Chapter 6
Food Security in the Context of Fisheries and Aquaculture – A Governability Challenge

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Abstract Food security is the right of all people to have access to sufficient, safe and nutritious food. Food security is governed across scales from household and local to national and global and food security issues are typically diverse, complex and dynamic – perfect territory for an interactive governance approach. Fish make essential contributions to food security at all levels, by providing high quality protein, lipids for brain development and function, and micronutrients. Many capture fisheries are in crisis and aquaculture, although having huge potential, is facing difficult intersectorial and environmental problems. These problems and potentials are reviewed from the perspective of making interventions to improve governability along the fish chains from fishery and farm to consumer. A worked example is attempted for three aquaculture fish chains.

Keywords Aquaculture • Capture fisheries • Fish chains • Fisheries • Fish trade • Food security • Governability

Introduction

Food security is a never-ending problem. Everyone always needs to know that the next meal, its sufficiency and acceptability are guaranteed. Food security is arguably the wickedest of wicked problems, as defined by Jentoft and Chuenpagdee (2009), because its supply and demand scenarios are always changing and because

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the consequences of not adapting to those changes are severe: conflict, sickness, death and, where ecosystems are damaged irreversibly, increased risks of the same for future generations. The world's food factories are ecosystems and the baselines of those ecosystems are always shifting, as Pauly (1995) showed for fisheries. Food security is won or lost on ecological battlegrounds.

Palaeolithic humans were opportunistic omnivores (Eaton et al. 1996). Omnivory was a major factor in the evolution and success of *Homo sapiens*, with fish as important providers of the fatty acids that are essential for the development and functioning of healthy nervous systems. Rich herring (*Clupea harengus*) and Atlantic cod (*Gadus morhua*) fisheries contributed much to the historical food security, prosperity and power of Europe and North America (e.g., Blaxter 1990; Kurlansky 1999). Many inland, coastal and open sea capture fisheries have declined, largely because of overfishing and ecosystem abuse, during massive institutional failures. Meanwhile, aquaculture has undergone rapid growth, contributing increasingly to food security but including some environmentally and socially unacceptable impacts.

Fish, whether from aquaculture and capture fisheries, contribute to human food chains through fish chains (Thorpe et al. 2005; Mahon et al. 2008; Chap. 2 by Kooiman and Bavinck, this volume). Sustaining those contributions is the wicked problem that requires continuous solution. Assessments of the governability (see Kooiman et al. 2008; Chap. 6 by Chuenpagdee and Jentoft, this volume) of entire fish chains and of the individual links along them might indicate entry points for interventions to improve governability.

This chapter begins by reviewing the importance of food security and the right-to-food approach. This is followed by discussion of some of the definitions and dimensions of food security, including food safety. The contributions of fish to food security are emphasized and the two supply subsectors, aquaculture and capture fisheries compared. Governability is then discussed in relation to food security, from the perspective of human behaviour. The case is made for an interactive governance approach to food security, and governability assessment is applied to evaluate three aquaculture fish chains. The chapter concludes with general discussion about food security and opportunities for improving governability along the chains.

Importance of Food Security: The Right-to-Food Approach

Food security is a non-negotiable fact of life for the wellbeing of every person and is essential for a stable society. Food insecurity causes strife and food deprivation and has long been a weapon of coercion and war. Haddad and Oshaug (1998) summarized the progress of a human right to food, from its implicit inclusion in freedom from want – one of the four freedoms called for by President Roosevelt in 1941 – and found that an explicit linking of democracy and food security had not yet been developed, compared to that achieved for democracy and economic growth, but that elements of human rights were becoming interwoven in approaches to food policy.

After a long history of UN deliberations and communications on the inclusion of food as a human right among others, a clear exposition of the right to food was agreed in 2002 under the International Covenant on Economic, Social and Cultural Rights: "the right to adequate food is realized when every man, woman and child, alone or in community with others, has the physical and economic access at all times to adequate food or means for its procurement". However, as Haddad and Oshaug (1998) warned, the human rights approach to food security can be a blunt set of tools. Human behaviour sometimes ignores human rights, as well as the environmental uncertainties and risks that attend food production.

The difficulties of governing and funding food production and distribution often make it very difficult to fulfill all rights to food. One cannot eat rights, just as one cannot eat money. It is little use having a right to food, if the basis for its provision, a healthy food-producing ecosystem, has been irreversibly compromised. Parties to International Conventions that should have helped to sustain the contributions of fish to food security (e.g., the United Nations Convention on the Law of the Sea and the Convention on Biological Diversity) emphasize their rights under those conventions rather than their obligations, especially those for the conservation of fisheries ecosystems.

Moore reviewed progress of the Food and Agriculture Organization of the United Nations (FAO) in following a right-to-food and rights-based approach to food security, defining the latter as: "…recognition that all people have a legal right to adequate food and to be free from hunger, and (taking) this right as a focus for actions" (2005, 141). FAO (2002) has continued to make huge contributions towards achieving food security; for example, publishing standard methods for assessing food deprivation, and establishing the Right to Food Forum and information service (www.fao.org/righttofood/).

FAO regards food insecurity as: "A situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active healthy life. It may be caused by the unavailability of food, insufficient purchasing power or the inappropriate distribution or inadequate use of food at the household level. Food insecurity, poor conditions of health and sanitation and inappropriate care and feeding practices are the major causes of poor nutritional status. Food insecurity may be chronic, seasonal or transitory." Within the United Nations Millennium Development Goal 1. Eradicate Extreme Poverty and Hunger, Target 1.c. is to "halve, between 1990 and 2015, the proportion of people who suffer from hunger" (www.un.org/millenniumgoals).

