISHERIES AND AQUACULTURE SECTOR IN SOLOMON ISLANDS

Using the dataset for 2005, as well as the results of the expert elicitation process, the model was used to generate projections from 2010 to 2030. This exercise required estimates of the growth paths for exogenous variables such as population, incomes and prices.

5.1 Developing scenarios through expert elicitation: Overview

As part of this study, we employed a strategic thinking tool called scenario building, also known as scenario planning or scenario thinking. This was used to create plausible scenarios that depicted a range of possibilities for the future of fisheries and aquaculture in the Solomon Islands in 2030 — a twenty-year time horizon. These scenarios are not predictions, or even forecasts; they are stories and descriptions that explore possible future outcomes and thus inform strategic conversations — an explorative mode of thinking. In this study we followed the approach for scenario building developed within the QUEST-Fish project[13] (Badjeck *et al.* 2010a and 2010b).

5.2 Scenario methodology

There are three modes of thinking about the future: predictive, explorative, and normative (Goeminne and Mutombo, no date). The predictive mode attempts to gain an indication of what will happen by trying to find the most likely development in the future (close to forecasting, "if trends continue what would the future look like?"). Normative scenarios involve taking normative (desirable) goals into account and exploring the paths leading to these goals ("what do we want the future to be?"). In this study we employed the explorative mode of thinking ("what could the future be?"), characterized by openness to several possible events and contrasting developments. Exploratory scenarios may challenge conventional assumptions, and accommodate high levels of uncertainty and ambiguity. This approach aids strategic planning and enables better preparation for handling emerging situations, with the understanding that it is impossible to predict what will actually happen (Goeminne and Mutombo, no date).

5.2.1 SCENARIO PROCESS

The explorative scenario building process followed a number of steps (Badjeck *et al.* 2010a; Goeminne *et al.* 2007):

1. Identification of the focal issue and time horizon—this study focused on the future of fisheries and aquaculture up to 2030 in the Solomon Islands (i.e., defining the "decision focus").

2. Identification of the drivers of change through expert elicitation.

3. Ranking of drivers according to their importance (level of impact) and their uncertainty (likelihood of impact occurring and the direction of the impact) through expert elicitation.

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[13] One of the objectives of the QUEST-Fish project is to develop improved ways of assessing vulnerability of fisheries to future climate change, in the context of other drivers of change using scenarios (see http://web.pml.ac.uk/quest-fish/)

4. Identification of two critical drivers (based on highest importance and uncertainty according to the experts) to generate two axes that will form the 2x2 matrix around which four scenarios will be built (i.e., defining the "scenario logic").

5. Generation of a narrative description that highlights the scenario main features including the relationship with drivers of change identified by the project team (i.e., defining the "storyline").

There are two phases: (i) the development phase which covers the first 4 steps; and (ii) the storyline phase which is the last step. The development phase consists of generating and collecting views on drivers of change to create scenario logics. This is a very important phase due to the high degree of openness to several possible events and different developments. This is where creativity and imagination are essential in generating ideas. Ideally, a series of workshops would have informed the scenario process, but due to time and budget constraints, identification and prioritization of drivers were undertaken through an email survey while the scenario logic and storylines were developed by the project team with input from other WorldFish staff.

5.2.2 SURVEY DESIGN

An e-mail survey was conducted in March 2009 with experts representing national government (including the Ministry of Fisheries and Marine Resources), academia, regional organizations, and non-profit organizations. The selection of experts was based on a list compiled by the WorldFish Center country office in Solomon Islands in cooperation with the Ministry of Fisheries and Marine Resources. The criteria for selection were knowledge and experience in analysis and management or policy formulation in fisheries and coastal/marine resource use for at least 10 years, representing government, research, and practitioner communities. Thirty experts were contacted with a response rate of 40 percent, of which 7 percent of responses were invalid. In the e-survey, the respondents were asked to think broadly about the critical issues of emerging change and to list 10 drivers that will have the most significant impact (positive or negative) on fisheries and aquaculture production systems until 2030 in the Solomon Islands. This was a "forced ranking" question where respondents were asked to rank items from 10 (most important, highest impact) to 1 (least important, lowest impact). They were also asked to identify the level of uncertainty associated with each driver on a scale of 1 to 5 (1 = highly likely, 5 = highly unlikely). Drivers were defined as any natural- or human-induced factor that directly or indirectly brings about change in fisheries and aquaculture production systems (see Hazell and Wood, 2008).

Drivers may be social, technological, economic, environmental, political, or values (STEEPV approach). Drivers alter the future trajectories of fisheries and aquaculture systems in significant ways.

5.2.3 DATA ANALYSIS

Questions about the drivers of change were open-ended, and a first step in the analysis was to codify the answers. The coding of qualitative data involves assigning unique labels to answers that contain specific categories of information. From the answers, the project team identified codes and developed a codebook that served as a frame or boundary used to systematically map the information (Appendix I). The code identification and codebook development were based on the approach developed by MacQueen *et al.* (1998) and each answer was classified using this codebook (Appendix III). To limit bias, unavoidable in this kind of exercise, the codebook was assessed by the project team; necessarily overlapping codes were clustered, and inter-code agreement was assessed (several team members applying the codes).

5.3 Scenario results: "aquaculture plus", "super tech", "where's the fish?", and "classic"

5.3.1 IDENTIFICATION OF DRIVERS OF CHANGE

From all the e-survey responses the project team identified 10 drivers of change to inform the scenario building in this study. The drivers were (a) climate variability and change; (b) population change; (c) governance and fisheries management, particularly interactions between actors; (d) legislation and formal and informal institutional arrangements; (e) political situation; (f) technological and capacity development; (g) aquaculture-related issues; (h) social behaviors and preferences; (i) environmental changes; and (j) market forces (see Appendix II for definitions).

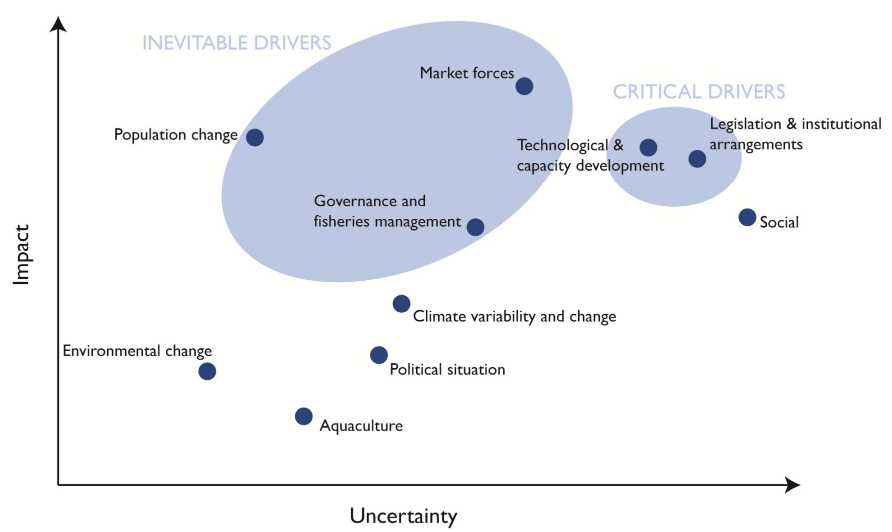

Figure 4: Identified drivers of change on fisheries and aquaculture systems to 2030 in the Solomon Islands (in total), by importance and uncertainty.

