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منظمة الأغذية والزراعة للأمم المتحدة

COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Item 4 of the Provisional Agenda

AD HOC INTERGOVERNMENTAL TECHNICAL WORKING GROUP ON AQUATIC GENETIC RESOURCES FOR FOOD AND AGRICULTURE

First Session

Rome, 20 – 22 June 2016

DRAFT STATE OF THE WORLD'S AQUATIC GENETIC RESOURCES FOR FOOD AND AGRICULTURE

COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Draft State of the World's Aquatic Genetic Resources for Food and Agriculture

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Background

Aquatic Genetic Resources for Food and Agriculture are a core function of the work of FAO, and the FAO Fisheries and Aquaculture Department has been requested by member countries, through the FAO Commission on Genetic Resources for Food and Agriculture (Commission), to lead the process towards a State of the World on Aquatic Genetic Resources. Therefore in 2007 the Commission called upon its Members to initiate steps to determine the current state of the world's aquatic genetic resources. Since then, this work has been supported by FAO's Fisheries and Aquaculture Department and by the Commission itself.

The State of the World's Aquatic Genetic Resources for Food and Agriculture (SoW AqGR) will be the first global assessment based on national reporting on aquatic genetic resources for food and agriculture.

Process

In 2013, following the process established by the Commission, the FAO's Fisheries and Aquaculture Department invited countries to nominate National Focal Points and to prepare and submit country reports, which will be the main source of information for the preparation of the SoW AqGR. The FAO's Fisheries and Aquaculture Department provided the necessary Guidelines for the preparation of these country reports to all National Focal Points[1] in 2013, including a recommended structure and methodology for country reports[2].

The development of the country reports should be seen by countries as an opportunity to conduct a national strategic exercise to assess the status of AqGR at national level, and to reflect on needs and priorities for their conservation and sustainable use. In order to train National Focal Points and other national on the preparation of the country reports. The FAO's Fisheries and Aquaculture Department has been organizing a series of regional workshops on the status of AqGR at regional level, in collaboration with partners in the aquaculture sector in various regions of the globe**.**

The first SoW is a country driven process, therefore the steps that have been followed are:

(1) Commission members have submitted their National Reports on the status of aquatic genetic resources to FAO
(2) the FAO Fisheries and Aquaculture Department has reviewed these National Reports and incorporated relevant national data into the SoW AqGR document; (
(3) the Department of Fisheries and Aquaculture has compared the data provided by countries in their National Reports to official statistical data received from its member countries, in order to identify information gaps, errors and limitations on the number of species reported as farmed within the aquaculture sector in each country;
(4) the FAO Fisheries and Aquaculture Department has lead the preparation of four thematic background studies, which will complement National Reports in thematic areas where scientific and official data and information is missing, or where existing information is unreliable, outdated or there are wide gaps in knowledge (Table 1); and
(5) the SoW AqGR will be updated reports on the status of aquatic genetic resources for food and agriculture from relevant international, regional and sub-regional organizations.

Table 1. Selected thematic background studies

[1] ftp://ftp.fao.org/FI/DOCUMENT/aquaculture/AqGR/List_of_NFPs.pdf

[2] http://www.fao.org/fishery/AquaticGeneticResources/en

Subject	Rationale
Incorporating genetic diversity and indicators into statistics and monitoring of farmed aquatic species and their wild relatives	Production and value statistics for farmed aquatic species and their wild relatives are highly aggregated to species or community levels, with many not even identifying the species used. Management of fish stocks, traceability of fish and fish products, and oversight and development of responsible aquaculture requires management of genetic diversity, linked to production. Increasingly, resource managers and the development communities are asked to identify indicators of the status of AqGR. Once better production data are available, indicators can be developed for monitoring and assessment.
Biotechnology and genomics in aquaculture	Aquaculture is making increasing use of biotechnology and application of genomic research for domestication, increased production, improved management and better traceability of fish and fish products in the supply chain. With advances often outpacing the development of policy and regulatory frameworks and consumer awareness the key is to harness biotechnology for beneficial ends, with biosecurity ensured through precaution and sound management of risks, and through understanding consumers' attitudes
Genetic resources for farmed seaweeds and freshwater macrophytes	The farming of seaweeds and freshwater macrophyes to produce chemicals for the food and other industries, as well as products for direct consumption as human food, is the world's largest aquaculture operation. The genetic resources of these important aquatic plants require coverage in a State of the World Report as they have often been omitted from other reports.
Genetic resources of microorganisms of current and potential use in aquaculture	Bacteria, cyanobacteria, microalgae and fungi are cultured extensively as feed sources in aquaculture. Some bacteria are used as probiotics to enhance fish growth and health. Many species and strains of microalgae are kept as *ex situ* culture collections. The genetics resources of these important microorganisms for food and agriculture require coverage in a State of the World's Report.

National Reports comprising the State of the World's Aquatic Genetic Resources for Food and Aquaculture

A total of 57 national reports have been received as of May 2016; 47 of which have been reviewed and analysed in this draft report (Table 2)[3]. The relative response per region is an indication of how representative the national reports are per region. Countries in nearly three quarters (73%) of the 22 regions responded, with greatest levels of response from Central America (75% of countries) and South-Eastern Asia (55%). However, six subregions representing over 60 countries and territories to date have not submitted any national reports (Table 3).

Table 2. Country reports received from FAO members as to May 2016

Asia	Pacific	Africa	America	Europe
Lao PDR	Kiribati	Tanzania	Chile	Estonia
Nepal	Tonga	Uganda	Argentina	Latvia
Japan	Samoa	Kenya	Colombia	Hungary
Korea	Vanuatu	Malawi	Brazil	Czech Republic
Thailand	Fiji	Cameroon	Mexico	Germany
Philippines		Benin	Panama	Ukraine
Iran		Ghana	Honduras	Sweden

[3] Additional national reports will be analysed as they are received during the summer of 2016.

Iraq		Zambia	Guatemala	Cyprus
Viet Nam		Morocco	El Salvador	Poland
Philippines		Senegal	Belize	Slovenia
India		Burkina Faso	Paraguay	
Malaysia		Mozambique	Venezuela	
Cambodia		South Africa	Ecuador	
			Nicaragua	
			Costa Rica	
			Peru	
			Canada	
13	**5**	**13**	**17**	**9**

Table 3. Number (percentage) of countries and territories per region that have submitted national reports.

Region	Number of Countries	Number of Countries responding	Percentage
Caribbean	29	0	
South America	15	7	47
Central America	8	6	75
Northern America	5	0	
Eastern Africa	23	5	22
Western Africa	17	4	24
Middle Africa	9	0	
Northern Africa	8	1	13
Southern Africa	7	0	
Western Asia	19	1	5
South-Eastern Asia	11	6	55
Southern Asia	9	2	20
Eastern Asia	8	2	25
Central Asia	5	0	
Southern Europe	18	1	6
Northern Europe	17	3	18
Eastern Europe	11	2	18
Western Europe	11	1	9
Polynesia	11	3	27
Micronesia	7	1	14
Oceania	6	0	
Melanesia	5	1	20

Some 45 (17%) of member countries responded, more than half of responses being from 'other developing countries or areas' (27) and fewest responses (8) from 'developed countries'. In percentage response terms, by economic class, twice as many responses came from 'least developed countries' (21%) and 'other developing countries or areas' (20%), than from 'developed countries' (11%) (Table 4).

Table 4. Number of responding countries and territories in each economic class.

Category	Number of countries/territories	Number of respondents	Percentage
Developed countries or areas	73	8 (11)	11
Least Developed Countries	53	11 (21)	21
Other Developing Countries or Areas	134	27 (20)	20

1 THE STATE OF WORLD AQUACULTURE AND FISHERIES

PURPOSE: Present a summary overview of production of species and general trends in aquaculture. The systems that are used and the type of species that are cultured. The species types have implications for the intensity of the productions system, how it is fed (or not), the environment they are grown in, their value, the source of seed/broodstock and the extent to which the system has domesticated its stock or relies on wild relatives.

KEY MESSAGES:

- Aquaculture production is increasing in most countries
- A tremendous amount of AqGR is used in aquaculture and fisheries
- Wild relatives of farmed aquatic species play important roles in both aquaculture and capture fisheries.
- Aquaculture production systems are highly diversified in term of species and methods
- Aquaculture and fisheries are closely linked production systems.
- Wild relatives of farmed aquatic species play important roles in both aquaculture and capture fisheries.

The FAO reports every two years on the *State of World Fisheries and Aquaculture* (SOFIA[4]). This publication covers issues of *inter alia* production, trade, consumption and sustainability, as well as special topics of importance to fisheries and aquaculture and a summary of recent highlights of the Fisheries and Aquaculture Department.

The processes to create the State of World Fisheries and Aquaculture and the State of the World's Aquatic Genetic Resources for Food and Agriculture are complementary and will help facilitate the responsible use of fishery and aquaculture resources.

1.1 Global trend in fisheries and aquaculture production

Global aquaculture production of aquatic living genetic resources reached a total of 101 million tonnes in 2014, including 27 million tonnes of aquatic algae, 48 000 tonnes of non-food production and 73.8 million tonnes of food fish[5] with an estimated first sale value of USD 166 billion 2014. This production is derived from aquaculture operations conducted in freshwater, brackish water and marine waters. Farmed food production comprised 49.8 million tonnes of finfish (USD 99.2 billion), 16.1 million tonnes of molluscs (USD 19 billion), 6.9 million tonnes of crustaceans (USD 36.2 billion) and 7.3 million tonnes (USD 3.7 billion) of other aquatic animals including amphibians (FAO 2016).

Production from capture fisheries have plateaued whilst aquaculture has experienced growth of about 6 percent/year over the last several decades (Figure 1) and has become the world's fastest growing food production sector (FAO 2014). More aquatic species are being farmed now than ever before. The general consensus is that marine capture fisheries have reached a point whereby they will no longer provide more fish than they do at present, indicates that the substantial increase in demand for fish will need to be met by fish culture systems (World Bank 2013, FAO 2014/2016).

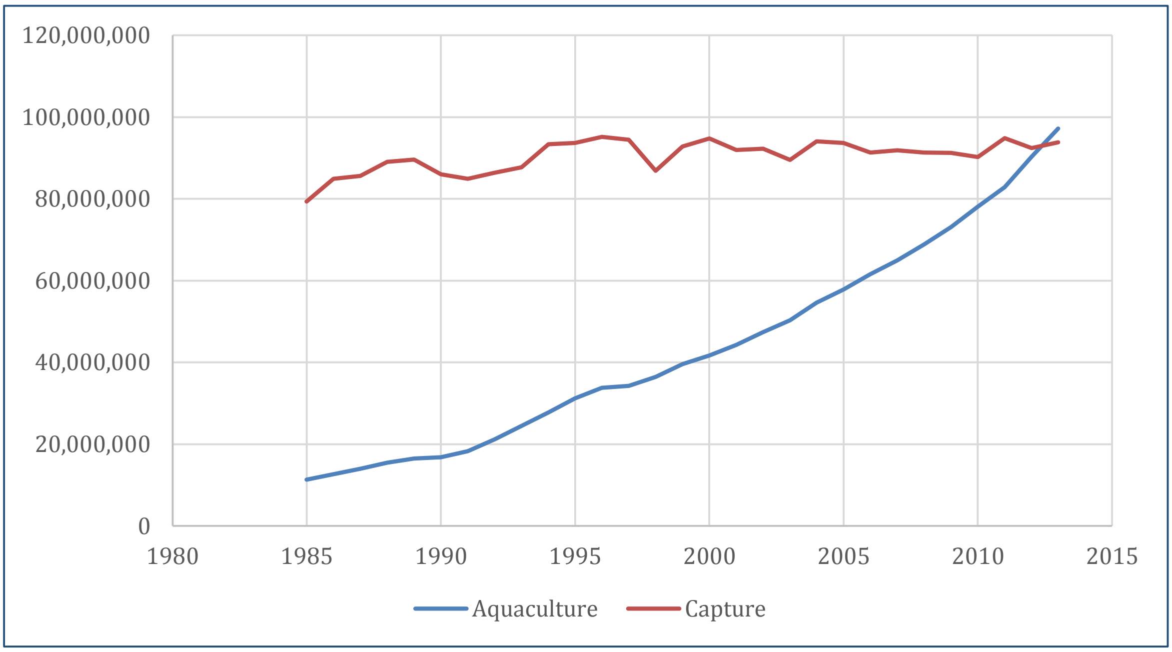
Production estimates from inland capture fisheries are not well known (Bartley et al. 2015), but inland fisheries are threatened by loss of habitat and competition for freshwater from sectors outside the fishery sector (FAO 2012; 2014). The majority of catch from inland fisheries is not identified to species when reported to FAO (Bartley et al. 2015). This lack of knowledge on what and how much is being harvested from the world's freshwater ecosystems is all the more problematic in conservation efforts as freshwater fish are the most threatened group of vertebrates used by humans (Reference to be added).

[4] http://www.fao.org/fishery/sofia/en

[5] The term "food fish" includes fin fishes, crustaceans, molluscs and other aquatic animals like frogs and sea cucumbers for human food, excluding aquatic mammals and crocodiles.

At the same time that the expectation is placed on the expansion of aquaculture production to meet increased demands for seafood, existing aquaculture production systems are facing challenges in terms of available space, competition for water and feed resources alongside health and genetic concerns. Despite these constraints, aquaculture continues to grow owing to the increasing demand for food fish among most producing countries.

Figure 1. Global fisheries and aquaculture production (tonnes)



1.2 Diversity of aquatic genetic resources used in aquaculture and fisheries

The world's fisheries harvest over 2000 species including fish, crustaceans, molluscs, echinoderms, coelenterates, and aquatic plants (FAO, 2014). The number of farmed aquatic species is smaller, but still extremely diverse (Table 1). By 2014, a total of about 580 species and/or species groups were farmed around the world and production reported to FAO (Table 5).

Table 5. Diversity of aquatic species (FAO FishStatJ, 2016; SOFIA 2016 and World Conservation Union, 2010)

Taxon	Wild species	Number of farmed species	Number of families
Finfish	31,000	362	>90
Molluscs	85,000	104	27
Crustaceans	47,000	62	>13
Other aquatic animals	**	15	>8
Aquatic plants	13,000	~37	>22
Total	180 000	580	

**These include echinoderms, coelenterates and tunicates too numerous to list, many of which have no potential as food and are all marine species, as well as a few amphibian and reptiles.

According to the latest available fisheries and aquaculture statistics published by FAO Fisheries and Aquaculture Department, the total production in 2014 from capture fisheries and aquaculture was 195.8 million tonnes (Table 6).

Table 6. World capture fisheries and aquaculture production in 2014 (Unit: thousand tonnes, in live weight)

	Capture	Aquaculture	Total
Fin fishes	78 265	49 862	128 127
Molluscs (edible)	7 674	6 113	23 788
Molluscs (pearls and ornamental shells)	10	48	59
Crustaceans	6 870	6 915	13 785
Aquatic invertebrates (edible)	632	409	1 041
Aquatic invertebrates (inedible)	5	0	5
Frogs and turtles	3	485	488
Aquatic plants	1 185	27 307	28 491
Total	**94 645**	**101 139**	**195 784**

The diversity of AqGR for food and agriculture is extensive including two kingdoms and several phyla. Aquatic genetic resources can be split into major components according to phyla and or taxa:

Kingdom	Phylum	Examples
Plantea	Aquatic plants	Algae (seaweeds and micro-algae) Vascular plants
Animalia	Phylum Chordata	Finfish Amphibians and reptiles
	Phylum Mollusca	Clams and mussels Gastropods snails, abalone Octopus and squids
	Phylum Arthropoda	Crabs and shrimps Cladocerans, brine shrimp
	Phylum Cnideria	Jelly fish and corals
	Other invertebrates e.g. Phylum Echinodermata	Sea urchins and sea cucumbers

1.3 State of World Aquaculture

Aquaculture production is not geographically homogenous, with significant differences between regions. The Asian region is a predominant producer accounting for about 89 percent of world food fish aquaculture production over the past two decades. Africa and the Americas have slightly increased their respective shares in world total production in recent years, while both Europe and Oceania have experienced a slight decline.

Declining production in some industrialized countries that were previously major regional producers (most notably the United States of America, Spain, France, Italy, Japan and the Republic of Korea) (FAO SOFIA 2014) is driven mainly by the availability of fish imported from other countries where production costs are relatively low and the ability to capture the opportunity of developed country export markets is seen as a major reason for such production falls. This has also encouraged expansion of production strongly focussed on export-oriented species in those countries (e.g. Pangassius, Penaeid shrimp, tilapia, salmon, molluscs and seaweed)(FAO SOFIA 2014).

The majority of aquaculture production is destined for direct human consumption, although some by-products may be used for non-food purposes and a few farmed-types are expressly produced for processing for industrial purposes (e.g. aquatic plants use to produce phyco-colloids such as agar and carrageenan. These may or may not be subsequently used for food purposes).

1.3.1 Diversity and production of farmed species

The diversity of species farmed is one reason for the growing production in aquaculture and a breakdown of global aquaculture production by each of the major groups and the number of species and families represented is shown in Table 7. Finfish are the largest category of farmed aquatic species by volume in all regions (Table 8).

Table 7: Global aquaculture production by major components

NOTE 2013 figures not 2014	No. Families	No. Species	Fresh water (tonnes)	Brackish-water (tonnes)	Marine (tonnes)
Aquatic plants	19	37	82,307	978,446	25,917,558
Molluscs	24	104	283,387	93,631	15,137,259
Freshwater/diadromous finfish	54	INSERT	40,461,874	1,731,314	2,593,909
Marine finfish	35	INSERT	40,679	454,613	1,788,164
Crustaceans	13	62	2,578,112	3,633,863	499,702
Holothuria/echinoderms, others	7	9	-	-	-
Amphibians/reptiles	2	6	-	-	-
TOTAL			-	-	-

Table 8. Number of taxonomic units reported to FAO by continent and environment

Inland aquaculture	Africa	Americas	Asia	Europe	Oceania
Finfish	66	86	115	82	22
Molluscs	0	3	5	1	0
Crustacean	0	8	16	7	5
Other animals	0	4	5	3	0
Algae	3	4	4	2	0
Total inland aquaculture taxa	69	105	145	95	27

Marine & coastal aquaculture	Africa	Americas	Asia	Europe	Oceania
Finfish	26	41	106	59	15
Molluscs	16	40	27	35	21
Crustacean	9	13	27	15	12
Other animals	3	0	7	5	1
Algae	5	8	20	12	3
Total marine & coastal taxa	59	102	187	126	52

All aquaculture	Africa	Americas	Asia	Europe	Oceania
Finfish	81	119	194	122	30
Molluscs	16	41	31	35	21
Crustaceans	14	19	39	20	17
Other animals	3	4	11	7	1
Plants	8	11	23	14	3
Total - all aquaculture taxa	**122**	**194**	**298**	**198**	**72**

Asia farms the most species of aquatic organisms and has the longest history of aquaculture (Table 9) The relatively few species farmed in Africa (in relation to the size, habitat diversity of the continent and the potential number of species available for farming) demonstrates the potential for further use of AqGR in African aquaculture.

Table 9. Number of species in aquaculture production by region and environment

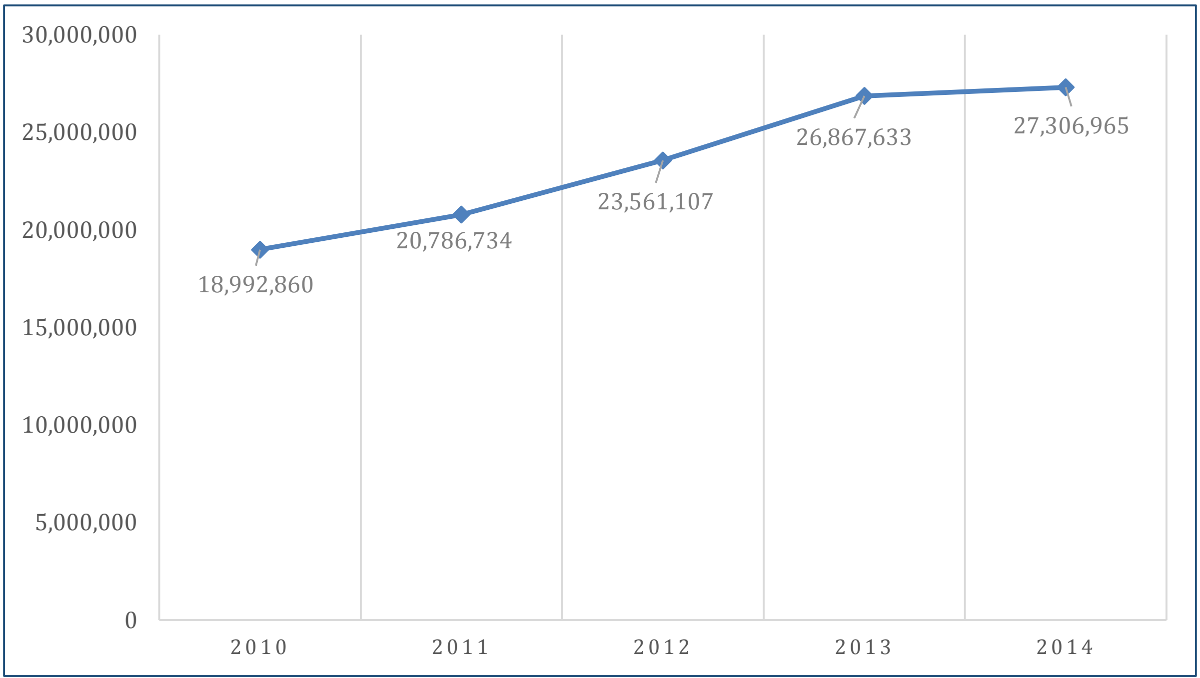
Environment/Region	Africa	Americas	Asia	Europe	Oceania	Total by environment
Marine & coastal	59	102	187	126	52	526
Inland aquaculture	69	105	145	95	27	441

*Totals do not sum as some species are farmed in marine & coastal and inland areas.

Aquatic plants are largely produced in marine and brackish waters, but some microalgae are cultured in freshwaters. There are 27 species reported by FAO representing 19 families (Table 10). They are a mixture of food plants consumed directly and those produced for processing to extract phyco-colloids such as agar and carrageenans.

Aquatic plant aquaculture systems typically rely on natural productivity and are not typically fertilized, there are however managed culture systems. Farming of aquatic plants is undertaken in more than 50 countries and over the past decade has grown by 8 percent per year (FAO, 2016) (Figure 2)

Figure 2. Aquatic plant (excluding micro-algae) production from 2010 until 2014



Information on microalgae is not well reported in available aquaculture statistics despite being of increasing economic importance both as a food supplement (e.g. *Spirulina spp*., as well as an important base for the hatchery production of many species (especially marine species). There are more than 17 genus of microalgae commonly cultivated for aquaculture purposes and there is a considerably great number of species use both commercially and within research collections.

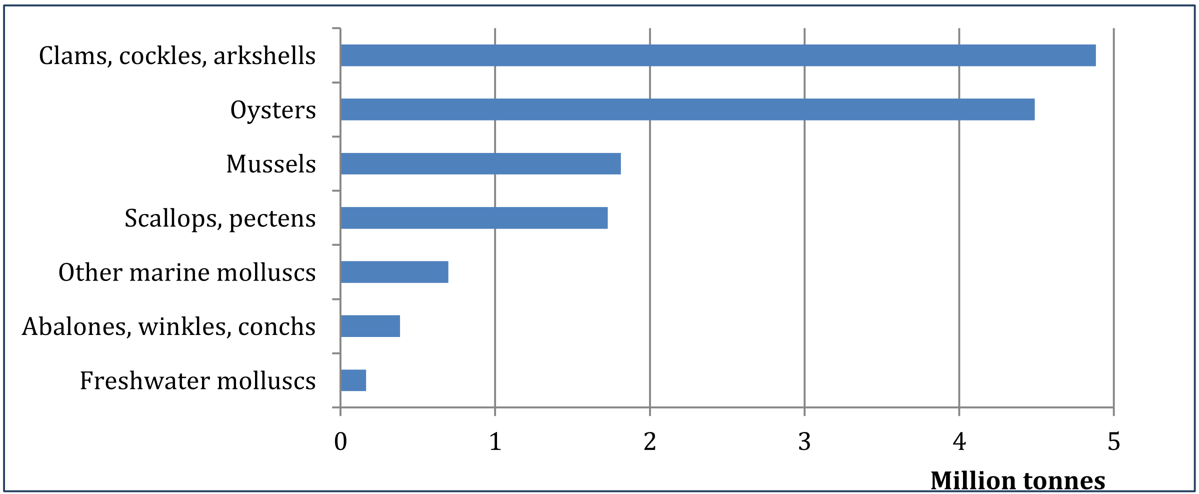
Table 10. World aquaculture production of aquatic plants in 2014 (unit: tonnes, in live weight)

Scientific name	FAO common name	2014
CHLOROPHYCEAE		
Monostroma nitidum	Green laver	6 055
Codium fragile	Fragile codium	5 550
Caulerpa spp	Caulerpa seaweeds	1 199
Enteromorpha clathrata	Bright green nori	1 000
Haematococcus pluvialis	(Haematococcus pluvialis)	226
Chlorophyceae	Green seaweeds	3
Chlorella vulgaris	Unicell. chlorella green alga	-
CYANOPHYCEAE		
Spirulina spp	Spirulina nei	85 705
Spirulina platensis	(Spirulina platensis)	100
Spirulina maxima	(Spirulina maxima)	...
PHAEOPHYCEAE		
Laminaria japonica	Japanese kelp	7 654 586
Undaria pinnatifida	Wakame	2 358 597
Sargassum fusiforme	Fusiform sargassum	175 430

Scientific name	FAO common name	2014
Phaeophyceae	Brown seaweeds	19 149
Macrocystis pyrifera	Giant kelp	2
Laminaria saccharina	Sea belt	2
Undaria spp	Wakame nei	...
Alaria esculenta	Babberlocks	...
Laminaria digitata	Tangle	...
Macrocystis spp	Giant kelps nei	...
Nemacystus decipiens	Mozuku	...
RHODOPHYCEAE		
Eucheuma spp	Eucheuma seaweeds nei	9 053 044
Gracilaria spp	Gracilaria seaweeds	3 751 396
Kappaphycus alvarezii	Elkhorn sea moss	1 698 469
Porphyra spp	Nori nei	1 141 710
Porphyra tenera	Laver (Nori)	664 463
Eucheuma denticulatum	Spiny eucheuma	240 817
Gracilaria verrucosa	Warty gracilaria	936
Chondracanthus chamissoi	(Chondracanthus chamissoi)	2
Rhodophyceae	Red seaweeds	0
Gelidium amansii	Japanese isinglass	...
Gelidium spp	Gelidium seaweeds	...
Asparagopsis spp	Harpoon seaweeds	...
Palmaria palmata	Dulse	...
Porphyra columbina	(Porphyra columbina)	...
Miscellaneous aquatic plants		
Algae	Seaweeds nei	443 501
Plantae aquaticae	Aquatic plants nei	5 023
TOTAL		**27 306 965**

Farmed molluscs can be broadly split into bivalves and gastropods with 104 species in 24 families reported by FAO (FAO 2016). The overwhelming majority are cultured in marine systems. Bivalve mollusc are produced in systems using natural water fertility and therefore unfed. Some gastropod systems (abalone, conch, Babylonia) can be relatively intensive and utilize feeds. There is a very minor production of cephalopods (octopus) (Figure 3).

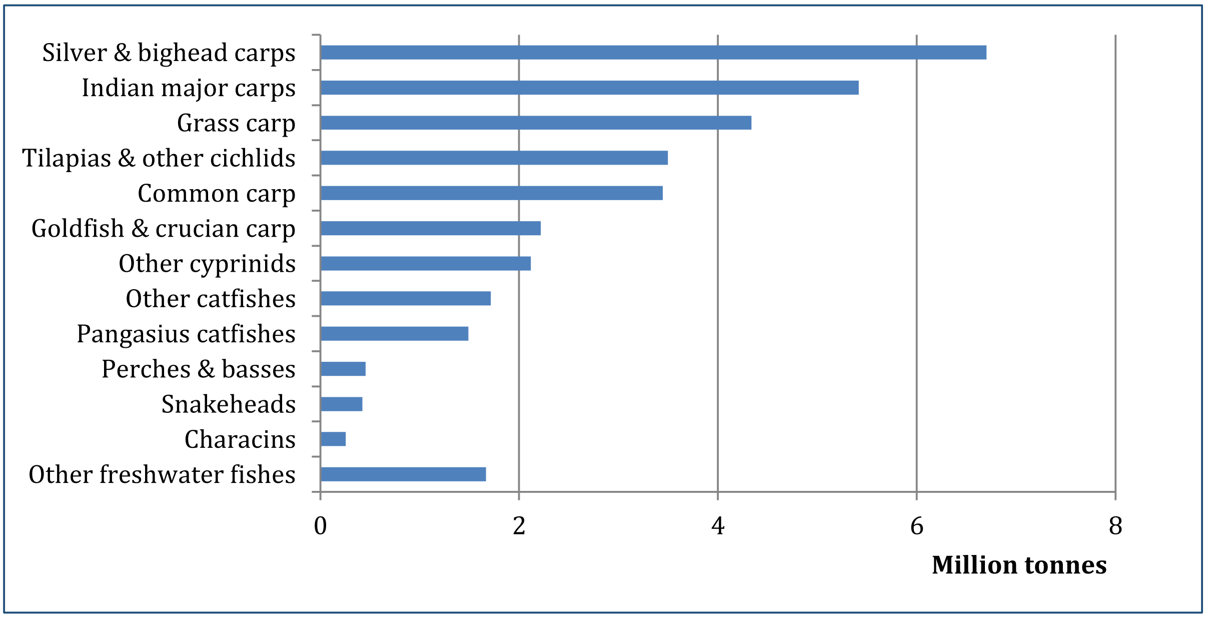
Figure 3: Global aquaculture production of molluscs (2010)



Freshwater/diadromous finfish are the largest group in terms of families and species (54 families and XX species) cultured; it the largest in terms of total volume of all of the types of aquaculture production. Inland finfish aquaculture has been the most important driver for the global increase in annual output of farmed fish representing 65 percent of the annual fish production increase between 2005–2014 (FAO, 2016).

This high level of production from freshwater emphasizes the importance of access to adequate quality and quantity of water for both farmed types and wild relatives as well as the vulnerability of these systems to external impacts on freshwater resources and land.

Figure 4: Production of freshwater fish (2010)



The farmed–types used range from low trophic level species (carps, barbs, tilapia, pacu) to highly carnivorous species (salmon, eel, snakehead). The majority of production volume is based on the lower trophic level species. This underscores the contribution of these species to global food security and their relatively efficient production of high quality protein relative to other livestock systems. The salmonids are a carnivorous species and are highly significant in value terms; even these production systems are now being developed to a point where they are becoming much more efficient users of feed resources. There are a wide range of ornamental freshwater species which are not included but do represent a significant value in terms of trade. (Figures 4 & 5).

Figure 5: Production of diadromous fish (2010)

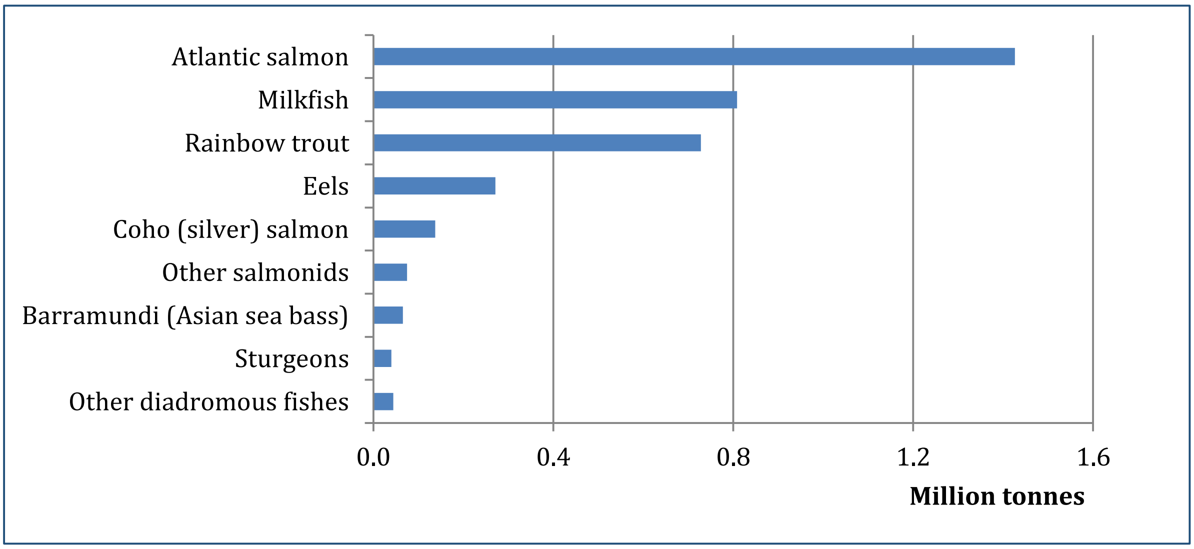
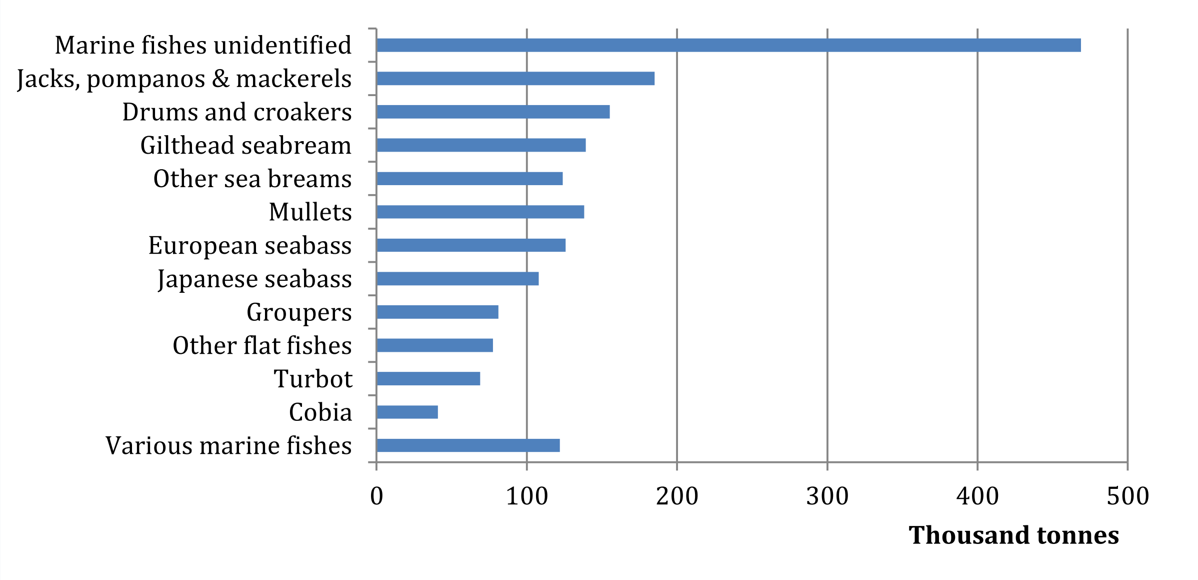


Figure 6: Production of marine finfish (2010)

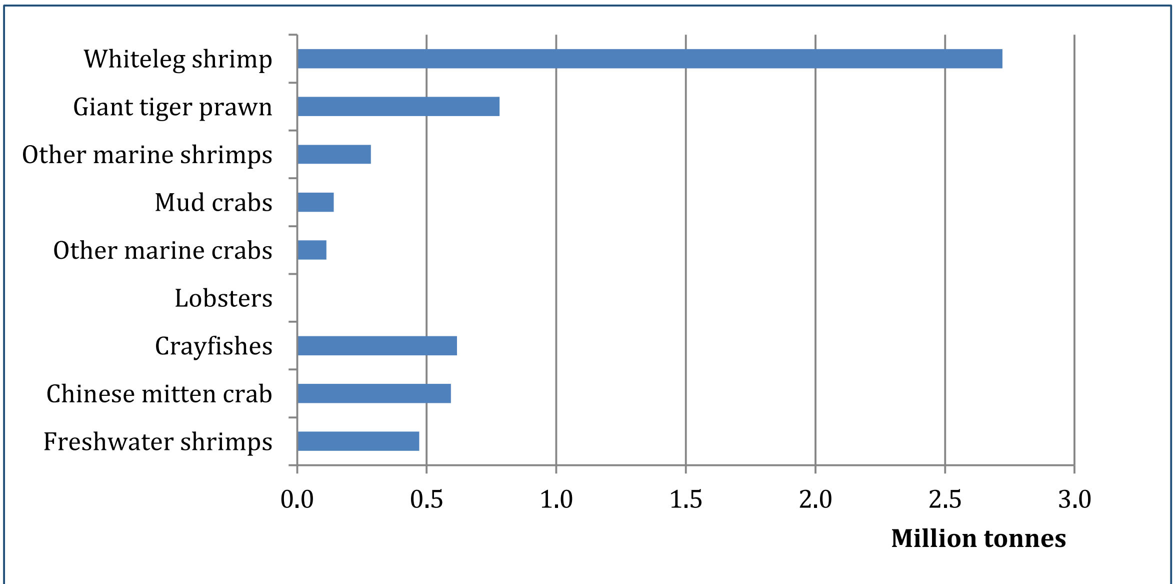


Marine finfish represent a much low proportion of the total volume of finfish produce, but still represent 35 different families (and xx species). The species tend to be carnivorous (snappers, groupers, pompano, tuna), but are also represented by a few species that are omnivorous or herbivorous (mullet, scats, rabbitfish) (Figure 6).