Definitions of Food Security

The FAO definition of food security is used widely and is accepted here: "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life" (FAO 1996, 2). However, applying this broad definition to food fish is difficult, because most mainstream literature on food security and most food security policies emphasize, mainly or exclusively, food energy security, with hunger defined on the basis of inadequate per caput food energy intake per day. FAO defines the per caput hunger threshold as 1,600–2,000 kcal/day. Food security policy emphasizes the foods that provide the most energy: staple cereals, oils and fats, and sugar and related products. From that food energy security perspective, animal products (meat, offal, dairy products and fish) and other foods (fruit and vegetables) are often lumped together as minor contributors. FAO (2009a) gave average dietary energy contributions for high (H) and low (L) income countries as: cereals – H, 48%, L, 55%; oils and fats – H, 13%, L, 9%; sugar and related products – H, 11%, L, 9%; and totals for all these components – H, 72%, L, 73%.

Good nutrition, or comprehensive food security, involves much more than food energy security. This is where fish and fish products become important. Comprehensive food security requires adequate availability and affordability of all human nutritional requirements: proteins that provide all essential amino acids; lipids that provide for normal development and functioning of tissues and organs, especially cell membranes and the central nervous system; and micronutrients (essential vitamins and minerals). Emergency interventions by governments and by organizations such as the World Food Programme (www.wfp.org) and Oxfam (www.oxfam.org) recognize this. For the purposes of this chapter, food security means that same sufficiency in all human nutritional requirements, including assurance of food safety.

The very word security implies that the resources upon which food production and distribution depend be managed for their sustainability. The sustainability of food production is therefore synonymous with food security. In this context, sustainability does not necessarily mean reliance on the same foods and food producing ecosystems, as long as others are accessible and affordable. This is inevitable because of seasonal variations in the availability of many food products, short-term climatic uncertainties and long-term climate change, and changing dietary preferences. However, ringing the changes on human food items and their production and distribution systems should, as far as possible, avoid constraining the options of future generations. This was made explicit, as follows, in the following definition of sustainable development in the 1987 Report of the World Commission on Environment and Development, Our Common Future: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (www.un-documents.net/wced-ocf.htm).

Dimensions of Food Security

Food security is required at household level, at sub-national (village, district or province) level (for which the present author prefers the term local), and at national level (Alamgir and Arora 1991). All household members must avail of a minimum necessary food intake, relative to their age and size, gender, type of work and, for women, pregnancy or lactation status. Local food security requires that all in the locality meet their minimum food needs, to which Alamgir and Arora add the requirement that the available foods "reflect, at least partially, tastes and preferences and household status" (1991, 7). Kawarazuka and Béné (2010) identified three pathways by which those who work in small-scale fisheries and aquaculture improve their household nutritional security: direct consumption of fish; increased purchasing power to buy good food; and empowerment of the women who work in the fish chains to effect better management of family income. Moving up from the household to the local level already weakens the link to the food intakes of different types of individuals and this link largely disappears at national and global levels, where the main or exclusive target becomes average minimum food requirements per caput. FAO is developing voluntary, cross-sectoral guidelines, the purpose of which is stated as follows in the opening to its Preface as follows: "To improve the governance of tenure of land, fisheries and forests with the overarching goal of achieving food security for all to support the progressive realization of the right to adequate food in the context of national food security" (FAO 2012).

There are large differences within and among the vulnerabilities of rural and urban populations to food insecurity. Research on food system vulnerability, in the face of societal change and global environmental change, is increasing: see, for example: www.gecafs.org. Urban food security is particularly challenging because of burgeoning city populations and the logistics and economics of food distribution. Low-income urban households typically spend 60–80% of their budgets on food (FAO 2000). From almost 6,000 household surveys in Asian developing countries, Dey et al. (2005) found that fish consumption and the choice of fish species and products varied greatly with income class and location, with rural people consuming more fish than urban people and poor people consuming more low value, mostly freshwater, fish. Globalization is bringing many other pressures to bear on food security; for example, recent and still emerging intellectual property arrangements for food biotechnology and genetic resources have huge implications for ownership of and access to the means for food security (e.g., Tansey 2002).

For all of the reasons mentioned above *inter alia*, the realities and risks of food insecurity are widespread and persistent. FAO (2009a) estimated the world's population of hungry persons at 923 million in 2007, 80 million more than at a 1990–1992 baseline. ADB (2008) reported that 2008 global food prices had increased by over 50%, with food stocks at their lowest levels since the early 1980s. The concept of food sovereignty is increasingly promoted, largely by non-governmental organizations, citing the rights of all individuals to produce food, to access resources for food production, and to unite in using "*people power*" to realize their right to food; for examples, see www.peoplesfoodsovereignty.org and www.ibon.org.

Specific micronutrient deficiencies are a health problem for many millions of poor persons and are targetted by food fortification (e.g., Hardianti 2005) and by the breeding of vitamin-rich staple foods (e.g., the vitamin A-enriched golden rice; www.goldenrice.org). In 2008, the Copenhagen Consensus ranked micronutrient (Vitamin A and zinc) supplements for children as the most cost-effective among 30 forms of aid (www.copenhagenconsensus.com). Though less well supported to date by technophile donors and politicians, simple diet diversification is also potentially a very cost-effective and powerful contributor to the relief of protein, essential lipid, and micronutrient insecurity, especially at household level. In Ghana, for example, small homestead ponds have enabled family production of vegetables, condiments such as chillies, and small quantities of fish, that together not only improved household income by 229–679% but also transformed household micronutrient security (Ruddle 1996).

Food Safety

Food fish, meaning here all finfish and aquatic invertebrates and their products in the human food chain, are prone to rapid spoilage unless well stored and preserved. This and a wide variety of other human health hazards that can accompany fish production and consumption make food safety an integral requirement for food fish security. The principle here is that all human food must be safe to produce and to eat. In practice, however, absolute safety can never be guaranteed, because potential risks are always possible from factors that cannot be completely and continuously monitored; including microorganisms, allergens, and wind- and water-borne pollutants.