Once the drivers were identified, the rankings of uncertainty and impact for each driver were summed (see Figure 4). A driver that has a high impact and a high uncertainty was considered a critical scenario driver. One that has a low level of uncertainty but is important is considered a critical planning and policy issue (inevitable driver, a known trend we need to deal with). Based on this categorization two critical drivers were identified: i) legislation and formal and informal institutional arrangements, and ii) technological and capacity development. Legislation, formal and informal institutional arrangements refers to legal framework (laws, regulations, fines, penalties) and formal (legislation) and informal (property and access rights) institutional arrangements, while technological and capacity development refers to advances in technology, improvement of fisheries or harvesting equipment, increased quality of fisheries products and also improvement of fisheries infrastructure; support services and capacity (expertise).

5.3.2 SCENARIO LOGIC AND STORYLINES

Legislation, formal and informal institutional arrangements, and technological and capacity development (as the most critical drivers) were selected to form a four-cell matrix defining the boundaries of the scenarios (Figure 5). This was translated into two axes of a scenario cross, of which the horizontal axis distinguishes between a bottom-up community based management (co-management and customary management) and top-down centralized type of management. This axis thus represents different approaches to fisheries management (legislation and institutional arrangements). The horizontal axis goes from a high level of innovative technological development and capacity building, to a lack of innovation and slow capacity development. With the boundaries of the scenarios defined, titles were given to help develop the story line of four contrasting future outcomes:

- Aquaculture plus: high level of technology and bottom-up management;
- Super tech: high level of technology and top-down management;
- Where's the fish?: low level of technology and bottom-up management; and
- Classic: low level of technology and top-down management.

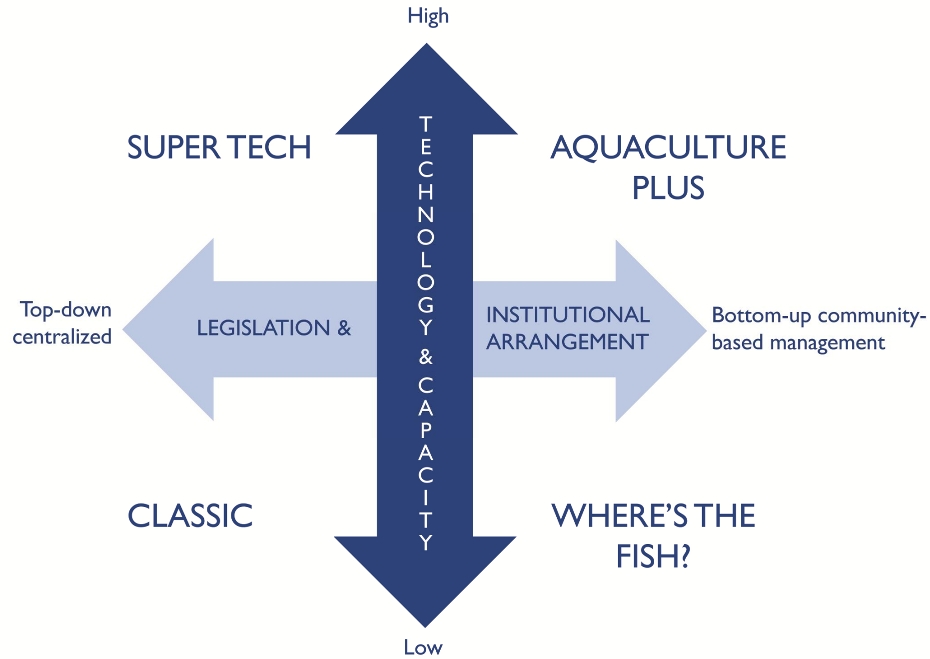

Figure 5: Selected future scenarios for Solomon Islands fisheries

AQUACULTURE PLUS - Story line

Aquaculture development achieves an unprecedented breakthrough, despite previous abandonment of prawn farming and limited success with other species. This will fill the gap between supply and demand of fish, resulting from a decreasing growth rate of the marine catch. A sufficient number of people adopt fish farming, supply aquaculture inputs, and engage in marketing of produce. Fish feeds that do not put pressure on marine fish catches are developed. Consumer preferences change from wild marine fish to include farmed fish. Alternatively farmed fish is exported and cash incomes enable the purchase of imported marine fish or canned fish. Behaviors of other drivers in this scenario are presented in Table 8.

Table 8: AQUACULTURE PLUS scenario: Positive and negative driving forces.

Drivers	Positive forces	Negative forces
Population change	lower rural-urban migration	
Governance and fisheries management	consolidate partner collaboration; more coordinated fisheries program and information sharing (local and regional levels)	
Political situation	Stability	
Market forces	cash economy	demand for export commodities; higher operating cost
Aquaculture	strong development of aquaculture	
Social	educational; alternative livelihood	
Environmental change		pollution
Base year	*2010*	
Time horizon	*2030*	
Stakeholders	*Fishers, fish farmers, producer groups. Ministry of Fisheries and Marine Resources (MFMR), private sector, research organizations, and NGOs*	

SUPER TECH - Story line

Technology and capacity development will be combined to enhance larger-scale fishing of pelagic fish species, as well as post-harvesting processes. This will create opportunities for local fishers to join the offshore pelagic fish industry, as inshore reef fish supplies decrease. Efforts to attract more foreign vessels to land their catch in the Solomon Islands or increase the capacity of domestic catches result in growth of the post-harvesting sector (processing industry) creating alternative livelihoods for Solomon Islanders and at the same time helping to better meet local demand. However, adoption of this new technology requires financial resources. As most fishers in the country are subsistence-oriented and do not have adequate cash incomes, it is difficult for them to adopt new technology without external support (e.g., government or financing sector). Thus, communities will rely heavily on government assistance or external investors for adopting new technology. Behaviors of other drivers in this scenario are presented in Table 9.

Table 9: SUPER-TECH scenario: Positive and negative driving forces.

Drivers	Positive forces	Negative forces
Governance and fisheries management		Corruption
Market forces		
Technological, capacity development	private investment;	
Aquaculture	development of aquaculture	local land issues
Social	Education	
Environmental change		pollution and poor land management
Base year	*2010*	
Time horizon	*2030*	
Stakeholders	*Fishers, fish farmers, producer groups, Ministry of Fisheries and Marine Resources (MFMR), private sector and regional organizations*	

WHERE'S THE FISH? - Story line

Fishing communities are willing to take action to protect the stocks, and governments are willing to empower communities. However, due to population pressure, most fisheries conservation measures — including the prevention of destructive fishing and the imposition of fish size limits — cause a short-term decrease in catch. As most subsistence fishers require fish on a daily basis as food for their families, fishing communities struggle to adopt effective conservation measures such as fishing restrictions. A community-based fisheries management approach that does not provide support or promote alternative means of obtaining fish or the income to obtain fish turns out to be unsustainable. Technology falls far short of expectations. Behaviors of other drivers in this scenario are presented in Table 10.

