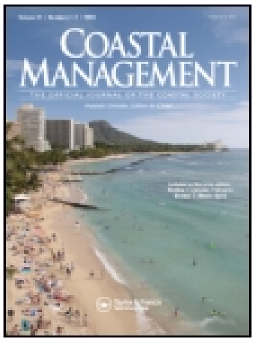

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Coastal Management

ISSN: 0892-0753 (Print) 1521-0421 (Online) Journal homepage: http://www.tandfonline.com/loi/ucmg20

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To cite this article: Annabelle Cruz-Trinidad , Porfirio M. Aliño , Rollan C. Geronimo & Reniel B. Cabral (2014) Linking Food Security with Coral Reefs and Fisheries in the Coral Triangle, Coastal Management, 42:2, 160-182, DOI: 10.1080/08920753.2014.877761

To link to this article: http://dx.doi.org/10.1080/08920753.2014.877761

Published online: 12 Feb 2014.

Coastal Management, 42:160–182, 2014

ISSN: 0892-0753 print / 1521-0421 online
DOI: 10.1080/08920753.2014.877761

Linking Food Security with Coral Reefs and Fisheries in the Coral Triangle

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Maintaining ecosystem services of coral reefs, sustainable fishing, and improved food security are the three higher level outcomes of the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF). Food security is an obvious concern of the CTI-CFF because of 130 million people dependent on fish resources for food, income, and livelihoods, and also because it provides 11.3% (19.1 million tons) to global fisheries production from capture fisheries and aquaculture. Yet, anthropogenic stressors, especially overfishing, threaten the ecosystems that support food production. Fish supply deficits and undernourishment are observed in varying degrees across the CTI-CFF countries to be further exacerbated by increasing populations, increasing demand for fish from developed economies, unabated coastal development, and climate change. Short-term and urgent strategies to improve food security focus on arresting continued deterioration of coral reefs and fisheries to improve availability of fish, stabilize ecosystem services, and improve incomes at the local level. Wealth-focused and welfare-based approaches to achieve food security at various governance levels are proposed.

Keywords coral reefs, Coral Triangle Initiative, CTMPAS, fisheries, food security, LMEs

Introduction

Eradicating extreme poverty and hunger is Goal 1 of the Millennium Development Goals. The proportion of undernourished people worldwide decreased from 23.2% in 1990–1992 to 14.9% in 2010–2012; still, one in eight people worldwide remain chronically undernourished (United Nations 2013). Cutting hunger and undernourishment pose serious challenges as populations continue to rise, demographics are changing with increasing urbanization, lower-income countries are graduating to middle to higher income economies, and

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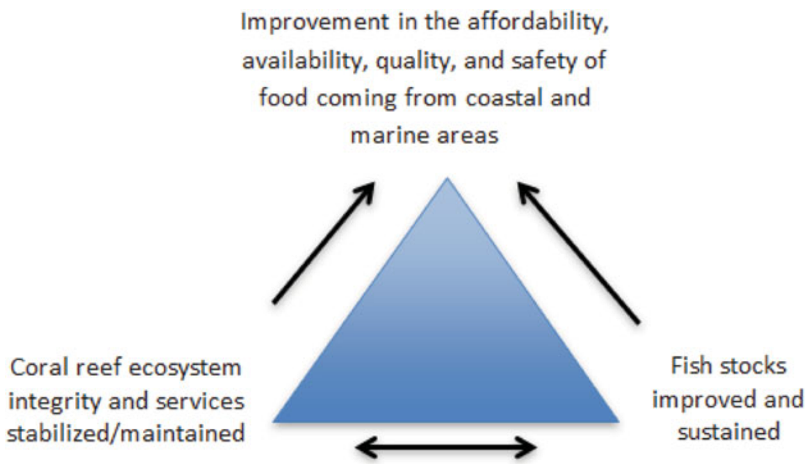

Figure 1. The hierarchy of the three higher-level outcomes of the CTI.

agriculture's share to economic growth is shrinking (FAO 2005).The six countries (CT6) of the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF), Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands, and Timor-Leste, confront these challenges which are further exacerbated by increasing pressure on coastal resources and climate change impacts, in varying degrees (Cabral et al. 2012).

Food security is an urgent concern of the CTI-CFF because of 130 million people[1] dependent on fisheries ecosystems for food, income, and livelihoods, and also because capture fisheries and aquaculture contributes 11.3% (19.1 million tons) to global fisheries. Yet, fisheries ecosystems are threatened by anthropogenic stressors, their already debilitated condition further exacerbated by climate change impacts and extreme natural disturbances (Burke et al. 2012). Although total fish catches have continued to increase in the CT6 since 1951, several studies have predicted that the countries are nearing, or have already exceeded, the critical carrying capacity of their demersal and pelagic fishery resources (Lymer, Funge-Smith, and Miao 2010). Using marine trophic indices, SAUP (2012) observed that Indonesia, Malaysia, and Philippines have been fishing down the food web over the past half century and catching lower trophic level species. Many fishing grounds in the CT6 also suffer from overexploitation and illegal, unreported, and unregulated (IUU) fishing (Cabral et al. 2012, 2013a; Burke et al. 2012). Hall et al. (2013) conclude that the major anthropogenic threat to fisheries is fishing itself.

The triumvirate of coral reefs, fisheries, and food security are the higher level outcomes into which all the five goals of the CTI-CFF converge: seascapes, fisheries, marine protected areas (MPAs), climate change, and species. In terms of the hierarchy, food security forms the apex of the triangle with coral reefs and fisheries occupying an intermediate position (Figure 1).

Fisheries directly contribute to food security through the provision of animal protein for those who catch fish as well as the larger economic sector, and indirectly, through the generation of incomes, livelihoods, and employment that allow fisherfolk households to purchase food and other services (Worldfish Center 2011; Foale et al. 2013; Hall et al. 2013). Coral reefs are habitats that nurture fish, mussels, crustaceans, and sea cucumbers, which are consumed as food and provide recreational, spiritual and cultural services, coastal protection, build-up of land, maintains biodiversity and regulation of ecosystem processes, and so on (Moberg and Folke 1999). Values associated with fish species dependent on the reef ecosystem at one or more stages of their life cycles pale in relation to the myriad ecosystem services derived from coral reefs that provide direct and indirect linkage to food security. Of fishes caught in the CT6 in 2009, 30% or 2.66 million tons are reef-associated fish and invertebrate families, which would increase considerably if subsistence fisheries are taken into account (Geronimo and Cabral 2013). Beyond its contribution as food, Holmlund and Hammer (1999) identified two categories of ecosystem services for fisheries: linking services (linkage within aquatic ecosystems, linkage between land and aquatic ecosystems, and transport of nutrients and minerals) and regulating services (regulation of food web dynamics, recycling of nutrients, and redistribution of bottom substrates).