The Codex Alimentarius Commission (CAC) (www.codexalimentarius.net), established in 1963 by FAO and the World Health Organization, provides a near-comprehensive set of safety standards for human foods, including a Code of Practice for Fish and Fishery Products, with standards covering about 60 general or specific categories. Food safety has undergone substantial development, largely through the CAC, with widening implementation of Hazard Analysis Critical Control Point (HACCP) principles (FAO 1995a). Fish producers and processors who fail to adopt HACCP principles become greatly disadvantaged in the markets, especially for exports. The result has been a steady transition to greater safety in the production and consumption of fish and fish products. From the traditional focus on hygiene and on removal of unsafe foods from the human food chain, food safety risks are now analyzed and managed proactively along the human food chain and, in the case of fish and fish products, "from farm or sea to plate" (FAO 2006a, para. 25). FAO/NACA/WHO (1999) reviewed food safety issues associated with aquaculture fish chains, including risks from water-borne parasites and pathogens. Huss et al. (2004), for FAO, published a comprehensive review on seafood safety. In aquaculture, food fish safety issues are being linked to production site quality and environmental impacts (Focardi et al. 2005). Research on food fish safety has included analyses of consumer attitudes (e.g., Jussaume and Higgins 1998) and private sector understanding of compliance with regulations (e.g., Henson and Heasman 1998).

Despite these advances, food safety problems from fish and fish products remain, especially in some developing regions. Poor coastal dwellers are at risk from unsafe seafood that is self-caught or purchased from local markets, including bivalve molluscs contaminated with red tide organisms and pathogenic microorganisms, ciguatera toxin in reef fish, and histamine from poor quality, inadequately stored tuna (e.g., see Chamberlain 2000). Global warming is increasing the risks of toxic algal blooms, and Hales et al. (1999) have predicted that it will increase risks of ciguatera poisoning. On a wider front, in inland and coastal waters, government agencies do not always communicate effectively to the public the potential risks of eating self-caught fish from polluted waters (Chess et al. 2005). On the other hand, the mass media sometimes publish eye-catching but misleading items concerning food fish safety; for example, in the U.S.A, gross exaggeration of the risks of mercury poisoning from eating tuna, as opposed to its health benefits.

The debate over the potential benefits and risks of farming and consuming so-called Genetically Modified Organisms (GMOs) has long been highly polarized between those who see them as essential for future world food security and those who see them as products that are dangerous and that will enable rich corporations to dominate world food security (e.g., FAO 2001). This debate continues with widespread ignorance and misconceptions as to how GMOs might or might not be hazardous. Every captive-bred farmed organism is to some extent genetically changed (i.e., modified in the broad sense), whether it has been selectively bred, or produced by hybridization or by any biotechnology. Genetic engineering is just one type of biotechnology, which produces transgenic organisms, otherwise known as GMOs (narrow sense) or Living Modified Organisms (another confusing term used in international conventions and protocols). Hybrids that are crosses between two species are more genetically modified (broad sense) then transgenic organisms. The same applies to some other forms of genetic manipulation, including multiplication of chromosome numbers (polyploidy). The pros and cons of farming GM fish are being hotly debated, but a broader view is needed, encompassing the use of all biotechnology in aquaculture.

Contributions of Fish to Food Security

Fish and fish products make essential contributions to human food security worldwide (e.g., Elvevoll and James 2000; ADB 2005; www.seafood.net.au), both directly as dietary components and indirectly in feeds for farmed animals. FAO (2009b) summarized the latest (2006) average regional annual per caput fish consumptions in kg as: China, 26.1; Oceania, 24.5; Europe; 20.8; North and Central America, 18.9; Asia (excluding China), 13.9; South America, 8.4; Africa, 8.3. Gupta (2006) concluded that fish contributes over 20% of the animal protein intake of more than 2.6 billion people. FAO (2006b) gave per caput annual fish consumption in traditional Asia-Oceania fish eating countries as mostly above 25 kg/year (above 50 kg/year in some and 190 kg/year in the Maldives) and estimated that fish was providing 22% of total protein intake in sub-Saharan Africa and approaching or exceeding 50% in some poor countries: e.g., Sénégal, 47%; Gambia, 62%; Ghana and Sierra Leone, 63%. In the 1990s, the average annual fish consumption of Pacific islanders was 34 to 37 kg per caput, compared to the world average of 16.5 kg per caput, and provided 50% of their recommended protein intake. The value of total fish exports annually from Pacific island nations and territories has increased from US$48 million in 1999 to US$101 million in 2007 (Gillett 2009).

Fish as food provide humans with comparatively little dietary energy: a per caput average of 20–30 kcal/day, and up to 180 kcal/day where there is a lack of alternative food items (FAO 2009b). The main role of fish in food security is to provide the following: high quality animal protein containing all essential amino acids, especially those such as lysine that are low in other protein sources; lipids, especially the omega-3 polyunsaturated fatty acids required for brain development and function and energy- and vitamin-rich oils; and micronutrients (vitamins and minerals; especially calcium, iodine, iron, phosphorus, zinc, and Vitamins A, B1, B2 and D). Small indigenous fish species supply vitamins and minerals to poor consumers in Bangladesh; for example, 43–90% of Vitamin A and 31–36% of calcium recommended dietary allowances for children of 4–6 years (Thilsted et al. 1997). Subsistence inland and coastal fishing provides huge, though largely undocumented, contributions to the protein, lipid and micronutrient security of poor persons; for example, rice farmers (e.g., Halwart and Bartley 2005). Fish are particularly important providers of docosahexaenoic acid (DHA). DHA deficiency in humans has very serious implications for mental health and stable societies (e.g., Crawford et al. 2008; and other publications from the Institute of Brain Chemistry and Human Nutrition; www.londonmet.ac.uk).