Table 10: WHERE'S THE FISH scenario: Positive and negative driving forces

Drivers	Positive forces	Negative forces
Climate variability and change		coral reef health
Population change		urban drift (for employment)
Governance and fisheries management	a more coordinated fisheries program and knowledge sharing	
Political situation		social pressure
Market forces		higher operating costs (fuel) and demand on fish
Aquaculture		aquaculture technology falls far short of expectation
Social		lack of alternative livelihood
Environmental change		habitat degradation
Base year	*2010*	
Time horizon	*2030*	
Stakeholders	*Fishers, MFMR, NGOs and CBOs*	

d) CLASSIC - Story line

Fisheries resources are further degraded by pollution, physical damage (e.g., to a coral reef), and overfishing. While local people realize the problem, they believe the responsibility to do something rests with the national fisheries authorities. Fisheries agencies are located in urban centers, are poorly funded, and unable to monitor or assess inshore fishery activities. When fishing success decreases, subsistence fishers employ ever more destructive fishing techniques and catch ever-smaller fish and invertebrates. Conflicts between fishing communities are commonplace. This cycle is unlikely to promote sustainable supply. Behaviors of other drivers in this scenario are presented in Table 11.

Table 11: CLASSIC scenario: Negative driving forces

Drivers	Negative forces
Climate variability and change	coral reef health
Population change	urban drift
Governance and fisheries management	Corruption
Political situation	conflicts between fishing communities
Market forces	higher operating cost (fuel)
Aquaculture	failures of aquaculture development
Environmental change	habitat degradation
Base year	*2010*
Time horizon	*2030*
Stakeholders	*Fishers and MFMR*

5.4 Modeling the scenarios

The results of the expert elicitation, as well as the outcome of the literature review, were used to generate a set of 12 scenarios, including a baseline. The integration of knowledge of several individuals through the expert-based scenarios allows for the contextualization of the secondary data collected and adds layers of complexity that are often not expressed in modeling exercises. However a balance between accuracy of descriptions of "real world complexities" and simplified story lines must be reached. In this study, we therefore use simpler scenarios developed by the modeling team to test the impact of a number of different future developments on fish supply and demand. The baseline scenario of the model uses historical growth rates for the exogenous variables (Table 12). Given the absence of estimates regarding productivity growth of fisheries in Solomon Islands, the baseline scenario assumes that this variable is equal to zero.

To address uncertainties regarding the future paths of the exogenous variables, we used the model to run projections for eleven alternative future scenarios. These are as follows:

Scenario 1 (Super Tech): A productivity change that, prior to market-related adjustments, makes fish catches 5 percent higher than its baseline value from 2010 to 2030. This could represent improved technologies and/or conditions for catching fish, or higher fishing effort.

Table 12: Growth rates of the exogenous variables in the baseline scenario, % p.a.

Variable	Growth rate	Years covered
Prices		
Fish imports[1]	2.1	2001-2005
Fish exports[1]	2.9	1980-2005
Non-fish food[2]	7.2	2000-2006
Non-food[3]	7.0	1990-2007
Labor[3]	7.0	1990-2007
Population		
Rural[4]	2.5	2000-2007
Urban[5]	4.4	1990-2007
Nominal income[6]	8.1	1970-2007
Productivity growth[7]	0.0	n.a.

1. The values were calculated using information from the FAO FishStat, http://www.fao.org/fileadmin/templates/ess/documents/food_security_statistics/country_profiles/eng/Solomon_Islands_E.pdf.

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3. This represents the growth rate of the CPI from 1990-2007. It was obtained from UNICEF, http://www.unicef. org infobycountrysolomonislands_statistics.html#57.

4. This represents the growth rate of the entire population from 2000-2007. It was based on estimates reported by the World Bank, http://devdata.worldbank.org/AAG/slb_aag.pdf.

5. The growth rate was obtained from UNICEF, http://www.unicef.org/infobycountry/solomonislands_statistics. html#57.

6. This was chosen so the growth of real GDP per capita is 1.1% p.a. The latter was based on information available from UNICEF, http://www.unicef.org/infobycountry/solomonislands_statistics.html#57

7. The study did not find estimates of productivity growth in Solomon Islands.

Scenario 2 (Where's the fish?): A productivity change that, prior to market-related adjustments, makes fish catches 5 percent lower than its baseline value from 2010 to 2030. This could represent deterioration in the conditions of fishing grounds and/or a reduction in fish stocks, or lower fishing effort.

Scenario 3 (Classic): This is similar to Scenario 2. However, the changes are more drastic as fish catches are assumed to be 50 percent lower than its baseline value from 2010 to 2030.

Scenario 4: Export prices grow at an average annual rate of 11.75 percent. Faster than the 2.9 percent growth that was assumed in the baseline, this value reflects the growth of fish export prices from 2001 to 2005.

Scenario 5: Per capita income changes at an average annual rate of negative (-) 1.6 percent per annum. This reflects the trends observed for the country from 1990 to 2007.

Scenario 6: Population growth rates are lower than for the base case. In particular, this scenario uses World Bank projections that assume an average growth rate of 1.9 percent per annum.

Scenario 7: Rates of urbanization are higher than anticipated. In particular, this scenario used a population growth rate for urban areas one percentage point above the baseline.

Scenario 8: Consumer preferences change. This scenario was modeled by applying a 10 percent increase in the demand for non-fish meat, with no changes in the growth rate of incomes from 2010 to 2030.

Scenario 9: The growth rate of fish catches from 2010 to 2030 follows the trend from 1991 to 2006 (i.e., an average annual growth rate of 4.8 percent). This scenario was modeled by increasing the productivity growth in fisheries by 2.1 percent p.a. and fish export prices by 2.0 percent p.a.

Scenario 10: Similar to Scenario 6 but assuming that the growth rate of fish catch from 2010 to 2030 follows the trend from 1991 to 1999 (i.e., prior to the period of ethnic tensions). An average annual growth rate in fish catch of 5.5 percent as applied to the model.

Scenario 11: Similar to Scenario 6 but assuming that the growth rate of fish catch from 2010 to 2030 follows the trend from 1991 to 2006, excluding 2000. This excludes the unusually large decline in fish catch (64 percent) recorded in 2000 and resulting from the ethnic tensions. An average annual growth rate of fish catch of 9.4 percent was applied to the model.

All simulations were implemented using the Generalized Algebraic Modeling Software (GAMS).

In addition, as aquaculture production values in Solomon Islands were too low for robust modeling, a separate methodology was used to estimate the output of the aquaculture sector and its ability to meet nutritional requirements as envisaged in the Aquaculture Plus scenario that emerged from the expert elicitation process.

Estimation of the target outputs for the aquaculture sector was computed as follows.

1. The aggregate consumption of fish necessary to meet nutritional requirements was estimated (required consumption). The average person in the Pacific island countries needs to consume 34-37 kg of fish per year to satisfy nutritional requirements (Bell *et al.* 2009). Aggregate required consumption was calculated by multiplying the consumption rate of Bell *et al.* by the total rural and urban population of Solomon Islands. This aggregate was adjusted for future projections of rural and urban population growth to calculate required consumption from 2010 to 2030.

2. The projected consumption of fish under the four scenarios (baseline; Super tech (Scenario 1); Where's the fish? (Scenario 2); Classic (Scenario 3) was determined (projected consumption).

3. The difference between projected and required consumption of fish was calculated, to provide the target output for aquaculture. To simplify the analysis, the target output of aquaculture was based on the lower threshold for required consumption of 34 kg person^{-1} year^{-1}.