Crustaceans can be split between marine/brackish and freshwater production systems comprising 13 families and 62 reported species. Marine/brackishwater production is dominated by the penaeid shrimp with minor contributions from other families such as lobsters and metapenaeids. Freshwater production is comprised of the Chinese mitten crab, different crayfish/crawfish species and the Macrobrachium freshwater prawns.

Some production of *L. vannamei* is also recorded as undertaken in freshwater inland areas, although this may not be strictly freshwater but extremely low salinity brackishwater. The majority of production is from warm water systems (Figure 7). There are a number of ornamental crustacean species across all the families including the Atyiidae.

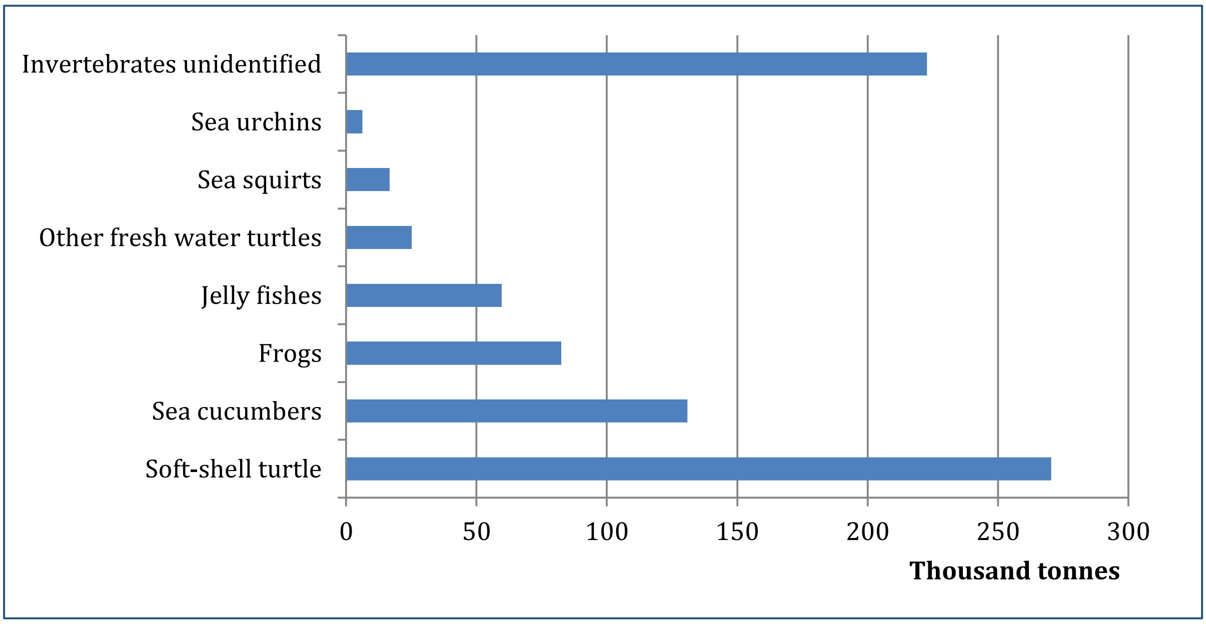
Figure 7: Production of the different crustacean groups (2010)



A range of niche species are also produced comprising 7 families of sea cucumbers (Holothuria), sea urchins (Echinodermata) and other invertebrates, and 2 families of amphibians (2 species of frog) and reptiles (2 species or groups of freshwater turtle – note crocodile/alligator are not included). Ornamental invertebrates are not included (these comprise corals), as well as those produced for shell (pearl, mother of pearl).

Crocodile production is growing quickly in the Asian region with export of juvenile crocodiles to producing countries. China PR, Viet Nam, Cambodia, Thailand and Papua New Guinea all have crocodile farms, however this production is rarely or never reported in fishery or aquaculture statistics (Figure 8).

Figure 8: Production of other aquatic animals (2013)



1.3.2 Diversity of production systems

With the wide diversity of farmed types (>580 reported to FAO), global aquaculture production systems are equally diverse. They cover a range of systems, extensive to intensive, across all types of aquatic environment (fresh-, brackish- and marine waters) and in every inhabited continent of the world.

These systems also have different characteristics with respect to the diversity and use of aquatic genetic resources, ranging from the use of wild seed to domesticated breeding lines. The diversity of aquaculture systems, the typical species produced and the source of broodstock and seed, is summarized in Table 11.

1.3.3 Marine and freshwater ornamental fish in the aquarium trade

In 2000, the Global Marine Aquarium Database (GMAD) was created and by August 2003 the dataset contained trade records covering a total of 2,393 species of fish, corals and Invertebrates and spanning the years 1988 to 2003. Asia provided more than 50 percent of the global total ornamental fish supply (FAO, SOFIA 2000).

- A total of 1,471 species of marine fish are traded worldwide but the ten 'most traded' species account for about 36 per cent of all fish traded for the years 1997 to 2002 (Wabnitz et al., 2003).
- A total of 140 species of stony coral, nearly all scleractinians, are traded worldwide. Coral species are in seven genera (*Euphyllia*, *Goniopora*, *Acropora*, *Plerogyra*, *Catalaphyllia*) are the most popular, accounting for approximately 56 per cent of the live coral trade between 1988 and 2002. There were also 61 species of soft coral traded.

- More than 500 species of invertebrates (other than corals) are traded as marine ornamentals, though the lack of a standard taxonomy makes it difficult to arrive at a precise figure.

There is no equivalent database for the freshwater aquarium trade and the diversity of species being produced and traded is not readily available. However, various aquarium guides list 650 (Sakurai et al. , 1983) to 850 (Baensch & Riehl,1997) common freshwater aquarium species.

An important distinction that can be made between the freshwater and marine aquarium trades is the level of reliance on capture of animals rather than culture. It is roughly estimated that the freshwater aquarium trade relies on cultured animals for 98 percent and only two percent of the products are captured.

The marine aquarium trade relies on capture for 98 percent of its production versus two percent culture (Wabnitz et al., 2003). There is a significant potential for increasing the contribution of aquaculture to the marine aquarium trade and the freshwater aquarium trade is also a significant contributor to the value of aquaculture production in some countries.

Table 11: Summary table of the diversity of aquaculture systems and the typical species produced

System type	Typical species/species groups	Source of seed stock	Source of Broodstock
Industrial/high technology systems	Marine Finfish: Atlantic salmon, Pompano, Crustacean: *Penaeus vannamei*,	Hatcheries	Captive broodstock Selective breeding and other genetic improvement; Domestication programmes
	Freshwater Finfish: Rainbow trout, *Pangassius*, GIFT Tilapia, other Tilapia strains, Jayanti Rohu, Common carp strains, sturgeon, channel catfish		
Higher value species fattening systems	Marine: Bluefin tuna, groupers, lobster, mangrove crab, yellowtail Freshwater: European & Japanese eel, marbled sand goby	Wild captured from targeted fisheries	Wild relatives
Lower value species fattening systems	Marine/brackishwater: Mullet, milkfish		
	Freshwater: giant snakehead; African catfish		
Medium technological level commercial finfish & crustacean fed-systems	Marine/brackishwater Fishfish: Turbot, sea bream, European sea bass, Asian Sea Bass, milkfish, snappers, cobia Crustacean: *Penaeus monodon*	Hatchery	Captive broodstock used from growout systems No/limited selective breeding Some genetic material used from wild relatives for broodstock
	Freshwater Finfish: intensive tilapia, *Pangassius*, Indian major carp, Chinese carp, Mandarin fish Crustacean: *Macrobrachium* spp., crayfish spp., Chinese mitten crab		
Higher value mollusc systems	Marine/brackishwater: Fed systems: Abalone, Babylonia, Lantern net systems: scallop Lines: Green lipped mussel Racks/poles: Pacific & European oyster systems Open water: Giant clam	Hatchery produced seed	Captive broodstock
Low technology / artisanal & backyard systems	Marine: rabbitfish, milkfish, scats	Hatchery	Broodstock maintained on farm or held in hatchery. Quality of strain ranges between highly inbred on-farm strain, to genetically well-managed national broodstock systems.
	Freshwater: Indian carp, common carp, Chinese carp, tilapia, catfish, snakehead, climbing perch, silver barb, snakeskin gourami, giant gourami, pacu		

System type	Typical species/species groups	Source of seed stock	Source of Broodstock
Integrated or mixed systems	Marine/brackishwater: Mangrove/ aqua-silviculture (crab/shrimp/trap pond systems)	Trapped wild species ongrown Hatchery culture species introduced	Wild broodstock Hatchery maintained broodstock
	Freshwater: Rice-fish (common carp, barbs, tilapia, channel catfish); rice-crayfish (Pacifastacus)		
	Freshwater-brackishwater: rice fish/rice-prawn rotation systems (tilapia; mixed brackishwater fish; penaeid shrimp; Macrobrachium spp.)		
	Freshwater: Wastewater improvement systems (aquatic plants and/or molluscs/herbivorous fish)	Mainly hatchery	Hatchery maintained broodstock
	Marine: Integrated, multi-trophic systems (Seaweeds; Invertebrates - scallops, mussels, sea cucumber, sea urchin; finfish cages)	Mostly hatchery raised or vegetative growth (in the case of seaweed)	Mainly on farm stock or hatchery maintained broodstock.
Lower value mollusc systems	Extensive stake systems (oyster, mussels) Extensive bottom systems (blood cockle, manila clam)	Natural Spatfall Spat collectors	Wild broodstock on farm or wild relatives
Aquaculture Feed species	Invertebrates (e.g. polychaete worms)	Hatchery	Hatchery maintained strains or use of farm stock (in the case of worms)
	Zooplankton (e.g. moina)		
	Phytoplankton (e.g. chaetoceros, chlorella, skeletonema, tetraselmis, isochrysis, etc.)		
	Zooplankton (artemia)	Wild collection	Inoculation of open waters with maintained strains Wild relatives naturally recruited
Food supplements	Spirulina	Hatchery	Maintained strains
Seaweeds/aquatic plants	Marine: seaweeds (euchema, gracilaria, laminaria, porphyra etc.)	Hatchery & vegetative reproduction	Maintained stock or hatchery held strains
	Freshwater: aquatic plants e.g. *Ipomea*, water cress (including ornamental/aquarium plants)		
Aquarium fish and other species	Indicative number of species marine Indicative number of species freshwater Also significant use of exotic species outside of their natural range	Hatchery	Hatchery maintained broodstock

1.4 State of World Fisheries[6]

Harvest from marine capture fisheries and plateaued at approximately INSERT tonnes (Figure 9). Refer to FAO SOFIA 2014 until release of FAO SOFIA 2016

UPDATED TEXT FROM SOFIA 2016 TO BE INSERTED

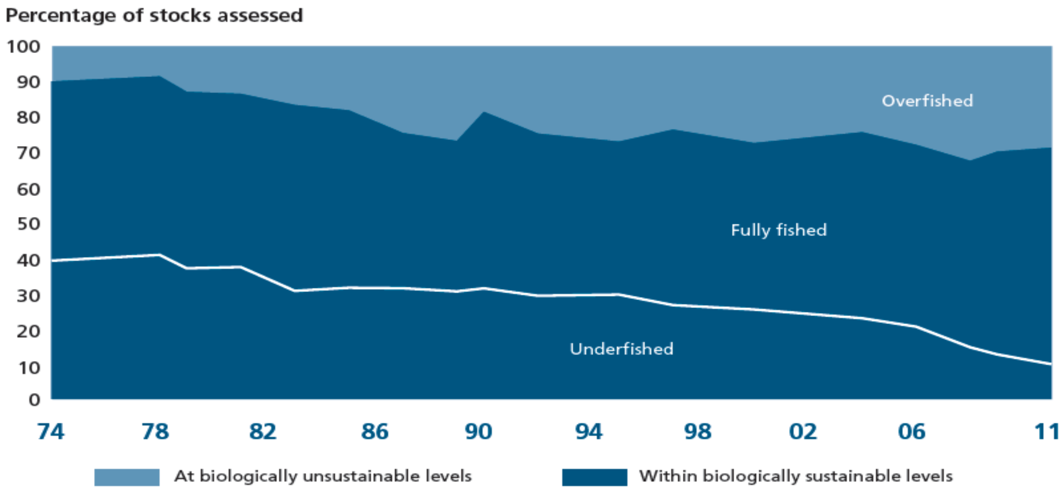
Figure 9: Production in volume (tonnes) from marine and inland capture fisheries (period 1990-2013)

1.4.1 Marine fisheries

The status of marine fisheries is based on an in depth analysis of over 450 fish stocks (SOFIA 2014). The world's marine fisheries expanded continuously to a production peak of 86.4 million tonnes in 1996 but have since exhibited a general declining trend. The fraction of assessed stocks fished within biologically sustainable levels has exhibited a decreasing trend, declining from 90 percent in 1974 to 71.2 percent in 2011. In 2011, 28.8 percent of fish stocks were estimated as fished at a biologically unsustainable level and therefore overfished. Of the total number of stocks assessed in 2011, fully fished stocks accounted for 61.3 percent and underfished stocks 9.9 percent. The majority of marine fisheries (61.3%) are harvested within sustainable limits (Figure 11).

Figure 11. The global trends in the state of world marine fish stocks, 1974–2011 (Source FAO SOFIA 2014)

[6] Analyses will be completed using most recent data following the release of the State of World Fisheries and Aquaculture 2016, in July 2016.



Notes: Dark shading = within biologically sustainable levels; light shading = at biologically unsustainable levels. The light line divides the stocks within biologically sustainable levels into two subcategories: fully fished (above the line) and underfished (below the line).

Asia harvests the majority of marine fish stocks, followed by Africa and Latin America (Table 12).

Table 12: Production of global marine capture fisheries by region in 2013, excluding aquatic plants

Geographical region	**2013**	**Percentage of global total**
Australia and New Zealand	595 184	1%
Melanesia	342 090	0%
Micronesia	213 052	0%
Polynesia	50 367	0%
South America	9 930 299	12%
Northern America	5 807 001	7%
Central America	1 878 751	2%
Caribbean	219 288	0%
Western Africa	1 763 872	2%
Northern Africa	1 647 189	2%
Southern Africa	895 018	1%
Eastern Africa	457 014	1%
Middle Africa	411 111	1%
Eastern Asia	20 880 008	26%
South-Eastern Asia	16 118 889	20%
Southern Asia	5 216 587	7%
Western Asia	968 789	1%
Central Asia	828	0%
Northern Europe	6 055 445	8%
Eastern Europe	4 092 538	5%
Southern Europe	1 541 822	2%
Western Europe	1 059 475	1%
Quantity (tonnes)	**80 144 617**	**100%**

Table 13: Main species harvested from marine fisheries and production in volume from 2008 until 2013

Species (ASFIS species)	Measure	2008	2009	2010	2011	2012	2013
Atlantic cod	tonnes	770 503	868 049	951 933	1 051 545	1 114 401	1359 568
Atlantic herring	tonnes	2 479 203	2 516 755	2 203 687	1 780 268	1 773 235	1816 987
Marine fishes nei	tonnes	8 786 014	9 934 983	10 391 131	10 403 497	1 0879 822	1 0951 308
Pacific herring	tonnes	283 915	306 104	330 802	397 440	451 457	510 015
Japanese flying squid	tonnes	403 722	408 188	359 322	414 100	351 229	330 136
European pilchard(=Sardine)	tonnes	1 065 295	1 244 588	1 245 956	1 037 161	1 018 940	1 001 126
Haddock	tonnes	332 178	365 611	396 483	430 028	430 917	308 671
California pilchard	tonnes	742 028	758 070	696 585	639 235	364 386	255 291
Japanese anchovy	tonnes	1 270 331	1 072 589	1 204 106	1 325 758	1 296 383	1 326 077
American cupped oyster	tonnes	90 947	96 141	115 925	121 165	137 884	173 514
Chub mackerel	tonnes	1 937 613	1 641 344	1 641 508	1 715 551	1 581 180	1 654 545
Atlantic redfishes nei	tonnes	39 933	59 456	46 603	50 005	56 255	53 961
Atlantic menhaden	tonnes	187 742	182 210	228 966	227 141	224 404	167 590
Japanese pilchard	tonnes	192 159	191 907	205 327	318 791	269 972	380 023
Pacific saury	tonnes	622 119	475 727	432 372	458 954	460 961	402 386

Table 14: Principle taxonomic groups that make up the 98% of the global marine harvest

Taxonomic group	Production (tonnes)	% of total global marine catch
Clupeiformes	15 670 089	23%
Scombroidei	13 555 855	20%
Pisces miscellanea	11 851 081	18%
Percoidei	10 052 462	15%
Gadiformes	8 652 069	13%
Salmoniformes	1 131 795	2%
Pleuronectiformes	1 040 586	2%
Beloniformes	758 946	1%
Mugiliformes	539 911	1%
Scorpaeniformes	508 976	1%
Stromateoidei, Anabantoidei	489 633	1%
Trachinoidei	455 527	1%
Anguilliformes	447 902	1%
Aulopiformes	402 831	1%
Siluriformes	367 685	1%

1.4.2 Inland fisheries

Global inland fishery harvests are in excess of 12 million tonnes, however there are credible reasons to believe that this production figure is under-estimated. Asia harvests the most from inland fisheries producing at least 65% of the global production. Africa produces 23% of the production.

Table 15. Global production from inland capture fisheries (freshwater and diadromous fish) by region (2013)

Geographical region	2013	Percentage of global total
Melanesia	11 732	0%
Australia and New Zealand	3 837	0%
Polynesia	51	0%
Eastern Africa	1 318 114	11%
Western Africa	733 920	6%
Middle Africa	515 225	4%
Northern Africa	243 902	2%
Southern Africa	4 181	0%
South America	354 754	3%
Central America	129 583	1%
Caribbean	3 177	0%
South-Eastern Asia	2 920 062	24%
Southern Asia	2 661 492	22%
Eastern Asia	1 962 203	16%
Western Asia	86 820	1%
Central Asia	54 070	0%
Eastern Europe	697 845	6%
Northern America	554 759	4%
Northern Europe	50 967	0%
Southern Europe	19 563	0%
Western Europe	19 021	0%
Totals - Quantity (tonnes)	**12 345 278**	**100%**

Figure 12: Inland capture fisheries production in volume from 1984 until 2013

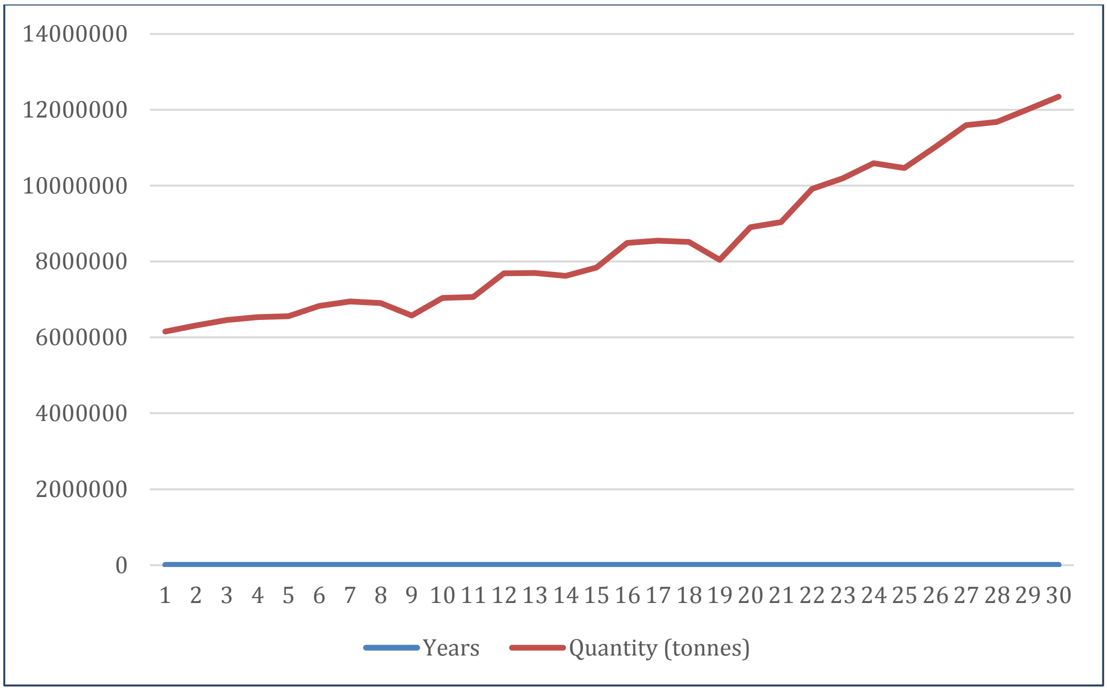


Table 16: Main species harvested from inland fisheries

Species (ASFIS species)	2013 (tonnes)
Freshwater fishes nei	6 456 211
Chum(=Keta=Dog) salmon	199 501
Black and Caspian Sea sprat	74 385
Freshwater bream	41 337
Pink(=Humpback) salmon	562 850
Roaches nei	20 570
Sockeye(=Red) salmon	136 597
Caspian shads	350
Pike-perch	18 098
Characins nei	66 864
Alewife	2 800
Common carp	89 715
Coho(=Silver) salmon	28 939
Northern pike	22 893
Whitefishes nei	3 581

The status of the world's inland fisheries is difficult to determine for most fisheries. Unlike marine fisheries were fishing pressure is a major determinant of the status, other factors external to the fishery sector has a major influence on status (FAO SOFIA 2012, FAO SOFIA 2014). Habitat condition, water quality and connectivity of water bodies often influence inland fisheries more than fishing pressure. Complicating the determination of the status of inland fisheries is the fact that much of the harvest is unreported or not reported to species (FAO FishStatJ; Bartley et al. 2015).

Table 17: Main species in inland capture fisheries and the % of total inland harvest

Species (ASFIS species)	% of Total global inland harvest
Freshwater fishes nei	52.3

Pink(=Humpback) salmon	4.6
Chum(=Keta=Dog) salmon	1.6
Sockeye(=Red) salmon	1.1
Common carp	0.7
Black and Caspian Sea sprat	0.6
Characins nei	0.5
Freshwater bream	0.3
Roaches nei	0.2
Coho(=Silver) salmon	0.2
Northern pike	0.2
Pike-perch	0.1
Caspian shads	0
Alewife	0

1.5 Key findings and conclusions

Aquaculture production is increasing in most countries	This trend is expected to continue with the production from the majority of species being reported as either increasing or stable.
	Developing countries account the most fisheries and aquaculture production
Capture fishery production is stable or declining	Capture fisheries production has plateaued over the last several years
	The abundance of wild relatives, as indicated by catch records, is decreasing or depleted in many areas.
A tremendous amount of AqGR is used in aquaculture and fisheries	Aquatic organisms derived from two kingdoms, several phyla and hundreds of species. The marine and coastal areas contain the most number of farmed species and their wild relatives due to the presence of several phyla that are not present in inland waters.
Aquaculture production systems are highly diversified in term of species and methods	Aquaculture systems range from simple, systems based on open water, non-fed growout of wild caught seed, to fully-industrialized, closed-cycle production using domesticated broodstock and sophisticated genetic management.
Aquaculture and fisheries are closely linked production systems.	Wild types, i.e. those species with very little or no domestication or genetic improvement, play an important role in aquaculture
	About 50% of the farmed types reported were wild type.
	Aquaculture relied on wild populations for a source of brood stock or early life history stage to at least some extent in over 50% of the country reports
	Only 15% of the reports stated there was no sourcing at all from wild populations
	85% of the wild relatives reported are part of capture fisheries

[To be completed]

1.6 References

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[To be completed]

2 THE USE AND EXCHANGE OF AQUATIC GENETIC RESOURCES OF FARMED AQUATIC SPECIES AND THEIR WILD RELATIVES WITHIN NATIONAL JURISDICTION

PURPOSE: The purpose of this chapter is to provide annotated inventories on and the status of aquatic genetic resources of farmed aquatic species and their wild relatives.

KEY MESSAGES: Major findings from an examination of country reports and other information sources include:

- A tremendous amount of AqGR is used in aquaculture and fisheries
- There are important species and farmed types not reported to FAO
- Aquatic plants and microorganisms have not been well reported in FAO statistics.
- Wild relatives of farmed aquatic species play important roles in both aquaculture and capture fisheries.
- Selective breeding is the most widely used technology to improve AqGR for food and agriculture
- Genetic information and technologies has great potential
- There will be challenges in using genetic technologies on a wide scale as they require financial resources and technical capacity.
- Biotechnology, and specifically genetic biotechnologies, are advancing rapidly
- Numerous species have potential for use in aquaculture either through domestication or sourcing material from wild populations.
- Non-native species have an important role to play in aquaculture and fisheries development
- There is limited use of genetic information in the development and management of farmed aquatic species and their wild relatives.
- A global information system on aquatic genetic diversity does not yet exist
- Up to date, standard and consistent nomenclature on products of genetic improvement and on wild relatives below the species level is lacking

2.1 Background

The use and exchange of Aquatic genetic resources (AqGR) of farmed aquatic species and their wild relatives has been practiced for millennia. The earliest humans gathered fish, shellfish and aquatic plants from wetlands and coastal areas in Africa and continued this practice as early humans migrated out of Africa and prehistoric examples of fishing are found in middens around the world (Sahrhage and Lundbeck. 1992.).

Early evidence of fish farming is found over two thousand years ago in China; the ancient Romans held marine species in special coastal enclosures not only for eventual consumption, but also as an indication of wealth and status. European monks farmed and transferred the common carp from its native range in Asia and the Danube River to many parts of Europe; the scientific name for common carp, *Cyprinus carpio*, is derived from the fact that the fish was introduced to Western Europe through Cyprus (Nash 2011).

Most information on production and number of farmed organisms is at the species level. Very little information is available on the genetic diversity of farmed organisms and their wild relatives.

2.2 Definitions and nomenclature

Aquatic genetic resources for food and agriculture include DNA, genes, chromosomes, tissues, gametes, embryos and other early life history stages, individuals, strains, stocks and communities of organisms. Unlike domesticated crops and livestock where many breeds, varieties and cultivars have been well established and recognized for centuries or millennia, aquatic species have very few recognized strains (i.e. the equivalent to breeds in livestock or cultivars in crops). The operational definitions report[7] are included in Table 18.

Table 18. Nomenclature suggested by the meeting to designate genetic diversity

Term	Definition
Breed	A specific group of domestic animals having homogeneous appearance (phenotype), homogeneous behaviour, and/or other characteristics that distinguish it from other organisms of the same species and that were arrived at through selective breeding. Despite the centrality of the idea of "breeds" to animal husbandry and agriculture, no single, scientifically accepted definition of the term exists (FAO 2007).
Cultivar or variety	A plant or grouping of plants selected for desirable characteristics that can be maintained by propagation. The International Union for the Protection of New Varieties of Plants requires that a cultivar be distinct, uniform and stable. To be distinct, it must have characteristics that easily distinguish it from any other known cultivar. To be uniform and stable, the cultivar must retain these characteristics under repeated propagation.
Strain	A farmed type of aquatic species having homogeneous appearance (phenotype), homogeneous behaviour, and/or other characteristics that distinguish it from other organisms of the same species and that can be maintained by propagation. As with breeds and cultivars a strain must be distinct, uniform and stable.
Stock	A group of similar organisms in the wild that share a common characteristic that distinguishes them from other organisms at a given scale of resolution. For infra-specific use a stock would signify a segment of a species that can be distinguished from other segments of that species.
Farmed type	A farmed organisms that could be a species, hybrid, triploid, mono-sex group, other genetically altered form, variety or strain. Wild relatives of farmed types were defined to be
Wild relative	An organism of the same species as a farmed organism (conspecific) found and established in the wild, i.e. not in aquaculture facilities.

Unlike the terrestrial agriculture sector, all wild relatives of farmed aquatic species can still be found in nature (although wild types are becoming threatened through introgression with farmed types and non-native genotypes (see below) for some species. Thus, the term 'wild relative' signifies an organism of the same species (conspecific) as that being farmed. This natural reserve of genetic diversity not only supports capture fisheries and helps the species adapt to anthropogenic and natural impacts, but it also provides a source of individuals and genes to be used in aquaculture.

2.3 Information on fisheries and aquaculture

Accurate and timely information lies at center of documenting the use and status of genetic resources of farmed species and their wild relatives. FAO serves as the global repository for national statistics on fisheries and aquaculture production.

[7] These operational definitions were agreed by the Expert Workshop on Incorporating Genetic Diversity and Indicators into Statistics and Monitoring of Farmed Aquatic Species and their Wild Relatives, Rome, Italy, 4–6 April 2016, and follow the custom in naming plant cultivars and animal breeds.

The international standard for reporting this production is the Aquatic Sciences and Fisheries Information System (ASFIS) list and the classification system of the International Standard Statistical Classification of Aquatic Animals and Plants (ISCAAP). When members of FAO submit fisheries and aquaculture statistics to FAO they should follow ASFIS nomenclature.

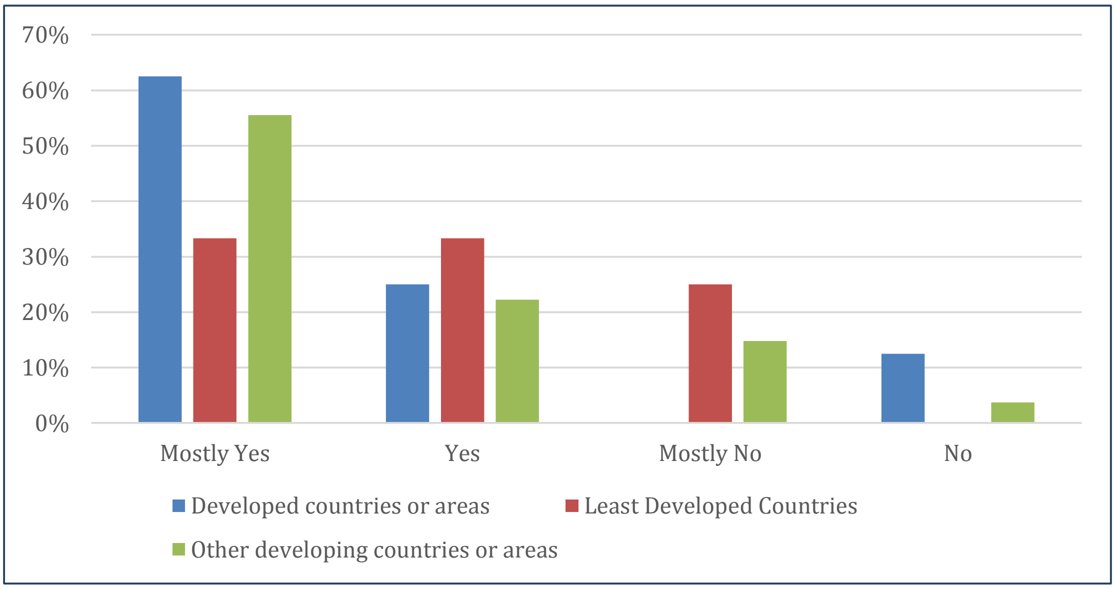
Country reports indicated that the naming of species and farmed types was generally accurate and up to date (Figure 13). However, it is unclear what taxonomic level this accuracy refers to in the country reports. Is it at the species level or below?

To date the ASFIS[8] list contains 12 700 species items. The nomenclature includes only twelve taxa below the species level, i.e. interspecies hybrids. The list does not include any subspecies, stocks, strains or varieties of farmed species or their wild relatives.

Information about aquatic genetic resources below the species level can be extremely useful to resource managers, policy makers, private industry and the general public. Not only is genetic diversity the basic building block for selective breeding programmes and other genetic improvement technologies in aquaculture, and for natural populations to adapt to changing environments and evolve; information on genetic diversity can be used *inter alia* to help meet production and consumer demands, to prevent and diagnose disease, to trace fish and fish products in the production chain, to monitor impacts of alien species on native species, to differentiate cryptic species, to manage broodstock, and to design more effective conservation and species recovery programmes.

However, the majority of resources managers and those government officials submitting information to FAO, do not use or have sufficient access to information of aquatic genetic diversity of farmed species and their wild relatives.

Figure 13. Is naming of aquatic species and farmed types accurate and up to date?(% of responses)



2.4 Incorporating genetic diversity and indicators into national statistics and monitoring of farmed aquatic species and their wild relatives

The FAO Commission on Genetic Resources for Food and Agriculture, realizing that substantial production from aquaculture and capture fisheries is based on groups below the level of the species and that genetic information has a variety of uses in fishery management,

[8] http://www.fao.org/fishery/collection/asfis/en

requested FAO to undertake a thematic study[9] to explore means to incorporate genetic diversity and indicators into statistics and monitoring of aquatic genetic resources (AqGR) of farmed aquatic species and their wild relatives.

Examples of incorporating genetic diversity into national and global reporting and monitoring do exist, but primarily in the agriculture sector, where nomenclature for breeds and varieties has been standardized and used for centuries. In the aquaculture sector, the establishment of breeds of most species is a much more recent practice and thus the nomenclature and characterization of breeds is not standardized.

In capture fisheries genetic diversity is sometimes used in fishery management of high value species, but this is dependent on the establishment of baseline data and on regular sampling, monitoring and analyses of the fish stocks which are often beyond the financial and technical capacities for many species and areas. Stock identification in capture fisheries has traditionally been based on geographic location; production has been reported and monitored accordingly.

Some countries maintain registries of nationally important aquatic species, but production information is not routinely included unless the stock or species is considered threatened or endangered.

There are significant constraints to developing an information system below the species level for AqGR including:

- the lack of standardized genotypic and phenotypic description of a 'strain' or 'stock',
- the lack of complete baseline data that genetically characterize a strain or stock, and
- the private aquaculture industry's view that genetic information on their products is proprietary.

None the less, an information system was designed (Table 18) that would complement FAO's current work on fishery and aquaculture statistics (Table 19).

Table 18. Data structure for an information system on aquatic genetic resources of farm types and their wild relatives

Information for farmed types	Information for wild relatives
Respondent – name of person providing information	Respondent – name of person providing information
Taxonomic status, genus and species	Taxonomic status, genus and species
Genetic characteristics of the farmed type	Genetic status and characteristic of the wild relative
Source of farmed type, from wild or aquaculture	Source of wild relative, native or introduced
Breeding history	Migratory pattern
Distinguishing characteristics and common name	Designation of stock name and distinguishing characters
Where farmed	Records of occurrence
Farming system(s)	Habitat(s), distribution, range
Time series of production	Exploitation or use
Status	Status, presence and abundance
Source of further information	Source of further information

[9] Report of the Expert Meeting on Incorporating genetic diversity and indicators into national statistics and monitoring of farmed aquatic species and their wild relatives. FAO Fisheries Report No xx, 2016. FAO, Rome. See also Appendix on Thematic Background Papers

Given the complexity and resources required, incentives would need to be developed to motivate governments, resource managers and private industry to participate and contribute to the information system. Incentives included, inter alia:

- Countries accessing funds to meet international commitments, e.g. to the CBD
- Private industry accessing markets through improved traceability
- International organizations becoming centres of excellence in information on AgGR.

To address costs and complexities, options exist for incorporating genetic diversity into statistics and monitoring programmes. As a first step, an inventory of farmed types and strains of wild relatives could be created that would not involve monitoring and assessment.

This inventory would provide an accessible system documenting the aquatic genetic diversity in fisheries and aquaculture. For an information system that would permit monitoring, options also exist for the time interval between data input and thus the cost of inputs to and maintenance of the information system would be lower with less frequent input.

The country reports are being incorporated into a database that would allow some monitoring on the status and trends of aquatic genetic resources through the process of producing the State of the World report. The rapid advances in genetic technologies and a growing need for sustainably produced seafood would suggest a need for monitoring at 2-3 year intervals to provide current information on change, opportunities and threats.

Reporting at this level would further promote capacity building and continuity, i.e. a body of experts, resource managers, industry representatives and other interested stakeholders that would provide, analyze and use the information.

International organization, private industry and national governments would need to commit to contributing to the information system. In light of the need to efficiently feed a growing human population, these stakeholders will be well served by incorporating genetic diversity information into national management, reporting and monitoring programmes and then reporting this information to the global community.

In light of the facts that a global information system on AqGR does not exist, and at national levels where they do exist, they are not comprehensive and include information on only important species, a new information system with input from countries would need to be established. This will take human and financial resources as well as significant capacity building in many areas.

2.5 The use of aquatic genetic resources in food production

2.5.1 Aquaculture

The wide use of aquatic genetic resources in aquaculture is a relatively recent activity, for all but a very few species, such as the common carp (Balon 1995). Unlike the plant and livestock sectors where farmers have been domesticating and maintaining hundreds of useful breeds and varieties for millennia, domestication of aquatic species only became widespread during the last century (Nash 2015).

Aquaculture is now the fastest growing food production sector and is expected to play a major role in providing seafood in the future as production from capture fisheries has plateaued (SOFIA 2014; Figure 1). Currently about 50% of the seafood we eat comes from aquaculture. In order for aquaculture to fulfil this expectation, management of AqGR and the application of useful genetic technologies will be essential.

2.5.1.1 Diversity of farmed aquatic species

The current list of farmed aquatic species reported to FAO contains over 500 species items from inland, marine and coastal waters. Farmed aquatic species are derived from an incredible taxonomic diversity that includes, two kingdoms and over four phyla (chordata, mollusca, arthopoda and echinodermata) (See Chapter 1, Table 5).

Aquatic species are farmed throughout the world with approximately 130 countries reporting to FAO through the annual submission of statistics by member countries.