Kurien (2004) recognized the complex relationships between fish trade, as imports and exports, and food security and endorsed the four entitlements, recognized by Sen (1981), that provide direct or indirect food security to an individual: production-based, growing one's own food; trade-based, selling or bartering other possessions for food; labor-based, selling labor for food; and transfer-based, receiving transfers or gifts of food. Kurien (2004) found that although the entry of a fish species into international trade was correlated with depletion of that species, there was little evidence that exporting fish results in food fish insecurity in the country of origin. For 11 widely differing countries, the impact of fish trade on domestic food security was as follows: positive and large, 1 (Nambia); positive and significant, 5 (Chile, Fiji, Nicaragua, Sri Lanka, Thailand); positive and small, 2 (Brazil, Sénégal); negative and small, 2 (Kenya, Philippines); negative and large, 1 (Ghana). In addition, many Low Income Food Deficit Countries earn from fish exports very significant foreign exchange, which is used for many purposes, including the financing of food, especially grains, and fuel imports.

Contributions of fish to the food security of poor persons have been enhanced greatly by imports of cheap and durable products such as canned fish and by coastal states exporting from seasonal gluts of wild caught fish to their land-locked neighbors (e.g., Hara 2001), though this brings with it a dependency on foreign fish stocks that might decline and can undercut progress towards more self sufficiency through development of sustainable aquaculture (present author's observations in Southern and West Africa).

Aquaculture

Aquaculture, the farming of aquatic organisms, is still widely regarded as a separate sector within food production and/or as a separate subsector of capture fisheries, despite the fact that farming domesticated fish and hunting wild fish have little in common. Unfortunately, monosectorial and subsectorial policies and institutions have typified many sectors – agriculture, fisheries, forestry, mining, tourism, transport, water supply and waste disposal that depend upon the very same ecosystems. This is a major impediment to equitable and sustainable use of natural resources and therefore a threat to the health of ecosystems and to food security. Institutional change to remedy this is likely to be slow.

The main shifts that are needed concerning the role of farmed aquatic organisms in food security are: (i) recognition that aquaculture is the farming of aquatic plants and animals and therefore requires subsectorial policies and institutions within the agriculture sector, like those for crops and livestock agriculture; (ii) capture fisheries, including those enhanced by artificial stocking, also require sectorial policies and institutions; and (iii) policies and institutions for both the aquaculture subsector and the capture fisheries sector must be integrated with those for all other sectors and subsectors that use the same resources, especially ecosystems, so that they can proceed in partnership rather than conflict.

In 1970, aquaculture provided only 3.9% of world fish supply. From 1990 to 2002, aquaculture production grew on average by 10.2% per year, more any other animal protein food sources: beef, 0.8%; mutton, 1.5%; pork, 2.5%; eggs, 3.6%; and poultry, 4.8% (Moffit 2005), and now contributes about 50% by volume to world fish supply. Traditional aquaculture, especially in China and adjacent countries, was closely integrated with agriculture, water management and waste recycling, but those highly resource-efficient systems, have now been largely replaced by non-integrated systems, including intensive pellet-fed fishponds (Edwards 2004). Similarly, in India, a long-established polyculture of six carp species, using the different natural feeding niches in fertilized ponds, has been intensified for higher yields, through supplemental feeds (Nandeesha 2001).

Intensive aquaculture, like all forms of intensive food production, has large ecological footprints. In 2003, at least 41.6% of production of farmed finfish and crustaceans was derived from feeding them with farm-based and/or industrially manufactured feeds (Tacon et al. 2006) who also reported, citing Gill (2005), that in 2004 aquaculture took 3% of the global total of industrially manufactured animal feeds, compared to: cattle, 24%; pigs, 32%; poultry, 38%: pigs, 32%, and other animals, 3%. Aquaculture's share of those feeds must now be much higher and increasing, though its reliance on fishmeal and fish oil is being substantially reduced through highly innovative feed formulations. Pullin et al. (2007) reviewed possible biological, ecological and intersectorial indicators for the sustainability of aquaculture and Pullin (2011) has further reviewed the paramount issue of choice of species and feeds, for responsible and sustainable aquaculture.

Aquaculture, like agriculture and forestry and in concert with them and other natural resources sectors, must become more responsible and sustainable, and less environmentally damaging. Some forms of aquaculture have had a bad history of booms and busts and environmental damage: over-abstraction of surface and ground waters; destroying mangrove and other wetlands to establish production units, some of which then fail anyway; exposing acid sulphate soils; increasing salinization of lands and aquifers; causing eutrophication of inland and coastal waters; introducing invasive alien species; spreading parasites and diseases; changing wild genetic resources by interbreeding etc.

Many of the same charges can be laid against other sectors; for example, shrimp aquaculture was found to be contributing only 1.5 and 0.9% respectively of the total anthropogenic sources of nitrogen and phosphorus entering Mexican coastal waters (Páez-Osuna et al. 1998). Aquaculture has a particularly bad image and gets a bad press where it is blamed, whether entirely correctly or not, for adverse impacts on nature and natural resources; for example, salmon farming on wild salmon stocks and fisheries (e.g., Ford and Myers 2008). Costa-Pierce summarized the solutions to this problem as follows: "the aquaculture world community needs to focus its attention on a new paradigm, in order to evolve an 'aquaculture revolution' that is technically sophisticated, knowledge-based, and ecologically and socially responsible" (2002, 364–365).

Aquaculture is indeed changing for the better, following the provisions of the FAO CCRF (FAO 1995b) and its Technical Guidelines. There are some excellent commentaries on what this change implies (e.g., Consensus 2006). In particular, there is a huge effort underway to replace with cheaper and more sustainable sources of lipids the fish oils that are used in farmed fish feeds (Turchini et al. 2009). Similarly, the use of vegetable proteins in farmed fish feeds is increasing, with a view to making large reductions in fishmeal and trash fish requirements. According to Finley and Fry (2009), soy protein will provide half of the protein requirements of farmed fish feeds by 2020. Aquaculture products are included in the organic food movement (e.g., www.ifoam.org) and the criteria for them being accredited as organically farmed often include broad assessments of the earth-friendliness of their production systems and not just the avoidance of use of chemicals etc.