6. PROJECTED CHANGE IN FISH SUPPLY AND DEMAND: SIMULATION RESULTS

6.1 Baseline scenario

The model reveals that aggregate fish catch (domestic output of fresh fish) is expected to grow at a sluggish rate of 1.3 percent p.a. from 2010 to 2030 (Figure 6). This finding explains the relatively slow growth of fish exports (0.6 percent) over the projection period. On the other hand, consumption of fish is projected to grow at 1.8 percent p.a., with this faster growth relative to production partly explained by the relatively slow growth of fish exports and fast growth of fish imports.

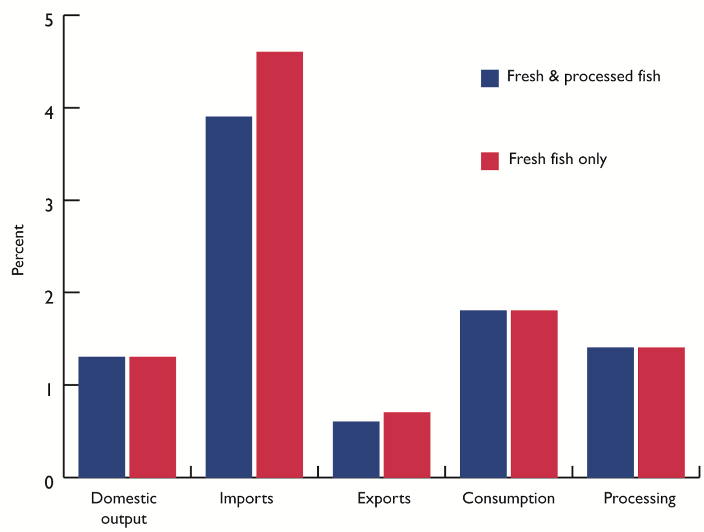

Figure 6: Projected annual growth rates of the quantities of fish in the aggregates, 2010-2030, %. Aggregates for fresh fish represent sums of their corresponding results for skipjack tuna, yellowfin tuna, big-eye tuna, other tuna and other fish.

There are two important points to be made with regard to the aggregate projections presented above. First, projected output and exports are lower than the actual growth rates observed from 1990s to the mid-2000s. This suggests that the baseline projections are conservative relative to recent performance. Second, projected growth rates of fish consumption are lower than population growth. This suggests a potential limit to the capacity of the domestic fisheries sector to support the nutritional requirements of the people living in Solomon Islands, particularly with respect to animal protein. Moreover, the projections indicate that this occurs despite the increase of fish imports.

Fishery outputs are expected to increase for all fish types, with the highest projected growth rates seen in big-eye tuna and other fish (Figure 7). Catches of skipjack and yellow fin tuna are projected to increase slowly, with these species having a strong influence on the sluggish growth of aggregate fish catch due to their dominance in the catch.

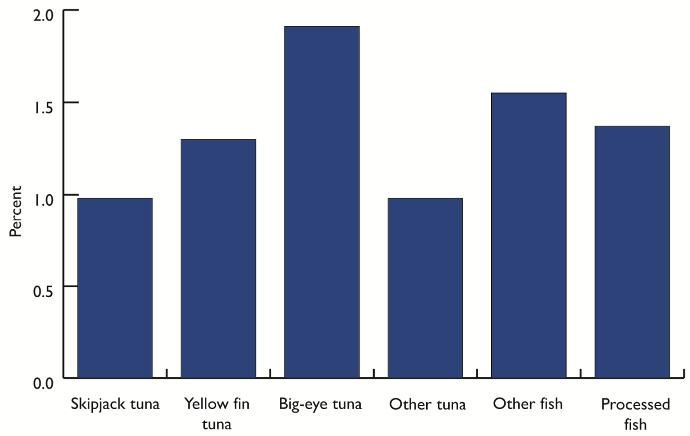

Figure 7: Projected annual growth rates (%) of fisheries output, by species, 2010-2030.

Fish consumption in 2030 in both rural and urban regions is projected to be lower than 2005 levels and below the 34-37 kg threshold estimated by Bell *et al.* (2009) (Figure 8). Projections suggest that this decline will be more pronounced in urban areas, partly as a result of higher population growth rates.

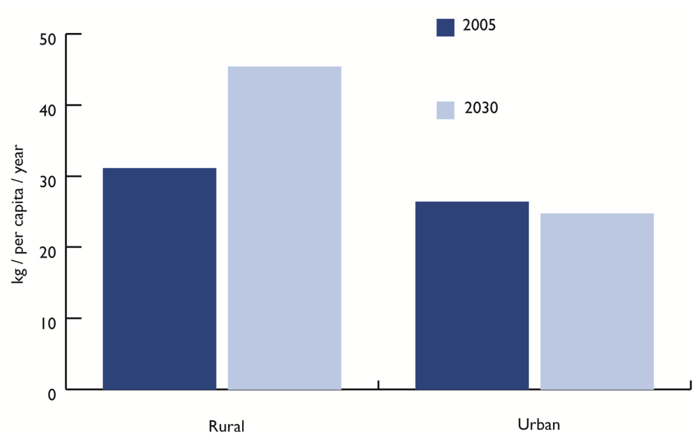

Figure 8: Projected annual per capita fish consumption (kg) in 2005 and 2030.

6.2 Alternative scenarios

Table 13 shows projected growth rates for the quantities of fish aggregates in all scenarios. The findings for Scenario 1 indicate the importance of higher productivity and/or fishing effort in raising the growth rates of fish catch (output of fresh fish), exports and consumption. While the higher output growth is expected, the impacts on exports and consumption in the model are brought about by lower domestic prices, compared to the base case, caused by higher domestic supply. In the case of exports, the decline in fish prices makes fish from Solomon Islands more competitive in the world market. Lower fish prices also tend to raise consumption spending as these induce households to substitute alternative protein sources for the category indicated as “other fish”. Moreover, lower prices raise the purchasing value of household incomes. However, we have to caution that Scenario 1 may cause over-fishing and, in the long term, deplete fish stocks – thus not offering a sustainable solution.

Scenarios 2 and 3 represent situations that are the opposite of Scenario 1 by assuming a 5 percent and 50 percent productivity decrease, respectively. As expected the impacts are lower projected growth of fish catch, exports, and consumption compared to the baseline.

Table 13: Projected growth rates of the quantities of fish aggregates, 2010-2030, % p.a.