Information from the country reports revealed that of the species reported farmed in the most countries (Figure 14), seven are from freshwater habitats with one alga, crustacean and mollusk from the marine environment.

The most commonly reported species being farmed was common carp, *C. carpio,* and it was introduced into 16 of the 20 countries where it is farmed. In fact, many of the commonly farmed species are not native to many (most) of the countries that farm them (Table 19).

Figure 14. Top 10 aquatic species being farmed in different countries (number of countries farming species)

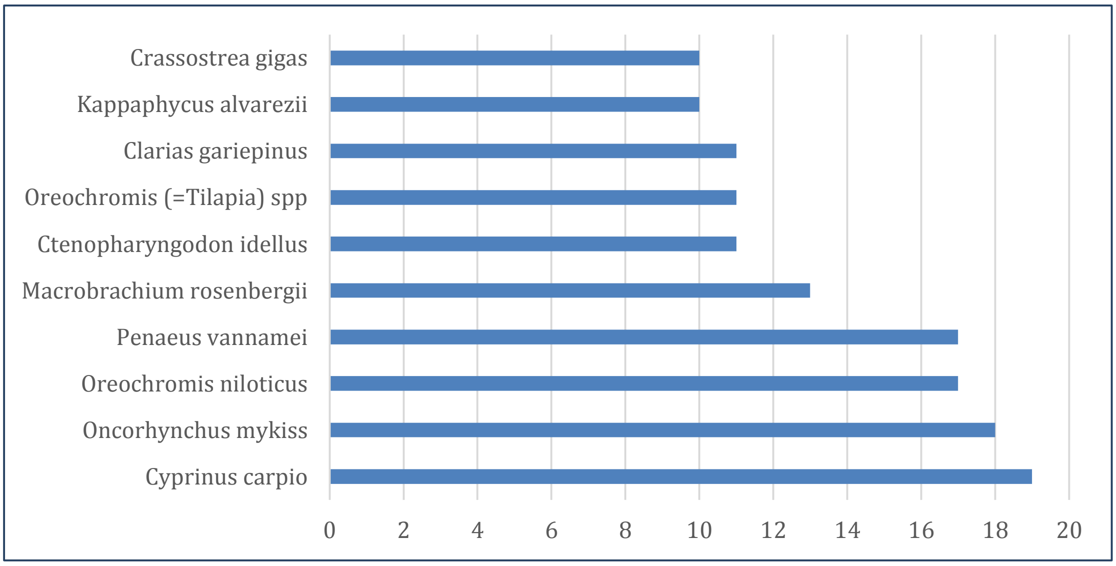
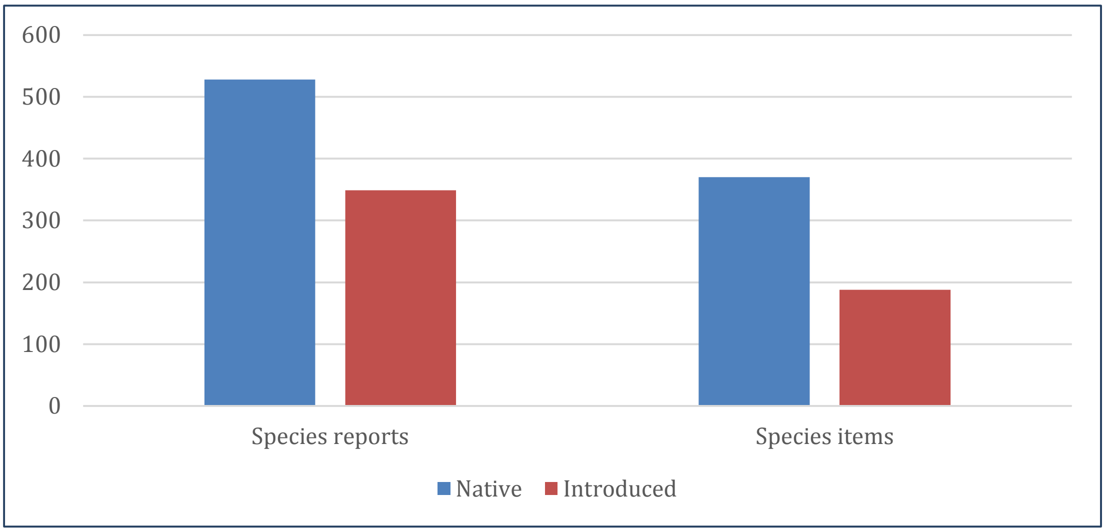


Table 19. For the most commonly farmed species reported, the number of countries where the farmed species is native and introduced

Species	Native	Introduced
Oncorhynchus mykiss	2	16
Cyprinus carpio	4	4
Macrobrachium rosenbergii	5	8
Penaeus vannamei	8	9
Oreochromis niloticus/spp	5	23
Clarias gariepinus	5	6
Kappaphycus alvarezii	3	7
Crassostrea gigas	1	9

Introduced species play a significant role in aquaculture production (see also section 2.5.4 below). Approximately 200 species items were reported farmed in countries where they are non-native (Species Items in Figure 15) and there were over 300 reports of farming non-native species (Species reports in Figure 15).

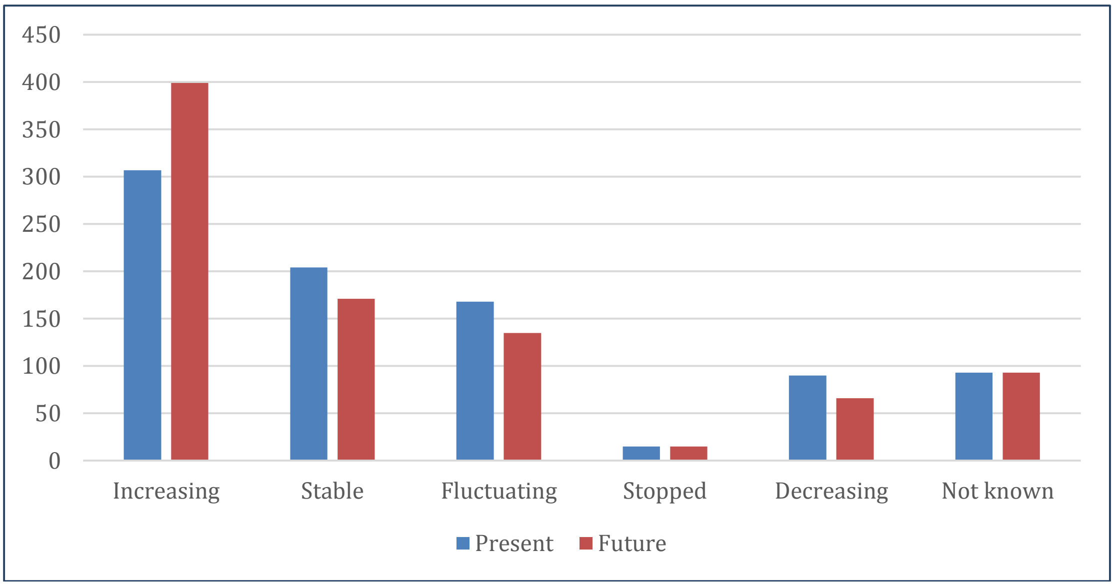
Figure 15. Numbers of native and introduced species reported in aquaculture



Aquaculture production is increasing and there is an expectation for this trend to continue (SOFIA 2014). Production has been and is expected to continue increasing in the vast majority of species included in the country reports as well (Figure 16).

A few countries have discontinued farming of some species, e.g. *Argopecten ventricosus*, *Cherax quadricarinatus*, *Rachycentron canadum*, *Crassostrea gigas*, *Ctenopharyngodon idellus*, *Hypophthalmichthys molitrix*, *Hypophthalmichthys nobilis*, *Isochrysis galbana*, *Metapenaeus affinis* and *Oreochromis aureus*. However the farming of these species was only reported as stopped in no more than one country.

Figure 16. Present and expected future trends in production of farmed aquatic species (number of reports for all species)



The country reports reflect the current national reporting and contain additional information not previously reported to FAO. Numerous countries reported farming more species and 'species units' than they report through the regular FAO statistic survey and even reported species units not currently listed in ASFIS (Table 20).

The country reports clearly demonstrate that more aquatic genetic diversity is being used than previously recognized.

Table 20. Indicative number of additional species reported in country reports

Country	Total number of species reported	Number included in ASFIS	Additions to ASFIS
Philippines	56	46	10
Venezuela	8	8	0
Vietnam	69	47	22
Tanzania	7	7	0
Malaysia	52	46	6
Japan	24	14	10
Paraguay	12	12	0
Iran	19	17	2
Colombia	24	0	11
Kenya	36	13	23
Lao	7	5	2
Tonga	12	8	4
Malawi	5	4	1

Currently the ASFIS contains 11 hybrid species items. (Table 21), however countries do not always provide production information on the farming of these hybrids. Additional hybrids reported in country reports but not on the ASFIS list included:

- *Pseudoplatystoma reticulatum x Pseudoplatystoma corruscans, Pseudoplatystoma corruscans x Pseudoplatystoma reticulatum, Pseudoplatystoma reticulatum x Pseudoplatystoma corruscans* and *Pseudoplatystoma reticulatum x Phractocephalus hemeliopterus* from Brazil;
- *Oreochromis mossambicus x O. niloticus* from the Philippines;
- *Epinephelus lanceolatus x E. coides, E. coides x E. fuscoguttatus, E. lanceolatus x E. fuscoguttatus* from Viet Nam and Malaysia;
- *Onchorryncus mykiss x O. masou* from Japan;
- *Barboniomus gonionotus x B. schwanefeld,; Clarias batrachus x C. microcephalus* from Thailand;
- *Channa micropeltes x C. striata* from Lao PDR;
- *Patinopecten caurinus x P. yessoensis* from Canada.

Species units reported for the SoWAqGR may not have been reported previous because they:

- may have limited production;
- may be primarily used in research;
- may have very localized niche markets;
- may be ornamental species;
- may have been misnamed or
- may be new species being farmed.

Table 21. Hybrids in the ASFIS list and indication of whether data are reported to FAO

Scientific name	Family	Production data registered in FAO database	English name (FAO)	Names in other languages used by FAO
P. mesopotamicus x C. macropomum	Characidae	Yes	Tambacu, hybrid	Spanish: Pacotana, híbrido
C. macropomum x P. brachypomus	Characidae	Yes	Tambatinga, hybrid	
Clarias gariepinus x C. macrocephalus	Clariidae	Yes	Africa-bighead catfish, hybrid	French: Poisson-chat, hybride Spanish: Pez-gato, híbrido Chinese: 尖齿胡鲇与大头胡鲇杂交种
Morone chrysops x M. saxatilis	Moronidae	Yes	Striped bass, hybrid	French: Bar d'Amérique, hybride Spanish: Lubina estriada, híbrida Arabic: قاروس أمريكيّ هجين Chinese: (current name is wrong and needs to be corrected)
Oreochromis aureus x O. niloticus	Cichlidae	Yes	Blue-Nile tilapia, hybrid	Spanish: Tilapia azul-del Nilo, híbrido
P. mesopotamicus x P. brachypomus	Characidae	No	Patinga, hybrid	Spanish: Patinga, hibrido
Ictalurus punctatus x I. furcatus	Ictaluridae	No	Channel-blue catfish, hybrid	Chinese: 斑点-长鳍叉尾鮰杂交种
Pseudopl. corruscans x P. reticulatum	Pimelodidae	No		
Oreochromis andersonii x O. niloticus	Cichlidae	No		Chinese: 奥尼罗非鱼杂交种
Channa maculata x C. argus	Channidae	No		Chinese: 斑鳢-乌鳢杂交种
Leiarius marmoratus x P. reticulatum	Pimelodidae	No		

The ASFIS list does not include strains or varieties, some country reports listed numerous infra-specific genetic diversity (Box 1. Strains)

Box 1. Strains

Several country reports, e.g. the Philippines, described strains of farmed aquatic species.

This box to be completed after analysis of the Philippine and other country reports

Although countries reported numerous farmed types, species and hybrids not currently in ASFIS, FAO as developer and curator of the ASFIS nomenclature is reluctant to add additional items to the list unless it can be shown that the new taxon, i.e. new hybrid or species, would be reported in a reliable and consistent manner by members of FAO. There is no mechanism within the structure of the ASFIS list to include strains, stocks or subspecies. An analysis of the country reports revealed that several new species and hybrids are being farmed than are currently on the ASFIS list. Several of these species items were reported by more than one country and will be added to the ASFIS list.

No country reports listed any subspecies as being farmed or as a wild relative; current taxonomists have recommended the abolishment of this term (Nicolas Baily, FishBase coordinator, personal communication).

Additionally, there are several species that countries identified as having aquaculture potential. Some of these are wild relatives of species that are farmed in other countries but are not yet in a specific country; other species are currently being developed in research stations or by private industry in pilot programmes.

The most often reported species for future domestication was the grey mullet, *Mugil cephalus*. The top 10 species reported for domestication included (number of countries reporting), *Mugil cephalus* (9); *Macrobrachium spp* (8); *Sander lucioperca* (7); *Epinephelus spp* (5); *Lutjanus spp* (5); Milkfish (4*);* *Perca fluviatilis* (4); Holothuroidea (4); *Centropomus spp* (3); *Heterotis niloticus* (3); and *Scylla serrate* (3). These organisms are mostly fin fish, but include crustaceans and sea cucumbers, and come from marine, coastal and inland areas.

Pullin (2016) reviewed models that included growth and economic parameters that would be important when considering the farming of a new species. The model was not extremely good at predicting future use of a species in aquaculture however. Pullin incorporated other criteria to identify species suitable for culture, such as maximum length, growth performance, indicative trophic level, water(s) inhabited, temperature tolerance and other general considerations, e.g. ease of culture.

Interestingly, several of the papers reviewed by Pullin and his own prioritization identified species of river mullet, although not the same species as was identified in the country reports, as having future farming potential.

2.5.1.2 Aquatic plants

To be completed

Genetic diversity of aquatic plants is an often overlooked component of fisheries and aquaculture reporting in national and international reporting.[10]

[10] To be completed preliminary text from AQ Hurtado (seaweeds) and William Leschen (freshwater macrophytes) Thematic Background Papers. See also Appendix on Thematic Background Papers

2.5.1.3 Aquatic plants - farmed seaweeds

The genetic resources of farmed seaweeds are often omitted from regular reporting to FAO despite the significance of these seaweeds as sources of human food, natural colloids as food ingredients, cosmetics, biofuel, pharmaceutical and neutraceuticals; and feed ingredients in aquaculture. Seaweeds are also being used as bioremediation or phyto-mitigation in integrated multi-trophic level aquaculture as a means to recycle aquaculture effluents by absorbing nutrients from other parts of the aquaculture system.

Insert: Graph of seaweed production graph

Insert: List of farmed plant species from report vs those reported to FAO.

Global seaweed farming is predominantly in Asia both for the brown (*Saccharina* and *Undaria*) and red seaweed (*Euchuema*, *Gelidium*, *Gracilaria*, *Kappaphycus*, and *Pyropia*) compared to Europe which is still small in scale and can be found in countries such as Denmark, France, Spain, Portugal, Ireland and Norway. Since the beginning, brown seaweed (*Saccharina* and *Undaria*) dominates the farming of seaweed globally, until this was overtaken by the red seaweeds in 2010 which came mainly *Kappaphycus* and *Eucheuma*.

The brown seaweeds are farmed normally from sub-temperate to temperate countries like China, Japan and Korea, while *Kappaphycus* and *Eucheuma* are farmed from sub-tropical to tropical countries dominated by Indonesia, Philippines and Malaysia. At present, 20 species of red seaweed dominate commercial cultivation, followed by 9 species of brown, and finally 7 species of the green seaweeds.

There are other red seaweeds which are presently farmed either in the open seas, brackish water ponds or land-based tanks. These are *Asparagopsis, Chondrus crispus, Gelidium, Gracilaria, Hydropuntia, Palmaria palmata* and *Pyropia.* Among the green seaweeds, *Caulerpa, Codium, Monostroma,* and *Ulva* are farmed for commercial purposes.

Traditional selection of strains based from growth performance and resistance to 'disease' are still used in propagating farmed species. The breakthrough in the hybridization of *Laminaria japonica* in China paved the way to massive cultivation of this species globally. The development of plantlets from spores for outplanting purposes is still practiced to the present in some brown (*Laminaria, Saccharina, Undaria),* red *(Palmaria, Pyropia),* and green seaweeds *(Codium, Monostroma* and *Ulva).* Micropropagation through tissue and callus culture is becoming a popular method in generating new and improved strains in *Eucheuma* and *Kappaphycus*, though vegetative propagation is still widely used.

The main driver for the continued interest on seaweed cultivation has been the potential for the production of large volumes of a renewable biomass that is rich in carbohydrate and therefore attractive to 3rd generation biofuel production. Seaweed biomass has a wide range of applications as:

- Bio-based and high-value compounds in edible food, food and feed ingredients, biopolymers, fine and bulk chemicals, agrichemicals, cosmetics, bio-actives, pharmaceuticals, nutraceuticals, botanicals; and
- Lower-value commodity bioenergy compounds in biofuels, biodiesels, biogases, bio-alcohols, and biomaterials. Global consumption of sea vegetables is rising as consumers become more aware of their health and nutritional benefits

2.5.1.4 Aquatic plants - freshwater macrophytes

The cultivation of freshwater macrophytes can be generally divided into two sectors. The first is the production of aquatic vegetables, which is usually regarded as horticulture other than aquaculture. Because aquatic vegetables have not been covered by the SoW report on plant genetic resources, as an expediency the horticulture of aquatic vegetables is currently covered by SoW-AqGR review. The second is the cultivation of aquatic macrophytes for ornamental use or for use within aquaculture as shelter as well as natural food of farmed animals such as Chinese mitten crab.

Freshwater macrophytes are relatively under-researched/under-documented which in fact plays important role in rural economic development, particularly in Asia, where they have both historical and cultural significance in providing healthy food and also employment whilst often recycling valuable nutrients in what are essentially low input systems, this benefitting millions of lower income primarily per-urban stakeholders.

To be completed

2.5.1.5 Microorganisms

Microorganisms, feed organisms and aquatic plants have not been comprehensively reported to FAO, yet they are a valuable component of AqGR. (Box 2. Micro-organisms and Annex xx).

Box 2. Micro-organisms in fisheries and aquaculture

This box will contain a summary of the results of the thematic background study "*Genetic resources for microorganisms of current and potential use in aquaculture"*

by Russell T. Hill (not yet available). See also Appendix on Thematic Background Papers.

Aquaculture is the farming of aquatic organisms ranging from microbes to shellfish and finfish and in 2015. World food fish aquaculture production more than doubled from 2000 to 2012 and contributed 42% of total fish production in 2012. Aquatic microorganisms are indispensable resources for growth of shellfish and finfish in natural aquatic ecosystems and in aquaculture. This State of the World report provides information on the genetic resources of key microorganisms on which aquaculture depends.

These microorganisms fall into the microbial groups of (1) microalgae and fungal-like organisms, (2) bacteria, including cyanobacteria and (3) zooplankton. Many microalgal species are important in aquaculture, with different species being suitable as feed for shellfish and finfish larviculture, as components of "green water" widely used to enhance survival and growth of larval and adult fish, and as feeds to enhance the nutritional quality of *Artemia* and rotifers.

Microalgae are also grown in aquaculture to produce pigments and fatty acids of importance in fish aquaculture and as human nutraceuticals. Bacteria that are used in aquaculture include cyanobacteria such as *Spirulina* used for human diet supplements and a rapidly-growing suite of probiotic bacteria. These probiotic bacteria include species that improve survival and growth of fish and shellfish larval and adult stages.

Probiotic bacteria are expected to become increasingly important for disease prevention in aquaculture as antibiotic use is further curtailed and species are grown in more intensive aquaculture systems. Bacteria also play an important role in filtration systems needed in recirculating aquaculture systems.

Zooplankton, specifically *Artemia* and rotifers, have a long history and very wide application as feed for the aquaculture industry. Several species of *Artemia* are used, with *Artemia franciscana* being the most important. Of more that 2,000 species of rotifers, *Brachionus plicatilis* and *Brachionus rotundiformis* are most commonly used. Other zooplankton used in aquaculture include copepods that are growing in importance and cladocerans such as *Daphnia* that are widely used in freshwater larviculture.

The future success and growth of aquaculture depends on continued availability and more efficient culture of these important microbes, as well as conservation and expansion of the biological diversity and genetic resources of microbes used in aquaculture. Important issues include the ability to achieve long-term storage of important organisms without them being subject to genetic drift, the role of commercial and public culture collections, and the need for increased use of genomics to characterize all key microbial species used in aquaculture.

2.5.2 Technologies

Genetic technologies, both in developing and in developed countries, can be applied in aquaculture for increased production, control of reproduction, improved marketability, more accurate and effective traceability in the supply chain, better disease and parasite resistance, more efficient utilization of resources, and better identification and characterization of aquatic genetic resources (Table 22). Some technologies can be used for immediate short-term gain, whereas others are for longer-term gain with genetic improvements accumulating each generation. The basic requirement for the application of all genetic technologies is the ability to reproduce the species under controlled conditions, i.e. under farm or hatchery conditions.

Table 22. Genetic technologies for improving farmed types and indicative responses in farmed aquatic species *(modified from Bartley, 1998*.

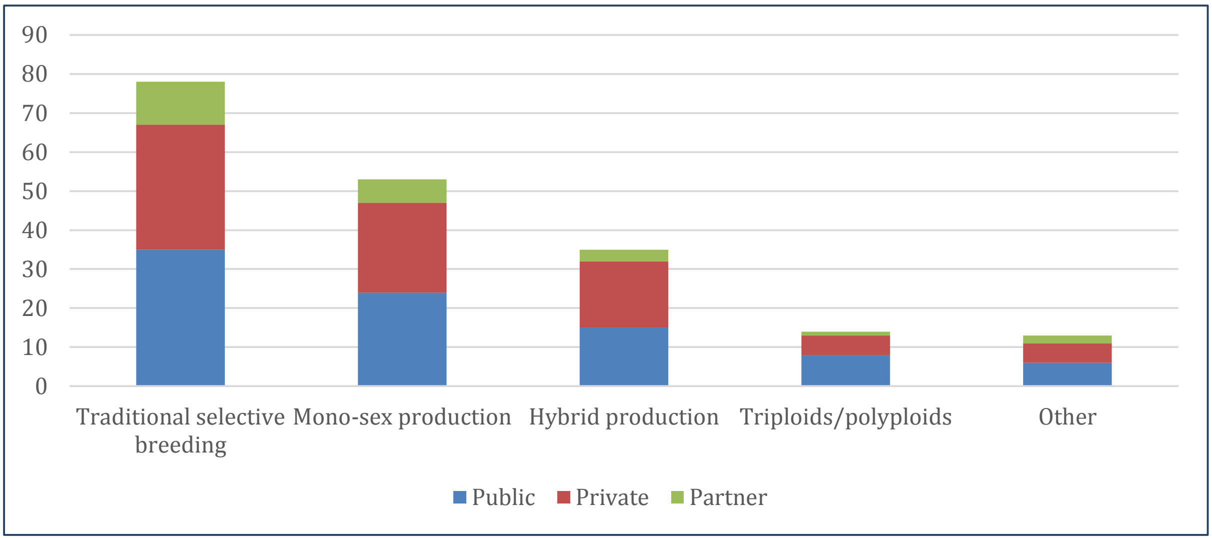
Long term strategies using selective breeding	
Growth rate	As high as 50% increase after 10 generations in coho salmon.
	Gilthead sea bream mass selection gave 20% increase/generation (Hulata, 1995).
	Mass selection for live weight and shell length in Chilean oysters found 10 - 13% gain in one generation (Toro et. al, 1996).
Body confirmation	High heritabilities in common carp, catfish and trout (Tave, 1995)
Physiological tolerance (stress)	Rainbow trout showed increased levels of plasma cortisol levels (reviewed in Overli et al, 2002).
	Increased resistance to dropsy in common carp (Kirpichnikov, 1981).
Disease resistance	Increased survival after challenge test against Taura syndrome in whiteleg shrimp (Fjalestad et al, 1997).
Maturity and time of spawning	60 days advance in spawning date in rainbow trout (Dunham, 1995).
Resistance to pollution	Tilapia progeny from lines selected for resistance to heavy metals survived 3 - 5 times better than progeny from unexposed lines (Lourdes et al, 1995).
Gene transfer	Coho salmon with a growth hormone gene and promoter from sockeye salmon grew 11 times (0 - 37 range) as fast as non-transgenics (Devlin et al, 1994).
	Atlantic salmon containing a gene encoding growth hormone from Chinook salmon grows twice as fast as selectively bred fish (Fox, 2010).
Short-term strategies	
Intra-specific crossbreeding	Improved growth seen in 55 and 22% of channel catfish and rainbow trout crosses, respectively (Dunham, 1995).
	Improved growth wild x hatchery gilthead seabream crosses (Hulata, 1995)
	Crossbreeds of channel catfish and common carp showed 30 - 60% improved growth
	Increased salinity tolerance and color in tilapia crossbreeds (Pongthana et al, 2010).
Inter-specific hybridization .	*Oreochromis niloticus×O. aureus* hybrids show a skewed male sex-ratio (Rosenstein and Hulata, 1993).
	Sunshine bass hybrids (*Morone chrysops×Morone saxatilis*) grew faster and had better overall culture characteristics than either parental species (Smith, 1988).
	Walking catfish hybrids (*Clarias macrocephalus* x *C. gariepinus)* exhibit morphological features which increase consumer acceptance (Dunham, 2011).
Sex reversal and breeding	All male tilapia show improvements in yield of almost 60% depending on farming system and little unwanted reproduction and stunting (Beardmore et al, 2001; Lind et al, 2015).
	All female rainbow trout grew faster and had better flesh quality (Sheehan, 1999).
Chromosome manipulation	Improved growth and conversion efficiency in triploid rainbow trout, channel catfish; triploid Nile tilapia grew 66-90% better than diploids and showed decreased sex-dimorphism (Dunham,1995).
	Triploid Pacific oysters show 13 - 51% growth improvement over diploids and better marketability due to reduced gonads (Guo et al, 1996).
	Polyploidization makes certain interspecific crosses viable, i.e. produces sterile offspring (Wilkins al, 1995).

2.5.2.1 Farmed types

The general term 'farmed type' has been suggested as an inclusive term to include the diversity of genetically altered organisms available for aquaculture. The majority of aquatic farmed types are very similar to the wild type, i.e. wild relative, and their genetic resources are not managed systematically. It has been stated that only about 10% of farmed aquatic species are subjected to genetic resource management in the form of an organized selective breeding programme. This has often been misinterpreted to mean that for 90% of farmed aquatic species genetic resources are not managed at all.

The country reports indicate that in fact genetic resources are being managed to some extent for improved production. Selective breeding has the longest history of use in aquaculture and was the most common form of genetic technology reported by countries (Figure 17). Selective breeding permits the accumulation of genetic gain in each generation. It is therefore a good long-term strategy for breed improvement and domestication.

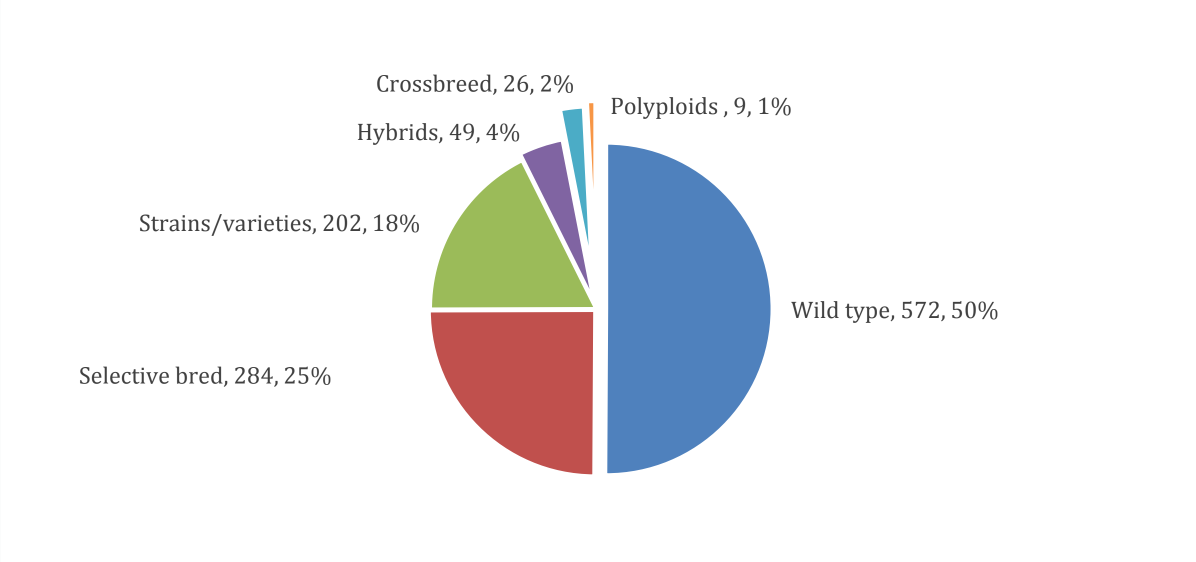
Figure 17. Genetic improvement types and source of funding (number of responses)



Several farmed types of aquatic organisms are available to aquaculturists. These farmed types include, in addition to selectively bred organism, polyploids (Tiwary, Kirubagran and Ray, 2004), hybrids (Bartley et al. 2001) and mono-sex groups (Mair et al., 1995).

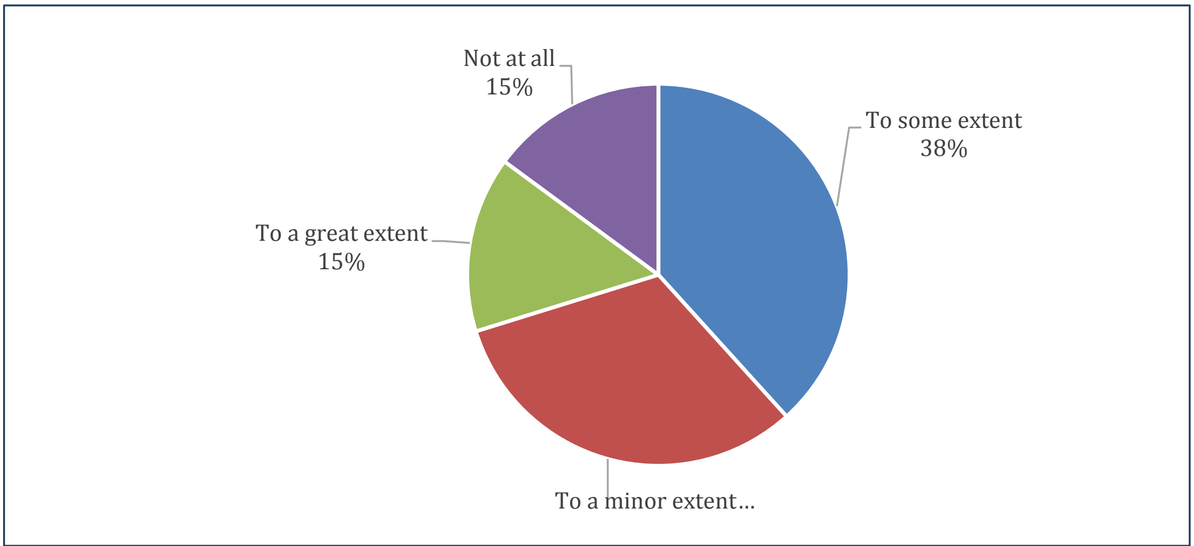
The country reports demonstrated that the use 'wild types' is the most common practice in aquaculture (Figure 18). However, the reports further demonstrated that genetic technologies and genetic resource management at some level is occurring in about 50% of the species being farmed. This is a substantial increase in the commonly cited figure that only 10% of aquaculture is using genetically improved or managed organisms.

Figure 18. Farmed types of aquatic genetic resources (number from responses for all species)



In addition to farming wild types that may not be very domesticated, many aquaculture facilities depend on the organisms from the wild for a supply of seed, juveniles and broodstock in aquaculture or hatchery facilities. Overall, 85% of countries reported that aquaculture depended on aquatic organisms collected from the wild to some extent (Figure 19).

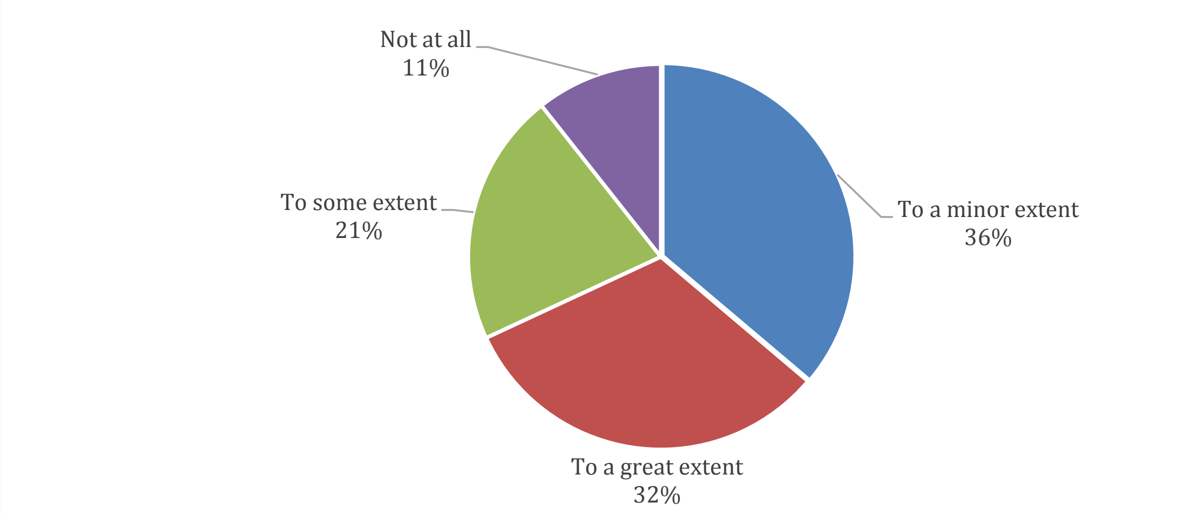
Figure 19. Extent to which aquatic organisms farmed in your country are derived from wild seed or wild broodstock



In spite of the reliance on wild types in aquaculture, approximately half of the countries reported that genetically improved aquatic organisms contributed at least somewhat to national aquaculture production (Figure 20)[11].

Figure 20. Extent to which genetically improved aquatic organisms contribute to national aquaculture production (Number of countries = 47)

[11] Regional analyses of these data will follow when more country reports are received.



2.5.2.2 Extent of the use of genetics in aquaculture

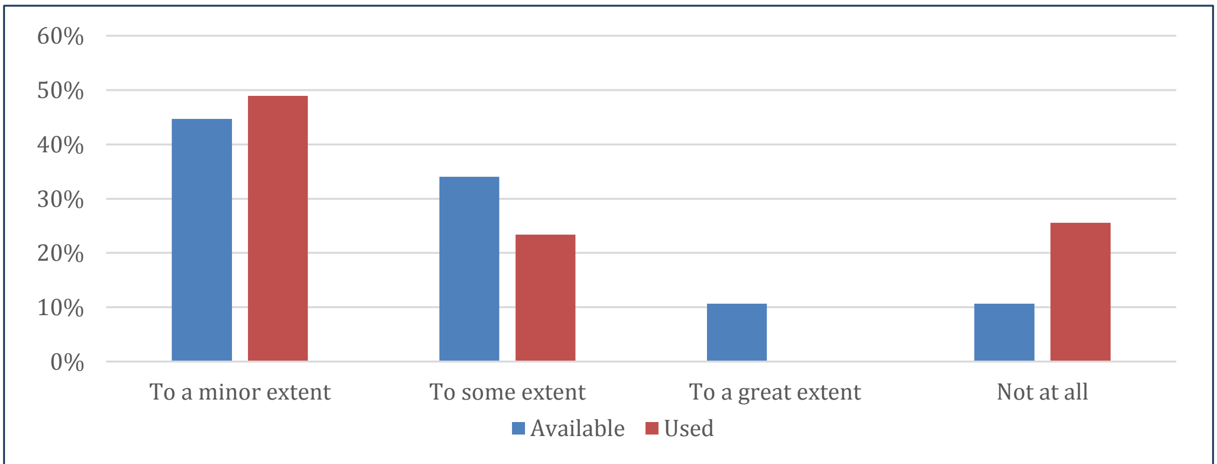
The world's demand for seafood is expected to increase by about 2% per year over the next decades and genetic improvements from selective breeding produce increases of about 10% per generation. Aquaculture geneticists have stated that if all the farmed aquatic species were in traditional selective breeding programmes, aquaculture production could double by 2050 meeting the additional need for seafood with very little extra land, water, feed or other inputs (Gjedrem, 1997; Gjedrem et al, 2012).

Clearly there are tremendous opportunities to increase food production through the use of genetic technologies. However, there are challenges.

Genetic data are more technically demanding and costly to collect (see above) and therefore not often available or used in management of farmed aquatic species (Figure 21). Although no country reported that genetic data were used to a great extent in aquaculture and fisheries, over 50% of country reports stated genetic information were used to some extent and only about 10% reported no availability or use of genetic information (Figure 21).