In this article, we describe the food security situation in the CT by focusing on the linkages between coral reefs, fisheries, and food security, and we offer some strategies that can directly address the availability of fish and enhance affordability by improving incomes, generating revenues from sustainable resource use, and providing for redistribution of incomes. Equality in income redistribution means resources and benefits are shared towards greater good. We recognize the contribution of small pelagics and tuna fisheries to food security in the CT but it is outside the scope of analysis mainly because examination of the socioecological linkages of MPAs on coral reef fisheries would deserve another chapter (Courtney et al. 1998; Bernascek 1994; Lachica et al. 2006; Allain et al. 2012). We characterize food security by focusing on its components: availability, affordability, and quality. Two case studies based on Cruz-Trinidad et al. (2013a, 2013b) and Albert et al. (2012) were used to illustrate how subsistence fisheries contribute to food security at the local level. We emphasize the various ecosystem services provided by coral reefs, one of which is fisheries, and propose methods for better attribution.

Extraneous factors or drivers affect the potential of coral reefs and fisheries to optimally contribute to food security. ADB (in press) and Cabral et al. (2013b) identify population, poverty and governance, demand for fish, climate change, coastal development, and trade as the key drivers of change in the CT. Following Foale et al. (2013) and Bene, Macfayden, and Allison (2007), we provide examples of wealth-based (resource-access limits) and welfare-focused (resource-access maintained, community involved in development process) approaches and recommend its level of application as being local, sub-national/national, or regional.

Coral Reefs, Fisheries, and Food Security in the CTI

The FAO uses the definition of food security adopted at the World Food Summit of 1996: “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.” Widely acceptable indicators of food security are: food availability, food access, utilization, and stability. Availability means sufficient quantity and quality of food. This can be sourced from local production or importation, although the latter can be very sensitive to perturbations (stability). Access refers to distribution system for food, prices, or may be driven by the pertinent local access arrangements of resources. Utilization highlights the non-food resources, describing the diet/food choice behavior of the population and the underlying social services and environmental conditions (e.g., water and air quality). Stability describes the ability of the population to absorb food supply

Table 1
Components of food security in the CTI and suggested indicators

Components of food security	Indicators
Availability	• food sufficiency of fishing household; • food consumption of coastal communities
Quality and safety	• contribution of fish to protein requirement; • health of fishing communities
Affordability	• income of fishers; • price

shocks or adapt to the cyclical nature of the food supply (e.g., for the case of farming and fishing).

A similar set of food security indicators has been agreed on by the Monitoring and Evaluation Working Group (MEWG) of the CTI-CFF resulting from a series of meeting[2] (Table 1). Affordability affects access to food and can be influenced by fish prices and/or income of consumers. An improvement in incomes would make fish more affordable and vice-versa although varying health needs between developed and developing economies are observed. Developed economies give import to fish as sources of good oils and poly unsaturated fats while developing economies consume fish to combat undernourishment (Worldfish Center 2011). Affordability is also influenced by the availability or supply of fish, and/or prices of fish substitutes, such as meat and other proteins, prices of other non-fish food, and real food expenditures (Weeratunge et al. 2011).

FAO developed a Fish Price Index (FPI) starting in 2010 to compare trends in fish prices relative to the overall food price index, using trade data from 1990 onward (Tveterås et al. 2012). From 2001 to 2010, price index for all food rose, including that of fish, but the increase in fish prices was 40.9%, less than half of the increase in food prices. As the global supply of seafood becomes more influenced by aquaculture, fish prices became more competitive. From 2005 onward, the increase in FPI for capture fisheries has been more pronounced compared to the general FPI, which, in turn, is higher than the aquaculture index. Using volume and value of production, Geronimo and Cabral (2013) derived prices of capture fisheries and aquaculture across the CT and confirm that the former registered higher prices. Furthermore, fish is generally more expensive by at least 50% in the Pacific compared to South East Asia. In contrast, the derived prices from aquaculture are more dispersed with Indonesia and the Philippines registering lowest prices (possibly due to importance of seaweeds as aquaculture produce). Malaysia's derived price is almost three times that of the Philippines' price, which can be attributed to higher valued species cultured.

Consumption of Fish and Contribution to Nutrition

Per capita fish supply and contribution of fish to animal protein of four CT countries except for Papua New Guinea and Timor-Leste is higher than the global average and that of Asia (Table 2 and Figure 2). Although there is an obvious decline in the per capita fish consumption of Malaysia from 60.23 (2000–2002) to 51.10 kg per year (2005–2007), Malaysians still tallied the highest per capita fish consumption for the CT6. There is a continuous increase in per capita fish consumption for Indonesia while a decrease was observed for Solomon Islands from 1990–1992 to 2005–2007. There is no clear trend for

Table 2
Food security parameters of the CT countries

	Malaysia	Indonesia	Papua New Guinea	Philippines	Timor-Leste	Solomon Islands	Asia	Oceania
Fish supply (2007) (ton)[a]	1,489,953	5,460,553	103,692	3,138,560	4024[c] (2004 data)	16,734	75,207,046	868,210
Per capita fish supply (kg/person/year) (2007)[a]	56.1	24.3	16.1	35.4	4.4[c] (2004 data)	33.6	18.7	25.2
Fish protein (gram/capita/day) (2007)[a]	17.1	8	5.2	11.3		11.6	5.1	6.5
Fish protein as a% of total protein supply (2007) [b]	21.9	14.1	6.9	18.9		22.2	7.1	6.6
Fish consumption (kg/person/year)[b] (Average)								
1990–1992	48.18	15.33		35.41		45.63		
1995–1997	55.85	18.98		29.93		41.25		
2000–2002	60.23	21.54		29.2		31.03		
2005–2007	51.1	23.36	13[d]	32.49	6.1	31.03		

[a]FAO (2010). [b]FAO (2012b). [c]FAO (2012a),[d]Bell et al. (2009).
Source: Cabral et al. (2013a, supplementary file).