Item	Supply		Utilization		
	Output	Imports	Exports	Consumption	Intermediate demand
Fresh fish only					
Baseline	1.30	4.57	0.65	1.77	1.37
Scenario 1	1.60	4.57	1.06	2.00	1.66
Scenario 2	1.01	4.57	0.25	1.54	1.08
Scenario 3	(1.55)	4.45	(3.10)	(0.69)	(1.41)
Scenario 4	4.37	2.73	6.91	(1.08)	3.99
Scenario 5	0.71	1.31	0.94	0.40	0.71
Scenario 6	1.15	3.79	0.73	1.47	1.19
Scenario 7	1.34	4.70	0.63	1.64	1.41
Scenario 8	0.49	(0.14)	1.02	(0.18)	0.47
Scenario 9	4.81	4.40	5.98	3.19	4.64
Scenario 10	5.50	4.39	6.91	3.37	5.30
Scenario 11	9.41	4.47	11.66	3.58	9.01
Fresh and processed fish					
Baseline	1.30	3.94	0.61	1.81	1.36
Scenario 1	1.59	4.05	1.00	2.03	1.64
Scenario 2	1.02	3.83	0.23	1.59	1.09
Scenario 3	(1.41)	2.54	(2.97)	(0.55)	(1.29)
Scenario 4	4.19	2.30	6.54	(1.02)	3.86
Scenario 5	0.73	0.19	1.01	0.42	0.73
Scenario 6	1.15	3.39	0.68	1.51	1.18
Scenario 7	1.34	4.14	0.58	1.67	1.40
Scenario 8	0.51	(1.66)	1.12	(0.22)	0.49
Scenario 9	4.77	4.55	5.90	3.19	4.62
Scenario 10	5.45	4.61	6.80	3.36	5.26
Scenario 11	9.28	4.76	11.42	3.60	8.91

The results for Scenario 4 suggest that faster growth rates of export prices are likely to cause higher growth rates of output. The reason is that higher export prices increase returns from each unit of fish caught, thereby raising the incentive to catch fish. However, the downside of higher export prices is the likelihood that it will also raise domestic prices. This hurts consumption because it makes the fish available in domestic markets more expensive. In this regard, the magnitudes of the changes in Scenario 4 are projected to cause declining fish consumption from 2010 to 2030.

Scenario 5 attempted to capture more recent trends in per capita income growth, which are lower than the baseline assumptions. Its major impact is the reduction in the projected annual growth rate of fresh consumption from 1.8 percent in the baseline to about 0.4 percent. Since the decline in consumption tends to reduce domestic prices, another impact is the decline in the growth of domestic production. Lower domestic prices and lower output have opposing effects on exports. In the case of Scenario 5, the impact of lower prices is stronger than the decline in outputs as export growth is projected to be higher than in the baseline.

Scenario 6 captures the possibility of lower population growth in the country. Other things held constant, lower population growth leads to lower growth of aggregate fish consumption compared to the baseline scenario. This is reflected in Table 13 and also explains the decline in the growth of fish imports. Lower consumption growth translates to a lower growth rate of fish prices. Since this reduces the incentive to fish, the outcome is a slower growth in aggregate fish catch. The lower growth rate of fish catch is the primary reason for the slower growth of exports relative to the baseline scenario.

Scenario 7 is designed to capture a higher degree of urbanization in the country. The simulation results suggest that this tends to raise the growth of aggregate fish consumption. This is due to increase in the number of fish consumers in urban regions. Faster growth in aggregate fish consumption leads to faster growth in fish prices. This explains the projected increases in the growth rates of domestic output and imports, and the projected decline in the growth rate of exports relative to the baseline.

Scenario 8 depicts a case in which households exhibit a greater preference for non-fish meat products. The key result is a lower growth of aggregate fish consumption relative to the baseline. This is explained by the assumption that the change in preferences was not accompanied by faster income growth in the experiments, which means that a smaller proportion of household expenditures will now be available for fish and other products. The decline in the growth rate of aggregate fish consumption is likely to cause slower growth in fish prices. This impact explains the slower growth of fish catch and faster growth of fish exports in the scenario.

The baseline scenario depicts a situation in which the projected growth rate of fish output is only about a quarter of its growth rate from 1991 to 2006. Scenarios 9 to 11 attempted to replicate historical patterns by introducing productivity growth in fisheries and higher growth of export prices. The key impacts in these scenarios were higher growth rates of exports and fish consumption compared to the baseline. Fish consumption is higher mostly because productivity growth tends to reduce domestic prices. On the other hand, higher export prices and fish output stimulate the growth of exports.

Figure 9 shows the projected quantities of fish aggregates by 2030 as a result of the growth rates described earlier. It indicates that production, net exports and consumption in 2030 are generally projected to be higher than the respective figures in 2005. The only major exception occurs under Scenario 3 (productivity change that causes a drastic cut in fish output/catch), where fish catch in 2030 is projected to be 36,100 tons or about 60 percent of the 2005 fish catch.

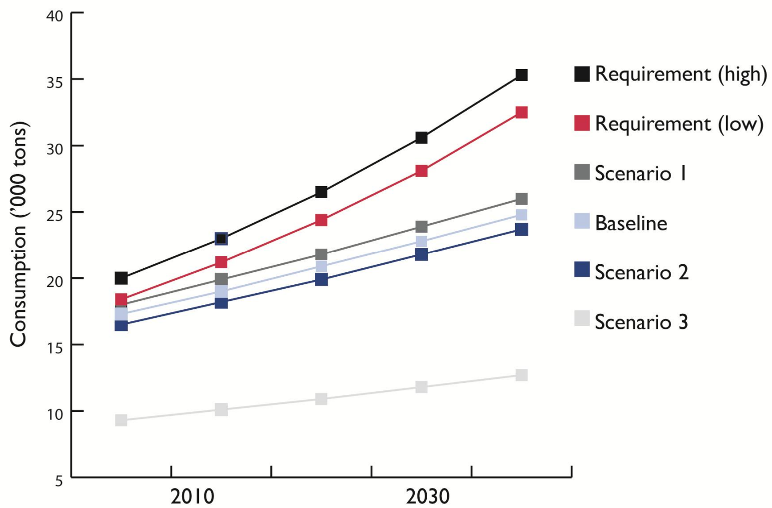

Figure 9: Aggregate consumption of fish, 2010 to 2030, 000 tons

It is important to note that the projected outputs for Scenario 4 (higher export prices) and Scenarios 9 to 11 (output growth depicting historical experience at different periods) in 2030 are much higher than their counterparts in 2005. This is especially true for Scenario 11 where the output in 2030 (519,300 tons) was projected to be more than 8 times larger than the actual output for 2005. The key question for these scenarios is whether the stocks in the fishing grounds of Solomon Islands are able to sustainably support such an output. A related question is whether the country can develop aquaculture to an extent that will make such outputs possible.

Table 14: Projected per capita fish consumption, in Solomon Islands (kg/year), 2030

Scenario	Rural	Urban
Baseline	26.39	24.74
1	27.64	25.90
2	25.13	23.57
3	13.52	12.52
4	14.27	12.90
5	19.54	18.18
6	29.74	27.85
7	25.62	24.03
8	16.10	17.03
9	36.90	33.86
10	38.52	35.13
11	41.44	36.49

Table 14 shows the projected per capita fish consumption in the rural and urban regions of the country by 2030. It indicates that per capita fish consumption is likely to be lower than the baseline in most of the scenarios. The only exceptions are Scenarios 1, 6, and 9-11. The results for Scenario 6 highlight the role of population growth with respect to per capita fish consumption. On the other hand, Scenarios 9 to 11 highlight the role of higher fish output. It is interesting to note that it is only in Scenarios 9 to 11 that per capita fish consumption is projected to be above the nutritional requirement for fish of 34-37 kg per person per year. Given the points raised in the previous paragraph, this suggests that, in the absence of strong and positive developments in aquaculture output, fish catch may have to rise to levels that will exert heavier pressure on fish stocks to support the nutritional requirements of the people.

Meanwhile, the results for the Aquaculture Plus scenario, which fall outside this model, are based on targets that are conservative for two reasons. First, it assumes that all aquaculture output will be destined for domestic consumption only. It therefore ignores the possibility that part of the aquaculture output will be exported. Second, estimates of target output were based on the lower limit of required consumption. The targets could be higher by about 9 percent, if the authorities adopt the upper limit of required consumption (37 kg/person/year).