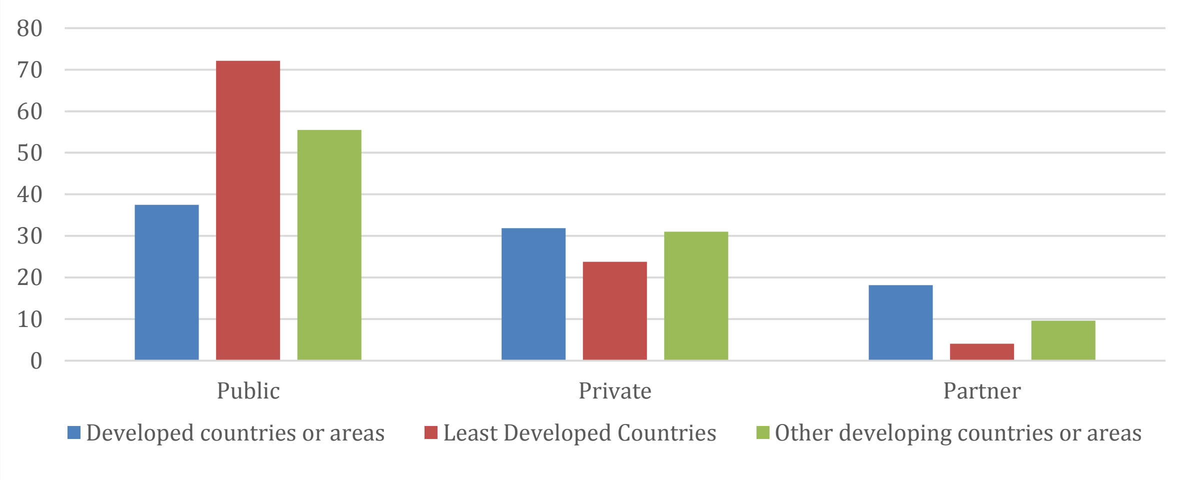
Although genetic resource management and breeding programmes provide increased production and profit, they are often difficult to fund. The WorldFish Center developed the Genetically Improved Farmed Tilapia (GIFT) in partnership with Asian Development Bank, the Philippines and advanced scientific institutions (ADB 2005). The impressive gains in farming Atlantic salmon in Norway were due in large to private public partnerships that also involved Scandinavian Airlines, a government research group (Akvaforsk) and other private companies.

Figure 21. Availability and use of information on aquatic genetic resources of farmed types (% of responses)



The country reports revealed that the majority of breed improvement programmes in aquaculture were funded by public sources with the fewest funded through public/private partnerships (PPP) (Figure 22). Given the success of the GIFT programme (ADB 2005) and the Norwegian Atlantic salmon programme, more use could be made of PPP's.

Figure 22. Source of funding for genetic improvement programmes (%)



2.5.2.3 Biotechnologies for improved characterization of AqGR[12]

(To be completed)

Biotechnologies can be used to increase performance under farming conditions, but can also be important in characterizing AqGR in farmed types and wild relatives (Ruane and Sonnino 2006). Improved characterization will facilitate monitoring and management of AqGR and will be necessary for incorporating genetic diversity into national reporting and monitoring programmes (See Section 2.4 Incorporating genetic diversity and indicators into national statistics and monitoring of farmed aquatic species and their wild relatives).

Genome technologies have been developed to study genome structure, organization, expression, and function, and to select and modify genomes of interest to increase benefits to humans. Of these genome technologies, DNA Marker technologies have been intensely used to map the genome to understand genome structure and organization. These DNA marker technologies included RFLP (restriction fragment length polymorphism) markers, mitochondrial DNA markers, DNA Barcoding, RAPD markers, AFLP markers, microsatellite markers, SNP markers, and RAD-seq markers (SNP markers per se). Although these marker systems were used at various levels for various purposes, the microsatellite markers and SNP markers are currently the most important to characterize and monitor AqGR.

Various genome mapping technologies were developed including both genetic mapping and physical mapping methods. Genetic mapping are based on recombination during meiosis, while physical mapping is based on fingerprints of DNA segments. Although several variations of physical mapping methods are available such as radiation hybrid mapping and optical mapping, the most popular physical mapping method is the BAC-based fingerprinting.

The most dramatic in the genomic sciences is the invention of the next generation sequencing technologies. The second and third generation sequencing technologies literally revolutionized the way

[12] Biotechnologies here are limited to genetic technologies only. Fermentation and bioremediation are excluded except when genetic alteration of the micro-organisms has occurred. Selective breeding is also excluded as a biotechnology because it is covered elsewhere.

science is conducted. These technologies now allow sequencing of the whole genome de novo, or mass sequencing of genomes of populations. Extension of their application allows characterization of the transcriptomes, and the non-coding portions of the genome and their functions

2.5.2.4 Biotechnologies for improved performance in aquaculture

By coupling genome mapping technologies with aquaculture trait evaluations, QTL mapping allow the identification of genes underlining the performance and production traits. Following mapping of QTLs, marker-assisted selection or genome selection can be conducted. Genomes can be edited or modified almost any way now as designed by scientists. Therefore, technologies are mature to make some really large contributions for improving aquaculture traits.

There are a number of challenges including bioinformatics challenge, lack of resources in some parts of the world, difficulties in working with individual farmers, and ethical and legislative challenges that must be overcome in order to have broad applications of genome technologies. A range of biotechnologies were used to improve AqGR according to country reports.

Table 23: Extent of use of biotechnology tools

Extent of use	Selective breeding	Hybridization	Poly-ploidy	Monosex	Marker assisted selection	Andro-genesis
Great extent	34%	13%	9%	38%	6%	6%
Some extent	53%	28%	2%	26%	6%	0%
Minor extent	13%	26%	32%	19%	15%	19%
Not at all	0%	34%	57%	17%	72%	74%

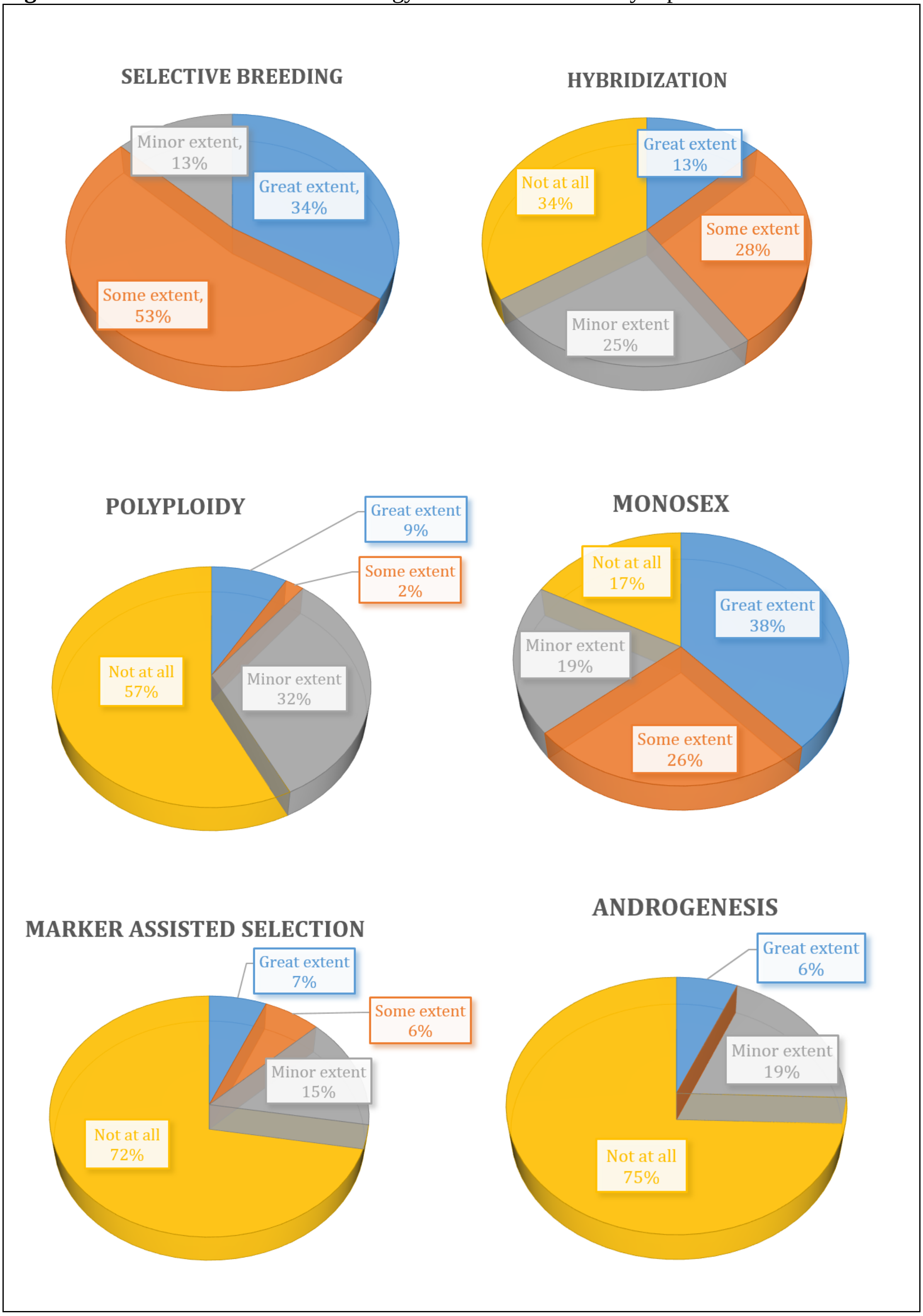
Notable findings from the country responses are:

- Selective breeding was the most widespread tool being used with 34% of countries using it to a great extent and 53% using to some extent.
- Monosex production was relatively widely used with 38% of countries using to a great extent and a further 26% using to some extent.
- There was no clear picture with respect to use of hybridization. This was used to a great extent or some extent by 40% of countries, but only to a minor or no extent at all by 60% of countries.
- Polyploidy was used by 32% of countries to minor extent, but 57% of countries did not use it at all.
- The more complex technical techniques of Marker assisted selection and androgenesis were not widely used with 72% and 74% of countries respectively, reporting there were not used at all.
- 83% of countries reported they were using “other” biotechnology tools beyond those listed in the questionnaire and this needs to be explored further.

The detailed information regarding the extent of use of common biotechnologies in conservation, sustainable use and development/management of aquatic genetic resources is provided in Table 23 (Figure 23).

(To be completed)

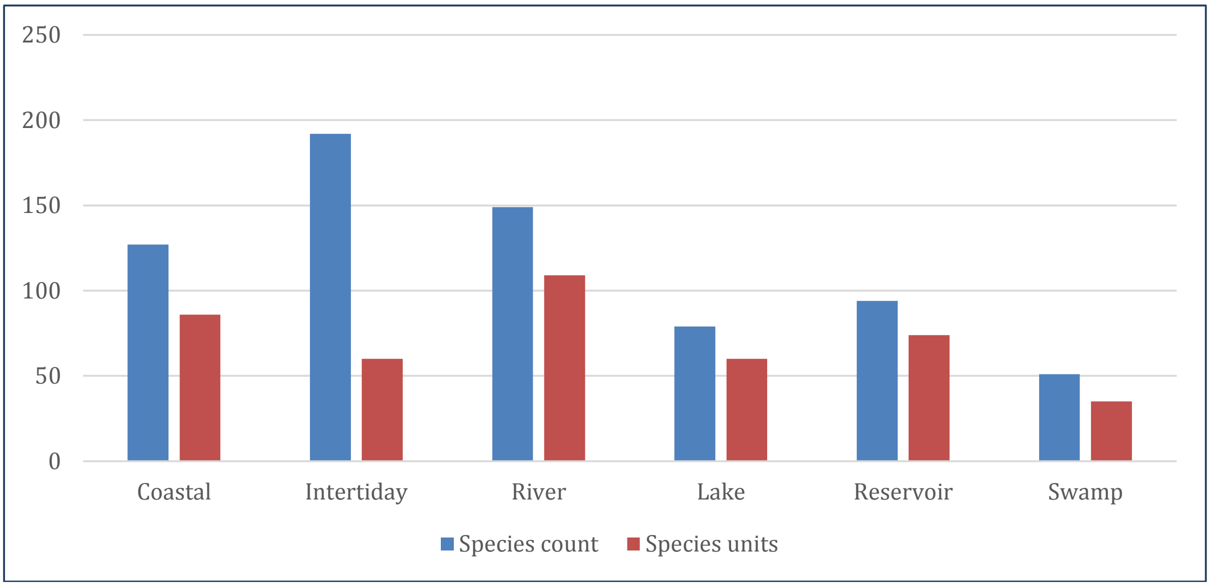
Figure 23: Extent of use of biotechnology tools based on country reports



2.5.3 Wild relatives

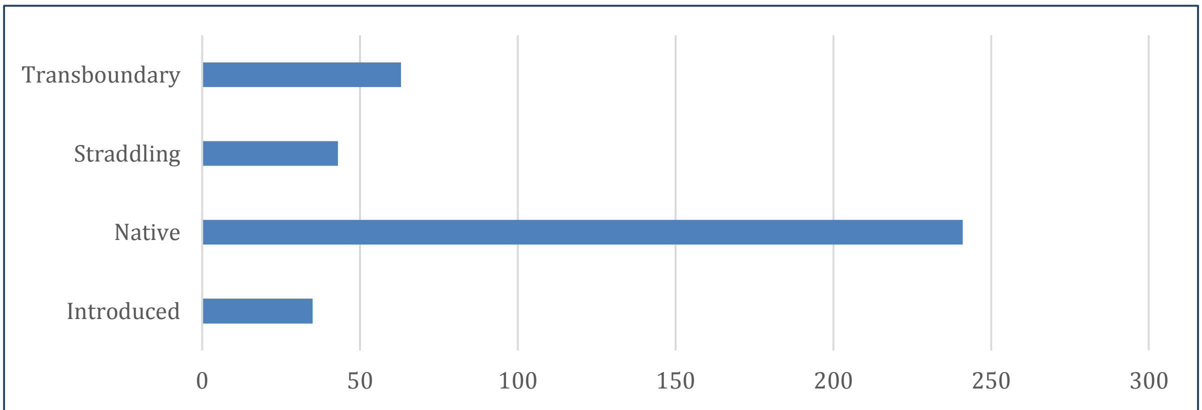
Wild relatives of farmed species are defined here to be the same species living in the wild as the species being farmed, i.e. they are conspecifics. There are other species living in the wild that are closely related to farmed species, e.g. the same genus or family, and some of these have been identified as having aquaculture potential above or are important in capture fisheries. Wild relatives, in addition to having farming potential, are important components of many aquatic ecosystems (Figures 24 & 25) and capture fisheries, and perform beneficial ecosystem services.

Figure 24. Habitats of wild relatives of farmed aquatic species (number of responses for all species)



Wild relatives are found throughout aquatic ecosystems (Figure 25). Coastal and intertidal habitats are where most countries reported wild relatives (species counts in Figure 24) and where the highest diversity of taxa were found (number of species units in Figure 11a). The majority of wild relatives reported were native, but several species were transboundary and straddling stocks (Figure 25).

Figure 25. Description of wild relatives of farmed aquatic species (number of species)

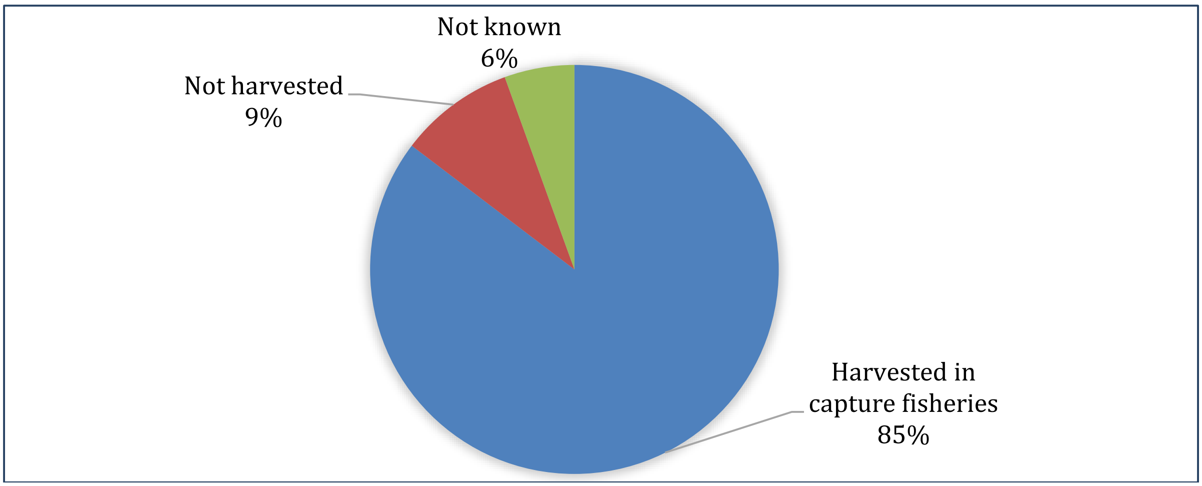


	Introduced	Native	Straddling	Transboundary
Series1	35	241	43	63

2.5.3.1 *Use of wild relatives in fisheries*

The majority (85%) of the wild relatives reported contribute to capture fishery production (Figure 26). This further demonstrates the close relationship between farming and fishing aquatic genetic resources. Many of the wild relatives not fished were introduced species or fishes for which capture fisheries would be highly regulated, e.g. sturgeons due to their listing on CITES appendices.

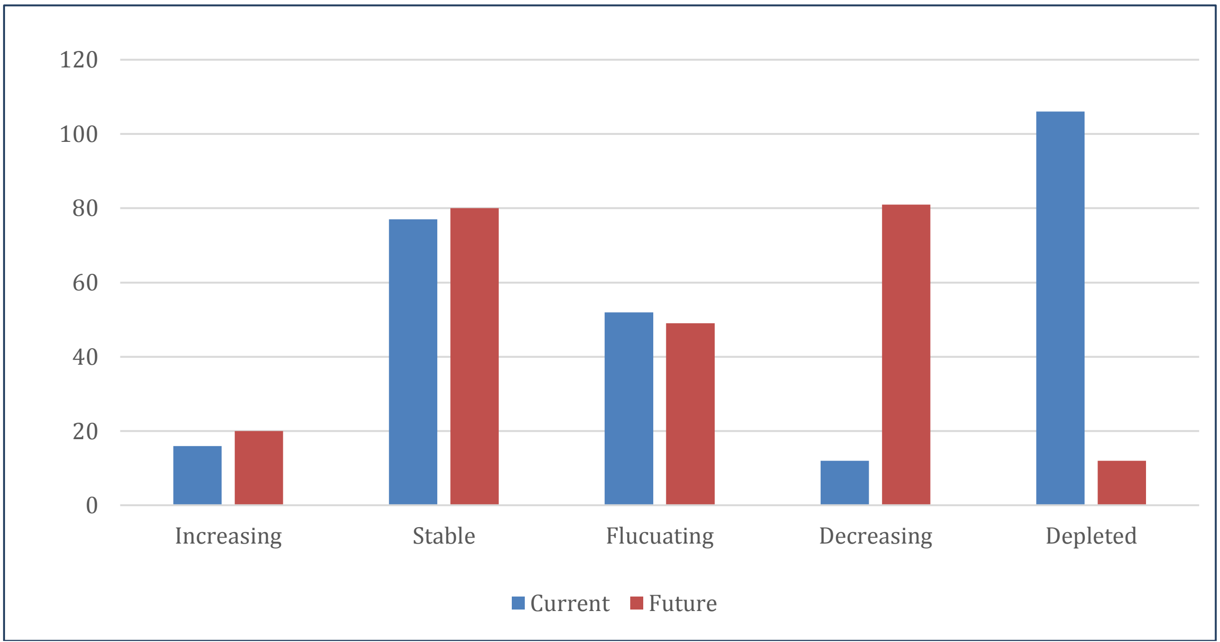
Figure 26. Wild relatives in capture fisheries



2.5.3.2 Trends in abundance of wild relatives

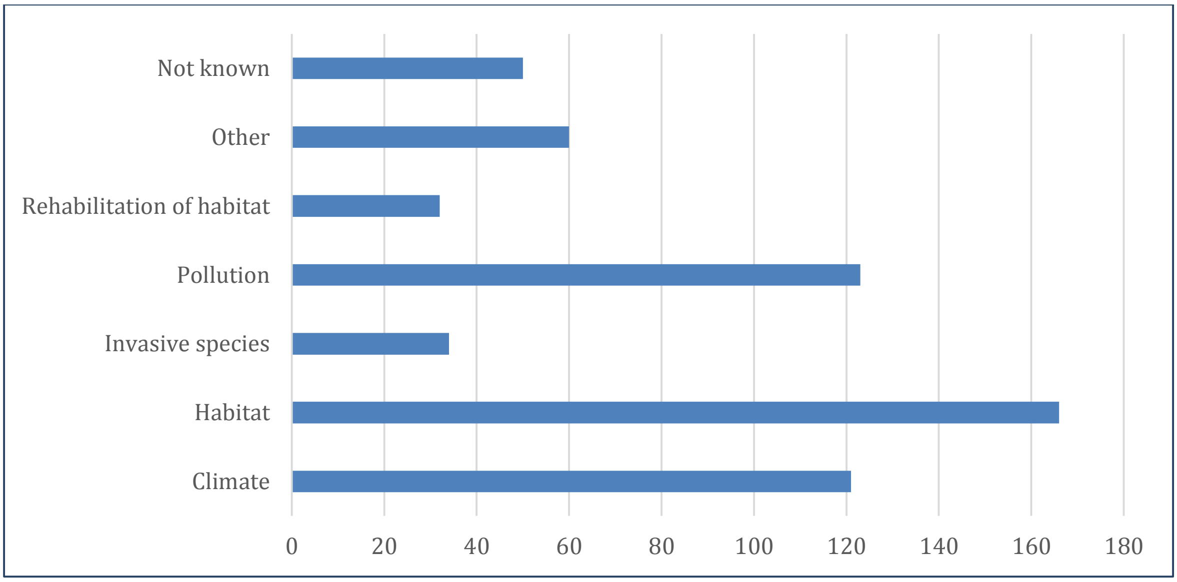
Figures 24 and 25 on the use of wild types in aquaculture reveals how dependent aquaculture still is on aquatic species found in natural ecosystems. However, countries reported numerous cases where the abundance of wild relatives was currently decreasing and is expected to decrease further in the future (Figure 27).

Figure 27. Catch trends in wild relatives of farmed species (number of fisheries)



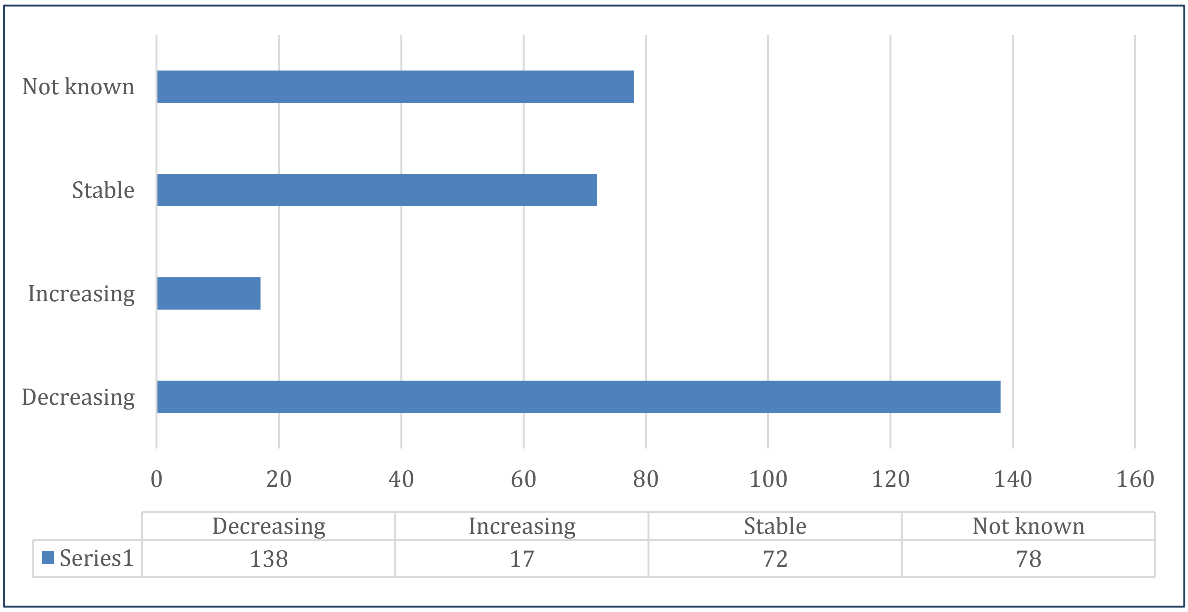
The main reason for the change in numbers of wild relatives, as indicated by trends in catch, was change in habitat (Figure 28). Change in numbers could be both positive, e.g. rehabilitation of habitat, or negative e.g. pollution. Climate change for example could increase the range and abundance of species well adapted to warm water, but would decrease abundance of species less tolerant to warmer temperatures.

Figure 28. Reasons for change in abundance of wild relatives (number of reports for specific species)



Countries reported that the habitat for most wild relatives of farmed aquatic species was decreasing (Figure 29), and in only a few cases was habitat reported as increasing. These findings reinforces the need to protect natural populations of AqGR and suggests that protecting habitat would be a good strategy.

Figure 29. Change in habitat of wild relatives of farmed aquatic species



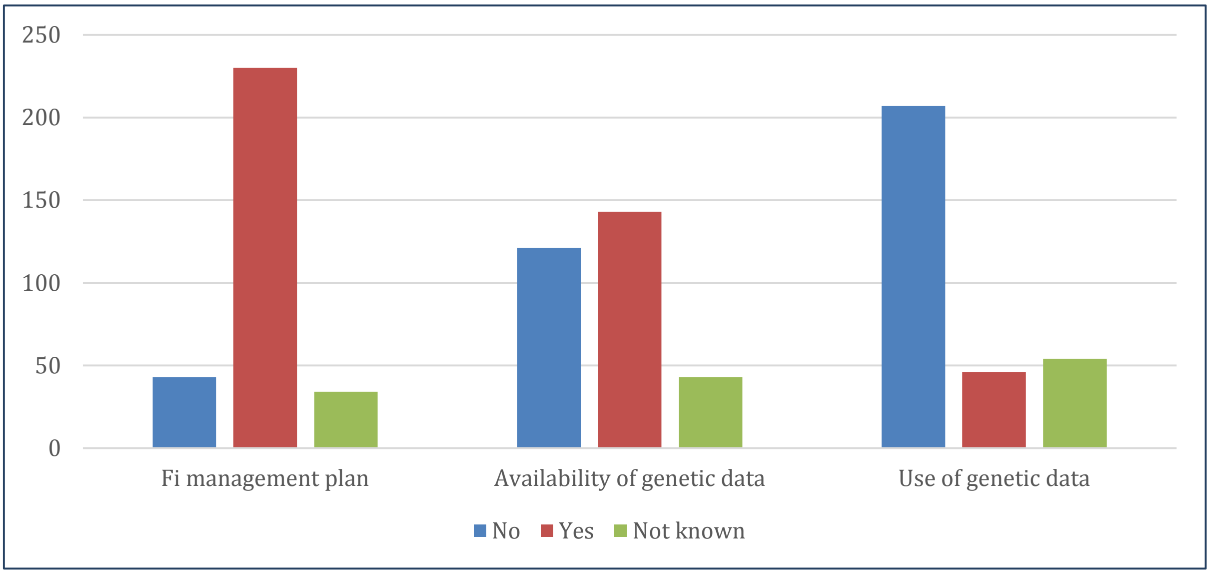
Comparisons of the importance of habitat loss by economic classification of countries have not been made as yet and they may be misleading. In many developed countries the aquatic habitat for wild relatives was lost or degraded centuries ago and the human communities became accustomed to this lack of fishery resources and alternative food sources.

This phenomena is called the 'shifting baseline' (Pauly 1995) and is used to explain humans' short-term perspective on managing natural resources, i.e. humans forget how things were in the past because they accept and have become familiar with the current situation.

The country reports did not indicate that fishing pressure was a major cause for the change in abundance of wild relatives of farmed species. For many inland capture fisheries factors outside of the fishing sector, e.g. draining wetlands and damming of rivers, have a much larger impact (SOFIA 2014).

For many coastal areas a similar condition could occur where loss of coastal spawning or nursery habitat or land-based pollution could impact fisheries more than fishing pressure, especially in small-scale fisheries. None the less for numerous wild relatives that are fished, fishery management plans exist. However genetic data are used to only a limited extent for most species (Figure 30).

Figure 30. Fishery management of wild relatives and the use of genetic information (number of species)



Examples do exist where genetic data are used in management of high value species or iconic species, such as Atlantic cod, Pacific salmon and Atlantic salmon (reference in Ruane and Sonnino 2006)13. Genetic stock identification (GSI) helps set season, area and catch limits on commercially important species in North America and Europe.

However, GSI depends on an accurate genetic analysis of the potential stocks contributing to a fishery, as well as real time sampling and analysis of the fishery. As such, fishery management based on GSI may be beyond the financial and technical capacity of many government resource agencies.

A decreasing fishery combined with decreasing habitat could provide a proxy indicator for level of endangerment. The level of endangerment would be even higher if the species had a restricted distribution or was limited to a specific habitat type, e.g. salt marshes or vernal pools.

Table 24 shows the top 10 wild relatives whose populations and habitat were decreasing. A comparison with the IUCN Red List shows that only two of these species are listed as vulnerable, several are of least concern and the majority haven't been assessed.

Table 24. Top 10 species for which habitat was reported to be declining and status on IUCN Red List (NA = not assessed; LC = Least Concern; DD = data deficient to assess; V = Vulnerable)

Species	Common name	Number of reports	Red List
Oreochromis niloticus	Nile tilapia	4	NA
Penaeus vannamei	Whiteleg shrimp	4	NA
Clarias gariepinus	African catfish	3	LC
Arapaima gigas	Pirarucu (Bonytongue)	2	DD
Astacus astacus	Noble crayfish	2	V
Chanos chanos	Milkfish	2	NA
Clarias spp	Calarias Catfish species	2	NA

[13] Further analysis will be done when more country reports are received

Colossoma macropomum	Pacu	2	NA
Cyprinus carpio	Common carp	2	V (wild type)
Mugil cephalus	Grey mullet	2	LC

Although at the species level *O. niloticus* is not threatened, concern has been raised that many natural populations are being introgressed with genes from other stocks and species (ADB 2005). Thus, the genetic differences between stocks of natural Nile tilapia may be lost. The *Arapaima gigas* is listed in Appendix II of CITES[14] that includes species that are not necessarily now threatened with extinction, but that may become so unless trade is closely controlled. CITES had data to suggest listing of *Arapaima* whereas IUCN said data were deficient.

An improved global information system would help communicate authoritative information to help resolve such issues (See Table 18).

2.5.4 Use of non-native species in fisheries and aquaculture

As in terrestrial agriculture, non-native aquatic species (also called alien or exotic species) contribute significantly to production and value in fisheries and aquaculture (Gozlan 2008; Bartley 2006). FAO maintains the Database on Introductions of Aquatic Species (DIAS) that contains records of introductions across national boundaries. This database was started by Robin Welcomme in the 1970s; at that time it included about 1300 records of freshwater fishes. The database has since been expanded to include over 5000 records that include fishes, molluscs, crustaceans, echinoderms and plants from inland and marine ecosystems. The database may be accessed on line[15] and is linked to FAO production figures and species fact sheets.[16]

Analysis of DIAS revealed that carps, trout, tilapia and oysters were the most widely introduced aquatic species. The country reports confirmed this analysis with the most often exchanged species (import and export) being *Oreochromis niloticus* followed by *Oncorhynchus mykiss* (Table 25). Countries reported over 100 species had been exchanged across international borders (data not shown).

Table 25. Top 10 species exchanged by countries, includes both import and export.

Species	Common name	Number of exchanges
Oreochromis niloticus		79
Oncorhynchus mykiss		39
Penaeus vannamei		19
Clarias gariepinus		17
Cyprinus carpio		19
Acipenser baerii		13
Colossoma macropomum		10
Macrobrachium rosenbergii		10
Penaeus monodon		10;
Tilapia zillii		8

Although country reports did not contain production statistics, production from non-native species was shown to be increasing in many areas for both fisheries and aquaculture.[17] As expected the most common form of genetic material exchanged with another country was living specimens. Of the over 200 reported exchanges of the most exchanged species, about 80% were of living specimens with about

[14] https://cites.org/eng/gallery/species/fish/arapaima_gigas.html

[15] http://www.fao.org/fishery/topic/14786/en

[1616] http://www.fao.org/fishery/factsheets/en

[17] Further analysis of country reports to provide more details

10% exchanging embryos and only a very few countries reporting the exchange of other genetic material (data not shown).

An analysis of DIAS (Bartley and Casal 1998 and Gozlan 2008) revealed that the majority of introductions of aquatic species have had negligible environmental impact on the surrounding ecosystem or biodiversity. Although some introductions have had serious adverse impacts, e.g. the golden apple snail in the Philippines or the crayfish plague in Europe that arrived with an introduced crayfish from North America, the records in DIAS further demonstrated that there have been far more positive social and economic benefits from the introductions than negative environmental impacts (Bartley and Casal 1998).

However, non-native species can become invasive and have been identified as one of the major threats to biodiversity throughout the world. In order to minimize the risks and optimize the benefits from non-native species, the international community promotes codes of practice and risk analysis before an introduction is made (ICES 2005 and Chapter 6). The codes of practice and risk analysis includes social and economic benefits as well as environmental risk (see Bartley and Halwart 2006 for a collection of documents and international guidelines on non-native species, including DIAS) (see Chapter 6).

2.6 Key findings and conclusions

A tremendous amount of AqGR is used in aquaculture and fisheries	Aquatic organisms derived from two kingdoms, several phyla and hundreds of species. The marine and coastal areas contain the most number of farmed species and their wild relatives due to the presence of several phyla that are not present in inland waters.
There are important species and farmed types not reported to FAO	The Country reports listed several species and farmed types, e.g. hybrids, that are important for food and agriculture, but that are not reported to FAO through the regular statistical reporting system and the Aquatic Science and Fisheries Information System (ASFIS). FAO will review these additional species and farmed types for potential inclusion in the ASFIS.
Aquatic plants and microorganisms have not been well reported in FAO statistics.	Thematic background papers and country reports document the wide variety of plants and microorganisms that are contributing to increased production from aquaculture and provide a variety of products such as animal feed ingredients, human food and health products, industrial applications e.g. food binders and pharmaceuticals,
Wild relatives of farmed aquatic species play important roles in both aquaculture and capture fisheries.	Capture fisheries production has plateaued over the last several years
	The abundance of wild relatives, as indicated by catch records, is decreasing or depleted in many areas.
	Almost 50% of the fisheries for wild relatives were reported to be decreasing or depleted
	Loss of habitat is a major reason for the decline in wild relatives
	These findings reinforces the need to protect natural populations of AqGR and suggests that protecting habitat would be a good strategy.
Numerous species have potential for use in	Some are well established in other parts of the world whilst others are being used in research or pilot scale operations.

aquaculture either through domestication or sourcing material from wild populations.	Criteria for using new species in aquaculture should include biological production and economic parameters and risk analysis.
Non-native species have an important role to play in aquaculture and fisheries development	This is similar to the agriculture sector.
	Risk analysis will help make good decisions on when to introduce new species into aquaculture or fisheries operations.
Selective breeding is the most widely used technology to improve AqGR for food and agriculture	Selective breeding is the most widely used technology to improve AqGR for food and agriculture with about 25% of the cases of genetic improvement using this technology.
	Genetic technologies and genetic resource management (at some level) is occurring in about 50% of the species being farmed. This is a substantial increase in the commonly cited figure that only 10% of aquaculture is using genetically improved or managed organisms.
Genetic information and technologies has great potential	Tremendous potential exists to use genetic information and technologies for increased food production, livelihoods and poverty alleviation. Increases in need for seafood are expected to be about 2%/year and genetic improvement through selective breeding can provide increases of 5-12%/year.
There will be challenges in using genetic technologies on a wide scale as they require financial resources and technical capacity.	Funding of genetic improvement programmes was reported as being primarily through the public sector with very little reporting of private public partnerships (PPP) for those countries reporting. Given the success of some PPP, this option for increasing the contribution of AqGR to food production should be explored more.
Biotechnology, and specifically genetic biotechnologies, are advancing rapidly	These can help characterize AqGR for both farmed types and their wild relatives.
There is limited use of genetic information in the development and management of farmed aquatic species and their wild relatives.	Fishery management plans exist for the majority of species reported, and genetic data often exist. However in about 80% of species reported genetic data were not used.
A global information system on aquatic genetic diversity does not yet exist	Such a system would be extremely valuable to resource managers, private industry and international organizations.
	A prototype information has been designed, but will take financial and human resources, as well as capacity building to implement.
Up to date, standard and consistent nomenclature on products of genetic improvement and on wild relatives below the species level is lacking	The majority of country reports stated that naming of species was accurate however, it is clearly not the case. This is essential in developing information systems and in monitoring and managing AqGR.