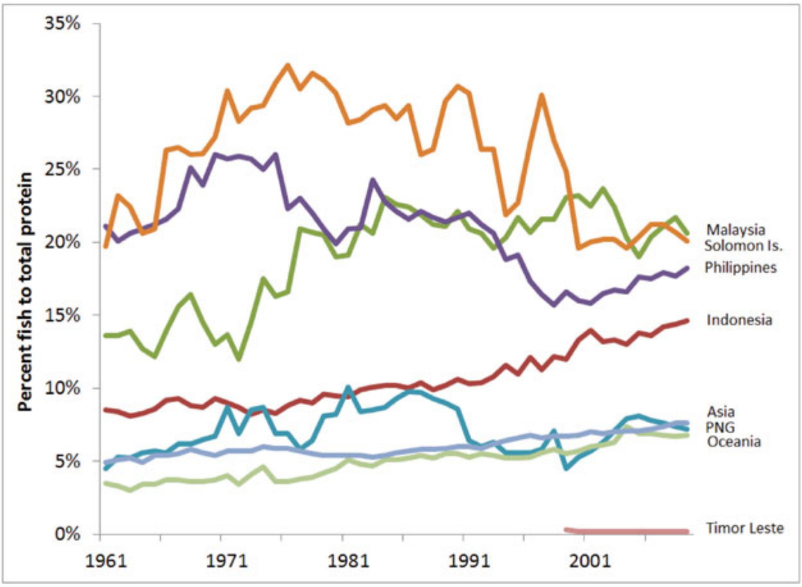

Figure 2. Proportion of fish to total protein provision in the CT. *Source:* FAO (2010).

the Philippines. Meanwhile, no trend can be deduced for Papua New Guinea and Timor-Leste due to the lack of time-series data.

Cabral et al. (2013a) indicated protein consumption deficiency in Indonesia and Philippines. The per capita fish consumption in the Solomon Islands and in Papua New Guinea is currently below the standard requirement to satisfy their present and future dietary protein needs (Bell et al. 2009). Furthermore, Timor-Leste suffers from chronic food insecurity (Ministry of Agriculture and Fisheries 2012). With these conditions, children suffer from insufficient weight and stunted growth (World Food Program 2009). Carbohydrates consist of the main staple of the diet while animal protein has minimal contribution. Fish per capita consumption in Timor-Leste is 6.1 kg, about a third of the average in Asia. Due to absence of ice making facilities and distribution network, inland communities in both Timor-Leste and Papua New Guinea are unable to access fish.

Data from the Secretariat of the Pacific Community (2008) shows an average of 50–90% of animal protein intake in rural areas, and 40–80% in many urban centers. Most of the fish eaten by rural people comes from subsistence fishing and per capita consumption in rural areas often exceeds 50 kg of fish per year.

Subsistence Fisheries and Food Security

In fisheries as in agriculture, paradoxically, it is often those who produce food who are among the most seriously malnourished (Kent 2003). Two case studies in the CT, however, show that where food fish is concerned, subsistence fishers and their households are secured.

Case Study 1. Muallil et al. (2012) collected socioeconomic and fisheries profile for 25 towns all over the Philippines. Using their data, we estimate the impact of fish catch retained for household consumption on production, poverty threshold levels, and wages. Muallil et al. (2012) estimated an average catch per fisher per day of 4.8 kg to which was

Table 3
Economic and food security implications of subsistence fisheries in the Philippines

Subsistence fisheries parameter	Estimation of subsistence fisheries contribution	Implications to economic variables
Volume of home consumption is 0.48 kg per fisher per day (Muallil et al. 2012) (assumed 10% retention)	• 0.48 kg/per fisher/day • 658,000 kg per day for household consumption based on 1.3 million municipal fishers (Bureau of Fisheries and Aquatic Resources) • 195,000 tons per year based on 300 fishing days per year	Fish consumed at household level amounts to at least 16% of municipal fisheries production from marine sector
Value of home consumption	0. 48 kg and price of US$1.8 per kg is US$0.86 per day (Php35.3)	Value of fish consumed at household level is 22% of daily food poverty threshold of US$3.95 or Php162 Value of fish consumed at household level is 16% of minimum wage rate for agriculture sector worker outside Metro Manila, i.e., Php225 or US$5.5 per day

Source: Cruz-Trinidad et al. (2013b). Exchange range used is US$1 = Php41.

applied a 10% retention rate (i.e., amount of fish consumed or given away). This translates to 0.48 kg per day per fisher or per household in cases where the fisher is also the head of the family. The volume of consumption translates to 195,000 tons of fish or 16% of total production of the municipal marine sector on a yearly basis (Table 3). Value of fish consumed at home is estimated to be 22% of food thresholds and 16% of minimum wage rate for areas outside Metropolitan Manila, the capital of the Philippines. Improving fish catch coupled with better access to markets can enhance fishers' income and allow them to purchase or exchange fish with other goods and services.

Case Study 2. The second case study used the Total Economic Value (TEV) framework to estimate direct, indirect, and non-use values of corals in four communities in the Western and Central Provinces of Solomon Islands (Albert et al. 2012). Direct use values of coral reefs to rural coastal communities were derived by asking respondents the type of food goods (including fish, clams, crayfish, shells, seaweed), construction materials (sand, rubble, and coral boulders), and trade goods (e.g., trochus, shark fins, coral lime, curio coral, aquarium coral, and other reef ornamentals) they collect from the reef. The respondents were also queried about the disposition of these goods, that is, whether they are consumed by the household or sold for cash. The main reef-derived food goods across all study communities were fish, clams, seaweed, trochus, lobsters, and shells. In general, food goods derived

Table 4
Value of food (showing reef fish value separately), material, and trade goods at the four communities in Solomon Islands (SI$ per year per respondent)*

	Coral trade communities		Non-coral trade communities	
	Community A	Community B	Community C	Community D
Food	9,619	32,683	42,920	17,778
reef fish	3,419	7,749	12,062	8,197
Materials	533	14,224	1,884	1,061
Trade	8,312	28,236	3,608	2,385
Total	18,464	75,143	48,412	21,224

*Exchange rate was US$1 = SI$7.28, November 2011.

from the reef were ranked equally important for consumption in the household and for sale, although some food items (e.g., shells) were mostly for household consumption.