Ahmed and Lorica (2002) and FAO (2009b) pointed to the high importance of aquaculture for food security, especially in Asia. Moreover, inland aquaculture is an obvious way to add value to scarce water resources, through their multipurpose use. It is therefore certain that the contributions of aquaculture to food fish security will continue to increase and will soon exceed those of capture fisheries. Aquaculture of plants and of herbivorous or omnivorous aquatic animals (mainly finfish, molluscs and crustaceans) is more feed- and energy-efficient than other ways of producing animal protein. As Brown put it: "The big winner in the animal protein stakes has been aquaculture, largely because herbivorous fish convert feed into protein so efficiently" (2006, 171).

Subasinghe et al. (2009) reviewed positively the future prospects for expansion of aquaculture, in spite of its many challenges, especially climate change. They concluded that aquaculture was expected to:

> Contribute more effectively to food security, nutritional well-being, poverty reduction by producing…with minimum impact on the environment and maximum benefit to society, 85

> million tonnes of aquatic food by 2030, an increase of 37 million tonnes over… 2005 (Subasinghe et al. 2009, 7).

Contributions from aquaculture to fish supply have been increasing rapidly and will have to increase further. FAO (2006b) noted an increased contribution (1994–2003) of aquaculture to fish supply in the Near East/North Africa as 4.5–18.7%, but also forecast that fish supply in sub-Saharan Africa would have to increase by 28% to maintain even its poor concurrent annual average fish consumption of 6.6 kg per caput, and commented that aquaculture has much scope to provide more than its 2% contribution.

Capture Fisheries

The historical and ongoing crisis in capture fisheries is well documented in the primary scientific literature (e.g., Pauly et al. 1998; Jackson et al. 2001; Pauly et al. 2005) and in many books and other products that are accessible to the public (e.g., Pauly and Maclean 2003; Sadovy et al. 2003; Clover 2004; Roberts 2007; and, most recently, the film *The End of the Line*, www.endoftheline.com). The picture is one of rampant overfishing and destruction of the ecosystems that produce fish, and of massive institutional failures, including management based on lies (e.g., see Bromley 2009). Marine and inland capture fisheries are often typified by untruthful and incomplete statistics. About 20% of the world fish catch is derived from what is officially called Illegal, Unregulated and Unreported fisheries. About 50% of the fishing by vessels off the West African coast is probably illegal. Open ocean catches, such as tunas, are often transferred at sea to factory ships, without being landed and properly recorded. Sometimes, the truth is told about how bad things are. For example, the European Commission has admitted that 88% of its fish stocks are overfished, that 93% of North Sea cod are caught before they have any chance to spawn, and that fishing is becoming unprofitable, despite large subsidies (European Commission 2009). Even so, it remains politically difficult or impossible to set sensible catch quotas and fishermen "exceed quotas with impunity" (Anon 2009, 52).

What then are the prospects for turning at least some capture fisheries around, so as to restore or to increase their contributions to food security? Hutchings (2000) was generally pessimistic, especially in terms of the time needed, citing little or no recovery in gadoid (cod family) and flatfish stocks after 15 years. Enhanced or culture-based fisheries and fish ranching are also not likely to work well for most open water fisheries, except in some special cases such as: regular stocking and harvesting of lakes and reservoirs; stocking rivers with highly migratory fish, such as salmon; and stocking semi-enclosed coastal waters, such as bays and lagoons, with species that have limited or no movements, especially molluscs.

The environmental impacts of stocking large numbers of captive-bred organisms, genetically different from wild types and feeding at one specific level in the trophic pyramids of an open water ecosystem are open to obvious criticisms. But the more telling argument, against many operations that attempt to enhance capture by stocking, is that they simply have "limited or no demonstrable success" (Molony et al. 2003, 409). Nevertheless, once started, they are hard to close down because they appeal to the public, the mass media, fishers, fisheries managers and politicians, who see them, even ineffective or unproven, as measures to restore fisheries. Such efforts are sometimes accompanied by other expensive and unproven measures, such as artificial reefs. Governors and the governed seem to be happily complicit in funding these questionable developments, and lots of money flows for the supply of fish seed and associated structures and services.

However, if better governance can be achieved, the future for capture fisheries is not all doom and gloom. In addition to the FAO CCRF (FAO 1995b) and its Technical Guidelines, there are many sources of free advice on how to improve and sustain capture fisheries; e.g., see www.seaaroundus.org. Pauly et al. (2002) pointed out that most capture fisheries have been unsustainable, but found that reducing fishing efforts and subsidies, together with management of the oceans for sustainable fishing and fish conservation in marine reserves, can be the way forward. Ecosystem-based management is the key. There are some other specific tools that will help: for example, the application of eco-labeling to inform more discerning consumers (e.g., FAO 2005).

Governability and Human Behavior in Food Security Scenarios

Kurien emphasized that: "Preserving the resource base and the integrity of the aquatic ecosystem is a *sine qua non* for food security – with or without international trade" (2004, 153). Throughout history, however, human behaviour with respect to food security has typically been selfish and irresponsible, especially in terms of the annexation, degradation and conversion for other uses of the aquatic and terrestrial ecosystems that produce food, often spurred by unfettered population growth. Diamond (2005) described the Easter Islanders' complete destruction of the ecosystem that supported them, including all sources of wood to make canoes. He speculated on what the person who felled the last tree might have thought or said: "Jobs, not trees…Technology will solve our problems, never fear we'll find a substitute for wood…We don't have proof that there aren't palms somewhere else on Easter, we need more research, your proposed ban on logging is premature and driven by fear-mongering" (Diamond 2005, 114)? He went on to point out the obvious and chilling parallels between this Easter Island debacle and ecosystem abuse in the modern, now thoroughly interconnected and interdependent world. That applies especially to the mismanagement of world fisheries. Faced with the opportunity to catch the last few fish or whales, many otherwise responsible persons will do just that, reasoning that if they do not, someone else will.