2.7 References and key documents

- Country Reports
- FAO Database on Introductions of Aquatic Species (DIAS) http://www.fao.org/fishery/topic/14786/en
- FAO FishStatJ (2016) http://www.fao.org/fishery/topic/18238/en
- FAOSTAT (2016) http://faostat3.fao.org/home/E
- FAO Commission on Genetic Resources for Food and Agriculture http://www.fao.org/nr/cgrfa/cgrfa-home/en/
- IUCN Red List of Threatened Species http://www.iucnredlist.org/
- International scientific journals, books and other publications – See References

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(To be completed)

3 DRIVERS AND TRENDS IN AQUACULTURE: CONSEQUENCES FOR AQUATIC GENETIC RESOURCES WITHIN NATIONAL JURISDICTION

PURPOSE: Explores the effects of different drivers on farmed and wild-relative aquatic genetic resources. These drivers are: Human population increase; Competition for resources; Strong or weak governance; Increased wealth and development of economies and Changing human food preferences and ethical considerations. The chapter also explores the effect of drivers which impact ecosystems and thus have implication for wild relatives and farmed types, these are: Effects of habitat loss and degradation**;** Pollution of waters; Direct and indirect effects of climate change**;** Establishment of invasive species

KEY MESSAGES:

Human population increase

- Population increase will drive demand for seafood, especially aquaculture products as capture fishery resources become limited. This will drive efforts to expand and diversify the farmed species produced and therefore aquatic genetic resources.
- This will also place pressure on wild type stocks, either as broodstock or directly as food.

Competition for resources

- Demand for freshwater for urban supply, for energy production will challenge aquaculture to become more efficient
- Wild relatives will be threatened by changes in priorities on use of water
- Pollution from industry, agriculture and urban sources all threaten the quality of water used for aquaculture and to sustain wild relatives.

Governance

- Increasing levels of good governance are seen as having an overall beneficial effect on aquatic genetic resources in both farmed type and wild relatives.
- Impacts range from improved regulation of farms and their operations to greater professionalization within the sector.
- Impacts on wild relatives pertain to improved environmental management and better control over stocking and movements and higher levels of conservation and protection

Increased wealth and development of economies

- Increasing wealth and developing economies is accompanied by greater intra and inter-regional trade and increasing urbanization and industrialization.
- There will be increasing consolidation and industrialization of large volume, internationally traded commodities
- There will be increased emphasis on food safety and traceability, challenging smaller operators
- There will be continuous exploration of new niche species to satisfy the demand for new, commodities
- Demand for ornamental fish will increase, driving the development of farmed-types as well as demands on wild relatives.

Changing human food preferences and ethical considerations

- With changing demographics, consumer attitudes to fish are also changing
- Fish consumption is increasingly recognized as part of a healthy and balanced diet and increasing urbanization will drive demand for seafood
- There remains concern over the use of GMO techniques and resistance in some markets.
- There is increasing awareness regarding the unsustainable exploitation of wild relatives driving demand for farmed-types

Effect of habitat loss and degradation on ecosystems

- Changes in use of land, water, coastal areas, wetlands and watersheds all have impacts on the quantity and quality of habitat for aquatic genetic resources
- Water management is one of the principal factors that affect aquatic systems. These impacts arise from damming of rivers, drainage, flood control and flood protection, hydropower development,

irrigation, partitioning of wetlands, road construction.
- Aside from the direct impact of competition or predation, the establishment of invasive species can impact food webs and ecosystems that support wild relatives

Direct and indirect effects of climate change

- Climate change will have impacts on freshwater availability and changing ambient temperatures, this will indirectly impact all AqGR through changing ecosystem functions, and directly impact AqGR
- This will have a disproportionate effect on equatorial/tropical regions
- Positive effects on farmed-types would be selection for climate tolerant traits
- Impacts on wild relatives are likely to be negative or unknown.

3.1 Direct impacts on farmed-types and wild relatives

Numerous drivers will impact AqGR and the people that depend on them for livelihood. It is expected that human population growth, competition for resources, ability to achieve good governance, increased wealth and demand for fish and fish products, consumer attitudes, i.e. food preference and ethical considerations, habitat management and climate change will be the most significant drivers in the coming decades (FAO 2014). The growth of the aquaculture sector itself will depend on many of these drivers and will have a significant influence on food production (see Outlook section in FAO 2014).

3.1.1 Human population increase

Projections of food consumption patterns and preferences into the future, linked to population growth models project significant increased demand in the future. While total fish supply will likely be equally split between capture and aquaculture by 2030, projections indicate that 62 percent of food fish will be produced by aquaculture by 2030.

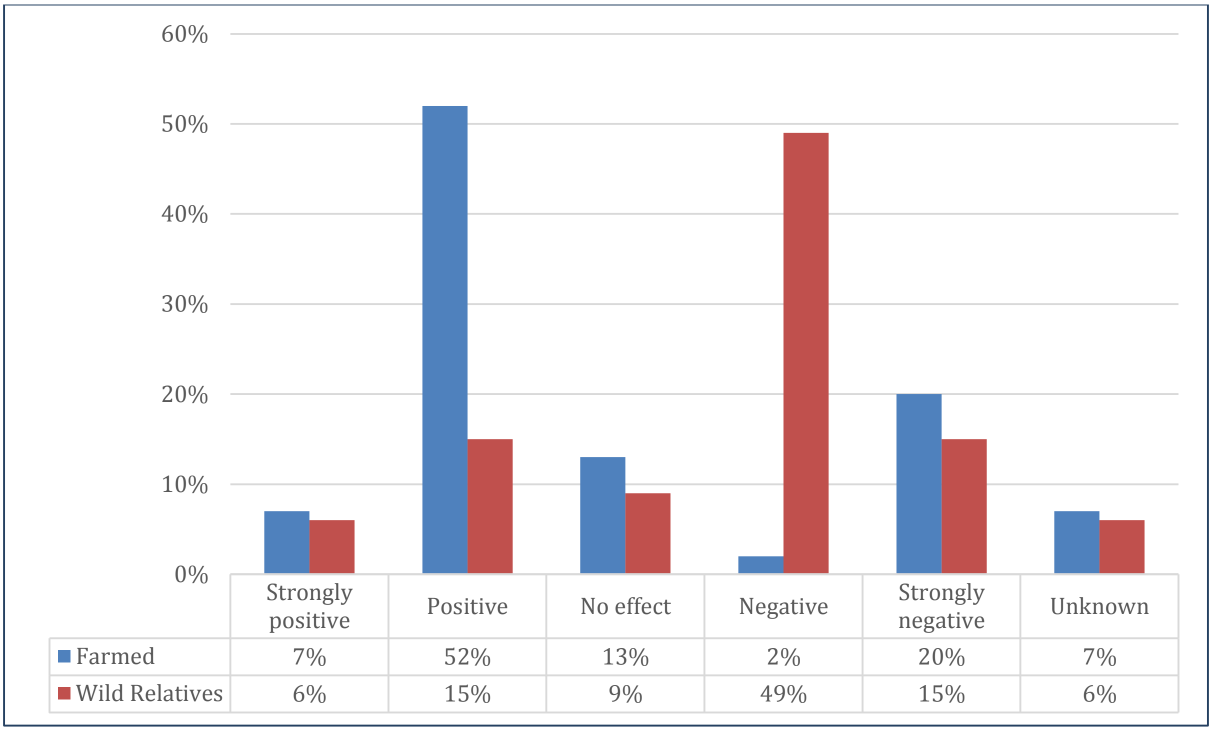
Beyond 2030, aquaculture will likely dominate future global fish supply. This aquaculture production of food fish (excluding aquatic plants) is expected to reach 93.6 million tonnes by 2030 (World Bank 2013).

Over the past three decades, global aquaculture development has outpaced population growth, resulting in increased per caput aquaculture production in most regions (with few exceptions). Asia has led other regions in this regard, but even within Asia there is substantial variation (FAO 2016). The overall the growth in global aquaculture (including aquatic plants) has been stable at around 6% per year over the past 15 years (FishStatJ).

More than half (59%) of country responses on the impacts of population growth indicate that overall the impact is likely to be positive on farmed-type genetic resources (Figure 31). This would appear to be linked to the consequent increase in demand for aquaculture products that will occur as populations increase. It is notable that some developed countries did not expect their populations to rise significantly and thus there would not be a strong increase in demand. The effect on diversity of farmed–type genetic resources would be to drive efforts to improve existing farmed-types and develop new species for culture, including:

- Development of domesticated farm-types
- Efforts to increase the number of species able to breed under farmed conditions
- Tolerance to high density production, and associated water quality conditions
- Increased disease resistance
- Improved quality traits (colour, shape, dress out weight, head:tail ratio; phyco-colloid gel properties etc.)
- Search for new species to culture (diversification).

Figure 31: Country responses on the impacts of population growth



Twenty-two percent of respondent countries viewed population growth as likely to be negatively impact farmed genetic resources and this was largely linked to pressures on resources.

- Pressures on water resources limits extensive systems and the associated species that are used
- Intensification and industrialization/rationalization may narrow the range of species (commodities) that are cultured. This is a similar trend seen in the livestock sector as high performing breeds displace locally adapted breeds (FAO 2007).
- The increasing intensification and globalization of movement of aquatic species, will increase the risk of spread of diseases

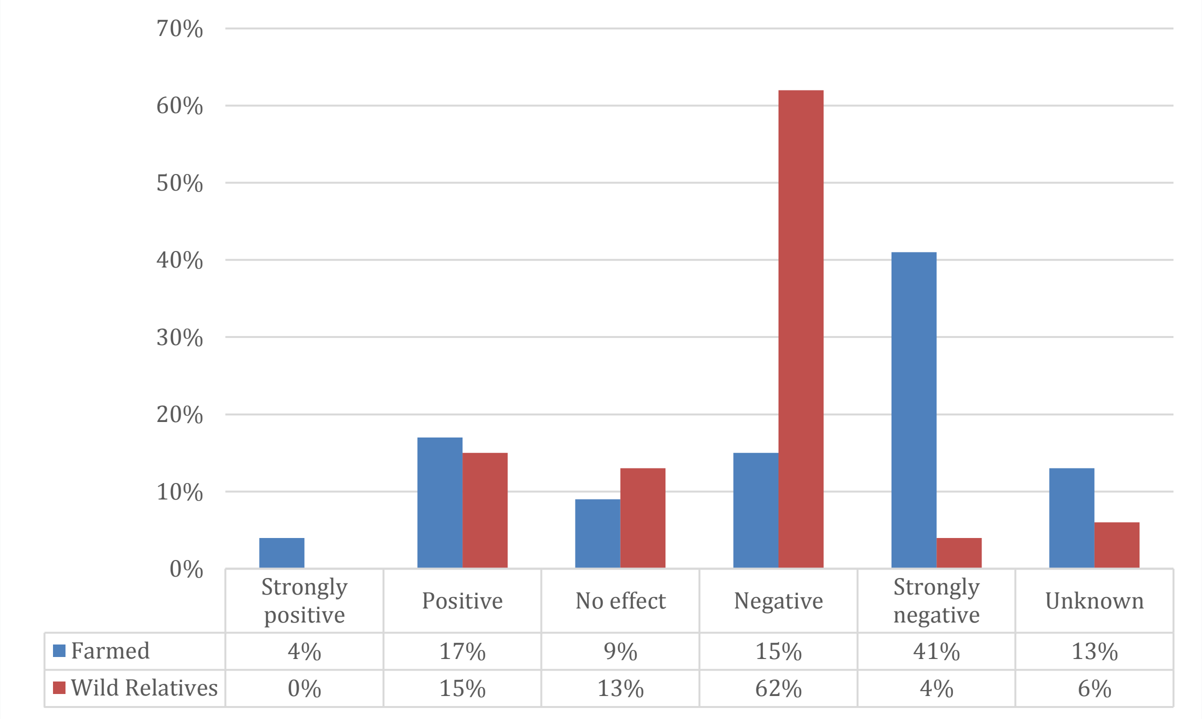
The impact of population pressure on wild relatives is foreseen as generally negative (64%) with only 21% of respondents considering there would be positive effects. The consideration was that increasing populations and consequent demand for fish would drive overfishing of wild relatives. This would particularly affect the most vulnerable species is not managed effectively. Vulnerable species have life history traits such as maturation at an advanced age, low fecundity and complex breeding or migratory characteristics. Part of this complexity also means that these species are challenging or prohibitively expensive to domesticate and breed in captivity (e.g. Bluefin tuna, eel, lobster). This places an additional pressure on the wild relatives as the sourcing of seed for aquaculture is typically through the capture of wild juveniles.

There is an additional, unquantified, potential selection effect on the wild-relatives created by fishing pressure, whereby gear selectivity may inadvertently drive selection in wild stocks (Hard et al., 2008).

3.1.2 Competition for resources

Overall, more than half of the country responses (56%) considered that competition for resources would have a negative effect on farmed aquatic genetic resources against 21% considering the effects would be positive (Figure 32).

Figure 32. Effect on AqGR from competition for resources



The changing priorities of use of water from food production to urban drinking water supplies and for recreational purpose also forces aquaculture to produce more with less. There is a general trend also towards rehabilitation inland waters in many countries and restoration of habitat and biodiversity. This in turn may limit the prospects for aquaculture expansion as the amenity value and increased demand for conservation and rehabilitation of aquatic environment will limit available sites for aquaculture and increasingly impose limits on water abstractions and effluent discharges.

In many countries, it will be necessary to increase aquaculture production though intensification approaches that utilize feed and water and space more efficiently than at present. This has strong implications for domestication and breeding of easing aquaculture species as well as the interest to develop aquaculture systems for species, which are not currently cultured. Several country respondents noted that competition for resources would have a positive effect on the development of more efficient production systems that had reduced nutrient discharge footprints.

Table 26: Farmed species items recorded with production until 2014: total of 575 species items recorded in FishstatJ

Aquaculture group	Production environment			
	Total	Marine	Freshwater	Diadromous
Finfish	359	134	180	45
Crustaceans	61	44	17	-
Molluscs	103	100	3	-
Other animals	15	9	6	-
Aquatic plants	37	35	2	-

The total number of farmed aquatic species in marine waters was 322 in 2014; while it was only 208 species in freshwater aquaculture and 45 species as diadromous fish. There is a total of 575 species recorded until 2014 as farmed species (Table 26). Freshwater aquaculture currently dominates finfish production (46 million tonnes versus 12 million tonnes in marine and brackishwaters) and increased expansion in this sub-sector will inevitably lead to competition for freshwater and land resources (Table 27). There remains an opportunity for aquaculture expansion (and thus expansion of aquatic genetic resources of farmed-types) in the development of systems and species in brackish and saltwater systems.

The higher number of species being farmed in marine and brackishwater environments is an indication of the diversity of these systems. It is worth noting that one of the advantages is that saline environments are one of the few areas where there is no direct competition with livestock and agriculture production for space and water. This means that there is potential for increased cultured food production from these environments in the future.

Table 27: the breakdown of aquaculture production, by production environment and by major division

Aquaculture grouping (ISSCAAP Division)	Production environment		
	Brackishwater	Freshwater	Marine
Aquatic plants	1,106,474	86,035	26,114,456
Crustaceans	3,662,912	2,737,268	514,893
Diadromous fishes	928,074	1,105,700	2,832,708
Freshwater fishes	1,116,463	41,500,547	71
Marine fishes	488,398	47,367	1,842,564
Miscellaneous aquatic animal products		1,979	46,402
Miscellaneous aquatic animals	110	520,900	372,558
Molluscs	103,876	277,744	15,731,575
Total production	**7,406,306**	**46,277,539**	**47,455,227**
Total aquaculture production excluding molluscs & aquatic plants	6,195,956	45,911,781	5,562,794
Total aquaculture production, excluding aquatic plants	6,299,832	46,191,505	21,340,771

The rising price of key feed ingredients for aquaculture (especially fish meal and fish oil) is already driving the aquaculture sector to explore lower cost alternatives. Development of innovative feeds is one outcome, but the selection of species for improved performance (growth, FCR) on these feeds is a parallel development. Considerable improvements in performance have been achieved for a number of species (Salmon, channel catfish).

Although availability of aquaculture feed is an important concern regarding the future of aquaculture development, 50% of the world's aquaculture production is cultured in systems that do not require the addition of feed. This is achieved mainly through the production of seaweed and microalgae (27 percent) and filter-feeding finfish (8 percent) and filter feeding molluscan species (15 percent). (FishStatJ). The production of un-fed aquatic animal species was 23 million tonnes in 2014 representing 23 percent of the world production of all farmed fish species (FAO 2016). This trend has been reasonably consistent over the past decade. The trend in carnivorous species has risen very slightly (from 8 percent to 9 percent), over the past decade, but is greatly outweighed by the production of non-carnivorous species. (Table 28).

The most important non-fed aquatic animal species include:

- Two freshwater finfish species, silver carp and bighead carp (tilapia in extensive systems are also able to filter feed but are not included here)
- Bivalve molluscs (clams, oysters and mussels, etc.) and,
- Other filter-feeding animals (such as sea squirts) in marine and coastal areas

Whilst many of these pressures could have a positive impact on farmed aquatic genetic resources the limitations imposed on water and land and the trend to rationalize systems, may tend to reduce the diversity of farmed aquatic animals in some regions.

Table 28: Comparison of production of fed and unfed aquaculture 2004 to 2014

	Species	2004	2009	2014	% of 2014 Total
Unfed	Algae	10,382,167	14,823,908	26,839,288	27%

	Molluscs	10,622,252	12,214,046	14,516,676	15%
	Filter feeding carp	5,381,150	6,568,469	8,220,882	8%
	Other filter feeding species	87,702	171,392	275,568	0%
Fed	Herbivorous species	3,980,855	5,138,466	6,722,240	7%
	Omnivorous species	17,991,921	26,541,037	33,347,307	34%
	Carnivorous species	4,754,449	6,597,555	8,942,613	9%
Unknown	Other species unknown	4,992,202	5,258,884	4,897,668	5%
Totals	Total unfed	26,473,271	33,777,815	49,852,414	50%
	Total fed	26,727,225	38,277,058	49,012,160	50%
	Total unfed animals	16,091,104	18,953,907	23,013,126	23%
	Total, all species	**58,192,698**	**77,313,757**	**103,762,242**	
Percentage of annual total	% Unfed	50%	47%	50%	
	% Fed	50%	53%	50%	

The picture of competition for resources is clearer for wild relatives. Competition for resources was considered to be overall negative for 66% of respondent countries versus only 15% considering there would be positive effects.

The typical negative impacts on wild relatives would be loss of habitat (due to drainage of wetlands, changing use of water bodies, altered environmental flows due to water management damming and flood control, etc.).

Environmental impacts on water that can affect wild relatives include land use changes and soil degradation impacting water quality, as well as agricultural runoff and unregulated urban and industrial discharges into water bodies.

There is an additional specific impact created by the demand for aquaculture feeds derived from capture fisheries, although the species targeted for aquaculture feeds (e.g. fish meal, low value/trash fish) are not typically wild relatives of aquaculture species (Table 29).

Table 29: Summary of impacts on wild relatives created by competition for resources

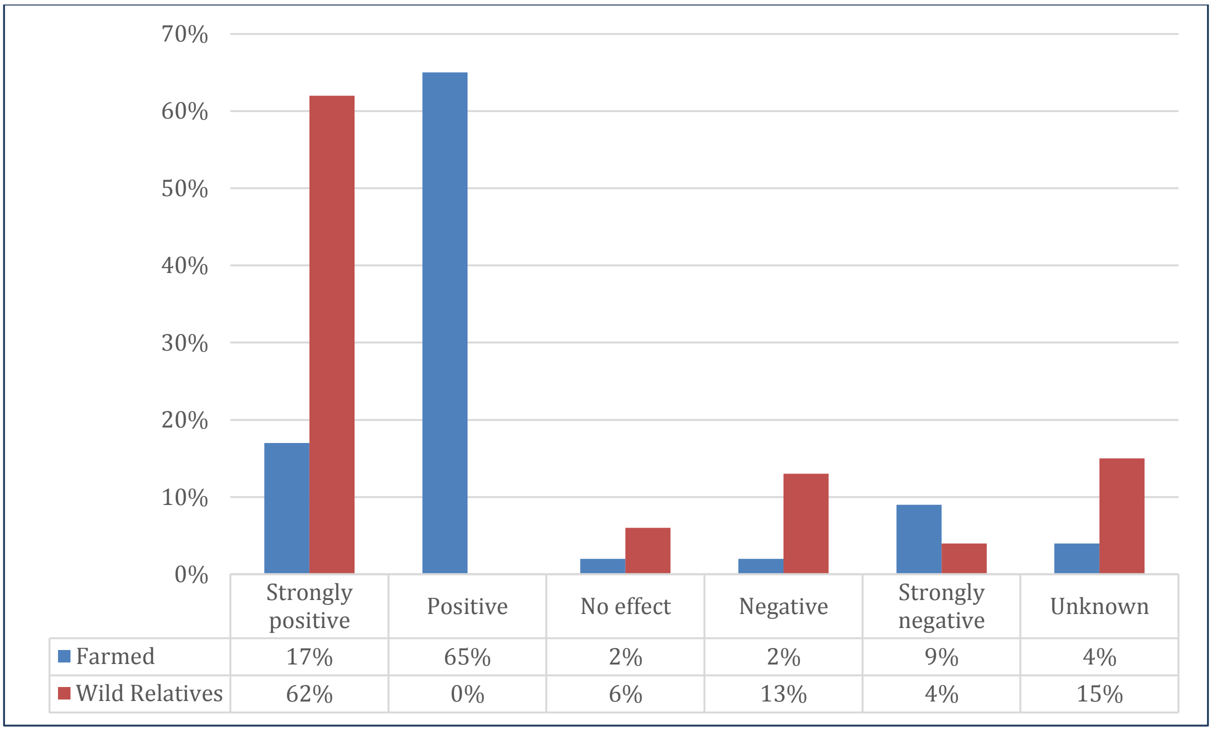
Typical impacts of habitat loss and degradation	Loss of wild habitat and water flows due to changes in rivers, wetlands and water bodies caused by changing land use, watershed development and drainage of freshwater wetlands. Reduces the available habitat to sustain populations, impacts the function of habitats during critical seasons (over-wintering; dry season refuges)
	Physical obstruction and changing water flow regimes impacting upstream and downstream migration and reproduction of riverine species. Caused by damming of rivers and loss of connectivity in waters ways (low water control structures, weirs, irrigation structures)
	Changing ecosystem quality (driven by land management, watershed management) leading to increased soil erosion and sediment loads in water bodies. Directly affects

	species sensitive to poor water quality and can affect quality of spawning grounds or nurseries
Impacts of pollution of waters	Direct effect of toxins and heavy metals from untreated industrial discharges
	Indirect effect of effluents from urbanization leading to eutrophication and changed water quality and food chains
	Direct impact on fish through feminization effects (oestrogen-analogues in effluents)
	Nutrients from agriculture runoff leading to eutrophication of water bodies
	Pesticide runoff from agriculture directly affecting fish, or indirectly through ecosystem level impact on prey/food chains
Impact of demand for seed or broodstock	Some aquaculture systems still rely on the wild relatives as the source of seed for stocking. This may be completely benign as in the form of capturing natural spatfall as in the case of molluscs (clams, oysters, mussels, cockles). The active fishing for seed for stocking may have greater impact if that activity takes place after there has already been significant mortality during recruitment. In this case there can be direct impacts on the wild population (e.g. collection of juvenile lobster or grouper for ongrowing). In other systems there collection of juveniles for stocking appears to have little or no impact on the wild population (e.g. Yellowtail (*Seriola*) seed collection in Japan).
Impact of demand for feeds	Capture fisheries that are specifically managed for production of fish for fishmeal are not typically comprised of wild relatives of aquaculture species. The use of trawl bycatch for fishmeal is more complex as the species targeted may be highly diverse. There are ecosystem effects of fisheries that are driven for this bycatch although the effect on wild relatives of aquaculture species is not quantified.

3.1.3 **Governance**

Governance factors were overwhelmingly perceived as having a positive effect on farmed aquatic genetic resources (82%), with only 11% of respondent countries considering this would have any negative effect. A similar figure (62%) was expressed for wild relatives (Figure 33).

Figure 33. Effect of governance factors on AqGR



In general, country responses indicated the belief that a combination of more effective regulation of the sector, coupled to increased organizations and empowerment of aquaculture producers was a desirable goal. This enables more effective dialogue between producers and regulators as well as improved understanding of the issues relating to aquaculture production. This was extended to engagement with civil society, CSOs and environmental groups in some reports.

The need to encourage better dialogue concerning aquaculture and its use of AqGR as well as potential impacts or threats to wild relatives was noted as important. The prospects of governance for positively impacting farmed genetic resource were considered to be as follows:

- Increased regulation and management of farmed strains including licensing of hatcheries can contribute to more systematic and effective controls over farmed aquatic genetic resources.
- Effective biosecurity systems to assess and manage risks of translocations, introductions of both farmed and wild species as well as possible pathogens and parasites associated with this.
- Professionalization of the sector, greater understanding and appreciation of good genetic quality stock
- Development of specific pathogen resistance in farmed types
- Development of effective measures to enable exchange of material between countries (this is currently increasingly constrained by national legislation on genetic resources and biosecurity, see Chapter 6)

Whilst not strictly a governance issue, some of the problems of mis-management of AqGR in farmed types are do arise from the governance structures and degree of regulatory control, research and communication. These management issues can be summarized as follows in Table 30.

Table 30: Aquaculture sector governance and management issues that impact AqGR

Limited genetic diversity in founder populations	Limited numbers of broodstock fish are used in research centres as the techniques for breeding are established. Successful mass production sees this stock disseminated to other hatcheries for upscaling, without accessing large numbers of new broodstock. This may be a particular issue where the broodstock were non-native and introduced from another country.
Small private hatcheries with limited numbers of broodstock	In many developing countries, small-scale private or state operated hatcheries may have very small numbers of broodstock. The replenishment of broodstock may not occur for year or some time never, resulting in inbreeding and loss of performance. This can be corrected by national broodstock and improved AqGR dissemination initiatives.
Species disseminated worldwide from a relatively limited number of sources?	Specific farmed-types may be held in reference centres and access to these farmed types may be limited by legal or financial constraints. Improved access may require cooperation or sharing agreements, and greater national financial support.
Limitations on refreshing genetic stocks from the wild	Replenishment of broodstock from wild relatives may be constrained in number of ways. One of the greatest threats is weak governance on the management of the habitats and stocks of wild relatives, which can lead to their decline in the wild and loss as a potential source of broodstock for the future.
Non-compliance with regulations by the private sector	It was noted in some country responses that private sector had the ability to bypass government controls on importation and movements of aquatic animals

Improved governance also benefits wild relatives with the strengthening of controls on biosecurity and farm escapees limiting impacts of genetic pollution. The improvement of management of the environment and biodiversity may be an additional positive effect, contributing to more effective conservation of wild relatives.

- The establishment of well-managed conservation hatcheries, to increase/maintain genetic diversity of wild relatives;
- Reduction of risks of transmission of parasites and pathogens to wild relatives through effective biosecurity, especially in relation to introductions;
- Prevention of the establishment of invasive species;
- Reduction of the risk of interactions between farmed and wild fish.

Reponses were fewer for the negative (10% farmed-type; 17% wild relatives) related to governance. Some country responses indicated that a general negative aspect of weak governance was policy fragmentation and weak institutional coordination on water and the environment. This is common in many countries where the roles and jurisdictions of water management and development is spread across multiple agencies and the private sector. This typically includes: irrigation; drinking supply; hydropower; biodiversity and environmental management; fisheries and aquaculture; coastal zone management; protected areas and conservation.

In the water sector the impacts of this can range from an inability to coordinate on the multi-purpose management and use of water and water bodies (e.g. for aquaculture, fisheries, recreation, conservation, drinking supply, irrigation), through to direct policy conflicts (e.g. power generation versus biodiversity conservation and food/livelihood security).

Another area that is quite commonly found in developing countries is a lack of effective assessment of risks on the introduction and movement of aquatic species, which can directly conflict with biodiversity and conservation policies, or simply undermine existing production systems and thus undermine policies on economic development, livelihoods and food security.

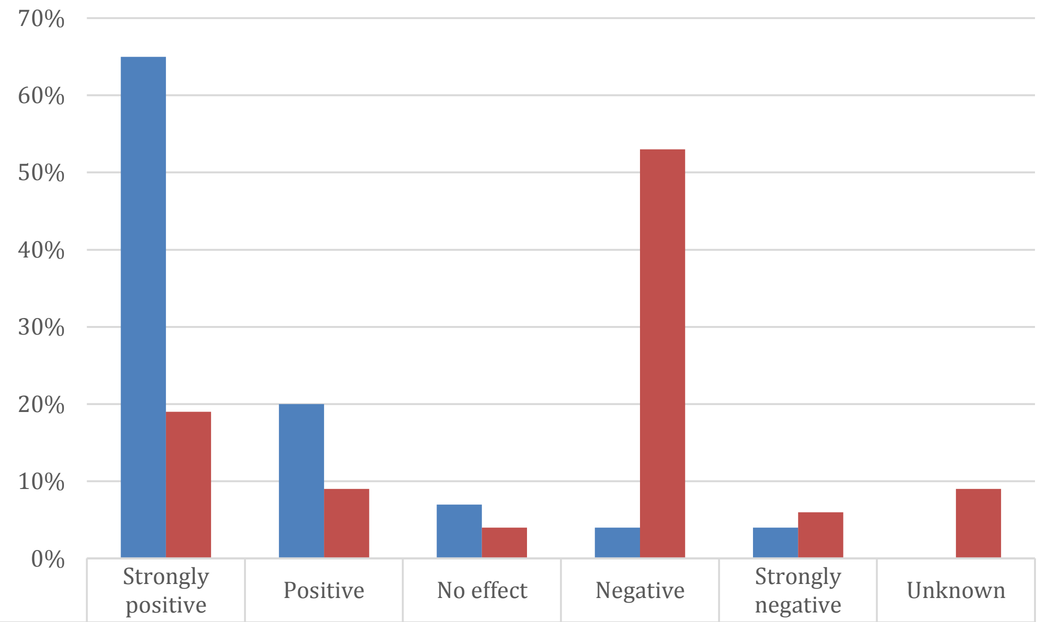
Modernization of legal frameworks and institutional reforms can assist to rectify this, especially in the area of water management and biosecurity (see Chapter 8).

3.1.4 Increased wealth and demand for fish

Eighty-five percent of respondent countries considered increased wealth would positively affect farmed aquatic genetic resources, with only 8% considering there would be negative effects (Figure 34).

Increased urbanization and standardization of aquaculture products may also have some negative impact on the range of species being cultured. This occurs as urban consumers purchase increased amounts of processed fish commodities (e.g. white fish fillet, salmon, frozen shrimp), or convenience food and hence there is less demand for a broad diversity of species, which may require more elaborate preparation.

Figure 34. Effect of increased wealth on AqGR



	Strongly positive	Positive	No effect	Negative	Strongly negative	Unknown
Farmed	65%	20%	7%	4%	4%	0%
Wild Relatives	19%	9%	4%	53%	6%	9%

Expanding economies and increasing wealth drive demand for seafood products, and aquaculture products form part of this demand. There is some evidence that increasing urbanization leads to a slight decrease in the relative amount of fish consumed (relative to other meats), but overall total consumption increases due to increased purchasing power as economies develop (Fish to 2020). Increasing wealth and greater interest in healthy eating was considered by several country respondents to be driving increased demand for seafood. Long-term projections indicate a general decline in global per capita fish consumption, but this would be more than compensated for by greater overall demand due to population increase. (World Bank 2013; Fish to 2020)

Increasing urbanization and economic development also see the emergence of value chains, supermarkets and increased processing and standardization of products. Aquaculture is well placed to meet the specific demands of supermarkets, which include: consistent quality, reliable supply, standard product form and dependable food safety.

Growing affluence also creates demand for luxury products and aquaculture responds to this demand. The rise of salmon, trout, shrimp, sturgeon (for caviar) aquaculture, are classic examples of how aquaculture has been able to bring previously inaccessibly and expensive foods into commodity chains available worldwide.

Over the last two decades (1995-2015) there has been a substantial increase in trade in many aquaculture products based on both low- and high-value species. New markets have emerged in developed, transitioning and developing countries. Aquaculture is now a significant contributor to the international trade in fishery commodities. This is dominated by high-value species such as salmon, seabass, seabream, shrimp and prawns, bivalves and other molluscs but also includes lower-value species such as tilapia, catfish (including Pangasius) and carps. These low-value species are traded in large quantities within and between countries in two main regions (Asia and South America) and are increasingly finding markets in other regions (e.g. Pangasius, tilapia) (SOFIA, 2014).

Increased wealth is also linked to increased interest in high value ornamental fish, where markets are largely found in cities and economically developed contexts. Trade in live fish also includes ornamental fish and fish for culture, which are high in value terms but almost negligible in terms of quantity traded (FAO 2014). It is probable that more than 870 freshwater and marine species are cultured for the ornamental trade[18], but they are not officially reported at National and FAO levels in most cases.

The impact of increased wealth on aquatic genetic resources of farmed organisms is therefore greater attention to improving strains, diversification and experimentation with new species to address demands from niche markets.

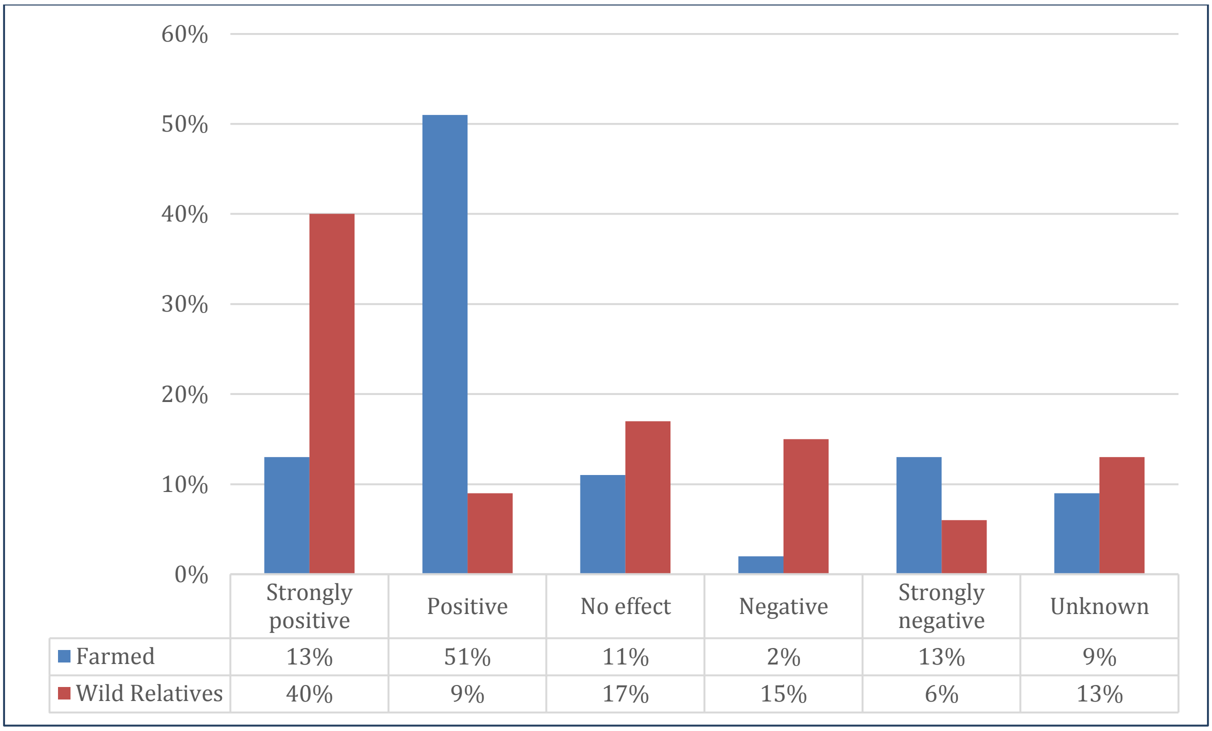
Country responses were mixed on the impacts of increased wealth on wild relatives. 59% considered overall negative impacts, whereas 27% considered the effects were likely to be positive. Increased wealth may drive demand for wild relatives of some species for food (e.g. bluefin tuna, sturgeon caviar, live reef fish, sea cucumber) and for ornamental fish keeping (e.g. Arowana species, marine aquarium species). It was also considered that this demand would drive IUU fishing for some species, particularly those that are threatened or protected.

3.1.5 Human food preferences and ethical considerations

64% of responding countries considered that human preferences and ethical considerations would have a positive impact on farmed-type aquatic genetic resources, with only 15% considering that there would be negative effects (Figure 5).

Figure 35. Effect of human preferences and ethical considerations on AqGR

[18] Based on an assumption that 95% of freshwater species (>850 species) and 5% of marine species (~1,400 species) are cultured.



There is developing interest in fish as a healthy food and this drives an increasing demand for fish in the diet. When linked to population increase this becomes a significant driver in the global demand for fish. Where consumer preferences and ethics will have an additional impact, is on the farmed-types fish, which become the highest priority and the characteristics of those farmed–types which are preferred. These consumer preferences will be quite diverse according to a range of socio-cultural factors and will therefore affect the demand for particular farmed-types including the preferences listed in Table 31.

The price of fish is a strong driver concerning consumer choice between wild and farmed fish, as well as the particular species. The eventual price to consumers is dependent upon the cost of production and this can be strongly influenced by genetic characteristics of the farmed-type being produced.

There are some consumer concerns regarding welfare of cultured fish. This has been accompanied by some regulation (e.g. the EU) and the development of health standards by OIE for welfare, slaughtering and transportation[19]. It may be considered that successive breeding of captured stock results in a domestication process, whereby fish become more tolerant of crowding and the conditions imposed by cages, raceways or ponds than their wild relatives.