Coral reefs provide on average SI$18,000–75,000 per respondent per year in Solomon Islands (Table 4). Food contributed the greatest proportion to the TEV of direct use goods at all sites. Food goods derived from reefs yield an average subsistence and cash value of SI$9,600–43,000 per respondent per year across the four study sites.[3] Fish was considered by all communities as the most important reef good and accounted for 23–39% of the total direct economic value at the two "non-coral trade" harvest communities and 10–18% at the two "coral trade" communities.

Using our estimate of 88,000 people involved in fishing and extrapolating from the four villages (Cruz-Trinidad et al. 2013b), it is estimated that the subsistence and cash value of reef fish is SI$300 million–SI$1,000 million per year (US$41 million–US$145 million per year). These estimates are 4 to 13 times greater than the value of coastal subsistence fisheries estimated by Gillett (2009), highlighting that current estimates may undervalue the role of reef fish to rural communities and the need for more accurate data on the subsistence value of reef fish in the country. To further contextualize the magnitude of underreporting, the value of subsistence fisheries was compared to per capita income, which was estimated at US$3,200 for 2011 (www.indexmundi.org) or roughly SI$22,857. Since virtually none of the subsistence economy is appropriately valued, we can assume that the real per capita income can be adjusted upward by roughly the value of the contribution of subsistence sector at the minimum, noting that other reef goods contribute likewise. The upward adjustments to per capita income range from a minimum of 11% to a maximum of 28%, reiterating how important CT subsistence fisheries are to food security.

Coral Reef Fisheries and Values

Coral reefs and fisheries contribute to food security directly through provision of fish as food for subsistence and indirectly through wealth-building by increasing the purchasing power of fishing households to augment food supply through the sale of fish and recreational uses reefs (Foale et al. 2013). Global estimates peg the number of coral reef fishers between 5.8 and 6.1 million (Teh, Teh, and Sumaila 2013). Reef catch per total marine landed value per region range from 11% for Southeast Asia to 43% in the Middle East, excluding scombrids, which are also commonly considered reef-associated (Teh, Teh, and Sumaila 2013).

Table 5
Value of fisheries attributed to coral reefs, 2007

Country	Percent volume of inshore reef fish in production (FAO 2007 data)	Value of marine capture fisheries (US$)	Value of fisheries from inshore reef fishes (US$)
Indonesia	15	4,931,010,735	728,643,755
Malaysia	17	1,466,371,836	256,549,861
Papua New Guinea	1[a]	811,730,952	4,082,824
Philippines	12	2,454,965,353	296,820,828
Solomon Islands	32[a]	210,079,814	67,225,540
Timor-Leste	0.4	5,817,600	23,974
Coral Triangle	14[b]	9,879,976,290	1,286,409,780

[a]Following Newton et al. (2007), "marine fishes nei" for Papua New Guinea (0.89% in 2007) and Solomon Islands (31.93% in 2007) were categorized as reef-derived and applied similarly in this study. *Source:* Based on catch composition reported in FAO 2007 data.
[b]Percent volume of other fish groups: small pelagics (35%), oceanodramous (25%), demersal marine (10%), estuarine (3%), marine fishes nei (13%).

Geronimo and Cabral (2013) estimated the contribution of coral reefs to fisheries value for the CT6 using the proportion of reef-associated fish in the FAO production data for 2007 and augmented with national statistics and data from other sources for the Pacific countries. Following the work of Newton et al. (2007), FAO marine capture fisheries landings were categorized according to source ecosystem (i.e., coral reef, demersal, ocean, freshwater, and estuarine) and the percentage of reef-associated fish production was multiplied by the total capture fisheries value to obtain the contribution of reefs to the CT6 fisheries. Reef-associated fishes contribute between 0.4% and 38% of the total capture fisheries production by volume amounting to $3 billion (2007). These estimates coincide with the percentage estimates of "reef / total landed value" for the CT countries by Teh, Teh, and Sumaila (2013), which ranges from 1% (Papua New Guinea) to 34% (Philippines).

In order to get a more conservative estimate of reef fish contribution to food supply and fisheries value, we separated "small pelagics," as defined in Trinidad et al. (1993) and Dalzell and Lewis (1989), from the reef-associated and oceanodramous fish classifications used by Geronimo and Cabral (2013). The remaining reef fish group was called as "inshore reef fish." Inshore reef fish production relative to the overall marine capture fisheries production in 2007 ranged from less than 1% (Timor-Leste and Solomon Islands) to 17% (Malaysia) with a CT6 average of 14% (Table 5). Although still substantial, this contribution is smaller than small pelagic fishes and oceanodramous fishes which respectively account for 35% and 25% of the total marine capture fisheries production in the CT6 in 2007. Nevertheless, coral reefs are important food sources for poverty-stricken coastal communities particularly for households who cannot afford to venture further than a few hundred meters to catch small pelagic fishes.

Based on the total value of marine capture fisheries production, the "inshore reef fish" value for the CT is estimated at $1.3 billion in 2007 (Table 5). A regional estimate of coral reef value to fisheries in the CT thus ranges from $1.3 billion to $3 billion.

Tuna adds another $0.15 to $0.30 billion to this value considering that albacore (*Thunnus alalunga*)and yellowfin tuna (*Thunnus albacares*) frequently consume reef prey, accounting for 10% to 30% of their diet depending on their size (Allain et al. 2012), albeit as one goes deeper the diet for the yellow tuna only contributed to 6% consistent with previous findings of Grandperrin (1977). These estimates of reef (and tuna) fisheries value from coral reefs represent, on a regional basis, 17.8% of reefs being situated within MPAs, with three countries, namely the Philippines, Papua New Guinea, and Solomon Islands registering less than 5% of total reef area within MPAs (White et al. 2014). By increasing MPA sizes possibly through networking and improving functionality, fisheries values from coral reefs will likely increase with significant impacts on food security for the CT countries where subsistence fisheries play a dominant role.