To what extent then might human behaviour become more responsible (i.e., more governable) in terms of caring for the ecosystems that produce fish and other human food? There are some grounds for optimism. Institutions for the support of more responsible behaviour in aquaculture and capture fisheries are increasing in number and influence, especially those concerned with implementing the FAO Code of

Conduct for Responsible Fisheries (CCRF) and its many Technical Guidelines (FAO 1995b; available at www.fao.org); for example, the Marine Stewardship Council (MSC; www.msc.org). There is a strong relationship between increasing economic welfare and increasing consumption of animal protein. This requires that more and more grain equivalents be used to feed livestock (including farmed fish) rather than to feed people directly (Fresco and Rabbinge 1997). There are, however, strong global, national and local movements towards making responsible dietary choices for food security and for the natural environment.

It can hardly be called irresponsible to eat well and to enjoy eating some animal protein, but a more vegetarian diet is indeed more earth-friendly, more sustainable, and therefore more conducive to food security at all levels. Goodland proposed a food conversion efficiency tax,

> In order to reduce food wastage and to improve health and food availability…The least efficient converters (pork, beef) would be highly taxed; more efficient converters (poultry, eggs, dairy) would be moderately taxed. Most efficient converters (ocean fish) would be taxed lowest. Grains for human food would not be taxed (1997, 189)

Goodland's tax-friendly stance on ocean fish was too simplistic, as many of them feed at high trophic levels, as carnivores. He omitted the products of aquaculture from his tax rankings, and considered aquaculture as having two extremes: low productivity/low impact, fed with autotrophs; and high productivity/high input energy/high impact, fed with manufactured feeds. He concluded that even the latter "can be more productive and at much less environmental cost than its competitor, livestock if grain inputs only are counted. If fossil energy and water costs are included, (high productivity) aquaculture is not competitive" (Goodland 1997, 193). Many, including the present author, would now find this to be too simplistic a view of the huge diversity and potentials, for good and ill, of responsible and irresponsible aquaculture (see below). On the broader front, whereas Goodland's tax proposals would surely have been politically impossible in 1997, some of them might be possible now, given the increasing public and private acceptance of painful earth-friendly measures such greenhouse gas emissions.

Dietary choices are major issues in attempting to balance sovereign preferences and sustainability. Norton et al. (1998) discussed this, considering three rank ordered goals of ecological economics (ecological sustainability, fair distribution and allocative efficiency), relationships between preference change and price change, and the extents to which attempts to influence individual preferences might be undemocratic. They concluded that: "Actively seeking to influence preferences is not inconsistent with a democratic society (and that)…in order to operationalize real democracy, a two-tiered decision structure must be used… in order to eliminate 'preference inconsistencies' between the short term and long term and between local and global goals" (Norton et al. 1998, 209). Their main point was that individual sovereignty is exercised in achieving democratic consensus on the broad and long term goals of society and that those broad goals can then, still democratically, "limit and direct preferences at lower levels" (Norton et al. 1998, 209). For example, overconsumption of animal fats and sugars and under-consumption of fruit, vegetables, and fish, pose huge and costly health problems, not only in affluent western and northern societies, but also in many developing countries. Increasing affluence and sometimes irresponsible, corporate behaviour and marketing, have led to nutritional transitions into over-nutrition, a form of malnutrition (e.g., Gillespie and Haddad 2001; Popkin et al. 2001).

Is there more cause for optimism or for pessimism concerning the future dietary behaviour of humans? Again, the present author sees grounds for optimism. Education and free information on the health aspects of food choices are increasingly available worldwide. Religious and cultural determinants of food choices are usually non-negotiable, but most tend to enhance global food security. Persuasion of vegetarians to eat more meat and fish would have the opposite effect. The world's livestock produce 18% of greenhouse gas emissions, measured as carbon dioxide equivalent, and occupy, including that needed for growing their feeds, 70% of all agricultural land (Steinfeld et al. 2006). In a Rockhopper TV film, *Taking the Credit* (www.rockhopper.tv), broadcast by BBC World News on October 23, 2009, the representative of a leading Swedish hamburger restaurant chain stated that over 70% of it carbon offsets purchased in Africa were accounted for by the production of hamburger beef itself.

Concerning responsible dietary choices with respect to fish, there is an increasing availability of free advice about which fish to purchase or to avoid, from wild harvests and from farms. For example, the Environmental Defense Fund's recommendations target the USA and include farmed arctic char, farmed rainbow trout and sablefish among its "Eco-best" buys, "tilapia (Latin America)" and "lobster, American/Maine" among the "Eco-OK", and farmed Atlantic salmon (for some reasons considered far worse than other farmed salmonids) and imported shrimps and prawns among the "Eco-worst" (www.edf.org). FishBase (www.fishbase.org) and Sealifebase (www.sealifebase.org) provide links to the increasing online and mobile phone-accessible sources that provide advice to earth-friendly purchasers of fish in markets and consumers of fish in restaurants, including, where possible, recommended minimum size limits and eco-friendly fishing and farming methods.

Food Security: The Case for an Interactive Governance Approach

Food security requires not only responsible human behaviour, but also effective institutions and tenable economics for all parties along human food chains, from producers through processors and vendors to consumers. Farmers, fishers, processors and vendors must be able to earn acceptable returns to their investments and the prices of food products must be affordable to consumers. But all of those *negotiable* scenarios always face a *non-negotiable*, three-fold reality: (a) all food is produced in natural or artificial ecosystems; (b) most of those ecosystems are not entirely under human control; and (c) all food production is accompanied by uncertainty and risk, especially concerning the weather, pests and diseases. Food security, though itself a non-negotiable fact of life, is achieved or lost by mixes and interactions of those negotiable socioeconomic factors (mainly human behaviour, institutions and markets) and those non-negotiable ecological factors (sound ecosystem management, which means use *and* conservation). Responsible human behaviour, effective institutions and sound ecosystem management maximize and sustain food security in the face of climatic and other risks. Irresponsible behaviour, ineffective institutions and the degradation of ecosystems diminish food security and amplify risks.