Table 31: Consumer preferences and the relevance to genetic characteristics of farmed-type AqGR

Preference	Feature	Genetic and or culture characteristics
Appearance and taste	External colouration	Preference for red strains of tilapia over darker natural colouration A strong (fundamental) feature in the ornamental trade
	Flesh colour	Preference for white fish and avoidance of yellow/grey flesh (note this can be affected by the diet. Different levels of red colouration in salmonids.
	Body shape	This is typically to maximize the fillet or dress out weight (or head to tail ratio in shrimp) In some cases there is a preference for a larger head (bighead carp) Body shape is a major factor in selection of fish in the ornamental trade
	Taste and texture	Dependent upon the species (flesh qualities)

19 The OIE Aquatic Animal Health Code (the Aquatic Code) sets out standards for the improvement of aquatic animal health and welfare of farmed fish worldwide, and for safe international trade in aquatic animals (amphibians, crustaceans, fish and molluscs) and their products. http://www.oie.int/international-standard-setting/aquatic-code/

		Osmotic tolerance - salinity can influence the saltiness of the fish, and in the case of shrimp lower salinities can make the flesh taste sweeter as amino acids are used to maintain osmotic balance Culture method and feeds used will influence the fat levels in the flesh
	Processing	Increased interest in sashimi, smoked, dried forms of particular farmed-types.
Cost	High value	High value species which are farmed types of high value wild relatives (tuna, grouper, halibut, lobster, shrimp, salmon, etc.). These may still be cheaper than wild relatives.
	Low value	Lower value species that are affordable fish and which can be produced in systems with low per unit production costs (e.g. tilapia, pangassius, carp, catfish)
Fish welfare	Domestication	Manner of production, suitability for higher intensity of production
		Perceptions of stress to the animal
		Reduced stress in the case of domesticated farmed types
Other environmental concerns	Indigenous vs. exotic	A preference for indigenous species to avoid threat of introduced/exotic species.
		Organic certified production may require use of indigenous species
Genetic manipulation	Transgenic methods	General preference to avoid GMO is expressed in a number of country reports.
	Monosex/sex reversed	Preference for genetically manipulated monosex/sterile animals versus concern over use of hormones

A major challenge in developing improved aquaculture breeds will be consumer perceptions and ethical concerns regarding the use of genetically modified organisms. There are changing values and ethics of consumers with respect to the use of GMO and transgenic organisms. Currently there are no approved GMO/transgenic species being commercially farmed for food production in aquaculture.

There is general concern over the use of GMO and transgenic techniques in aquaculture and to date there are only a few examples of transgenic organisms being studied in research facilities. Limited examples are modification to increase growth rates and increased performance under cold temperatures (examples: Atlantic salmon, and chinook salmon, rainbow and cutthroat trout, tilapia, striped bass, mud loach, channel catfish, common carp, Indian major carp, goldfish, Japanese medaka, northern pike, red and silver sea bream, walleye, seaweed, sea urchin and artemia) (Rasmussen Morrissey, 2007; Beardmore & Porter, 2003)). Transgenic fish have been produced for the aquarium trade (altering fluorescence or colouration).

Positive impacts on wild relatives (49% of respondents) is linked to increasing consumer concern over unsustainable extraction of species from the wild and increasing calls for sustainable management and sourcing policies. The general feeling that consumer preferences would be good for wild relatives may also be interpreted that there will remain strong concerns over the impact on wild relatives of escapes to the wild of modified organisms and thus more stringent measures to prevent or reduce this in the future.

A general resistance to the use of GMO material may be considered a strong force for protection of wild relatives as well as limiting the risk of escape of modified material into the wild and subsequent interaction with wild relatives. This is linked to effective sector regulation and management and is therefore related to the degree of effectiveness of governance of the sector.

3.2 Drivers that are changing aquatic ecosystems

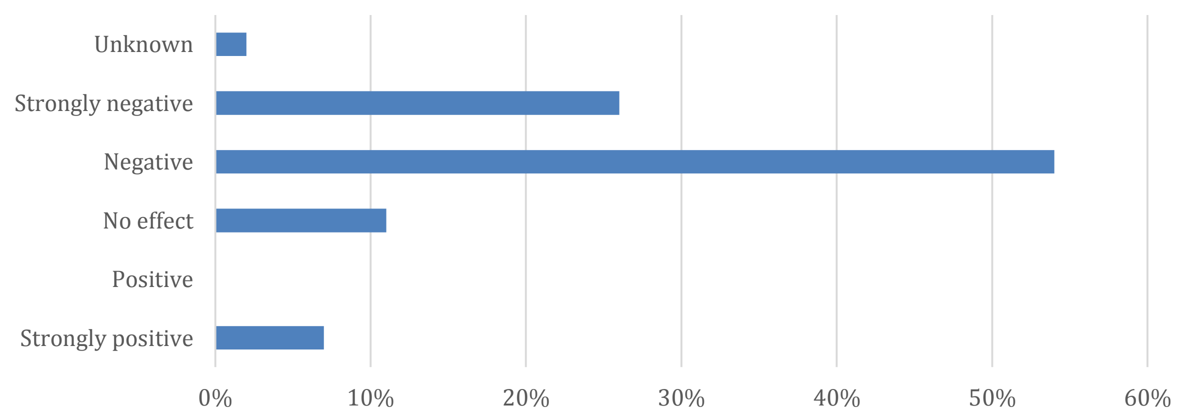
3.2.1 Habitat loss and degradation

Negative impacts on aquatic ecosystems of relevance for farmed aquatic genetic resources and their wild relatives resulting from habitat loss and degradation were ranked as negative and strongly negative by 80% of the surveyed countries (Figure 36). The main comments provided by countries regarding the impact of this driver on aquatic ecosystems of relevance for wild relatives of farmed aquatic genetic resources are listed below:

- Loss of breeding grounds, especially in the riparian zones of lakes (e.g. Malawi).
- Hydro morphological degradation of the watercourses as a result of dyke construction as protection against flooding, obstructing features to regulate water run-off, water damming and energy generation measures (Germany)
- Loss of riverine fisheries caused by creation of reservoirs/damming (Viet Nam)
- Degradation of rivers, water quality and habitat (Czechoslovakia)
- Loss of fresh water and salt water wetland (mangrove) habitats due to clearance or drainage for agriculture, aquaculture, tourism, urban development etc. (e.g. Philippines, Belize)
- Growth of inland shipping are having an adverse impact on discharge dynamics and on the possibility of the water bodies (Germany)
- **NOTE:** More examples to be inserted following more analysis of additional country reports.

Only 7% of the surveyed countries reported this driver as positive; while 2% of the countries indicated that the effects of this driver were unknown.

Figure 36. Effect of habitat loss and degradation on aquatic ecosystems that support AqGR



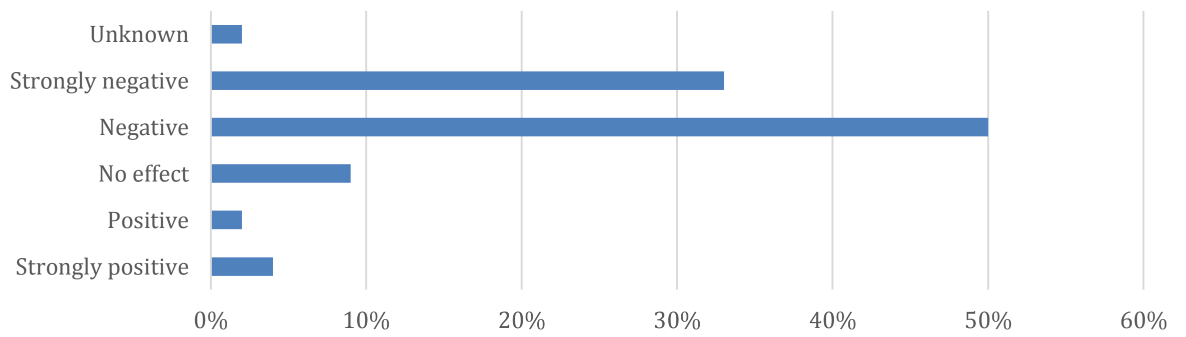
	Strongly positive	Positive	No effect	Negative	Strongly negative	Unknown
Series1	7%	0%	11%	54%	26%	2%

It should be mentioned that for example, recreational fishing may have both positive and negative impacts on AqGR. There are drivers for improving the conservation of wild relatives both in terms of conserving their habitats as well as populations. In terms of reducing the fishing impact on wild relatives, most recreational fisheries have regulations aimed at conservation of the stock.

3.2.2 Pollution of waters

83% of respondent countries recognized the negative impacts of pollution on ecosystems and consequent effect on AqGR (Figure 37) Both freshwater and coastal waters are impacted to varying degrees by pollution and this has a direct impact through acute toxicity or chronic, sub-lethal effects, affecting reproductive performance, causing mutations or deformities or bio-accumulation.

Figure 37. Effect of pollution on aquatic ecosystems that support AqGR



	Strongly positive	Positive	No effect	Negative	Strongly negative	Unknown
Series1	4%	2%	9%	50%	33%	2%

The impacts are more severe on wild relatives, but there can be indirect impacts on farmed types through contamination of water and sediments. It should be noted that only 6% of the countries identified this driver as positive on aquatic ecosystems of relevance for wild relatives of farmed aquatic species and 9% of the countries reported no effect.

Typically aquaculture operations would not be sited where there is a risk of toxic levels of pollution that could cause the loss of stock. However, aquaculture is vulnerable to accidental release of pollutants (e.g. spillage/discharges in water) as well as to sub-lethal or chronic pollution (e.g. heavy metals or other organic pollutants in sediments and water that may not have been monitored or detected. This is an issue in countries where comprehensive environmental monitoring is not in place.

The specific negative impacts on AqGR vary according to the form of pollution, the sensitivity of the ecosystem fauna and flora and the degree to which the pollution present at acutely or chronic/sub-lethal concentrations. Table 32 below indicates the various type of impacts where pollutants directly affect AqGR (farmed type or wild relatives):

Table 32: Types of pollution and their potential impact on AqGR

Source of pollution	Typical pollutants	Impacts on AqGR
Untreated or Inadequately treated domestic sewage	Organic and inorganic, nitrogen and phosphates;	Eutrophication and loss of water quality in of water bodies (ecosystem impact on wild relatives)
		Harmful algal blooms
	Some heavy metals and organic compounds	Sub-lethal effects on performance
		Oestrogen analogues causing feminization
Improperly stored solid waste	Leachates from landfill	A wide range of pollutants from urban and domestic garbage directly toxic to aquatic life
Industrial organic and inorganic wastes	Mining wastes (heavy metals suspended solids)	Direct toxicity Sub-lethal effects on performance
		Clogging of gills impacts on water quality Fouling of spawning areas
	Heavy metals , organic compounds in Industrial wastewater discharges and accumulation in sediments	Direct toxicity in acute cases Heavy metal accumulation (possible impacts on breeding performance in wild relatives (Pyle et al., 2005)

Agricultural run-off and wastes	Nutrient runoffs from agricultural fertilizers	Eutrophication and loss of water quality in of water bodies (ecosystem shifts) loss of habitat impacts wild relatives.
		Harmful algal blooms
	Pesticide runoff	Direct toxicity on wild relatives Indirect impacts on prey organisms
Soil erosion and sedimentation	Suspended solids/sediments	Clogging of gills impacts on water quality , Fouling of spawning areas
	Acidity	Direct acidification impacts
Oil/gas exploration	Oil and oil dispersant Heavy metals and organic compounds in drilling muds and cuttings	Direct toxicity on wild relatives Indirect toxicity on prey (especially in the marine environment)
Power generation	Waste heat (from industry and power generation)	Establishment of warmwater invasive species Displacement of wild relatives
Aerosol & atmospheric pollution	Acid rain - Acidified land and water un off mobilizes heavy metals	Direct toxicity of mobilized metals and acidity
	Dioxins - from industry/waste incineration	Accumulation in food chains with impacts on reproduction and performance of wild relatives Accumulation in fish used for fish meal
Radioactive waste	Radionuclide release from reprocessing or irresponsible disposal. Relatively point source	Accumulation of radionuclides in wild relatives

3.2.3 Direct and indirect climate change impacts

3.2.3.1 Direct impacts of climate change

The challenge of climate change also has implications for aquaculture, especially in the in the warm tropics where species may be cultured at the upper end of their temperature tolerance range. 57% of respondent countries indicated that climate change would have a negative or strongly negative impact on farmed-type genetic resources and most of these felt this was likely to be a strongly negative impact (Figure 38). Increased temperatures and impacts on water were considered a threat to farmed-types due to increased incidence of stress and disease.

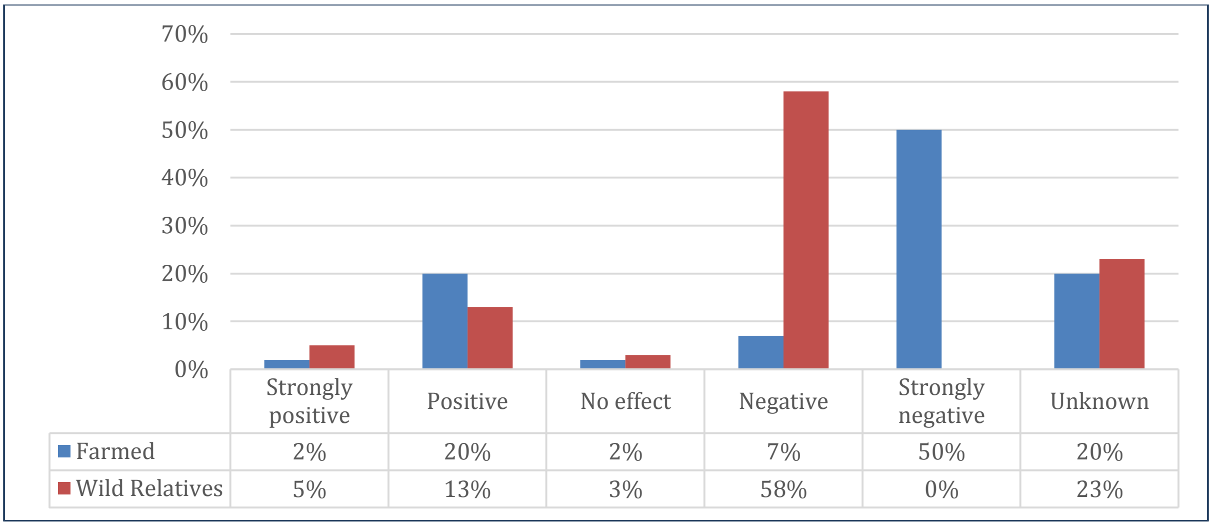
In terms of wild relatives, higher water temperatures may extend the range of native species within large continental rivers.

In terms of positive effects, only 22% of respondents felt that there would be a positive or strongly positive effect on farmed types. This may be due to opportunities for expansion of warm water systems into areas which were hitherto slightly too cold for some species. The development of cold tolerant warm water species is already established (e.g. tilapia hybrids), selection for salinity tolerance (e.g. where there are threats of saline intrusion) and transgenic approaches have greatly increased growth rates in some cold water species (transgenic Salmon).

Many respondents (58%) considered there would be negative effects on wild relatives (Figure 8), generally driven by the ecosystem impacts such as:

- Reduced water availability in rivers;
- Drying out of dry season refuge areas;
- Loss of habitat;
- Higher temperatures;
- Unseasonal rainfall and flooding;
- Effects caused by changing environmental cues for breeding and spawning;
- Increased stress leading to disease problems.

Figure 38. Direct effects of climate change on AqGR



Positive impacts on wild types were less obvious but 18% of respondents still felt there might be positive effects, but this was less than those which considered impacts were unknown (23%). In one case this was perceived as an opportunity to expand the range of brackishwater species in delta areas or in species that prefer warmer waters where migration is possible. This level of uncertainty indicates an area where there is a need for improved understanding of climate driven impacts on wild relatives.

3.2.3.2 Indirect impacts of climate change through effects on ecosystems

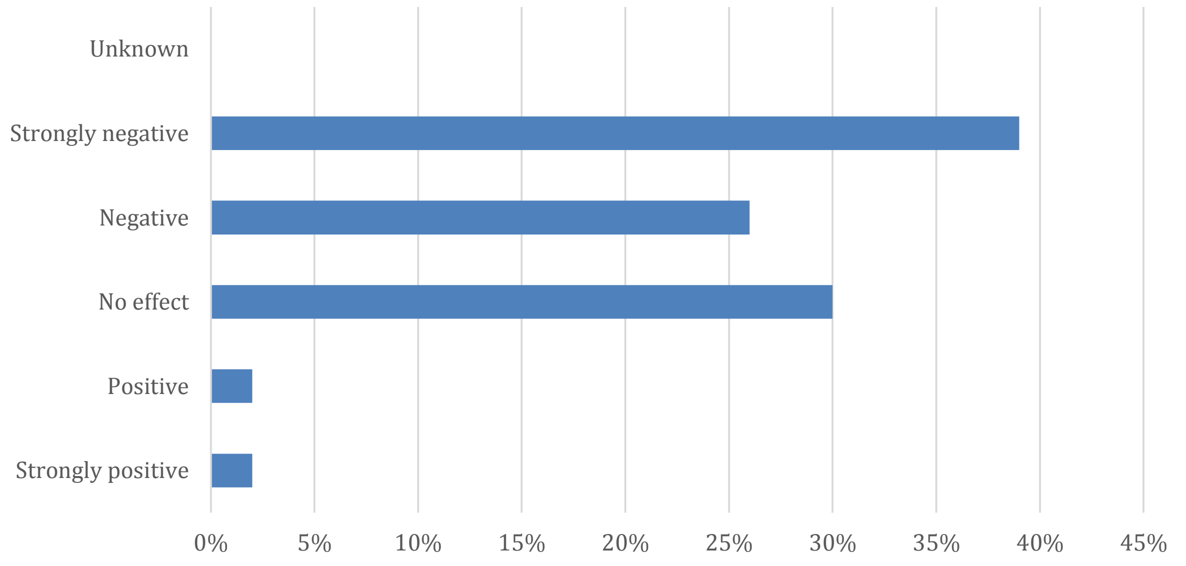
The indirect effects of climate change are those that arise from changes to aquatic ecosystems that have consequent impacts on AqGR. These drivers are the increased frequency of extreme climatic events and long-term climate change. 65% of respondents considered that the indirect effects of climate change through its impact on ecosystems would be negative (Figure 39).

Unseasonal rainfall leading to flash flooding was another identified threat. This can cause farmed-type stocks to be washed out into the wild and increases the escapee risk/threat. Improving the biosecurity of flood prone aquaculture is an important regulatory and management measure to introduce.

The converse of flooding is extended drought periods and unseasonal drying out of water bodies. This loss of water area and /or habitat can have serious consequences on wild relatives but also on aquaculture operations that are based in water bodies or dependent upon river flows for water. An extreme or unpredictable environment would drive aquaculture operations to be more self-contained, e.g. recirculating, oxygenated and fed systems with minimal contact with the environment.

Sea-level rise and reduced freshwater flows in rivers (due to abstraction or irrigation, climate variability) results in seawater intrusion in delta areas (e.g. Mekong Delta, Vietnam). This is seen as a negative impact, but will drive interest to develop salt tolerant farmed-types. It will also extend the range of brackishwater species in delta areas.

Figure 39. Indirect effects of climate change on AqGR though impacts on aquatic ecosystems



	Strongly positive	Positive	No effect	Negative	Strongly negative	Unknown
Series1	2%	2%	30%	26%	39%	0%

Water temperature rise will enable species to extend their ranges in temperate areas and encourage the establishment of invasive species. Warming temperatures also increases the range of some non-native species or allowed their establishment in the wild, for example the common carp and Chinese grass carp have become establishing in the wild in Sweden. This could be viewed as a negative impact on indigenous fauna.

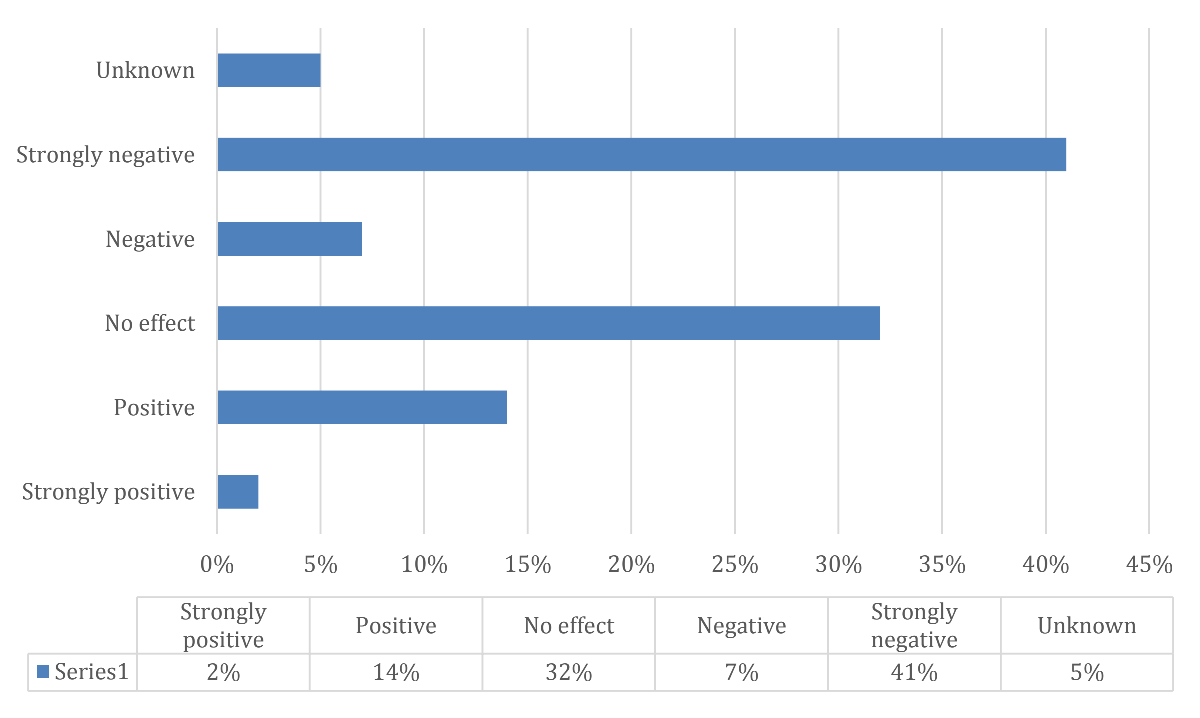
A major indirect impact of climate change is modification or loss of habitat. This occurs both in freshwaters (with declining water coverage in water bodies or drying out of wetlands). In marine environments, the demonstrable changes are seen in the form of coral bleaching and the consequent impacts on reef ecosystems, however these are not confined to tropical areas and warming waters sees ecosystem species shifts in temperate waters (also increasing the potential for the establishment of invasive species from shipping ballast water etc.)

Although few countries (4%) considered the impacts to be unknown, it was noted that there was a need to assess anthropogenic and environmental factors affecting aquatic ecosystems. The implications of climate change for fisheries and aquaculture should place emphasis on the ecological and economic resilience of fisheries and aquaculture operations to develop an effective and flexible fisheries management system in an ecosystem context.

3.2.4 Impacts of purposeful stocking and escapes from aquaculture

Just under half of country responses (48%) indicated negative impacts of on wild relatives due to ecosystem impacts from purposeful stocking and escapees from aquaculture (Figure 10). These responses were mostly related to the genetic issues of poorly managed stocking programmes and negative interactions of aquaculture stock with wild relatives. These negative interactions are both genetic (in the case of inter-breeding of escaped farmed-types with wild relatives; transmission of disease) and ecosystem-type impacts (e.g. Predation, competition for resources and space, etc.) as described in the section below on invasive species.

Figure 40. Impacts of purposeful stocking and escapes from aquaculture on wild relatives of farmed aquatic species



32% of countries responded that there were no effects regarding the impact of this driver on aquatic ecosystems of relevance for wild relatives of farmed aquatic species. This highlights the existing gap regarding the scientific assessment of negative and/or positive effects (pathogen-related, socio-economic, environmental, ecological, and genetic effects) of purposeful stocking and escapes from aquaculture in natural aquatic environments.

Only 16% of countries considered there were positive impacts of purposeful stocking and escapees on wild relatives, and these responses were largely based on the perceived positive impacts of culture based fisheries and stocking to establish capture fisheries and species recovery programmes (Chapter 3).

Few countries (5%) considered the impacts were unknown.

The variability in the country responses is partly due to the combination of purposeful introduction and aquaculture escapees (which are typically an accidental event). This inevitable results in a range of responses from countries which consider culture based fishery and fishery enhancements as largely positive or having no overall impacts, versus those countries which had experiences of aquaculture escapees which they consider to be a negative impact. It is not possible to clearly disaggregate between these two issues. Future questionnaires will need to treat these two issues separately.

The extent of the movement of aquatic species between countries and regions is not well documented. FAO has initiated a Database on Introductions of Aquatic Species (DIAS), but this is now in need of updating to support a strengthened understanding of the state of the world's aquatic genetic resources. (Box 3).

Box 3: The useful information contained in the FAO Database on Introductions of Aquatic Species (DIAS)

The FAO Database on Introductions of Aquatic Species (DIAS) was initiated in the early 1980's. Initially it considered primarily only freshwater species and formed the basis for the 1988 FAO Fisheries Technical Paper No. 294. Today DIAS has been expanded to include additional taxa, such as molluscs and crustaceans, and marine species. In the mid-1990s a questionnaire was sent to national experts to gather additional information on introductions and transfers of aquatic species in their countries.

The database includes records of species introduced or transferred from one country to another and does not consider movements of species inside the same country. The database contains more than

5,500 records of aquatic species introductions, which include minimum information such as the common and scientific name of the introduced species and the countries of origin and destination. Additional information, such as the date of introduction, the introducer, reasons for introduction, and detailed introduction features (status of the introduced species in the wild, establishment strategy, aquaculture use, reproduction features, ecological and socioeconomic effects, etc) are also available for a certain number of records.

DIAS can be used to establish purposes for introduction and their subsequent outcomes. Comparisons can be made on the beneficial versus adverse impacts of introductions. This can be further broken down into the purpose of the introduction (including accidental introductions) the pathway of that introduction. There is also information on the donor and recipient countries.

This database is now in need of considerable updating as the extent of movements has accelerated with the boom in aquaculture around the world and the increasing diversity of species being farmed. This is perhaps most notable in Asia, but trans-continental movements have also been increasing.

3.2.4.1 Impacts of purposeful stocking

Stocking through formal stocking programmes is generally recognized as an important tool to compensate for losses in fish productivity and fish species diversity. Stocking programmes are widely implemented in many countries across a variety of aquatic habitats but predominantly in inland waters (the major exception is salmon stocking programmes and specific countries such as Japan that have active marine stocking programmes). In developing countries the emphasis of stocking is typically on food security and inland fisheries to maximize the supply of protein for human consumption.

Since most inland water systems have now reached their maximum potential natural production, rising demand is now pushing fisheries managers to maximize yields in tropical waters through enhancement. In many countries this process is now advanced and the infrastructure to cope with the required production of fingerlings for stocking has been developed.

In developed countries there may be less emphasis on food fisheries and stocking is part of private or government sponsored programmes to sustain recreational fisheries or as part of conservation initiatives (Table 33).

Table 33: Differing strategies for management of inland waters for fisheries in developed and developing countries (after Welcomme & Bartley 1998a,b).

	Developed (temperate)	Developing (tropical)
Objectives	Conservation Recreation	Provision of food Income/livelihoods
Mechanisms	Recreational fisheries Habitat restoration Environmentally sound stocking Intensive, discrete, industrialized aquaculture	Food fisheries Habitat modification Enhancement through intensive stocking and management of ecosystem Extensive, integrated, rural aquaculture
Economic	Net consumer Capital intensive Profit	Net producer Labour intensive Production

There are five different types of enhancement system that utilize AqGR (Lorenzen et al.,2012). These are either aquaculture-related activities using farmed type or hatchery-produced individuals for release, or have conservation or capture fishery objectives. In the latter case these will be targeting stocks or wild relatives. Each of these systems has a different primary purpose and involves quite different management practices (Table 34).

Provided that conditions are conducive and the enhancement measures well-designed, these enhancements can be effective in increasing fisheries yields for food or income, or as opportunities for recreational fishing and wider socio-economic benefits. In practice, many enhancements are likely to be ineffective and some have caused demonstrable ecological damage.

More commonly, the need for introductions arises as a consequence of human activities. Many new reservoirs lack native species capable of fully colonizing lentic waters and there is interest in developing commercial fisheries through species introduction for example:

- *Limnothrissa miodon* introduced in Lake Kariba
- *Neosalanx taihuensis* ("Icefish") introduced to many Chinese reservoirs)
- *Cyprinus carpio* (Common carp) in Lake Naivasha and Tana River hydro-electric power Dams (Kenya)
- Economic impact of the establishment of *Lates niloticus* (Nile perch) fishery in Lake Victoria (Uganda/Kenya)
- *O. niloticus* and *O. mossambicus* (Tilapia) in Sri Lanka freshwater irrigation tanks and reservoirs

Table 34: The five types of fishery enhancement system that involve stocking (From Lorenzen et al. (2012)

Enhancement type	Primary purpose(s)
Culture-based fisheries and ranching	Increased fish production
	Creation of recreational fisheries
	Bio-manipulation
Stock enhancement	Sustaining and improving fisheries in the face of intensive exploitation
	Sustaining and improving fisheries in the face of habitat degradation
Restocking	Rebuilding depleted populations
Supplementation	Reducing extinction risk
	Conserving genetic diversity
Re-introduction	Re-establishing a locally extinct population

Much of the stocking that takes place in the Asian region can be more narrowly classified as culture-based fisheries. Culture-based fisheries and ranching systems are used to maintain stocks that do not recruit naturally, i.e. they are not self-reproducing, and typically the seed for stocking derived from aquaculture hatcheries. Some of these culture-based systems are relatively closed, take place in man-made water bodies or highly modified water bodies, and thus can be considered an extensive form of aquaculture.

Recently, there have been increasing concerns about the potential risks associated with the stocking and introduction of fish, particularly with respect to ecosystem functioning, changes in community structure and losses of genetic integrity. Although the stocking and introduction of species may have had obvious benefits, they are not without cost, and the issue of introducing fish species is highly controversial.

Many stocking activities, both deliberate and accidental, have had negative effects on indigenous fish communities and other fauna through predation, competition, introduction of pathogens and change in ecosystem dynamics. The effects of hybridization, loss of genetic integrity and reduction in biodiversity are also issues that must be considered.

Of particular concern are shifts in food-web structure and trophic status that may occur, and the impacts that these could have on indigenous flora and fauna. In addition, stocking or introductions may lead to competition with or predation on indigenous biota (Hickley and Chare, 2004; van Zyll de Jong et al.,2004); Lorenzen, 2014). This can have serious implications for waterbodies that are part of designated conservation sites or support protected plant or animal species. These impacts are summarized in Table 35 below.

Table 35: Potential detrimental impacts associated with stocking activities in a hierarchy from species-specific to ecosystem-wide outcomes. (Adapted from FAO (2015) modified from original by Molony *et al*. 2003).

Impact	Cause
Increased intra-specific competition	Due to increased abundance of the species by the addition of hatchery-reared fishes
Shifts in prey abundance	Changes in the abundance of prey species due to increases in fish predator abundance as a result of stocking
Prey-switching by wild predators	Changes in the targeted prey of wild predatory species, usually to focus on hatchery reared (naïve) fishes due to large numbers released
Starvation/ food limitation	Due to overstocking
Exceeding the carrying capacity of an ecosystem (swamping)	Due to continued stocking after recovery of a stock
Inter-specific competition	Competition between hatchery-reared fish and other species with similar ecological requirements. May lead to a reduction in abundances of competing species and prey species
Displacement of wild stock	Displacement by hatchery-reared conspecifics, although there are no well documented examples
Introduction of diseases and parasites	Especially due to poor hatchery management and husbandry of fish to be stocked
Genetic bottleneck	Due to lack of genetic management of broodstock within the production system of the fish to be stocked. A common problem of poorly designed stocking programmes.
Loss of genetic diversity and fitness	Certain alleles of wild fish may become rare due to the release of hatchery-reared fish with a low genetic diversity. This is of higher risk where the wild stock is reduced to very low levels prior to stocking.
Extinctions	The loss of species due to increase in the abundance of released fish and ecosystem shifts
Ecosystem shifts	Shifts in the distribution of biomasses or other species, possibly resulting in the loss of other ecosystem values

A major weakness of many stocking programmes is the failure to evaluate fully the outcomes of the activity or limiting the evaluation of their effectiveness, in terms of benefits as well as adverse impacts (FAO, 2015). An example of good practice in this regard is presented in Box 4.

Box 4: Case example of the value of effectively assessing national AqGR to inform stocking initiatives

It is important to have adequate knowledge of specific genetic features and characteristics in order to protect genetically independent populations from the harmful effects of stocking and resettlement measures.

The aim has to be to respect the genetic diversity in the entire distribution area of a species on population level, and to preserve such species as "evolutionary entities" with their regional genetic and phenotypical characteristics as well as to secure their stocks in the long term.

This not only serves the purpose of species protection but also promotes fish stocks that are regionally well adapted to prevailing conditions.

In this connection, the BMEL is currently engaged in a pilot-type project for the molecular genetic documentation of genetic management units of the crayfish, the brown, lake and sea trout, the barbel, the burbot, the grayling and the tench. The knowledge gained during this project is to be incorporated in practical recommendations for the stock management of these species and made available in the AGRDEU database for those active in the fish-related management of bodies of water

3.2.4.2 Purposeful stocking in recreational fisheries

Recreational fishing has traditionally been a developed country activity, but it is becoming more popular in developing countries. Recreational fisheries are also engaged in the stocking of open waters and rivers to enhance recreation fisheries (e.g. trout, salmon) using material for aquaculture hatcheries. This may have some impact on interactions between wild relatives and the cultured stock. Some recreational fisheries introduce and translocate species. In some cases non-native species are introduced from recreational fishing for example:

- Latin American species such as Pacu, arapaima, redtail catfish have been introduced to Asia
- North American species such as rainbow trout and black bass introduced to Europe
- The movement of the European catfish (Wels) has resulted in its subsequent establishment beyond its natural range within Europe.

3.2.4.3 Impact of escapees from aquaculture

Escapees from aquaculture have a range of potential impacts on AqGR, particularly with respect to wild relatives, although there are also threats to farmed-types. Farmed-types escapes form aquaculture operations in a number of ways and this has some bearing on how many escapees may get out and their consequent impact in the wild. Pathways for escapees are as follows:

- Flooding of aquaculture ponds or ornamental fish ponds releasing fish into nearby waterways (this can result in massive releases, e.g. flooding of coastal shrimp farms)
- Escape of farmed-types during harvesting operations (usually relatively small numbers as farms take precautions not to lose stock)
- Loss of larger numbers during emergency harvest or "dumping" of diseased stock
- Storm/cyclone damage to cages in the sea or freshwater bodies (can be considerable where cages are artisanal, poorly constructed and present in large densities)
- Net damage in cages
- Deliberate dumping of fish (aquarium species) into waterways

The range of threats that these escapees present is summarized on Table 35:

Table 35: The range of threats presented by aquaculture escapees on wild relatives and farmed types

Affected	Nature of impact
Wild relatives	• Genetic introgression as a result of genetically selected farm types breeding with wild relatives. • Note that this has been shown in the case of large scale purposeful stocking, e.g. wild Thai Silver Barb in Thailand (Wongpathom, 1996), and arguably in the case of escaped Atlantic salmon, but there are few other clearly demonstrated examples of this resulting from farm escapes
	• Transmission of disease/parasites to wild relatives
	• Establishment in the wild (invasiveness). Establishment of escaped farmed-types can compete with indigenous fauna.
	• Maladapted farm types breed with wild relatives. Typical maladaptation in farmed fish include: selection for precocious breeding or out of season breeding (selection for early spawning, or later migration) • Less obvious maladaptation for the wild may include less aggressive behaviour • Some of these maladaptations may limit the success of the escapee from successful breeding with wild relatives
Farmed types	• Transmission of disease or parasites between aquaculture farms
	• Establishment of naturalized fisheries that compete with farmed types in the market

3.2.4.4 Escapees from the aquarium trade

Whilst escapees from the aquarium trade are often limited to individuals and thus the risks of them becoming established are relatively low, the widespread movement of AqGR for the aquarium trade means that species are moved well beyond their range. The real threats are probably more closely linked to escapes from breeding and holding operations. This emphasizes the importance of effective regulation and monitoring of such operations and ensuring that they have adequate biosecurity controls in place. Urban-based breeding facilities are probably relatively low risk, but open pond based systems or riparian operations in peri-urban or rural areas may be vulnerable to flooding or other risks of escape and it is from this type of operation that escapes are more likely to become establishing in open waters.

3.2.5 Establishment of invasive species

There are numerous species of non-native species, which have become established accidentally or deliberately beyond their natural range. Some of these introductions have resulted in adverse environment and economic impacts, i.e. the introduced species became invasive or introduced pathogens into the production system. However, the majority of introductions recorded in DIAS had many more positive social and economic impacts than negative environmental impacts. (Bartley and Casal, 1998).

The FAO Database on Introduced Aquatic Species provides lists of known introductions according to purpose:

- Accidental introduction
- Aquaculture
- Ornamental
- Angling/recreational fishing
- Biological control

Not all introductions result in the establishment of the species. The Global Invasive Species Database[20] lists 129 recognized invasive species of freshwater, marine and brackishwater ecosystems (Table 36).