The percentage of reef-associated fishes in overall capture fisheries production varied across the CT6. The CT–SouthEast Asia countries' (CTI-SEA: Indonesia, Malaysia, and Philippines) marine capture fisheries are composed of around 30% reef-associated fishes. In the CT-Pacific countries (Papua New Guinea, Solomon Islands, and Timor-Leste), only the Solomon Islands has a significant volume of reef-associated fishes reported in FAO landings after the "marine fishes nei" group were interpreted as reef-derived (Newton et al. 2007). However, the dominance of tuna in the CT-Pacific's marine fish catches means that the contribution of reefs to capture fisheries production is most likely proportionately smaller than in the CT-SEA. In all countries, the contribution of subsistence fisheries that are known to exploit primarily coastal fishes could increase the percentage contribution of reef-associated fishes to total fish production in the CT6. Unfortunately, information on CT6 catches of subsistence fisheries and exploitation rates is limited to studies in small fishing communities, not integrated in most national statistical samplings, and insufficient for scaling-up to national statistics.

Drivers of Change in the CT's Coral Reefs, Fisheries, and Food Security

Drivers are broad macro socioeconomic issues and processes considered as root causes of pressures/problems (Chua 2010). Six key drivers of change were discussed in these reports: population growth, coastal development, poverty and governance, demand for fish, climate change, and trade (see ADB in press and Cabral et al. (2013b) for comprehensive discussions).

Population

As of 2011, there are 373 million people in the CT over a land area of 3 million km^2 (ADB 2011). Indonesia has the largest population, almost 242 million, and Solomon Islands the smallest at 500,000. The Philippines has the highest population density at 300 people/km^2 while Papua New Guinea is the least dense at 14 people/km^2. Populations in the CT6 have been growing steadily over past decades and in 2007–2011, population growth rate averaged 1.71%, slightly higher than the global figure for the same period (1.66%). Pacific countries have annual population growth rates greater than 2%. Even at current population levels and the projected increase in population, insufficiency in various aspects of food security are already being experienced in the region and will be a challenge in the future.

CIESIN (2007) estimates that 33% of the CT6 population live within 10 km of the coastline. Regionally, 8% of the CT6 population directly depend on fisheries and aquaculture for their livelihood; however, these numbers are based on formal employment in the commercial fisheries sector as well as aquaculture. Available estimates reveal that 50% of all women and 90% of all men in Solomon Islands participate in small-scale fishing activities (Gillet 2009).

Coastal Development

Considerable expansion and development in foreshore areas of the CT6 is ongoing (Burke et al. 2012; McLeod et al. 2010). Unregulated mining and poorly planned tourism, industrial development, housing development in the foreshore areas are the major issues in the CT6. While coastal development is not inherently damaging the lack of governance mechanisms to manage development, it has resulted in several unwanted consequences (Cabral and Aliño 2011). These include spatial and user conflicts, conversion of mangrove areas, and increased siltation and waste discharge that damages the reefs.

Poverty and Governance

Poverty incidence in three of the CT6—PNG, the Philippines, and the Solomon Islands—is between 20% and 30%. In Timor-Leste it was more than 41.1% in 2009. Urbanization of poverty has been occurring in the Pacific, replacing previously defined poverty standards by the harsh reality of hunger, destitution, and absolute poverty (ADB 2012). Population growth, political instability, ineffective governance, and ethnic strife are the main causes. Urbanization is also an internal driver and determinant of demand for fish as evidenced in the Solomon Islands and Timor-Leste (Geronimo and Cabral 2013).

Based on CT6 data, economic development, improvement in governance, and human development are all positively correlated (Cabral et al. 2012). Gillespie, Mason, and Martorell (1996) opine that economic growth results to reduction in poverty and hunger while FAO (2002) suggests that food security is the driver of economic growth. Certainly, economic growth and food security objectives can be harmonized by adequate social protection especially for the vulnerable sectors and decisive and focused public action that improves access to resources, empowerment (also of women), transparency, and governance (FAO, WFP, and IFAD 2012). WorldFish Center (2011) likewise suggests that food insecurity and hunger often result from political processes and social structures that deny people the right to access food or what Sen (1981) refers to as "entitlement failures."

Illegal, Unreported, and Unregulated (IUU) fishing depicts a major economic leakage, a direct threat to food security, and a failure of governance via absence of clear policies and procedures and inability to enforce them. In developing countries, illegal fishing by large-scale vessels, including distant-water fleets, is widespread. In the Arafura Sea of Indonesia, for example, the annual average of total loss due to illegal, unreported and unregulated fishing reaches 1.26 million tons at Rp11.4 trillion (Wagey et al. 2009). Such boats often come into conflict with small-scale fishers by encroaching on inshore waters, increasing competition for the resources, and leaving such areas depleted and habitats degraded.Accurate production from IUU is difficult to determine as, by its very nature, IUU operations are not well documented. Nevertheless, some studies estimated that the worldwide annual production from IUU operations could be ranging from 11 to 26 million metric tons (MT) accounting for about 10 to 22% of the world's total fisheries production, and valued at about US$10 billion to US$23.5 billion per year (Agnew et al. 2009). Other earlier studies suggested similar estimates, for example, US$25 billion (Pauly et al. 2002) and US$9 billion (MRAG 2005). In the Asia-Pacific region, total estimate of production from IUU could be around US$5.8 billion annually (Cabral et al. 2013b). Across the CT, some estimates of IUU have been prepared for the reef fisheries in Raja Ampat (Indonesia) valued at 20–26% of total production (Varkey et al. 2010). In Papua New Guinea, 6000 MT of tuna, 6000 tons of sharks, 2000 tons of beche-de-mer, and 11,000 tons of demersal/coastal fishes were estimated to reach US$27 million. In the Philippines, the estimate is 80,000

MT or US$1.6 million per year from foreign fishing vessels alone (Palma and Tsamenyi 2008).

Demand for Fish

Increasing fish demand is putting heavy pressure on coral reefs and pelagic fishery resources in the CT, which often results to illegal and destructive fishing practices. Fish trade in the CT is intensifying. From 2004–2008, the value of traded fish increased by 50%. Unmanaged, this poses a threat to all three higher level outcomes. Of particular concern is the multi-million dollar live reef fish food trade, from the Philippines, Indonesia, and Malaysia to Hong Kong and China. Potential yields of the highly traded grouper species from reefs in moderate condition is approximately 0.4 tons per km^2 (Sadovy et al. 2003) but current yields are 2 tons per km^2 (Muldoon, Cola, and Pet-Soede 2009), indicating overharvesting.