Ineffective institutions for food security derive largely from the persistence of monosectorial perspectives on food supply. In reality, the agriculture, aquaculture, fisheries and livestock sectors share the same ecosystems, but they usually compete for resources (land, water, investment, feeds, fertilizers, labor, research support, etc.) and accept little or no accountability for their adverse impacts on others. Most food is produced amidst sectorial land, water, energy and labor wars, not intersectorial partnerships. Irrigated crop agriculture receives about 70% of world freshwater withdrawals. Non-food sectors (e.g., forestry, industry, tourism and waste disposal) also have huge impacts on the resources and ecosystems required for food production. Sound ecosystem management for food production requires a rapid transition from unrealistic and unsustainable sector-specific policies and institutions to intersectorial ones. This would help to hedge against sectorial failures and risks, as extreme weather events, inexorable climate change and unpredictable pandemics of diseases common to farm animals and humans have increasingly large and negative influences on food security. The same intersectorial approach is needed when forecasting the pros and cons of future reliance on any given food producing sector or subsector.

Delgado et al. (2003) compared different production and price scenarios (slower and faster aquaculture expansion, lower production by China, efficiency of use of fishmeal and fish oil, and ecological collapse), from 1997 to 2020 for low- and high-value finfish, crustaceans, molluscs, fishmeal, fish oil, beef, pork, mutton, poultry meat, eggs, milk, and vegetable meals. They showed well how fruitless it is for any one food sector or subsector to ignore the rest and for any policymaker to miss the big picture when seeking to identify best bets. Some of the standardized scenarios of Delgado et al. (2003) can be criticized; for example, their ecological collapse scenario was more gradual and milder than some real world examples are likely to be. Under their ecological collapse scenario, by 2020 all the aquatic food prices would increase by 26–70% and fishmeal and fish oil prices by 134 and 128% respectively, while milk prices would reduce by 5% and egg and meat prices increase by 1–7%. That seems over-optimistic on the livestock front and probably over-pessimistic on what can be achieved in expansion of the more responsible aquaculture that is less dependent on fishmeal and fish oil. Accounting for the large influences of China's demand for and production of food would also need some recalculation.

Countries that operate distant water fishing fleets have long fished the rich waters of other countries, through agreements of varying degrees of equity and sometimes illegally. As food demand increases and food production and distribution have become globalized, foreign acquisitions and use of lands and inland waters have recently increased (Anon 2009). The People's Republic of China (PRC) is but one among an increasing number of Asian, Middle Eastern and North African countries (e.g., South Korea, Saudi Arabia and Libya) that are acquiring lands and waters in the developing countries of sub-Saharan Africa, Central and Southeast Asia, and Latin America, for producing food, fibre and biofuels. Cotula et al. (2009) found that 2,492,684 ha of such lands (excluding deals less than 1,000 ha) had been thus acquired in Ethiopia, Ghana, Madagascar, Mali and Sudan. Such arrangements are usually styled as cooperation in "*agribusiness*". They can include attempted and established cooperation in coastal and inland aquaculture; for example, PRC-Philippines and PRC-Ghana (www.ibon.org; present author's observations). From 2004, the PRC has been implementing a so-called "Going Out" policy to develop collaboration in business, including agribusiness, but announced in 2008 that its new 20-year Food Security Policy explicitly excludes any foreign land acquisition (Xinhua News Agency 2008, cited in Cotula et al. 2009). This situation will probably remain highly dynamic and somewhat opaque.

Kurien (2004) saw food security for all as a guided outcome and found that trade-enhanced food security inevitably requires cooperation between market, state and civil society. Kurien also described the so-called chains of custody of internationally traded fish products as "long and varied" (2004, 17). He saw the end of such chains that were closest to fishers and fish workers, as well as "first sale transactions and first product transformations," as most important for the food security of the poor, with the prospect of "people power" at these chain positions to "match 'market power'" (Kurien 2004, 17).

Food security is therefore highly diverse, complex and dynamic, and is typically defined across a range of scales, from household and local to national and global. These attributes make the case for an interactive governance approach (Kooiman 2003; Kooiman et al. 2005), but the result would have to be more than a re-description of well-published scenarios in a new jargon and there would have to be practical applications. At present, the best way forward seems to be assessing governability along fish chains and seeking critical entry points for improvement. To explore this, the following three examples of entire aquaculture fish chains were chosen as systems-to-be-governed, from ecosystem, through production cycles, harvests, post harvest processing, marketing, wholesale, and retail to consumers: A. pond farming of carps by community groups, in Bangladesh; B. pond farming of tilapia, in the Philippines; and C. lake-based cage farming of tilapia, also in the Philippines (ADB 2005). Their governing systems included actors and institutions that deal with the negotiable (man-made arrangements) and the non-negotiable (climate and ecosystem function). The governance interactions between these systems-to-be-governed and their governing systems were seen as the main determinants of governance success.

Governability Assessments for Three Aquaculture Fish Chains

Two methods were used to assess the governability of each link in the three chains, from prerequisites for farming, through seed procurement and growout, to harvesting to post harvest operations. With both methods, governabilities were scored as low (L), moderate, (M) or high (H). For the first method (I), a rapid, empirical and intuitive quick guess was made, without reference to any of the detailed parameters and relationships used in the interactive governance approach, of the likelihood of success (L, M, or H) of attempts to improve each link through better governance. With that approach, governability was taken as that score for amenability to better governance in general. With the second method (II), a systematic, though still entirely subjectively scored application of the interactive governance approach was attempted, to score governability (L, M, or H). Following Chuenpagdee et al. (2008), two of the main descriptors and criteria specified in the interactive governance approach were considered, i.e., prevalence of system properties and presence/absence of governing interactions (see Table 6.1).

The two methods used for estimating governability showed similar results. The types of links (rows) where there seemed to be scope for exploring improvement of governability (from L-, or M-) were the same for the two methods in many cases. The numbers of cells indicating scope for improvement of governability were also broadly similar for the three fish chains. Although no firm conclusions can be drawn from these governability assessments, there are indications that governability assessment can indicate weak links in the chains and potential scope for improvement. It also seems possible that a simple approach can be as good a method for this highly subjective, qualitative exercise, as can use of the full gamut of interactive governance descriptors and criteria.