Table 36. GISD list of invasive species of freshwater, brackishwater and marine ecosystems

Taxon	Number of species	Taxon	Number of species
Fish species	51	Ctenopherans (comb jelly)	3
Aquatic plants	17	Brachiopods	2
Bivalve molluscs	17	Echinoderms (starfish)	2
Gastropod molluscs	12	Calanoid	1
Decapod crustacean	6	Amphibian	1
Ascidians	6	Sponge	1
Ectoprocta (bryozoan)	4	Myxosporea (*Myxobolus cerebralis*)	1
Polychaete worm	3	Fungi (*Aphanomyces astaci*)	1
Cnidarians	3		

An example of an assessment of the number of species that have been introduced, or moved beyond their natural range within a country is the USA. The United States Geological Service (USGS) lists 759 non-indigenous fish species or species translocated outside of their natural range inside the USA[21]. The impact of these non-native species on an ecosystem may range from undetectable, to major ecosystem changes through effects on their prey changes to food chain linkages or other aspects of their behaviour (e.g. burrowing). Sometimes the impact is not directly apparent, and the species is simply an unwanted species, less preferred than other similar native species. Examples of this are presented in Table 37:

Table 37: Examples of impacts of non-native species on ecosystems and wild relatives and farmed-types

Effect on food webs	Direct predation of other species
	Predation of eggs of native species

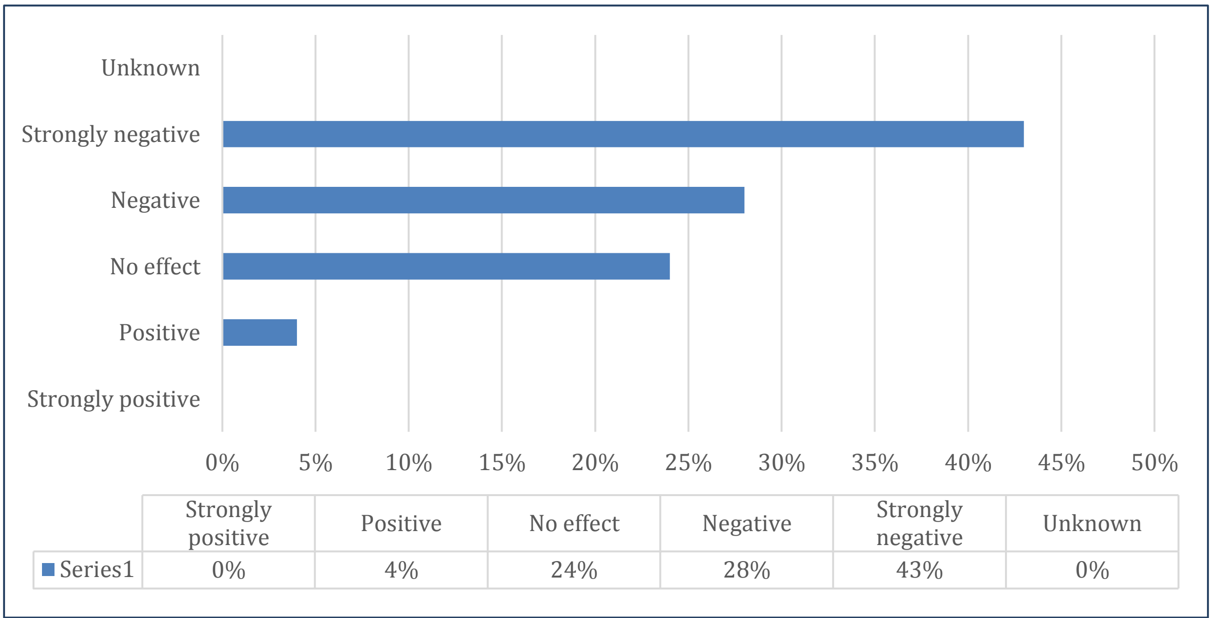
[20] Global Invasive Species Database (2016). Downloaded from http://193.206.192.138/gisd/search.php (April 2016)

[21] http://nas.er.usgs.gov/queries/SpeciesList.aspx?Group=Fishes (accessed April 2016)

	Transmission of parasites/disease to both wild and farmed-types
	Predation on prey species (e.g. insects, zooplankton) of other native fish
Competition	Higher fecundity than native species
	Greater tolerance for adverse environmental conditions Exclude native species from breeding areas Compete for matings
Engineer ecosystems, Undesirable behaviour or characteristics	Burrowing behaviour into river banks affecting stability etc.
	Increase turbidity Remove vegetation Crowd out native species

71% of countries considered that the establishment of invasive species as negative, with only 4% reporting positive effects (Figure 41). This perhaps reflects that whilst the introduction of species of aquaculture is generally considered positive, the establishment of invasive species in the wild is not viewed in the same way.

Figure 41. Effect of establishment of invasive species on wild relatives of farmed aquatic species



As it is extremely difficult, if not impossible, to eradicate introduced species that become invasive, the best protection is to prevention through more effective biosecurity and control on translocations. There is also a need to limit or prevent further movement within a country once a species has become established. This is a clear area where there is a strong justification for more effective and comprehensive monitoring of AqGR in general, and invasive species in particular (Germany, RO Korea)

Countries also indicated the impacts of non-fish species which impact ecosystems or which directly predate fish. Examples include invasive bird species that predate fish have impacts on wild AqGR (e.g. cormorant, *Phalacrocorax carbo sinensis* in Czechoslovakia). Mitigation would involve effective elimination of these invasive fish predators.

Controls and mitigation is achieved through strengthened biosecurity measures or more effective implementation of existing measures. In many developing countries there is a low level of awareness regarding the threat to aquaculture and wild AqGR from invasive species and transfer of aquatic pathogens through movements and introductions.

In several country reports there was a consistent theme of the need to Develop National guidelines for fish transfers and introductions and establishment of more effective import risk analysis (risk assessment, risk management and risk communication strategies) for potential fish invasive species and health threats (Kenya, Thailand, Viet Nam). Examples of risk assessment and guidelines on use of non-native species do exist, indicating a lack of awareness in countries, for example the ICES code of practice (ICES 2008) on introduction which has been adopted in principle by FAO’s inland regional fisheries bodies (see Bartley and Halwart 2006).

An example where regulations already exist is the EU regulation (REG (EC) No. 708/2007) concerning use of alien and locally absent species in aquaculture. This contains relatively strict provisions for the avoidance of risks associated with the use of alien species in aquaculture (e.g. fauna falsification and the introduction of diseases and parasites).

There have been various efforts to develop economic uses for established introduced species. This is partly to provide an economic incentive for their collection/removal from the wild. Examples include:

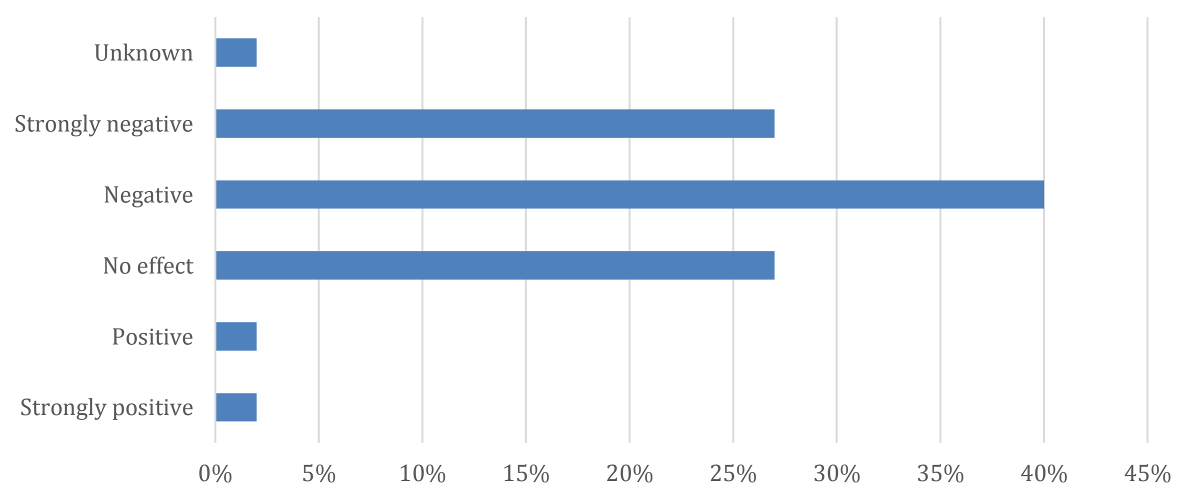
- Use as fish meal (e.g. Silver carp in USA; Knife fish in Philippines)
- Use as aquaculture feeds (Golden Apple Snail in Philippines, Bangladesh)

3.2.6 Introductions of parasites and pathogens

A majority (67%) of the surveyed countries reported a negative or strongly negative effect of introductions of pathogens and parasites in aquatic ecosystems of relevance for wild relatives of farmed aquatic species. 27% assessed no effect for this driver and only 4% noted a positive effect of this driver on aquatic ecosystems of relevance.

Accidental or purposeful introduction and transfer of aquatic species within the same country, between and within regions has been the main reason of pathogens and parasites introductions, together with other minor reasons such as ballast water and migrations. Only 2% of countries felt the impacts were unknown (Figure 42).

Figure 42. Effect of Introduction of parasites and pathogens on wild relatives of farmed aquatic species



	Strongly positive	Positive	No effect	Negative	Strongly negative	Unknown
Series1	2%	2%	27%	40%	27%	2%

Species transferred between regions for aquaculture purposes have also resulted in the introduction of diseases, which have severely impacted aquaculture production or stocks of wild relatives:

- The Noble crayfish (*Astacus astacus*) was decimated in the wild due to crayfish plague (*Aphanomyces astaci*), which was spread via introduction of the signal crayfish (*Pacifastacus leniusculus*).
- The spread of Bonamia through European oyster stocks, through the movement of non-native oysters in Europe, which were resistant to the disease
- The spread of Penaeid shrimp viral diseases has resulted in massive losses of production periodically since the start of shrimp culture. This has largely occurred through the large-scale translocations of postlarvae (TSV, IHHNV, WSSV, YHV, EMS) or new species for aquaculture.
- Streptococcus in tilapia, and possibly a recently discovered virus in tilapia
- The swimbladder worm (*Anguillicola crassus*) in eels introduced in the 1980s constitute a serious threat to indigenous stocks of eel in Europe. Asian eels are tolerant to the disease but Dutch analyses show that problems with spawning migration of European eel can occur if the infestation is serious enough.
- Various carp viruses have been transferred through movements of fish for aquaculture as well as for the aquarium trade (e.g. Koi Herpes Virus, CEV)
- Transmission of VHS, IHN, Whirling disease in salmonids

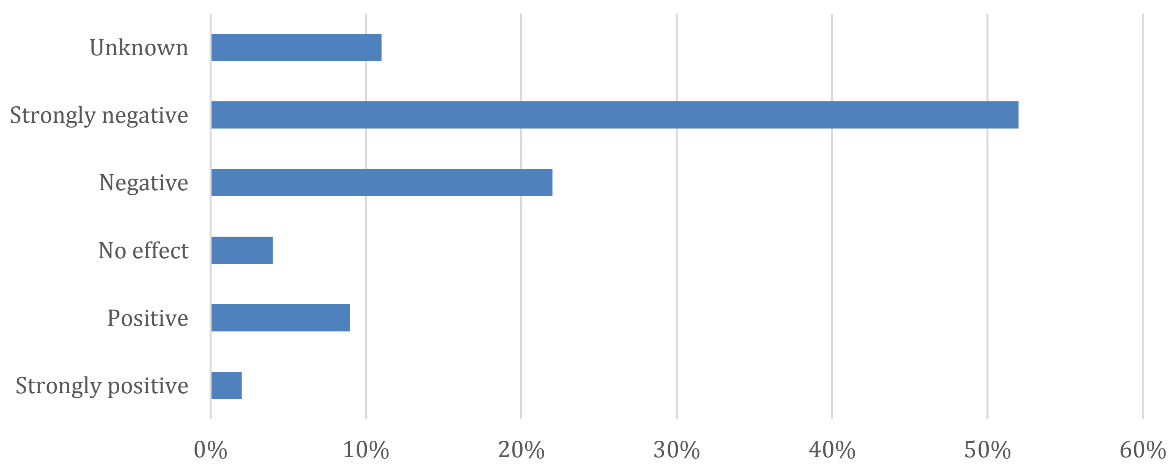
Management and controls to prevent or minimize impacts of spread of aquatic pathogens as similar to those which would be applied to introductions and movements of aquatic animals. This is because the spread of invasive species and introduction of aquatic pathogens require similar procedures of monitoring, risk analysis and border controls.

A second level of biosecurity, which is equally important, is the extent to which a country is able to control movements and transfers within its boundaries. Once a disease or invasive species has entered a country, it can still be prevented from spreading between water bodies, watersheds or river basins.

3.2.7 Impacts of capture fisheries on ecosystems and wild relatives

Capture fishery impacts on AqGR are most directly linked to impact on wild relatives where they are directly targeted and are generally negative (Figure 43). 74% of country responses considered these impacts to be negative or strongly negative.

Figure 43. Effect of capture fisheries on wild relatives of farmed aquatic species



	Strongly positive	Positive	No effect	Negative	Strongly negative	Unknown
Series1	2%	9%	4%	22%	52%	11%

The threats to AqGR via ecosystem impacts are linked to the fishing pressure, the extent to which the fishery is effectively managed and whether the capture fishery targets vulnerable or critical life stages. In the latter case, fisheries which target juveniles (as in the case of glass eel fisheries) or breeding adults (Sturgeon for caviar, targeting of grouper spawning aggregations. Fisheries based around spawning migrations) may have a disproportionate impact on the wild relative population. This fishing activity may be for the purpose of food or for capture of juveniles for fattening in aquaculture systems (e.g. eel, Bluefin tuna, grouper , marbled sand goby etc.).

More general fishing impacts on AqGR relate to unsustainable levels of exploitation which threaten the viability of wild populations and thus their future potential as a source of genetic material. Some fisheries may also impact AqGR that are not the target species. These may be "bycatch" issues or habitat impacts (as a result of gear interactions with habitat and consequent impact on a non-target species). An example of this sort of bycatch issue would be the capture of juvenile wild relatives in trawl and push net fisheries.

Country comments on how to mitigate or prevent these impacts proposed the adoption of ecosystem approaches to fishery management that take into account broader ecosystem impacts of the fishing activity beyond the target stocks and which also incorporate habitat and environmental considerations. It was also emphasized the more effective measure be applied to prevent the impact of fisheries on critical life stages and habitats.

11% of countries considered that capture fisheries had a positive impact on the ecosystem and consequently AqGR (Figure 43). This was difficult to interpret, although in the case of Belize, it was perceived that fishing pressure on invasive tilapia was keeping the species under control.

Other positive considerations were that in the case of freshwater fisheries in Germany, there is an obligation of fishery management to achieve diversity of fish species adapted to that water body/fishery. Responsibly managed fisheries, e.g. using an ecosystem approach, can be considered as *in situ* conservation (see Chapter 4). This also requires that the fisheries sector would be committed to the protection of aquatic habitats and the protection of aquatic species in addition to the species being targeted by the fishery. Another general consideration is that fishing pressure alone rarely results in the extinction of any fish species. Extinctions or loss in the wild is typically more influenced by ecosystem type impacts and change, particularly loss of habitat and changing water quality and flow (in the case of freshwater).

11% of the countries assessed the impact of captured fisheries as unknown.

3.3 Key findings and conclusions

The key findings of the analysis on drivers affecting aquatic genetic resources are summarized below.

Human population increase	Population increase will drive demand for seafood, especially aquaculture products as capture fishery resources become limited.
	This will drive efforts to expand and diversify the farmed species produced and therefore aquatic genetic resources.
	This will also place pressure on wild type stocks, either as broodstock or directly as food.
Competition for resources	A significant proportion of aquaculture production takes place in freshwater aquatic environments, in open water bodies or on land.
	Large open aquaculture systems compete for freshwater and space with other food production systems
	Demand for freshwater for urban supply, for energy production will challenge aquaculture to become more efficient, driving the demand for breeds and systems adapted to lower resource-use footprints
	Intensification of aquaculture operations will also require increasing attention to be paid to reduction of discharges. This will promote use of species more tolerant to

	reduced water quality in some systems.
	Rising prices of feed resources and the need to reduce production costs will place emphasis on lower trophic-level systems
	Further development of marine and brackishwater systems may be driven by reduced opportunities for use of freshwater
	Wild relatives will be threatened by changes in priorities on use of water (e.g. for irrigation, drinking water supply) and environmental flows in water bodies (especially rivers)
	Pollution from industry, agriculture and urban sources all threaten the quality of water used for aquaculture and to sustain wild relatives.
Governance	Increasing levels of good governance are seen as having an overall beneficial effect on aquatic genetic resources in both farmed type and wild relatives.
	Impacts on farmed types range from improved regulation of farms and their operations (including licensing and monitoring of hatcheries and farms, genetic management, biosecurity) to greater professionalization within the sector.
	Impacts on wild relatives pertain to improved environmental management, better control over farm escapees, more responsible approaches to stocking and movement of aquatic genetic material, increased use of risk assessment and higher levels of conservation and protection
Increased wealth and development of economies	Increasing wealth and developing economies is accompanied by greater intra and inter-regional trade and increasing urbanization and industrialization. This drives the development of value chains and marketing channels for seafood. This is in response to increasing demand from a growing population (see above), their increased spending power and changing dietary preferences (see preferences & ethics below)
	It is expected that there will be increasing consolidation and industrialization of large volume, internationally traded commodities (e.g. Pangasius, tilapia, salmon, and shrimp). This will drive the development of new farmed-types within these commodities.
	There will be increased emphasis on food safety and traceability, which will challenge smaller, less closely managed production systems.
	At the same time, there will be continuous exploration of new niche species to satisfy the demand for new, seafood commodities, especially as substitutes for limited supplies from the wild. This will drive the development of new farmed-types from species currently farmed in low volume, or the development of new farmed-types from the wild relative resource.
	Demand for ornamental fish will increase, driving the development of farmed-types as well as demands on wild relatives.
Changing human food preferences and ethical considerations	With changing demographics, consumer attitudes to fish are also changing
	Fish consumption is increasingly recognized as part of a healthy and balanced diet
	Increasing urbanization will drive demand for seafood as urban populations tend to eat more fish.
	There remains concern over the use of GMO techniques and resistance in some markets. This may also spill over into resistance to other farmed types (e.g. hybrids, triploids)
	There is increasing awareness regarding the unsustainable exploitation of wild relatives and this will drive demand for farmed-types (alongside increasingly limited supply from the wild)

Effect of habitat loss and degradation on ecosystems	Changes in use of land, water, coastal areas, wetlands and watersheds all have impacts on the quantity and quality of habitat for aquatic genetic resources
	Water management is one of the principal factors that affect aquatic systems. These impacts arise from damming of rivers, drainage, flood control and flood protection, hydropower development, irrigation, partitioning of wetlands, road construction.
	Changing land use can affect water quality and flows related: to watershed development, loss of land cover, erosion, soil degradation, agricultural development.
	Water quality can be directly impacted by pollution from industry and urban development (nutrients, heavy metals organic pollutants, solid waste, micro-plastics etc.) and agricultural runoff (nutrients, pesticides)
	Changing land use in coastal areas affects available coastal wetland habitat, the hydrology and quality of coastal waters. This is compounded by impacts of land-based runoff (nutrients, pollution)
	Aside from the direct impact of competition or predation, the establishment of invasive species can impact food webs and ecosystems that support wild relatives
Direct and indirect effects of climate change	Climate change will have impacts on freshwater availability and changing ambient temperatures, this will indirectly impact all AqGR through changing ecosystem functions, and directly impact AqGR through their ability to tolerate changes to ambient conditions in aquaculture and the wild, as well as changes to environmental cues to spawning and migration.
	This will have a disproportionate effect on equatorial/tropical regions where species are at the upper end of their thermal tolerance and is considered to be generally negative in terms of impact on aquatic genetic resources.
	Positive effects on farmed-types would be thorough greater emphasis on: selection for thermal and low dissolved oxygen tolerance and for lower water use systems; increased geographical range of some farmed-types expanding into previously cooler latitudes
	Emphasis on lower carbon footprint systems will also drive selection of farmed-types with lower trophic level feeding habits, increased food conversion efficiency and suitability for low energy systems.
	Impacts on wild relatives are likely to be negative or unknown.

The analysis of drivers and affecting aquatic genetic resources indicates where there are national gaps or room to improve or mitigate. Explanations and additional detail provided in the national reports indicated a wide range of actions that were either proposed or currently being put into place to correct or mitigate these drivers. These are summarized below.

Improving national monitoring of AqGR	AqGR surveys of both farmed-type and wild relatives are needed to develop comprehensive national database
	Strengthen the monitoring within country on the use and movements of farmed-types
	Strengthen access to information on fish genetic diversity, environmental integrity and aquaculture practices
	Monitor genetic variability AqGR wild relatives, especially those threatened or affected by environmental disturbances (e.g. hydro-power plant construction; dams; loss of habitat)
	Update and maintain the Database on Introductions of Aquaculture Species

	(DIAS)
Improving national capacity to manage farmed-type genetic resources	Establish/rehabilitate of brood stock development facilities and breeding and hatchery facilities to provide quality broodstock and seed stock
	Develop adequate supply of domesticated/captive broodstock for farmed-type hatchery requirements
	See public-private cooperation to achieve national level security of supply of key commodity farmed-types
	Develop breeding programs directed to avoid inbreeding and improve record keeping
Strengthening biosecurity	Establish measures to reduce risks of escapes from farms
	Promote the use of biological (sterile animals) to reduce impacts of escapees
	Regulate use or production of fertile inter-specific hybrids for aquaculture to avoid genetic introgression with wild relatives.
	Use risk analysis prior to importations, introductions and translocations, including assessments of invasiveness, genetic impacts, disease transmission
	Responsible stocking of open waters, including effective monitoring of post-stocking impacts
	Develop effective quarantine systems
	Improve veterinary surveillance of fish imports
Promoting more efficient resource use in aquaculture systems	Develop more efficient systems that are able to utilize less water per kilogram of production
	Develop farmed types with higher tolerance to intensive production systems (and the associated water quality parameters) such as has been achieved with carp, tilapia, Pangassius.
	Improve FCR in farmed-types to reduce feed demand and to utilize lower quality feeds
	Develop and promote systems for low trophic level farmed-types
	Reduce reliance on wild seed in those systems that are currently dependent upon this
	Protect sources of natural seed and their habitats
Improving farm management	Improve management of farmed-type escapees, especially in open water
	Strengthen disease control systems ,especially where there are farmed-type wild relative interactions (bi-directional)
	Develop certification and associated guidelines for hatchery operators
	Development and application of best management practices in fish farming
Improving integration with irrigation and water management	Improve the function of water storage and irrigation systems such that they provide benefits to aquatic genetic resources.
	Farmed types: adequate allocation of good quality water; reform of water pricing and allocation policies
	Wild types: Improved fish passage in partitioned systems (e.g. migration-friendly water management structures) effective use of water storage bodies in support of sustaining habitat and conservation of stocks
Reducing the impacts of pollution	More effective management of industrial and urban wastewater discharges
	Rehabilitation of degraded rivers and water bodies
	Reduction of impacts of agricultural fertilizer run off(through more

	responsible fertilization methods)
Sustaining or improving habitat and environments for wild relatives	Improve harmonisation of fishery and/or environmental legislation to strengthen conservation and protection of wild relatives
	Development compensation schemes to re-balance economic priorities in favour of critical habitats for protection of ecosystems supporting wild relatives (includes other associated non fish species that depend on fish)
	Promote restoration of critical aquatic habitats
	Cooperate with other sectors in land use and development or reduce impacts of erosion and deteriorated water quality from runoff.
	Establishment of freshwater and marine protected areas (e.g. Sanctuary, Refuge and Reserves) for conservation and protection of wild relatives, based on genetic, ecological and demographic parameters to conserve genetically distinct populations
	Implementation of effective regulatory measures for proper management of wild relatives
	Use an Ecosystem Approach to planning and management of riparian and open water habitats
Developing effective stocking programmes that take into account genetic diversity	Captive breeding programmes have become the major tool used to compensate the declining fish populations and simultaneously to supplement as well as enhance yields of wild fisheries.
	The genetic structure of the original wild population should be determined before any new fish are released into the waters ensuring that the stocked population has the same alleles as the wild population, to minimize impacts on genetic structure of wild relatives
Developing in-situ and ex-situ conservation programmes	Establish *ex situ* aquaculture facilities to maintain fish germplasm of threatened species used in aquaculture operation and restocking programs.
	Explore ex-situ conservation methods such as: Live Gene banks (LGBs): A live gene bank contributes to delisting of threatened species by captive breeding and restocking in species-specific recovery programmes; Cryopreservation of fish gametes and embryos; Tissue banking (e.g. India has 15,000 samples); DNA Barcoding
Reducing impacts of capture fisheries on wild relatives	Strengthen fisheries legislation, promote co-management of fisheries resources and control fishing effort
	Manage the impacts of fishing gears on vulnerable/sensitive habitats
	Limit and/or manage capture fisheries which target critical life stages of wild relatives
	Promote risk-analysis based responsible enhancement of fisheries in natural water systems
Promoting research	Promote research into development of new farmed-types
	Identify new potential aquaculture species
	Develop species-specific genetic markers (microsatellites or/and SNPs) for use in genetic monitoring.
	Focus on improvement of farmed-type aquatic genetic resources to mitigate adverse impacts on those that are derived from wild relatives.
	Strengthen public private partnership in research and dissemination of aquatic genetic resources.
	Establish a Geographic Information System to assist in planning, developing,

	monitoring and mitigating aquaculture ecosystems (taking into consideration sensitive habitats and the impact of climate change)
Strengthening governance	Support investment into applied research, education and public awareness of importance of AqGR
	Integrate the conservation and management of AqGR into national fishery and environmental legislation
	Develop cooperation and strategic partnership between aquaculture farmers, public sector and research institutes.
	Work to organize and professionalize aquaculture producers to improve their ability to maintain farmed-types and reduce genetic risks.
	Develop zonation of aquaculture development areas to manage biosecurity, genetic and environmental risks

3.4 References and key documents

Sources of information on invasive species

- FAO Database of Introduced aquatic species http://www.fao.org/fishery/dias/en
- Global Invasive Species Database (http://www.iucngisd.org/gisd/)
- Baltic Sea Alien species database http://www.corpi.ku.lt/nemo/
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4 IN SITU CONSERVATION OF FARMED AQUATIC SPECIES AND THEIR WILD RELATIVES WITHIN NATIONAL JURISDICTION

PURPOSE: The purpose of this chapter is to review the current status and future prospects for the *in situ* conservation of genetic resources of farmed aquatic species and their wild relatives.

KEY MESSAGES:

Major findings from an examination of country reports and an examination of other information sources include:

- *In situ* conservation is the preferred method of conserving AqGR according to international agencies
- *In situ* conservation including marine and freshwater protected areas are widely promoted as effective conservation tools.
- Several countries with effective *in situ* conservation programmes
- Principal objectives of *in situ* conservation were the *Provision of aquatic genetic diversity* and *Maintaining good strains for aquaculture production;*
- *To help adapt to impacts of climate change* and *Meeting market demands* were the least important objectives.
- It is unclear if countries consider aquaculture and fisheries operations as important mechanisms for *in situ* conservation
- Collectors of organisms from the wild for use in aquaculture were reported as playing a significant role in *in situ* conservation
- There is a need for increased awareness on the role of well-managed fisheries and aquaculture in *in situ* conservation of aquatic genetic resources.

4.1 Introduction

In situ conservation as defined by the Convention on Biological Diversity (CBD) includes areas both on farm and in nature. [INSERT definition & DATE]. In light of the fact that all wild relatives of farmed aquatic species still exist in nature and that the farming and fishing of wild types (or near wild types) play an important role in food production (See Section 2.5.4), maintenance of the aquatic habitats supporting wild relatives is essential for their *in situ* conservation.

Habitat rehabilitation has been undertaken in efforts to improve fishery production and conserve aquatic biodiversity and there are a variety of strategies available that can improve aquatic ecosystems (Roni et al. 2005). However, the efficacy of many habitat rehabilitation programmes for fish production has not been adequately evaluated on a global scale (Roni et al. 2005).

The CBD states that *in situ* is the preferred method for conserving biological diversity. Signatories of the CBD developed the Aichi[22] Targets to protect 17% of their terrestrial and inland water and 10% of their marine areas by 2020. Preservation or maintenance of habitat, whether on farm or in nature is crucial because it allows organisms to continue to be connected to the habitat in order to adapt to *in situ* conditions.

In situ conditions could be a fish farm, pristine aquatic ecosystems or those ecosystems impacted by development, such as habitat degradation, damming of rivers or coastal erosion, as well as the various impacts of climate change. It has often been said that to conserve something humans must use it. Therefore the extent to which the use of AqGR through aquaculture and fisheries contributes to its conservation is evaluated.

There are numerous examples of *in situ* conservation of aquatic genetic resources. The most widely cited are marine protected areas (MPA), freshwater protected areas (FPA), Ramsar sites and the IUCN categories of protected areas. In addition to geographically defined protected areas, certain types of

[22] https://www.cbd.int/sp/targets/

fishery management would also qualify as *in situ* conservation. This chapter reviews the current status and future prospects for *in situ* conservation of farmed AqGR and their wild relatives and includes both on farm and in nature conservation areas, as well as fisheries management.

4.2 In situ conservation of wild relatives of farmed aquatic species

Aquatic protected areas, both MPAs and FPAs have been promoted as the method of choice for conserving biological diversity. The Aichi Targets of the CBD have called for countries to establish protected areas in 17% of their terrestrial and inland waters and 10% of their marine areas by 2020. Recognizing that there are various levels of 'protection', the World Conservation Union (IUCN) defined six categories of protected area (Box 5).

Box 5. IUCN Protected Areas Categories System

(http://www.iucn.org/about/work/programmes/gpap_home/gpap_quality/gpap_pacategories/)

IUCN protected area management categories classify protected areas according to their management objectives. The categories are recognised by international bodies such as the United Nations and by many national governments as the global standard for defining and recording protected areas and as such are increasingly being incorporated into government legislation.

Ia Strict Nature Reserve

Category Ia are strictly protected areas set aside to protect biodiversity and also possibly geological/geomorphological features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring.

Ib Wilderness Area

Category Ib protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.

II National Park

Category II protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible, spiritual, scientific, educational, recreational, and visitor opportunities.

III Natural Monument or Feature

Category III protected areas are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.

IV Habitat/Species Management Area

Category IV protected areas aim to protect particular species or habitats and management reflects this priority. Many Category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.

V Protected Landscape/ Seascape

A protected area where the interaction of people and nature over time has produced an area of distinct character with significant, ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.

VI Protected area with sustainable use of natural resources

Category VI protected areas conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management.

These categories reflect different objectives of a protected area or of *in situ* conservation. The country reports also expressed differing objectives for *in situ* conservation with *Preservation of aquatic genetic diversity* and *Maintain good strains for aquaculture production* being the highest priority objective reported and *To help adapt to impacts of climate change* being the lowest priority.

These priorities for *in situ* conservation vary somewhat among economic classes but in all cases *Preservation of aquatic genetic diversity* had the highest priority. It is surprising that *Meeting market demands* scored so low, even in developing and least developed countries, and perhaps countries do not see role that the conservation of genetic diversity *in situ* has in meeting consumer demands and preferences in the market.

Table 38. Ranking of objectives for *in situ* conservation of AqGR by economic classification of countries (1 = highest priority; 10 = lowest priority)

Objective	**Rank**		
	Developed countries	Least developed countries	Other developing countries
Preservation of aquatic genetic diversity	3.5	1.6	1.4
Maintain good strains for aquaculture production	3.9	2.2	2.3
Meet consumer and market demands	5.4	4	3.2
To help adapt to impacts of climate change	4.9	5.1	3.5
Future breed improvement in aquaculture	3.8	2.4	2.7

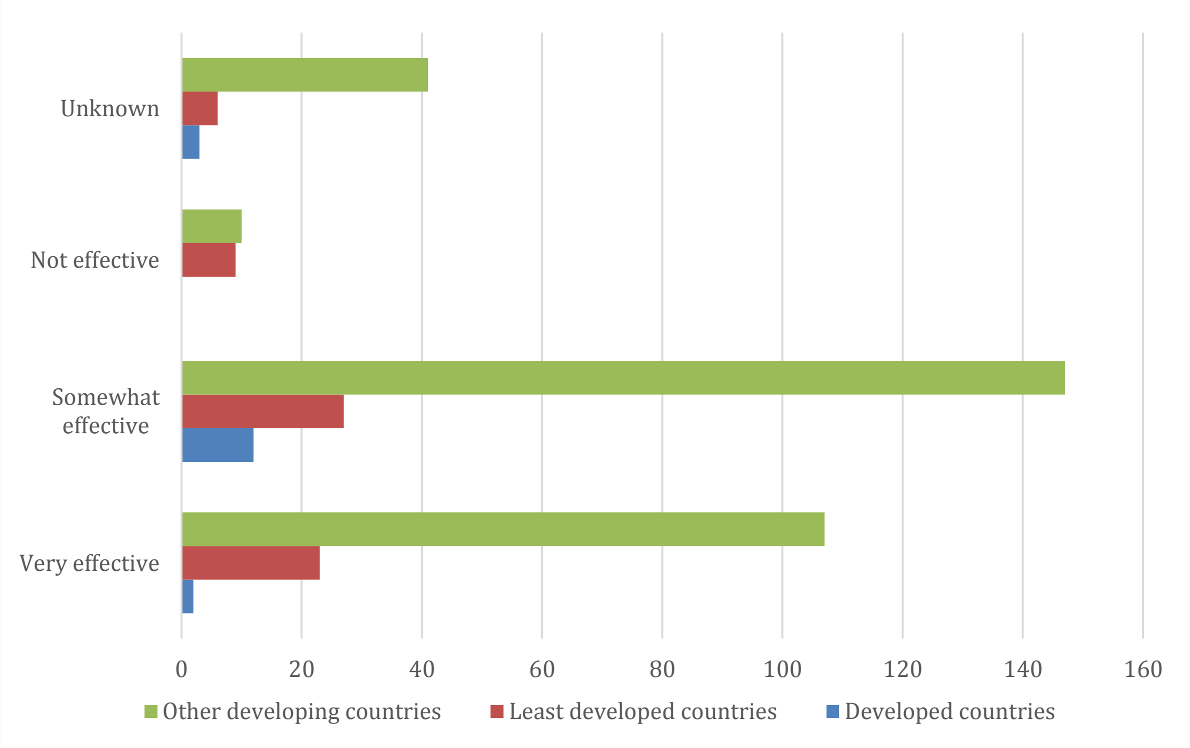
The Ramsar Convention in 1996 at its Sixth meeting of the Conference of the Contracting Parties adopted criteria based on fish for identifying wetlands of international importance thus allowing wetlands that support traditional fisheries and fishing communities to be included in the listing of wetlands of international significance. The Ramsar List is the world's largest network of protected areas with over 2,200 wetlands of international importance; these sites provide an excellent means of *in situ* conservation of AqGR. (Box 6).

Box 6. Examples of *in situ* conservation through Ramsar Sites and other protected areas (source: Country Reports)

To be completed on analysis of country reports for examples of Ramsar sites

Formally designated protected areas have been shown to be effective at conserving biological diversity in popular and scientific literature. Country reports confirmed this general statement (Figure 44). The trend was consistent regardless of economic class (to be confirmed). The results are heavily influenced by the reports from Tanzania, the Philippines and Columbia where a large number of protected areas were reported as being effective.

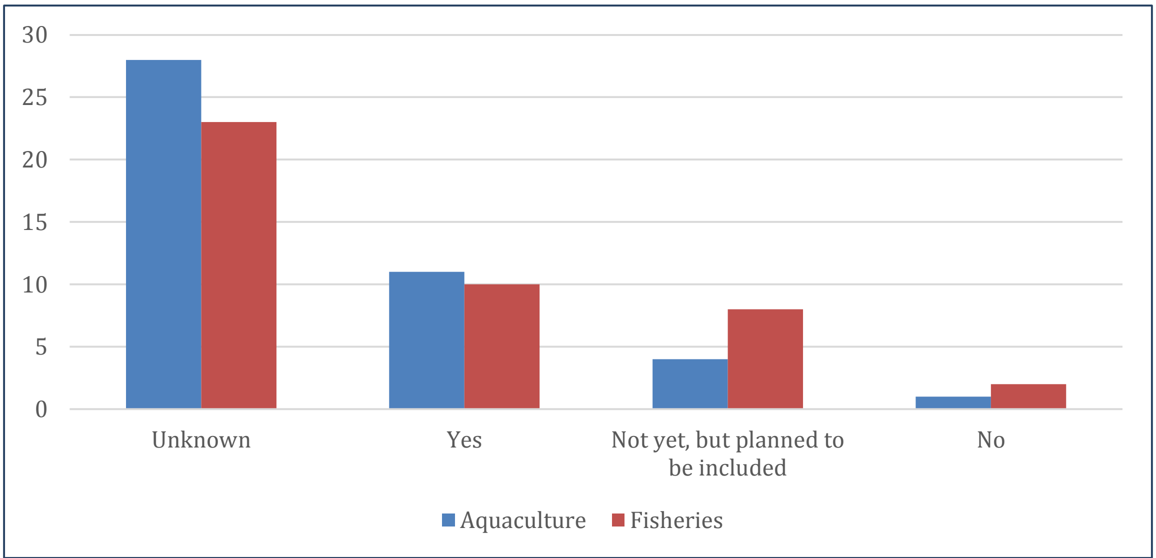
Figure 44. Effectiveness of *in situ* conservation (number of responses)



Fishery management can be considered *in situ* conservation under certain conditions. If the objective of the fishery management plan is to maintain natural populations of fish and the ecosystem that supports them, then this would qualify as *in situ* conservation (see below).

The Ecosystem Approach to Fisheries (EAF) (FAO 2003) encompasses such a broad view of fishery management and fishery managers around the world are adopting such an approach. However, policies and fishery management plans should explicitly state conservation as an objective. Countries are unclear on whether policies exist that explicitly include conservation as a goal for aquaculture facilities or for fishery management (Figure 45).