Figure 10 shows projected aggregate fish consumption (required and under the different scenarios) for Solomon Islands from 2010 to 2030. It indicates that aggregate consumption needed to satisfy nutritional requirements is estimated to range from 18.4 to 20.0 thousand tons in 2010. This is projected to rise to about 32.5 to 35.5 thousand tons by 2030. Figure 9 also shows that aggregate consumption under four scenarios is lower than aggregate nutritional requirements for fish in 2010. The difference is largest for Scenario 3, where aggregate consumption is only about half of the lower end of required consumption. The gaps between required and actual consumption is also projected to become larger over time because the estimated growth in actual consumption will be unable to keep pace with the growth of the population.

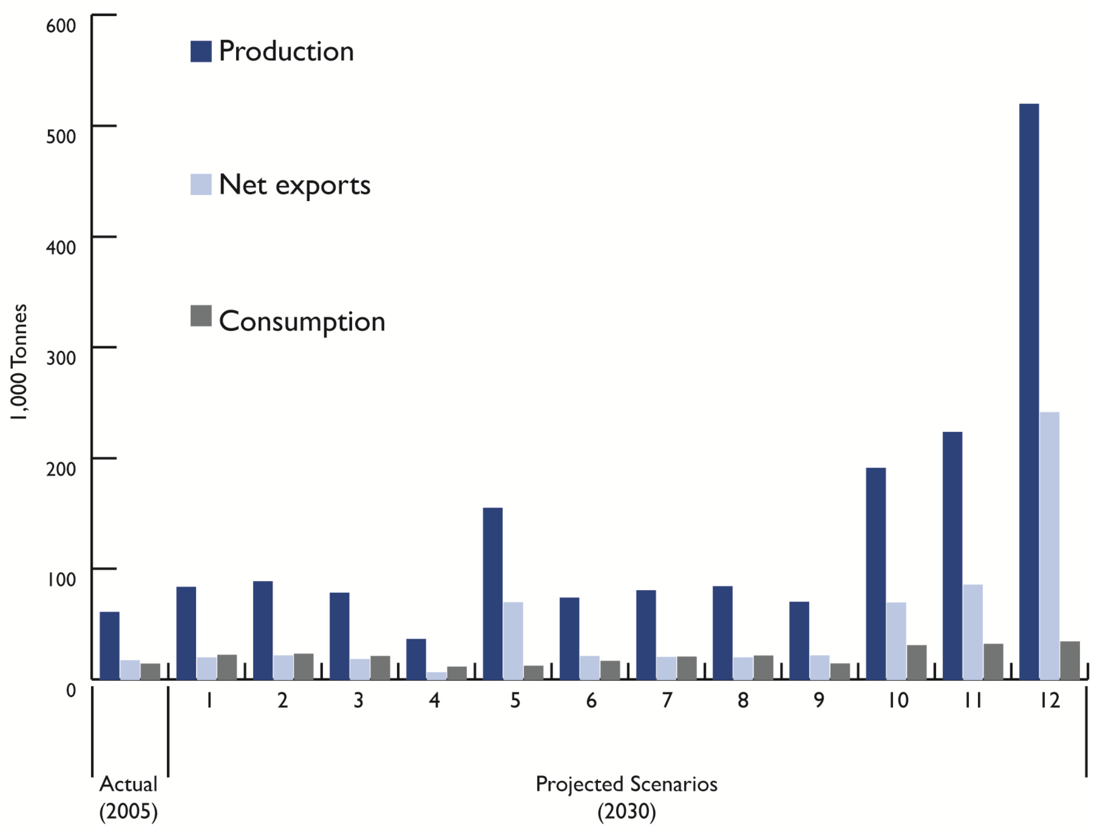

Figure 10: Projected quantities of output, net exports and aggregate consumption, 2030, ‘000 tons

Table 15: Target outputs for aquaculture under different scenarios, 2010 to 2030, tons.

Year	Baseline	Scenario 1	Scenario 2	Scenario 3
2010	1,113	366	1,870	9,112
2015	2,159	1,315	3,010	11,089
2020	3,515	2,567	4,470	13,461
2025	5,293	4,234	6,358	16,322
2030	7,636	6,463	8,816	19,788

The key implication of the previous finding is that Solomon Islands needs to better explore the potential of aquaculture. Based on the gaps between projected and required consumption, aquaculture output in 2010 could have been between 1,113 tons (Scenario 1) and 9,112 tons (Scenario 3) (Table 15). Moreover, the target output of aquaculture could grow to a range from 7,636 tons (Scenario 1) to 19,788 tons (Scenario 3) by 2030. The relatively large target in the case of Scenario 3 is due to the earlier finding that fish consumption is projected to be the lowest in this scenario.

Thus, based on these results, aquaculture is likely to be critical in meeting the nutritional requirements for fish in Solomon Islands. With the growing population of the country, aquaculture could play a more significant role in the next two decades.

7. POLICY IMPLICATIONS AND RECOMMENDATIONS

The model projects that fishery outputs, exports, and consumption will grow at a sluggish rate over the next 20 years. Current consumption levels of fish are already below estimated minimum nutritional requirements (Bell *et al.*, 2009). With the expansion in aggregate fish consumption failing to keep pace with population growth, per capita consumption of fish is expected to decline over time. At greatest risk are urban households, which are projected to consume significantly less fish than is required for adequate nutrition. Rural households are also estimated to consume less fish and might be more vulnerable because of their heavy reliance on fish as a source of animal protein.

The expert elicitation process identified legislation and institutional arrangements (both formal and informal), as well as technological and capacity development, as critical drivers determining the trends in the supply and demand of fish in Solomon Islands. From these two drivers, four scenarios were developed namely "Aquaculture plus" (high level of technology and bottom-up management); "Super tech" (high level of technology and top-down management); 'Where's the fish?" (low level of technology and bottom-up management) and "Classic" (low level of technology and top-down management). Aquaculture and large-scale offshore pelagic fishing could play an important role in the fisheries sector. However, for local farmers to participate in these activities productively and sustainably, new technologies, enhanced capacity, effective legislation, and formal and informal institutional arrangements are needed. Government assistance and external investors are equally important.

Model simulations also suggest that higher productivity growth, household incomes, and export prices are critical in strengthening the performance of the fisheries sector. However, higher export prices may hurt household consumption because of the increased incentive to allocate output away from domestic to foreign markets. The simulation results also show that fish output may have to increase substantially by about 5 percent annually over the simulation period, to support the nutritional requirements of the people of Solomon Islands by the year 2030. However, the key question is whether capture fishery resources can support such an increase in production.

The findings above lead to the following recommendations:

First, it is essential for the government to invest in measures to enhance the productivity of the domestic fisheries sector. This is important in raising fisheries output and may arrest, if not reverse, the projected decline in per capita fish consumption. However, this must be balanced against the potential over-exploitation of fisheries resources, which may negate the gains from higher productivity. Maintaining and restoring capture fisheries stocks by better governance and management of coastal and marine habitats is thus a significant factor in enhancing productivity.

Second, as recommended by Bell *et al.* (2009), promoting aquaculture as a source of fish for food and potential export revenues, as well as increasing the access of domestic fishers to the offshore tuna resource through fish aggregating devices may have to be considered. However, policy interventions that focus on economic incentives need to take into account socio-cultural motivations to participate in aquaculture and potential changes in consumption patterns.