General Discussion

Fish chains start with ecosystems and end with consumers. Fish as food come, directly or indirectly, from open water ecosystems that are exploited by capture fisheries and agro-ecosystems that host aquaculture. The health of those ecosystems is the non-negotiable bottom-line for optimizing and sustaining contributions of fish to food security. Some of the world's historical fish chains no longer exist because of ecosystem change or collapse. Folke et al. took the view that "a resilient social-ecological system may make use of a crisis to transform into a more desired state" (2005, 441). Fish chains have plenty of ongoing crises, and food security is more than just a desired state, it is an essential need. But it is usually specific links in fish chains that are seen as the systems-to-be-governed, not the whole chain and not whole social-ecological systems, resilient or not. Chain-long policies and their effective implementation, through chain-long governance are still rare. Any chain is only as strong as its weakest link.

At the institutional level, the most important entry points along a fish chain are those where institutional visions, roles and responsibilities can be broadened to recognize and to respond to the needs of the rest of the chain and of other interdependent sectors. Changes in human behaviour, as well as new and reformed institutions, are sorely needed, at international, national and local levels, to learn and to tell the truth about what is possible and sustainable in terms of the contributions of wild caught and farmed fish to food security, and then to act accordingly. Such

Table 6.1 Governabilities of three aquaculture fish chains, estimated by two methods: I. empirically; II. by an interactive governance approach (Chuenpagdee et al. 2008)

	Method I: empirical estimates			Method II: estimates using an interactive governance approach					
				Prevalence of system properties			Presence/absence of governing interactions		
Fish chain links	A	B	C	A	B	C	A	B	C
Prerequisites									
Sites	H	**M**	**L**	**L**	M	H	H	**M**	**L**
Permits	H	M	M	**L**	M	**L**	M	M	**L**
Skills,	**L**	M	M	M	M	M	**L**	M	**L**
Information	**L**	**M**	**L**	**L**	M	M	**L**	**M**	**M**
Policies	M	M	**L**	M	M	M	**L**	M	M
Financing	**L**	M	M	M	M	M	**M**	M	M
Markets	M	H	H	H	H	H	**L**	M	M
Engineering	H	H	**M**	**L**	M	M	M	M	M
Seed procurement									
Wild	**L**	–	–	–	L	–	L	–	–
Hatchery (own)	M	M	M	L	M	M	L	M	M
Hatchery (bought)	**L**	M	M	**L**	M	M	**L**	M	M
Growout									
Feed, fertilizers	**L**	M	M	M	M	M	**L**	M	M
Labour (family)	H	H	H	M	M	M	H	M	M
Labour (hired)	H	H	H	H	M	M	H	M	M
Fuel etc.	–	M	M	–	M	M	L	L	L
Equipment	**L**	M	M	**L**	M	M	**L**	M	M
Harvesting									
Labour (family)	H	H	H	H	M	M	M	M	M
Labour (hired)	M	M	M	M	M	M	M	M	M
Equipment	**L**	M	M	H	M	M	**L**	M	M
Fuel, ice etc.	**L**	M	M	H	M	M	M	M	M
Post harvest									
First handling	M	M	M	H	M	M	H	M	M
First sales (farm)	H	H	H	H	M	M	H	M	M
Processing	–	M	M	–	M	M	–	M	M
Domestic markets	**L**	H	H	M	M	M	M	M	M
Export markets	–	M	**L**	–	**M**	**L**	–	**L**	**L**
Certification	–	**L**	**L**	–	**L**	**L**	–	**L**	**L**
Promotion	–	M	M	–	M	M	–	L	L

A: Group carp ponds, Bangladesh; B: Tilapia ponds, Philippines; C: Tilapia cages, Philippines (ADB 2005)
Links where improvement of governability (from L to M, or from M to H) might be explored are in *bold font*
Abbreviations used are: L low governability, M moderate governability, H high governability

behavioural and institutional changes will be possible only if individuals, households and those in authority pursue them pro-actively, not just reactively in response to food and environmental crises. Food fish security will be achieved only if humans can agree to care, indefinitely, for the ecosystems that produce their food fish.

That would be somewhat analogous to the process of domestication. Animals that are amenable to domestication (i.e., governable) strike a great bargain with their governors, receiving food security, shelter, health care, and mating rights, in exchange for providing a wide range of goods and services: meat, milk, eggs, hunting, winning races and fights, companionship etc. If humans behaved more as domesticates of nature, their governor, and less as its wild exploiters, their food security and many other benefits would be maximized. The necessary change from irresponsibility to responsibility in food production is just that: a change from wild behaviour to governed behaviour.

Can humans become sufficiently governable to achieve that relationship with nature, or will human nature always preclude it? Time will tell. Irresponsible behaviour in food fish production, from aquaculture and capture fisheries, is still currently threatening food fish security. Economic growth itself can be at odds with food security. For example, the announcement of a forum on the conflicts between economic growth and the recovery of wild salmon populations contained the following quote from its author's son: "Dad, get a life. Most people out here in the real world just don't care that much about restoring wild salmon. They have other things to worry about!" (Lackey 2005, 21; see also Czech et al. 2006 for a summary of that forum). But food insecurity is a very powerful motivator for change. If planet Earth is indeed to support a population of over nine billion people, before reductions to levels more appropriate to its available resources, then human governability *will* have to improve throughout all food chains, including fish chains.

Further work is needed to explore whether governability estimates can indeed help to identify the links in human food chains in general, and links in fish chains in particular, at which improvements are most needed and possible. This will require robust, objective, quantitative methods. Existing methods that could be explored include the Delphi Method, which has been used for a wide range of purposes, including fish conservation (Barrett 2009), and Environmental Damage Schedules from community judgments (Chuenpagdee et al. 2001).

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