Climate Change

Increasing sea temperature and its anomalies in the past two decades have led to coral bleaching events in the Philippines, Indonesia, and Malaysia, which reduced the productivity of coral reefs. Further, warming reduced primary productivity that affects small pelagic fisheries, which are significant contributor to the food security in the CT (Villanoy et al. 2010; Chavez et al. 2003). Changes in pH and temperature in the CT6 can potentially cause massive recruitment failure. Intensifying waves and storms affect livelihood of coastal communities and destroy properties (Mamauag et al. 2013).

Trade

There are questions as to whether trade in fish products is beneficial to food security and at what particular level (i.e., community vis-à-vis national). Specifically, the question is the impact on real incomes and on local supply, and whether higher incomes compensate for the decline in availability, or of quality, of fish for local consumption. Of importance also is the impact of trade on coastal ecosystems and whether it hastens the pace of overexploitation as in the case of the live reef fish trade.

The CT6 are open economies with portions of their fisheries products catering to the international market. The volume of trade in fish and fishery products among the CT6 is not large compared to trade with countries outside the CT, due to similar factor endowments. For the CT6 as a region trading with the rest of the world, there is a consistent surplus over the nine years (2000–2008) that has increased by about 60% or an average of 7.5% increase per annum (Geronimo, Napitupulu, and Trinidad 2013). Yet, this rate of increase is barely above the world average inflation rate for that period of about 7.3%.[4] Therefore, the value has been more or less stagnant in real terms.

Value retention across the CT6 was analyzed using case studies for highly traded commodities, tuna, live reef fish, and corals (Cruz-Trinidad et al. 2013a). Value retention at exporting country is highest for tuna in the Philippines and lowest for dead corals in the Solomon Islands (Table 6). The low value retention for coral exports in the Solomon Islands is due to low prices received for corals ranging from SI$2 to 8 for live and dead coral, respectively, which is roughly 10% of the retail value. Value retention for live reef fish is 29% assuming that the exporter is a Philippines-based enterprise and 20% if the exporter is affiliated with the wholesaler and retailer based in Hongkong. For live reef fish, the percentage indicated is a composite number that includes values derived by the fisher

Table 6
Percent distribution of value retained/accrued between exporting and importing country

Value retention /accrual	Live corals, Solomon Islands (Cruz-Trinidad, Albert, and Boso 2012)	Dead corals, Solomon Islands (Cruz-Trinidad 2011a)	Tuna, Mindoro and Bicol, Philippines (Cruz-Trinidad 2011a)	Live Reef Fish, Palawan, Philippines (Cruz-Trinidad 2011b)
Value retained in exporting country	11%	8%	40%	29%
Value accrued to importing country	89%	92%	60%	71%

and the cager, who more often than not, is one and the same person. The export of live reef fish spurred local economies allowing fishers/cagers to purchase consumer durables such as televisions, karaoke machines, and support the education of their children.

At least 60% of the values derived from all exported products from the CT (tuna, live reef fish, corals) are absorbed by the importing country. Trade can contribute to food security by improving incomes of fishers if the conditions allow for competitive pricing, fishers or harvesters have a quasi-organization recognized by management authorities, the government policy on exports is coherent, market infrastructure is adequate, and buyers are willing to pay a premium for sustainable fishing. Adequacy of infrastructure is essential such as roads, ports, and airports to move the products as efficiently and quickly as possible in time and space. This is the main difference between tuna exports in Mindoro, Philippines, which can arrive at the international airport within a day, and corals from Solomon Islands, where distances between islands and Honiara render transport inefficient and expensive. Of interest also to the tuna trade in the Philippines is the development of sustainable standards at all stages of the value chain and an aware citizenry at the importing country prepared to pay price premiums. In the case of live reef fish, the price premium exists because of the strong demand in importing countries such as Hong Kong and China. Unfortunately, it is this strong demand that is also contributing to a faster pace of exploitation in the live reef fish trade.

Despite the low value retention for the coral trade in the Solomon Islands, it is considered an important source of cash income at the community level especially as the shift to a cash economy is occurring. Decisions concerning coral trade must be evaluated under the larger framework of benefits derived from corals and coral reefs including benefits accruing to the subsistence sector and benefits derived from coastal protection.

Opportunities to Strengthen the Links between Coral Reefs, Fisheries, and Food Security

Several short- and long-term strategies responding to five policy objectives with links to food security are proposed in Table 7: ecological/environmental, economic, social, equity, and governance. One of the short-term, direct, and urgent strategies is to reverse degradation of coastal habitats and overexploitation of fisheries. There are hosts of management interventions already practiced within the CTI-CFF framework that would favor the vulnerable sectors directly dependent on coastal resources; however, the link between

Table 7
Strategies to address poverty and food security in the CT

Broad policy objectives	Specific policy objectives	Relevance to poverty prevention (PP) and poverty reduction (PR)	Relevance to food security (FS)	CTI applicability
1. Ecological/ Environmental	1. EAFM & rational exploitation of resources 2. MCS 3. Compliance with international conventions	Indirect emphasis to PR	Improving productivity and availability in the long term sustainability	1. Regional/National 2. Regional/National 3. Regional/National
2. Economic	1. Increased value adding 2. Promotion of export earnings 3. Maximizing sectoral efficiency (e.g., technological modernization) 4. Marketing 5. Subsidies 6. Diversification of livelihood 7. Provision of credit 8. Payments for Ecosystem Services	1. PR 2. PR 3. PP, PR 4. PR 5. PP 6. PP, PR (e.g., through national redistribution) 7. PP. PR	Improve access through improve incomes, food consumption and coping mechanisms; need to be supported by distributional mechanisms	1. Local/National/Regional 2. National 3. National 4. Local/National 5. National 6. Local/National 7. Local/National 8. Local/National/Regional

(Continued on next page)

Table 7
Strategies to address poverty and food security in the CT *(Continued)*

Broad policy objectives	Specific policy objectives	Relevance to poverty prevention (PP) and poverty reduction (PR)	Relevance to food security (FS)	CTI applicability
3. Social	1. Maximize employment /livelihood 2. Ensure food security 3. Support for fisher organizations 4. Capacity building and education	1. PP 2. PR 3. PP, PR 4. PP, PR	Improve access and food consumption	1. Local/National 2. Local/National 3. Local/National 4. Local/National/Regional
4. Equity	1. Clarification of access arrangements 2. Issues relating to gender 3. Assessment & consideration of customary rights	1. PP, FS 2. PP, PR 3. PP. PR	1. Leveling of playing field and reducing asymmetry of information 2. & 3. Improve access to food resources	1. Local 2. Local 3. Local
5. Governance	1. Functionality of EAFM 2. Transparency & Science based management (e.g., SCTR) 3. Accountability through performance audits 4. Participatory decision making	1.PP, PR thru incentives, 2. Food for work programs 3. CCT+++ (Conditional Cash Transfer linked to +health, +education & +stewardship for poor fishers vulnerable to climate change) 4. PR	1. Enabling conditions for social enterprises, capacity building that empowers stakeholders allow access to food and consume better food quality	1. Local/National/Regional 2. Local/National/Regional 3. Local/National/Regional 4. Local/National/Regional