Third, it may be important to explore other potential sources of animal protein. This may be in the form of measures that will increase fish imports, or promote the consumption of other meat products.

Finally, it will be important for the government to ensure a healthy macroeconomic environment. As shown in the model simulations, lower income growth tends to reduce fish consumption and output. Hence, policies that enhance income growth will help promote food security in the country. Income growth needs to be accomplished within the context of a subsistence-oriented small-scale economy in rural areas, where livelihoods are closely linked with access to and the health of ecosystems. In conditions where people depend on cash for limited purposes and the prevailing livelihood system combining fishing and gardening is socially valued, growth-oriented fish production policies addressed at achieving national food security need to ensure that the self-reliance of rural people for their subsistence needs is not undermined.

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APPENDIX I MODEL PARAMETERS

Parameters for the different fish types in the model

Parameter	Skipjack Tuna	Yellowfin Tuna	Bigeye Tuna	Other Tuna	Other Fish
Price elasticity of household demand for fish	-1.185	-1.185	-0.738	-0.738	-0.684
Elasticity of household demand for fish with respect to fish expenditure	0.451	0.451	0.980	0.980	0.492
Elasticity of fish output with respect to price	0.370	0.370	0.370	0.370	0.240

Other model parameters

Parameter	Value
Fish expenditure equation[a]	
θ_1	-0.440
θ_2 (meat)	-0.368
θ_2 (cereals)	-0.482
θ_2 (fruits and vegetables)	0.220
θ_2 (other food)	0.984
θ_3	2.522
θ_4	-0.080
Food expenditure function[a]	
β_1	-1.141
β_2	-0.440
β_3	2.650
β_4	-0.076
Elasticity of substitution between domestic and imported fish	1.1000
Elasticity of transformation between fish destined for domestic and foreign markets	1.6700

[a] See equations below.

Fish expenditure equation

$$\ln FEX_i = \theta_0 + \theta_1 \cdot \ln PF_i + \sum_j \theta_{2j} \cdot \ln PFN_{ij} + \theta_3 \cdot \ln FDEX_i + \theta_4 \cdot (\ln FDEX_i)^2$$

Where:

FEX = fish expenditure
PF = price of fish
PFN = price of non-fish food commodities
j = {meat, cereal, fruits & vegetables, beverages, other food}

Food expenditure function

$$\ln FDEX_i = \beta_0 + \beta_1 \cdot \ln PFD_i + \beta_2 \cdot \ln PFDN_i + \beta_3 \cdot \ln Y_i + \beta_4 \cdot (\ln Y_i)^2$$

Where:

FDEX = food expenditure
PFD = price of food
PFDN = expenditures on non-food commodities

Y = income

APPENDIX II CODES AND DEFINITIONS OF DRIVERS OF CHANGE

Code ID	Code	Brief Definition	Full Definition	When to Use	When Not to Use	Example
1	CVC	Climate variability and change	Variations in climate on different time scales and impacts	Apply this code when respondents mentions all forms of climatic inconsistency, and factors causing climate change and variability and impacts on fisheries and aquaculture resources	Do not use this code to refer to answers mentioned in ENV	"Coral reef health impacted by climate change"
2	POPC	Population change	Population growth	Apply this code when respondents mention all forms of population change and factors causing the change	Do not use this code to refer to migration of people from other countries.	"rapid population growth has increased demand for finfish"
4	MANAG	Governance and fisheries management more specifically on interaction between actors	Governance and fisheries management	Use to refer to role and interaction of actors. Basically, how the actors interact between each other in managing the sector.	in cases mentioned in LEGINS code	"Reduced power of traditional governance systems"
5	LEGIS	Legislation and formal and informal institutional arrangement	Fisheries laws, regulations, enforcement and property right	Apply to legal framework (laws, fines, penalties) and formal (legislation) and informal (property right) institutional arrangements.	In cases mentioned in MANAG code	'National fisheries laws e.g. Fisheries Act, capacity to monitor marine resources, enforcement facilities, etc"
6	POL	Political situation	Political stability	Apply this when respondents mention government stability, social unrest.	Not to use to refer to government policies impacts on fisheries and aquaculture sectors	"Ethnic tensions"
8	MARK	Market forces	Basic market forces of supply and demand	Apply this code to answers that mention supply, demand, prices, earnings, buyers and sellers (local and internationally). This includes inputs and costs of producing activities	Do not use this code to make reference to microfinance needs	'Growth in demand in local markets for fresh and frozen fish"
9	TECHC	Technological, capacity and support services	(a) Technological advances and innovations; (b) capacity	Use this code when respondents refer to advances in technology, improvement of fisheries	Do not use to refer to grants, incentives or subsidies given	"up to date technology and capacity."

Code ID	Code	Brief Definition	Full Definition	When to Use	When Not to Use	Example
			development; (c) infrastructure; (d) support services that have brought changes in fisheries sector	or harvesting equipment, increased quality of fisheries products and also improvement of fisheries infrastructure; support services and capacity (expertise)	by the government	
14	AQUA	Aquaculture	Aquaculture activities	Apply this code when respondents mention any kind of aquaculture related information/issue.	Do not use for fish for feed	"new tilapia species for local demand"
17	SOC	Social	Social behaviors and preferences	Apply when making reference to changes in social, human development, cultural and value	Do not use to refer to how humans drive changes in the environment	'Norms to control resources exploitation, sacred fishing grounds"
18	ENV	Environmental changes	Any natural or human induced factor that cause a change in the fisheries and aquaculture sectors	Apply to refer to any environmental change (except climatic change) that impacts resources, e.g. loss of biodiversity, degradation of ecosystem, aquatic pollution, overexploitation of resources, destructive fishing methods, overfishing	Do not use to refer to factors affecting management of resources lack of enforcement	'Depletion of specific species or collapse of certain fishery''

APPENDIX III GROUPING OF DRIVERS OF CHANGE BASED ON SURVEY RESPONSES

Notes:

1. Impact (-/+) denotes direction of impact, either negative (-) or positive (+).
2. Impact level denotes ranking of importance from 1-10, where 1 = the lowest impact and 10 = highest impact.
3. Likelihood level denotes how certain the driver will occur, where 1 = highly likely, 2 = likely, 3 = even chance, 4 = unlikely and 5 = highly unlikely.
4. Driver ID denotes code ID of the identified 10 key drivers.