Source: Modified from Bene, Macfayden, and Allison (2007).

actions proposed under the CTI-CFF on MPAs, Ecosystem Approach to Fisheries Management (EAFM), and climate adaptation need to be more explicit. Said measures will not only improve access to food but also increase incomes and through the various multiplier effects in subsistence fisheries, contribute to general economic welfare. In the medium term, access of consumers to fish supply and access of fish producers to the markets must be supported through the appropriate infrastructure and information to foster competitive markets. The long-term vision addresses drivers—such as a population policy supporting slower growth, arresting reckless coastal development, and improving governance systems. Increasing incomes of the populace is another long-term objective that will enable people to have more alternatives to meet nutritional demand, including other sources of protein.

Ecological/Environmental Policy Objective

EAFM with effective monitoring, control and surveillance (MCS) and compliance (especially for IUU fishing) with international agreements support the ecological/environmental objectives through direct improvements in productivity and sustainability of the resources. These approaches can be implemented at the local, sub-national/national, and regional level, which are already happening at the LMEs. Adoption of a common EAFM regional policy is one of the actions supported by CTI-CFF, which will pave the way for cascading of common policies at the national and sub-national level (Pomeroy et al. 2013). As the preceding discussions emphasize the strong linkage between coral reefs, fisheries and food security and confirm the role of subsistence fisheries in assuring food security at the household level, efforts to arrest continued degradation of coral reefs and overexploitation of fisheries must be stepped up.

Russ (2002) summarizes Malthusian overfishing (Pauly 1990), growth and recruitment overfishing, and ecosystem overfishing as highly interlinked to the social and economic conditions wherein the mismatch of the appropriate governance responses often occurs. This happens also because the multifunctional objectives are not clarified and the directionality of their development trajectories manifests in varying spatiotemporal levels of governance. Cabral et al. (2012) and ADB (in press) highlights the differing capacities and urgent threats and vulnerabilities prevalent in the CT and relate these to the three desired higher level outcomes. These will require examining the sustainable development agenda of CT6 and record of progress toward achieving their Millennium Development Goals. For example, Juinio-Menez and Butardo-Toribio (2013) cites fishers in the Philippines as the poorest of the poor reinforcing the concordance of the relation of poverty, food insecurity, and governance. Bene, Macfayden, and Allison (2007) outlines the contribution of poverty reduction and poverty prevention to poverty alleviation while Allison et al. (2009) articulates the climate change dimension.

Economic

Several strategies are listed in Table 7 that promote poverty reduction and/or poverty prevention. When applied at the national level, economic interventions fall under the category of wealth-based approaches that tend to increase overall incomes but that suffer from slow trickle-down effects and redistributive frailties (Foale et al. 2013; WorldFish Center 2011). Economic instruments applied at the local level have the same impact as welfare-based approaches because the impact on resource users is immediate and direct. Examples of these are assistance packages toward livelihood diversification, credit provision, and marketing assistance.

Tuna handline fishing in the Philippines is a good example of twinning ecological and economic objectives with increased value adding and promotion of export earnings made possible by introducing sustainability objectives across the entire supply chain. Recognizing the weak economic connectivity among the CTI countries in terms of collectively acting as a marketing force, Geronimo et al. (2013) suggest that a common pricing strategy and branding for its numerous fish and aquatic species be developed.

Payments for Ecosystem Services (PES) deals can be implemented at various governance levels depending on the good/service to be traded. Tourism services such as aesthetics or mangrove carbon credits, for example, can be traded at the local level. Fisherfolk or coastal communities can be compensated for those who may be affected by interventions such as closed areas or closed seasons by those who would benefit from these interventions. At the regional level, PES arrangements to prevent the premature capture of juvenile tuna can be designed with payments flowing from countries benefitting from mature tuna catches to those who agree not to catch juvenile tuna. PES deals implemented at the local level can directly address food security issues through improvements in income levels and benefits from other social services as part of the PES deal.

User fee systems that are based on (1) appropriate valuation of the resource instead of an arbitrary amount; (2) payment schemes that maintain a certain level of ecosystem service; and (3) assessment and monitoring of ecosystem services also have the potential to improve the food security scenario in several ways. Financial and governance discipline in implementing work and financial plans that help enable plough back to improve management and minimize discretionary actions are also necessary (Cabral et al. 2012). These efforts avoid dissipation of resources and continue building goodwill and regional cooperation.

Social

Social mechanisms are welfare-based approaches that are suited at the local/national level, although capacity building and knowledge exchange are also suitable at the regional level. Direct transfers to vulnerable sectors such as conditional cash transfers, feeding programs, supporting social services, and organizational strengthening not only improve income levels but also empower local communities through meaningful participation (Foale et al. 2013). Such strategies also allow them flexibility of moving in and out of the sector through provision of alternative employment.