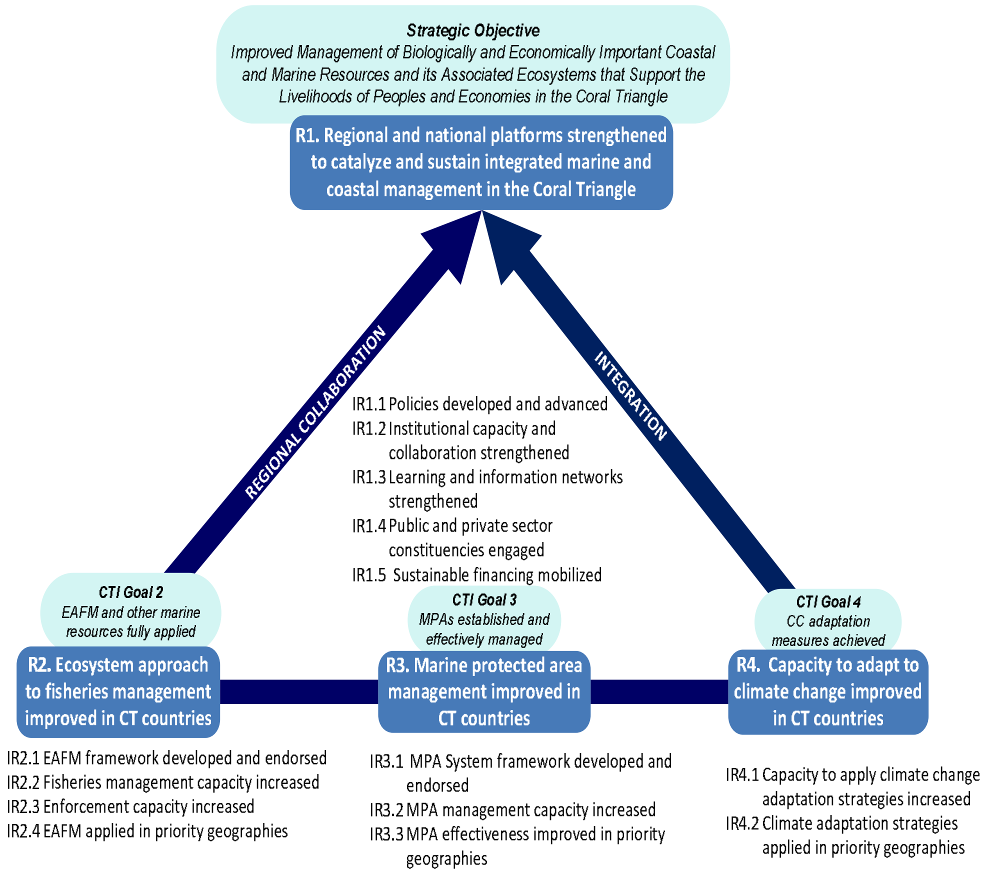
Respondent ID	Driver	Impact (-/+)	Impact level	Likelihood level	Driver ID
R1	Climate change	-	6	2	1
R2	Sea level Rise/Environmental	-	10	2	1
R5	Change in fish distribution and abundance and fish habitat degradation due to climate change	-	6	3	1
R10	Coral reef health (climate change)	-	8	4	1
R3	Climate Change impact on Fisheries	-	2	3	1
R1	Population increase	-	10	1	2
R5	Population growth	-	10	1	2
R7	Population growth in the Solomons including people living longer (better medical)	-	10	1	2
R9	Population growth of 3 percent per annum	-	10	1	2
R1	Urbanization	-	7	1	2
R7	Urban drift as people move from outer locations to main centers for employment	-	4	2	2
R12	Population growth	-&+	10	1	2
R1	Corruption	-	2	1	4
R1	External pressure from nations with vested interests e.g. in tuna	-	5	1	4
R2	Pacific Forum countries	+	7	3	4
R2	Conservation NGO	+	4	2	4
R2	Fisheries Research Institutions	+	5	2	4
R3	A more Coordinated fisheries programs and information sharing	+	5	2	4
R3	Consolidate Partners Collaboration	+	6	2	4
R9	Corruption at all levels	-	3	1	4

Respondent ID	Driver	Impact (-/+)	Impact level	Likelihood level	Driver ID
R12	Better governance of fisheries and aquaculture sector	+	8	3	4
R1	Increasingly improved policy and legislation	+	3	4	5
R10	Reduced power of traditional governance systems	-	10	1	5
R9	Community based management (only if real and effective)	+	5	4	5
R2	Customary/ Land tenure systems	+/-	1	2	5
R3	Enabling and clear Policies and Legislations	+	9	2	5
R3	Community Based Fisheries Management Approach	+	7	2	5
R9	Government Fisheries Legislation	+	1	2	5
R9	Customary Management	+	8	4	5
R12	Defendable property rights to farmed fish	+	7	3	5
R9	Marine Protected Areas	+	6	2	5
R5	Cost of fuel or availability of alternative energy	-	2	3	8
R1	Reduction in income from Forestry	-	9	1	8
R9	Extractive industries such as logging and mining	-	9	1	8
R9	Subsistence and Artisanal fisheries	-	2	1	8
R9	Industrial Fisheries	-	7	1	8
R2	Economical	+	8	2	8
R5	Food insecurity in other sectors caused by high prices for imported goods	-	5	3	8
R5	Demand for export commodities	-	8	1	8
R10	Increased price of processed foods	+	5	2	8
R10	Higher operating costs (fuel)	-	6	3	8
R12	Demand for fish	-/+	9	1	8
R1	Increasing connectivity of rural areas to the outside world (communications)	-/+	8	1	9
R1	Private investment	+	1	4	9
R2	Technological	+	6	2	9
R3	Availability of required expertise	+	3	2	9
R3	Up to date technology and capacity (HRD)	+	8	3	9
R3	Good leadership (Directorates)	+	10	2	9
R3	Timely availability of Sustainable Finance and Financing	+	4	3	9
R4	Fisheries capacity improves along with good governance	+	10	2	9

Respondent ID	Driver	Impact (-/+)	Impact level	Likelihood level	Driver ID
R4	Improvement in market infrastructure, particularly shipping	+	8	3	9
R7	Technology creep and/or more effective fishing practiced for tuna fishery	-	1	2	9
R2	Political stability	+	9	3	6
R3	Government Instability	-	1	4	6
R5	Social unrest	-	4	3	6
R7	Government stability and good governance	+	9	3	6
R5	Application of aquaculture technology	+	3	4	14
R7	Land ownership issues for developing aquaculture	-	3	3	14
R12	Local (ideally on-farm) inputs to aquaculture		6	3	14
R1	Hunger and poverty	-	4	3	17
R2	Educational	+	2	2	17
R9	Education	+	4	3	17
R2	Social	-	3	3	17
R4	Education and awareness amongst fishers ensures knowledge of sustainability issues; including the pursuit of CBFM	+	9	3	17
R7	Environmental awareness and education on the need to conserve natural resources	+	5	3	17
R7	"Westernization" as people want to move away from subsistence to a cash economy	-	8	2	17
R7	Dependence on money (and ways to earn it) to pay school fees etc	-	2	3	17
R5	Lack of alternative livelihoods	-/+	9	2	17
R5	Increased awareness of the benefits of eating fish by local people	+	1	4	17
R7	Pollution, deforestation, poor land management etc	-	6	2	18
R7	Natural disasters, cyclone, tsunami earthquake etc	-	7	2	18
R5	Habitat degradation not due to climate change	-	7	2	18

APPENDIX IV CTSP RESULTS FRAMEWORK

Progress for CTSP is measured against the USCTI Support Program Consolidated Results Framework illustrated below.



CTSP uses the USCTI set of common indicators to measure program progress:

Common USAID Indicators to Measure Program Progress

1. Number of hectares in areas of biological significance under improved management.
2. Number of hectares under improved natural resource management as a result of USG assistance.
3. Number of policies, laws, agreements or regulations promoting sustainable natural resource management and conservation that are implemented.
4. Number of people receiving USG-supported training in natural resources management and/or biodiversity conservation.
5. Number of laws, policies, agreements, or regulations addressing climate change proposed, adopted, or implemented as a result of USG assistance.
6. Number of public-private partnerships formed.

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