Equity

Fisheries management also seeks to fulfill equity objectives alongside efficiency objectives, although these two are not necessarily consistent and convergent. Similar to social objectives, equity considerations are best applied at the local level. This would include ensuring access rights, including those of women and disadvantaged sectors and respect for customary rights. Economic growth that directly includes the poorest section of the population will benefit the food security state because the extra income will be used to purchase more food and social services (Gillespie, Mason, and Martorell 1996). SuPFA (2006) compared incomes from various fishing gears (including illegal gears) and across several bays in the Philippines and estimated Gini coefficients (Figure 3). Results indicate

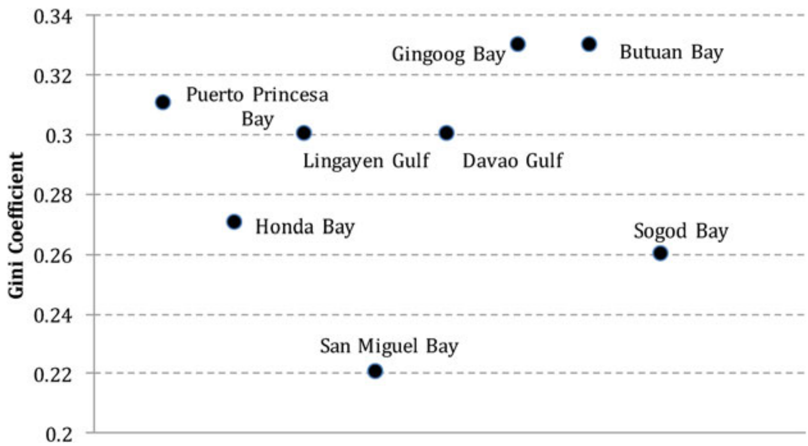

Figure 3. Gini coefficients for selected bays in the Philippines, based on 2000 data (SuPFA, 2006).

that Gini coefficients for all SuPFA bays were higher (more equal income distribution) than that of the country as whole whose Gini coefficient was 0.4814 in 2000.

Where more equal income distribution is a priority, the case of Butuan and Gingoog (highest inequality ratios) offers a test case because it is in these two bays where a small percentage of fishing gears, some of them illegal in nature, control a significant portion of fishery revenue. On the other hand, incomes of San Miguel Bay fishers (least unequality) gravitate more closely toward a mean value where no group(s) of fishers earn incomes with huge variance from the mean.

Governance

The governance of socioeconomic and ecological integrated system perspective has been alluded to by Browman and Stergiou (2004) in their EBM/EAFM discussion although the crucial consideration of poverty alleviation and food security has not been adequately highlighted. Putting these triple concerns upfront recognizes important transformational objectives, which provide a better link between poverty and food security (Cabral et al. 2012; ADB in press). At present, the CTMPAS, EAFM, and the CCA have developed an initial tracking of the NPOA/RPOA resulting to synergies in the scaling up and integration process. The CTI has initiated governance measures for functionality (e.g., CTMPAS management effectiveness at different governance scales) with transparency (e.g., SCTR/RSCTR and the formation of TWG around the five goals) and accountability processes (e.g., cognizance of the MEWG).

Conclusion and Way Forward

Increasing population, urbanization, overfishing, and resource destruction do not bode well for food security in the CT. Subsistence fisheries play a significant role in maintaining food security at the local level mainly through fish consumed in households but also through livelihoods and multiplier effects on the larger economy. With more than 100 million people residing within 10 km of coastline in the CT, the pressure on nearshore resources is of serious concern. We offer short-, medium-, and long-term strategies to address food security issues but emphasize that the short term strategies are crucial and urgent. Although the actions have been identified by the CTI NPOA and RPOA, replication and scaling up is required.

The large marine ecosystems (LMEs) approach for ecosystem-based management and sustainable development is a framework already being used in CTI with UN and GEF-supported projects (http://www.lme.noaa.gov/). LMEs are areas with high primary productivity, where 80%–90% of world's marine fisheries catch is derived. LMEs, serving as monitoring and evaluation framework for the area and a structure where EBM can be operationalized (Browman & Stergiou 2004), are established to improve the state of transboundary resources contributing to food security and maintenance and enhancement of ecosystem functions and services. LME framework is based on the five modules: (i) productivity and oceanography, (ii) fish and fisheries, (iii) pollution and ecosystem health, (iv) socioeconomics, and (v) governance. Out of 64 LMEs worldwide, three are located in the CT: (1) South China Sea bordered by China, Indonesia, Malaysia, Philippines, Vietnam, (2) Sulu-Celebes Sea bordered by Indonesia, Malaysia, and Philippines, and (3) Indonesian Sea bordered by Indonesia and Timor-Leste.

One of the primary goals of the CTI-CFF is to establish effective and functional MPAs and one target is to set a fully functional region-wide CT MPA System (CTMPAS) (CTI-CFF 2013). CTMPAS aims to scale up MPA and MPA network initiatives of each CT country to maximize the contribution of MPAs towards achieving fisheries sustainability, biodiversity conservation, and climate change resilient coastal resources (CTI-CFF 2013). Similar to LMEs, CTMPAS highlight the importance of managing transboundary resources (e.g., fish stock that cross national boundaries) and the need to address various ecological, political, and socioeconomic issues at the regional level. CTMPAS is based on the linkage of ecology, governance, and society. Similarly, LMEs focused on the same framework with modules 1–3 under ecology.

The acceptance and finalization of a common EAFM policy may address fisheries issues which the CTI-CFF Plans of Actions have not yet addressed comprehensively including issues on IUU, migratory stocks, and management of small pelagics. Further, all the CT6 national actions, when coordinated properly through the RPOA, are expected to result in synergistic benefits which can overcome the challenges in the region (e.g., increased capacity in regional governance, social capital, and economies of scale).

Since the launch of the CTI-CFF at the World Oceans Conference in Manado, an estimate of US$67 million has been invested by partner agencies, almost half of which is sourced from the U.S. government through the Coral Triangle Support Partnership and the Program Integrator (http://www.usctsp.org). ADB logs in US$27 million representing support to subregional projects in the Pacific (US$15 million) and Southeast Asia (US$11 million) and US$1.2 million for the regional Knowledge Management Project. All ADB projects have significant investments from the Global Environment Facility. Lastly, the Australian government pledged US$8 million as support for CTI. Although significant, the CTI investments represent only 2% of fisheries values derived from coral reefs, even at its current productivity levels.

Acknowledgments

We thank Alan White for inviting us to contribute to this special issue as well as his constructive comments and suggestions on the earlier draft of this article. We also thank the Asian Development Bank Knowledge Management Project and the anonymous external reviewers for their useful comments.

Notes

1. The 2013 total population estimate for the CT6 is 395 million (CIA 2013). It is commonly assumed that one third of the population in the CT6 countries (130 million) live within a close proximity of the coast and depend, at least partially, on coastal and marine resources.

2. The April 2012 (Manila) and October 2012 (Jakarta) Meetings of the MEWG were held jointly with the meetings on the Regional State of the Coral Triangle Report. Another meeting of the MEWG was held in April 2013 in Manila.

3. Exchange rate was SI$7.28 = $1.00, November 2011.

4. Calculated from World Bank inflation database: http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG

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