Figure 45. Conservation as an objective of aquaculture and fisheries policies (number of country responses)



Countries reported generally positive messages in regards to existing facilities, aquaculture and fisheries management, and collection of broodstock and early life history stages from the wild providing for effective *in situ* conservation. However, it was generally unknown whether *in situ* conservation was an objective in fishery and aquaculture management.

The 'not applicable' being reported indicated a lack of awareness of the role fisheries and aquaculture can play in conservation (Figures 46 & 47). Thus, objectives of *in situ* conservation should be explicitly stated in aquaculture and fisheries management policies and operating plans and communicated to resource managers, fishers and aquaculturists.

Figure 46. Contribution of existing fisheries and aquaculture management to *in situ* conservation (number of country responses)

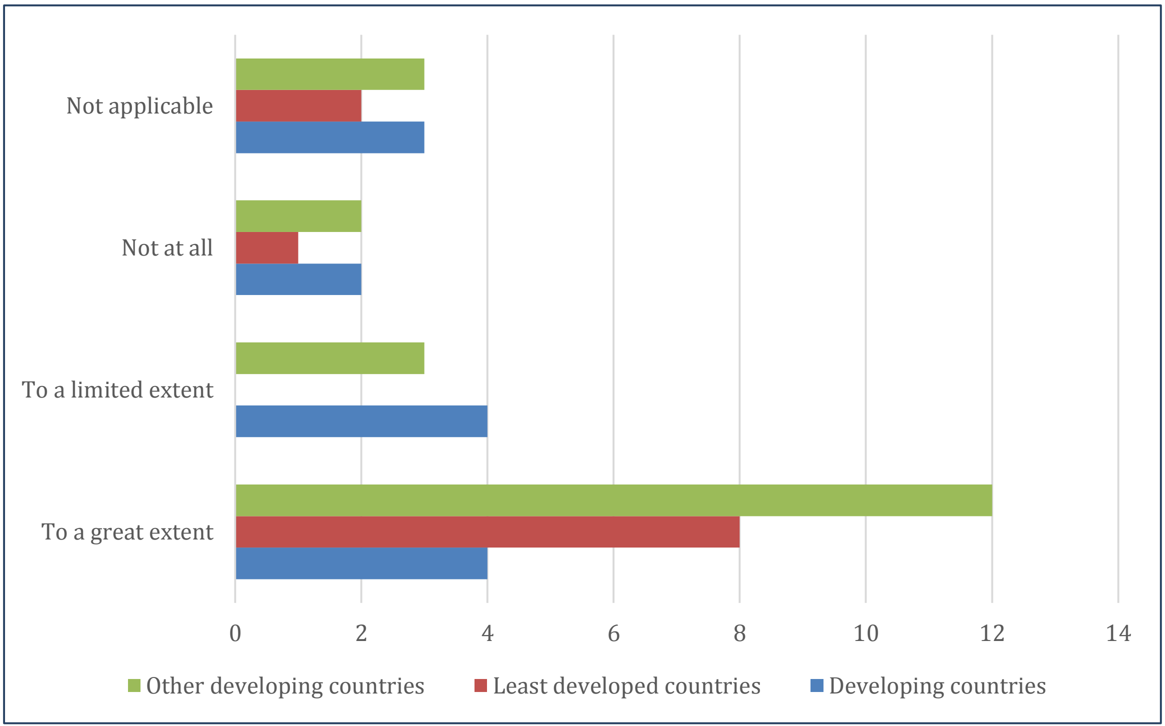
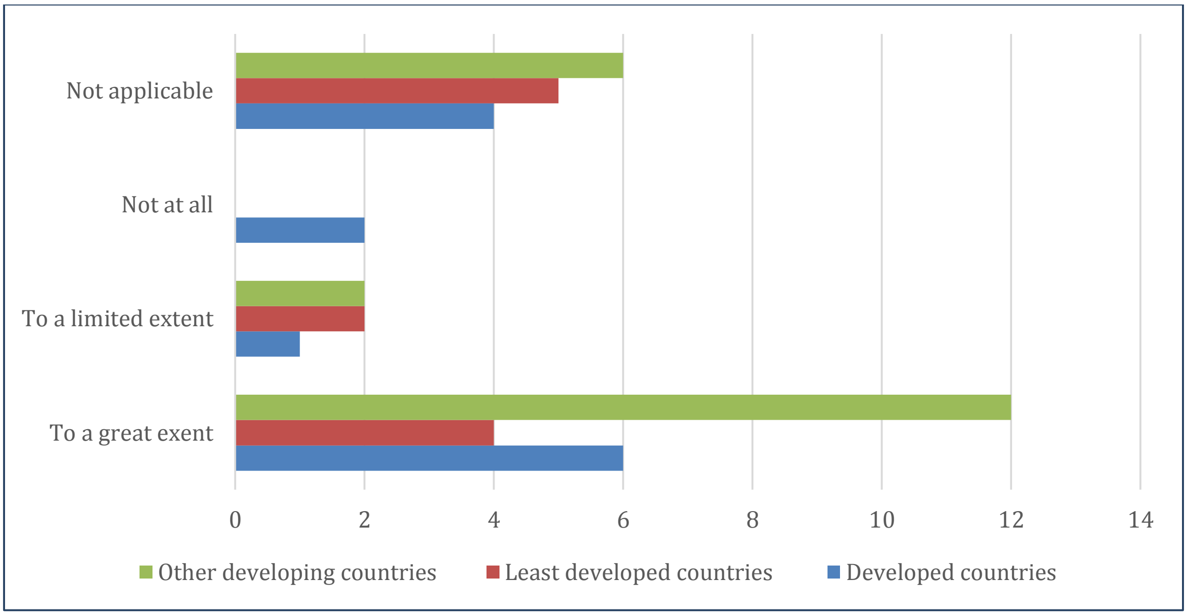


Figure 47. Contribution of collectors of wild broodstock and seed towards *in situ* conservation (number of country responses)



Additionally, awareness needs to be increased on national policies and conservation to determine if the policy framework is sufficient to address *in situ* conservation. If it is not sufficient it should be improved and if it is, increased implementation and awareness of the policies should be undertaken.

The objectives of a fishery management plan or an aquatic protected area should be clearly stated and would indicate whether they would be considered as *in situ* conservation. Fishery management plans that call for the introduction of non-native species, e.g. the introduction of non-native rainbow trout into high mountain lakes where they could prey on local fauna, or that support the selective removal of components of aquatic biodiversity, e.g. the removal of sea stars to enhance scallop growth, may increase the financial value of a fishery, but would not be a conservation measure.

MPAs have been promoted as a fishery management tool to maintain or rebuild capture fisheries. This provides a clear example of fishery management and conservation merging. This merge has not been without controversy however as the efficacy of MPAs as a tool for fishery management and increased fish production has been questioned (Adams et al 2004, Weigel et al). Human communities that depend on aquatic ecosystems and AgGR can play a large role in *in situ* conservation through responsible fisheries management (Kone 2012). However, there is often tension between those seeking more conservation from a protected area and those seeking more livelihood benefits.

Rice fields are an example of a modified ecosystem that can serve as *in situ* conservation of biological diversity if properly managed. In rice fields in Asia over 200 species, including fish, insects, crustaceans, molluscs, amphibians and reptiles have been recorded (Halwart and Bartley 2005). Integrated pest management (IPM) is a traditional practice in much of Asia that eliminates or reduces the amount of pesticides used and relies on natural enemies of pests and on beneficial species to facilitate production of rice. Country reports did not specifically mention rice fields as sources of *in situ* conservation, again indicating a lack of appreciation of the role modified ecosystems can play in conservation.

4.3 In situ conservation of farmed aquatic species

In situ conservation of farmed aquatic species essentially means 'on farm' conservation. This type of *in situ* conservation is less common in aquaculture than in agriculture due to the relatively recent domestication of most farmed aquatic species in relation to terrestrial agriculture.

Living on-farm gene banks of some species do exist that would qualify as *in situ* on farm conservation. However on farm *in situ* and on farm *ex situ* conservation are often difficult to distinguish. For the former, it would be necessary for the farm to maintain:

- A production environment,
- The desired species and
- No further genetic alteration or manipulation.

Thus the desired species would adapt to the production environment over time.

On farm *ex situ* conservation would require the farm to simply maintain the desired species in any kind of environment where no selection or genetic change would take place. Thus the desired species would not change over time because it was not in a production environment.

(The be completed on further analysis of country reports)

4.4 Key findings and conclusions

In situ conservation is the preferred method of conserving AqGR according to international agencies because it maintains the link between the resource and the environment regardless of whether that environment is in nature or on farm.
In situ conservation including marine and freshwater protected areas are widely promoted as effective conservation tools. The country reports support this conclusion, however results are strongly influenced by several countries with effective *in situ* conservation programmes.
The main objectives of *in situ* conservation were the *Provision of aquatic genetic diversity* and *Maintaining good strains for aquaculture production; To help adapt to impacts of climate change* and *Meeting market demands* were the least important objectives.
It is unclear if countries consider aquaculture and fisheries operations as important mechanisms for *in situ* conservation; even within a single country report contradictory information was provided on this question. The role of conservation was often seen as 'non-applicable' to existing aquaculture operations.
However, collectors of organisms from the wild for use in aquaculture were reported as playing a significant role in *in situ* conservation.
Increased awareness needs to be made on the role that well managed fisheries and aquaculture operations can play in *in situ* conservation of aquatic genetic resources.

(To be completed on analysis of additional country reports.)

4.5 References

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(To be completed)

5 EX SITU CONSERVATION OF AQUATIC GENETIC RESOURCES OF FARMED AQUATIC SPECIES AND THEIR WILD RELATIVES WITHIN NATIONAL JURISDICTION

PURPOSE: The purpose of this chapter is to review the current status and future prospects for the *ex situ* conservation of aquatic genetic resources of farmed aquatic species and their wild relatives. Specifically, this chapter will review:

- existing *ex situ* conservation of aquatic genetic resources of farmed aquatic species and their wild relatives in aquaculture facilities, culture collections and gene banks, research facilities, zoos and aquaria
- the contributions that various stakeholders are making to the *ex situ* conservation of aquatic genetic resources of farmed aquatic species and their wild relatives; and
- needs and priorities for the future development of *ex situ* conservation of aquatic genetic resources of farmed aquatic species and their wild relatives, including any that are threatened or endangered.

KEY MESSAGES:

- 70% of surveyed countries have current *ex situ* conservation programs.
- More than 344 aquatic genetic resources are the subject of *ex situ* conservation programs in 112 facilities among the 47 surveyed countries.
- There are significant differences regarding the number of facilities and aquatic genetic resources being maintained between sub-regions, being the South East Asian region the most important one at this regard.
- Certain differences are also observed between countries belonging to different economic classes, being the developed countries the nations with the highest number of *ex situ* programs and collections as well as species being maintained.
- 90% of the aquatic genetic resources being conserved are finfish (marine, freshwater and brackish water) while only 10% are invertebrates, mostly aquatic microorganisms such as small crustaceans, rotifers and microalgae.
- Most common uses for the conserved aquatic genetic resources are (1) direct human consumption and (2) used as live feed in aquaculture.
- Other important uses mentioned by countries are: conservation of aquatic diversity, restocking stock enhancement, recreational fisheries, potential uses in aquaculture, ornamental use, research, etc.
- Among the 112 facilities identified by surveyed countries, 63% of the facilities are research centres, 22 % are universities, 15% are zoo and aquaria and only 11% are aquaculture facilities.
- The most important of objective of the current *ex situ* conservation programs at National level for the 47 surveyed countries is the preservation of aquatic biodiversity, followed very closely by the maintenance of strains, stocks and lines for future improved breeds and aquaculture development.
- The less important objective of current *ex situ* conservation programs at National level for the 47 surveyed countries is the presentation of aquatic genetic resources for future adaptation to climate change.

5.1 Definitions

DNA	A self-replicating acid of very large molecular weight, which is the genetically active portion of a chromosome. It transmits genetic information from one cell generation to the next. It is comprised of deoxyribonucleotides containing the bases adenine, guanine,

	cytosine and thiamine. Single strand DNA (ssDNA) occurs in some viruses (usually as a closed circle). In eukaryotes and many viruses, DNA is double-stranded (dsDNA).
Embryo	The embryonic period begins after fertilization with the fusion of the two pronuclei of the zygote (caryogamy) or, in parthenogenetic or gynogenetic organisms, the triggering that begins cell division and ends with the first defined larval stage.
Ex situ conservation	According to the CBD, ex-situ conservation means "the conservation of components of biological diversity outside their natural habitats".
Gamete	Mature sex cell (egg or sperm), haploid, that unites with another gamete of the opposite sex to form a diploid zygote; such a union is essential for true sexual reproduction.
Gene	The basic unit of inheritance. Genes contain the blueprints that determine the production of phenotypes. Genes are located on chromosomes.
In vitro collection	Specimens maintained in a tissue culture laboratory rather than in the field; specimens are propagated clonally, therefore the strain and/or varietal genetics remain constant even when small populations are maintained. This is very different from sexual propagation, where genetic drift and small population size is a constant consideration in maintaining each variety's genetic diversity.
Species	In biology, a species (abbreviated sp., with the plural form species abbreviated spp.) is one of the basic units of biological classification and a taxonomic rank. A species is often defined as the largest group of organisms capable of interbreeding and producing fertile offspring.
Spore	A reproductive cell or body usually protected from the environment by one or more protective membranes, capable of developing into a new organism asexually, without fusing with another reproductive cell. Bacteria, fungi, some protozoans, and plants (e.g. seaweed), produce spores. In pathology: infective stage of an organism.
Stock	In fisheries: a quantity of fish considered in a given situation.
Strain	A group of organisms of the same species displaying certain differential traits based on parental lineage; that either come from the same area, e.g. the same catchment area of a river, or are the result of a particular breeding programme (exists as an interbreeding unit with no introductions from external sources).
Tissue	An aggregate of similar cells and cell products forming a definite kind of structural material with a specific function, in a multicellular organism.
Variety	Group of similar organisms within a species that clearly differs from other member of the species. Organisms of one variety transmit their characteristics to their offspring, but are also capable of interbreeding with other varieties within the same species. Term usually restricted to plant species.

5.2 Background

Because of the short history of domestication, breeding programmes and related research for most farmed aquatic organisms, the free-living populations of their wild and feral relatives and of other potentially farmable aquatic species have high importance as genetic resources. Many of these free-living populations, especially in freshwaters, are among the world's most seriously threatened biodiversity; for example, the wild genetic resources of farmed carps and tilapias.

Moreover in aquaculture, as in agriculture, most private sector seed producers and farmers keep only the most profitable farmed species and types, leaving others under threat of extinction. The use in aquaculture production and related research of alien species and of genetically altered forms (e.g. distinct strains, hybrids, polyploids, trangenes etc., whether developed from alien and/or indigenous species) is certain to increase. This will require more effective biosafety and biosecurity procedures than have been implemented to date, particularly with respect to thorough appraisal of the impacts of escapes and releases of farmed aquatic organisms before granting approvals for introductions and transfers, as well as strictly enforced quarantine.

These trends indicate an urgent need for better management – meaning fully integrated use and conservation – of aquatic genetic resources for aquaculture: *in situ* /in vivo, as free-living, wild and feral populations; *in situ* /in vivo, as captive populations on-farm; ex situ/in vitro, as collections of cryopreserved sperm, embryos and other tissues/DNA; and ex situ/in vivo as aquarium and research populations. This will require increased investment in the management of AqGR, commensurate with their high and growing contributions to world food security,

Keeping representative, free-living wild populations of farmed fish species undisturbed in their natural habitats and off-limits to aquaculture and to contact with farmed fish, has operational and opportunity costs. Therefore, unless there is equitable sharing of costs and benefits among the stewards and potential users of such aquatic genetic resources for aquaculture, the conservation element in their management will not be achieved. Establishing and maintaining ex situ, in vivo and/or in vitro, fish gene banks is also expensive and will require public and private sector investment and partnerships.

5.3 In situ versus *ex situ* conservation

Conservation techniques can be grouped into two basic, complementary strategies: *in situ* and ex situ. As also outlined in the articles 8 and 9 of the Convention of Biological Diversity (CBD), biodiversity is conserved by two major methods called *in situ* and ex situ. The conservation efforts, either *in situ* or ex situ, involve the establishment and management of protected areas and relevant research institutes or academic institutions, which establish and manage botanical or zoological gardens, tissue culture, and gene banks.

The concept of *ex situ* conservation is fundamentally different from that of *in situ* conservation; however, both are important complementary methods for conservation of biodiversity. The principal difference (and hence the reason for the complementarities) between the two lies in the fact that *ex situ* conservation implies the maintenance of genetic materials outside of the "normal" environment, where the species has evolved and aims to maintain the genetic integrity of the material at the time of collection, whereas *in situ* conservation (maintenance of viable populations in their natural surroundings) is a dynamic system, which allows the biological resources to evolve and change over time through natural or human-driven selection processes.

5.3.1 Ex situ conservation

Ex situ conservation is a technique of conservation of biological diversity outside its natural habitats, targeting all levels of biodiversity such as genetic, species, and ecosystems. Its concept was developed earlier before its official adoption under the Convention on Biological Diversity signed in 1992 in Rio de Janeiro. In general, *ex situ* conservation is applied as an additional measure to supplement *in situ* conservation, which refers to conservation of biological diversity in its natural habitats.

In some cases, *ex situ* management will be central to a conservation strategy and in others it will be of secondary importance. Broadly, *ex situ* conservation includes a variety of activities, from managing captive populations, education and raising awareness, supporting research initiatives and collaborating with *in situ* efforts. It is used as valuable tools in studying and conserving biological resources for different purposes through different techniques such as zoos, captive breeding, aquarium, botanical gardens, and gene banks

5.3.2 Types of *ex situ* conservation

Zoos	Zoos or zoological gardens or zoological parks in which animals are confined within enclosures or semi-natural and open areas, displayed to the public, and in which they may also breed. They are considered by universal thinkers and environmentalists as important means of conserving biodiversity.
Capture breeding	Captive breeding is an integral part of the overall conservation action plan for a species that helps to prevent extinction of species, subspecies, or population. It is an intensive management practice for threatened individuals, populations, and species by anthropogenic and natural factors. In small and fragmented populations, even if the human caused threats could be magically reversed, the species would still have a high probability of extinction by random demographic and genetic events, environmental variations, and catastrophes. Thus, under sufficient knowledge on the biology and husbandry of the species, captive breeding helps individuals in the relative safety of captivity, under expert care and sound management by providing an insurance against extinction.
Aquarium	An aquarium is an artificial habitat for living aquatic organisms. The 15,750 described species of freshwater fish comprise around 25% of living vertebrate species diversity and a key for global economic and nutritional resources of which more than 11% is threatened (60-extinct, 8-extinct in the wild and 1679-threatened). Fresh waters (0.3%) of available global surface water support 47–53% of all extant fish species that are threatened by overfishing, pollution, habitat loss, damming, alien invasive species, and climate change. However, despite the clear value of freshwater fish diversity, wetland habitats and their associated freshwater-fish species continue to be lost or degraded at an alarming rate. One recommendation is for aquariums to set up sustainable breeding program that prioritizes threatened species (VU, EN, and CR) and those classified as EW to support species conservation *in situ* and aid the recovery of species via collaborative reintroduction or translocation efforts when appropriate
Gene banks	Genome resource banking is another management technique used for biodiversity conservation. Different types of gene banks have been established for the storage of biodiversity, depending on the type of materials conserved. These include seed banks (for seeds), field gene banks (for live plants), in vitro gene banks (for plant tissues and cells), pollen, chromosome, and deoxyribonucleic acid (DNA) banks for animals (living sperm, eggs, embryos, tissues, chromosomes, and DNA) that are held in short term or long term laboratory storage; usually cryopreserved or freeze-dried.

5.3.3 Advantages of *ex situ* conservation

It is generally preferred to conserve threatened species *in situ* , because evolutionary processes are more likely to remain dynamic in natural habitats. However, considering the rate of habitat loss worldwide, *ex situ* conservation is becoming increasingly important. Furthermore, as many of the taxa are located outside natural habitats, *in situ* measures are not enough to assure their conservation. On the other hand, translocation, introduction, reintroduction, and assisted migrations are conservation strategies that are attracting increasing attention, especially in the face of climate change.

5.3.4 Disadvantages of *ex situ* conservation

Living organisms populations kept in captivity can deteriorate due to many reasons, for example: loss of genetic diversity, inbreeding depression, genetic adaptations to captivity, and accumulation of deleterious alleles. In the case of aquatic plants, ecological shifts, small population size, genetic drift, inbreeding, and gardener-induced selection may negatively affect population structure after several generations of *ex situ* cultivation. These factors could seriously put at risk the success of *ex situ* conservation programs. Furthermore, it is recognized that *ex situ* conservation has many constraints in terms of personnel, costs, and reliance on electric power sources (especially in many developing countries where electricity power can be unreliable) for gene banks. It requires high facilities and financial investments. It cannot also conserve all of the thousands of plant and animal species that make up complex ecosystems. Capture of individuals from the wild for captive breeding or translocation sometimes can have detrimental effects on the survival prospects of the species as a whole through biosecurity constraints.

5.3.5 Challenges of *ex situ* conservation programs

Ex situ conservation requires different kinds and levels of intensity of management, and a multi-stakeholder approach like the input from experts on aquarium husbandry, *ex situ* breeding, gene-banking, reintroduction, and habitat restoration. Other expert input may include taxonomy, ecology and conservation, ethnography, and sociology. For outreach program, there is a need to liaise with local communities and national government fisheries and wildlife departments; with international (nongovernmental and intergovernmental) conservation bodies. The most important challenges of applying *ex situ* conservation are the difficulty in recognizing the right time, identifying the precise role of the conservation efforts within the overall conservation action plan, and setting realistic targets in terms of required time span, population size, founder numbers, resources, insurance of sound management and cooperation, and the development of new technical methods and tools. Problems associated with small founder populations such as inbreeding depression, removal of natural selection, and rapid adaptation to captivity pose considerable challenges for managers of captive populations of threatened species.

5.4 Existing and planned collections of live breeding individuals of aquatic genetic resources of farmed aquatic species and their wild relatives

Countries were asked to provide a detailed list of their respective country's existing collections of live breeding aquatic organisms that can be considered as contributing to the *ex situ* conservation of aquatic genetic resources, including not only collections of species farmed directly for human use, but also collections of live feed organisms and collections of aquatic organisms devoted to other uses.

5.4.1 Existing and planned collections: general overview

A total of 33 countries out of 47 countries (70 % of the surveyed countries) have current *ex situ* conservation activities being implemented at National Level for aquatic living organisms of National relevance. A total of 344 aquatic species are being maintained in 112 *ex situ* collection in these 33 countries, which means that an average of 10.5 aquatic species are maintained in *ex situ* conservation programs per country in 3.3 *ex situ* conservation facilities per country. Table 39 shows the list of countries where *ex situ* programs are being implemented and the number of species maintained in each respective country. Countries with the largest number of species being kept in *ex situ* conservation facilities have been marked in red color in table 1, being those countries Colombia and Peru. Detailed information regarding specific species being maintained, main uses of maintained species, facilities were these resources are kept and level of threat of conserved species is provided below in following chapters.

Table 39. Countries with *ex situ* conservation programs in place and number of aquatic species maintained in each country

Countries	Count of species	Countries	Count of species
Belize	1	Kenya	3
Benin	5	Korea, Republic of	2
Burkina Faso	3	Latvia	1
Cambodia	4	Malawi	5
Canada	1	Malaysia	8

Chile	1	Mozambique	1
Colombia	78	Nicaragua	1
Costa Rica	12	Peru	70
Czech Republic	2	Philippines	20
El Salvador	2	Senegal	9
Estonia	7	Sweden	1
Germany	7	Tanzania, United Rep. of	4
Ghana	3	Thailand	6
Guatemala	2	Ukraine	7
India	15	Viet Nam	20
Iran (Islamic Rep. of)	11	Zambia	10
Japan	22		

5.4.2 Endangered species

Countries were also asked to include whether the species being maintained in *ex situ* conservation facilities are threaten or considered as endangered at national and/or international levels. 12 countries indicated the maintenance of threatened/endangered aquatic genetic resources in their *ex situ* conservation facilities (12 countries out of the 33 countries that have *ex situ* conservation facilities). There is a total of 100 endangered aquatic species being conserved under *ex situ* conservation programs. Table 40 provides a summary of these 12 countries and the % of threatened/endangered genetic resources being maintained in each country compared to the total number of aquatic genetic resources maintained. It should be noted that certain countries, such as Guatemala and Czech Republic have *ex situ* conservation programs in place that are devoted to endangered National species in exclusivity. Table 41 contains a detailed list of endangered aquatic species being maintained in *ex situ* conservation programs.

Table 40. Endangered aquatic species maintained in *ex situ* conservation programs

Countries	Total species	Endangered species	% Endangered
Cambodia	4	3	75
Colombia	78	49	63
Czech Republic	2	2	100
Germany	7	4	57
Guatemala	2	2	100
India	15	10	67
Japan	22	2	9
Malaysia	8	1	13
Philippines	19	7	37
Thailand	6	5	83
Ukraine	7	5	71
Viet Nam	20	10	50

Table 41. Detailed list of endangered aquatic species being maintained in *ex situ* conservation programs

Species	Countries	Species	Countries
Acipenser stellatus	2	*Lutjanus argentriventris*	1
Huso huso	2	*Lutjanus guttatus*	1
Acipenser gueldenstaedtii	1	Machorra	1
Acipenser persicus	1	Maxima clam *(Tridacna maxima)*	1

Acipenser ruthenus	1	*Mesonauta sp*	1
Acipenser sturio	1	*Monocirrhus polyacanthus*	1
Acipenser oxy-rinchus	1	*Naziritor chelynoides*	1
Aipenser nudiventris	1	*Osteoglossum bicirhosum*	1
Alosa alosa	1	*Osteoglossum ferreirae*	1
Apteronotus albifrons	1	*Pangasianodon gigas*	1
Apteronotus lepyorhyynchus	1	*Pangasianodon hypothalamus*	1
Arapaima gigas	1	*Pangasius krempfi*	1
Astacus astacus	1	*Pangasius kunyit*	1
Astronotus ocellatus	1	*Paracheirodon axelrodi*	1
Atractosteus tropicus	1	*Piaractus brachypomus*	1
Bear paw clam *(Hippopus hippopus)*	1	*Pimelodus grosskopfii*	1
Black Teatfish (*Holothuria fuscolgiva*)	1	*Plesiotrygon iwamae*	1
Boring giant clam *(Tridacna crocea)*	1	*Potamotrygon aireba*	1
Brycon henni	1	*Potamotrygon constellata*	1
Caquetaia kraussi	1	*Potamotrygon hystrix*	1
Caquetaia umbrifera	1	*Potamotrygon magdalenae*	1
Catiocarpio siamensis	1	*Potamotrygon motoro*	1
China clam *(Hippopus porcelanus)*	1	*Potamotrygon orbignyi*	1
Cichla intermedia	1	*Potamotrygon schoederi*	1
Cichla ocellaris	1	*Prachtocephallus hemiliopterus*	1
Cichla orinocensis	1	*Prochilodus magdalenae*	1
Colossoma macropomum	1	*Pseudoplatystoma fasciatum*	1
Crayfish	1	*Pseudoplatystoma magdalenensis*	1
Datnioides spp.	1	*Pseudoplatystoma metaense*	1
Epinephelus itajara	1	*Pseudoplatystoma orinocense*	1
Epinephelus quinquefasciatus	1	*Pterophylum scalare*	1
Fluted giant clam (Tridacna squamosa)	1	*Pyropia tenera*	1
Giant carp	1	*Pyropia tenuipedalis*	1
Giant catfish *(P. gigas)*	1	*Salmo salar*	1
Giant clam *(Tridacna gigas)*	1	*Salmo trutta caspius*	1
Glithoperthystis sp	1	*Scleropages formosus*	1
Groupers (*Epinephelus* sp)	1	*Siamese tigerfish*	1
Hemigrammus sp	1	*Simbranchus marmoratus*	1
Heros severum	1	*Sorubimichtys sp*	1
Horabagrus brachysoma	1	Southern clam *(Tridacna derasa)*	1
Hucho hucho	1	Spanner crab	1
Humphead carp	1	*Spot pangasius*	1
Hyphessobrycon metae	1	*Symphysodom discus*	1
Hyphessobrycon sp	1	*Systomus sarana*	1
Icthiolephas longirostris	1	*Probarbus jullieni*	1
L. calbasu	1	*Tor khudree*	1
L. dussumieri	1	*Tor mahanadicus*	1
L. fimbriatus	1	*Tor putitora*	1

Leiarius marmoratus	1	*Tor tor*	1
Litopennaeus vannamei	1	*Zungaro zungaro*	1

5.4.3 Main species being conserved

As it has been mentioned in previous section, among the 47 surveyed countries there are 344 aquatic specie being maintained in *ex situ* conservation facilities in 33 surveyed countries. The most common species being conserved are included in Table 42 detailed below.

Table 42. Most common aquatic species being conserved in *ex situ* conservation programs (N = Number of countries)

Species	N	Endangered or threatened	Species	N	Endangered or threatened
Oreochromis niloticus	5	No	*Heterosigma akashiwo*	2	Unknown
Clarias gariepinus	4	No	*Huso huso*	2	Yes
Isochrysis galbana	4	No	*Nannochloropsis oculata*	2	No
Oreochromis niloticus	4	No	*Oncorhynchus mykiss*	2	No
Rotifers (*Brachyionus plicatilis*)	3	No	*Prorocentrum micans*	2	Unknown
Acipenser stellatus	2	Yes	*Salmo salar*	2	Unknown
Brachionus plicatilis	2	No	*Scrippsiella trochoidea*	2	Unknown
Brachionus rotundiformis	2	No	*Shewanella putrefacies*	2	No
Chaetoceros sp.	2	No	*Tilapia rendalli*	2	No
Haematococcus pluvialis	2	Unknown			

Further, detailed information regarding the most important genus for *ex situ* conservation and their uses at national level is provided in Table 43.

It should be noted that 90% of the aquatic genetic resources conserved are finfish species and 10% are aquatic microorganisms, such as rotifers and microalgae. Finfishes are maintained both for direct human consumption and as live feed for aquaculture, while the microorganisms are used as live feed for aquaculture in most cases.

Table 43. Most important genus in *ex situ* conservation and their uses

Species	Number of countries	Type of use
Oreochromis niloticus	5	Direct human consumption
Oreochromis niloticus	2	Live feed organism
Heterotis niloticus	1	Direct human consumption
O. niloticus lake victoria strains	1	Direct human consumption
Oreochromis niloticus.	1	Direct human consumption
Clarias gariepinus	4	Direct human consumption
Clarias anguillaris	1	Direct human consumption
Clarias ngamensis	1	Direct human consumption
Clarias anguillaris	1	Live feed organism
Clarias gariepinus	1	Live feed organism
Brachionus plicatilis	2	Live feed organism
Brachionus rotundiformis	2	Live feed organism
Brachionus sp.	1	Live feed organism
Planktonic rotifers *(Brachionus sp.)*	1	Live feed organism
Rotifers *(Brachionus sp.)*	1	Live feed organism

Brachionus sp.	1	Other

5.4.4 Main uses of conserved species

Countries were asked to provide the main destination/use of each conserved aquatic species, including: used as live feed, used for direct human consumption and others. From the 344 species, 71 species are used as live feed (20% of the species); 133 species are used for direct human consumption (39% of the species), and 140 species are devoted to other uses (41% of the species), such as: future domestication or potential use in aquaculture; conservation of aquatic biodiversity; potential use as ornamental species; pharmaceutical uses; spat monitoring; restocking and stock enhancement purposes; recreational fisheries; research, among many other uses.

Tables 44 and 45 detailed below provide the list of species used as live feed and devoted to human consumption, respectively. Figure 46 shows the distribution of uses.

Figure 46. Uses of *ex situ* conserved aquatic species (Percent)

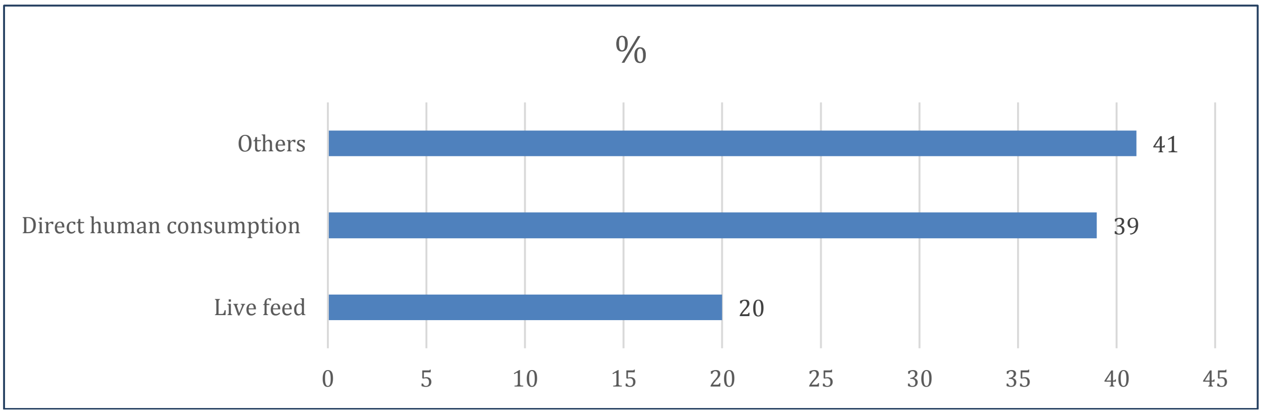


Table 44. Species used as live feed organisms for aquaculture activities

	Species	Number of countries
Rotifers	*Brachionus plicatilis*	2
	Brachionus rotundiformis	2
	Rotifers *(Brachyionus plicatilis)*	2
	Brachionus sp.	1
Artemia	*Artemia franciscana*	1
	Artemia salina	1
	Artemia urmiana	1
	Isochrysis galbana	4
Copepods	Copepodes *(Thermocyclops sp.)*	1
Cladocerans	Cladocerans	1
	Daphnia moina	1
	Daphnia pulex	1

Microalgae	*Tetraselmis tetrahele, Dunaliela tertiolecta, Nannocloropsis occulata, Chaetoceros gracilis, Skeletonema costatum, Nitzschia alba, Chlorella vulgaris*	1
	Chaetoceros lorenziano	1
	Chaetoceros compressus	1
	Chaetoceros debilis	1
	Chaetoceros socialis	1
	Chlorella sp	1
	Dendrocephalus affinis	1
	Diaphanosoma	1
	Dunaliela sp.	1
	Ankistrodermus sp	1
Cyanobacterium	*Spirulina spp.*	1
Live fish	*Clarias anguillaris*	1
	Clarias gariepinus	1
	Oreochromis niloticus	2

Table 45. Main conserved species used for direct human consumption

Species	Number of countries	Species	Number of countries
Oreochromis niloticus	5	Black Teatfish *(Holothuria fuscolgiva)*	1
Clarias gariepinus	4	*Brycon amazonicus*	1
Acipenser stellatus	2	*Brycon henni*	1
Common carp	2	*Brycon moorei*	1
Huso huso	2	*Brycon siebenthalae*	1
Lutjanus guttatus	2	*C. gariepinus*	1
Oncorhynchus mykiss	2	*Caquetaia kraussi*	1
Tilapia rendalli	2	*Caquetaia umbrifera*	1
Acipenser gueldenstaedtii	1	*Catla catla*	1
Acipenser persicus	1	*Chelon labrosus*	1
Acipenser ruthenus	1	*Chinese silver carp*	1
Ageniosus pardallils	1	*Cichla intermedia*	1
Aipenser nudiventris	1	*Cichla ocellaris*	1
Arapaima gigas	1	*Cichla orinocensis*	1
Atractosteus tropicus	1		

5.5 In vitro collection

This section presents a global assessment of "*ex situ* and in vitro" (as collections of cryopreserved sperm, embryos and other tissues/DNA) of farmed aquatic genetic resources and their wild relatives, including an overview of existing and planned in vitro conservation programs, main species being preserved, main uses, type of genetic material being preserved and facilities where these material is being maintained. These data is being assessed with a regional, sub-regional and economic class perspective in certain cases.

5.5.1 Introduction

This section provides a global review of existing *ex situ* conservation activities of aquatic genetic resources of farmed aquatic species and their wild relatives in vitro. In vitro collection has been defined for the purpose of this study as specimens maintained in a tissue culture laboratory rather than in the field; specimens are propagated clonally, therefore the strain and/or varietal genetics remain constant even when small populations are maintained. This is very different from sexual propagation, where genetic drift and small population size is a constant consideration in maintaining each variety's genetic diversity.

5.5.2 Existing and planned in vitro collections: general overview

Countries were asked to provide a detailed list of in vitro collections and gene banks of gametes, embryos, tissues, spores and other quiescent forms of farmed aquatic species and their wild relatives, using cryopreservation or other methods of long-term storage. Furthermore, countries were also requested to describe major examples, identifying the facilities in which the collections are held, and including examples of any such genetic material from the country that is being kept in in vitro collections outside the country, on behalf of beneficiaries in your country. 20 countries out of 47 surveyed countries reported in vitro collections of aquatic genetic resources, both farmed and wild relatives. This means that 20% of the surveyed countries have in vitro collections in place nowadays. A total of 95 aquatic species are being maintained in these 20 collections. Table 46 below provides the list of 22 countries and the number of aquatic species being maintained in each respective country.

The country with the largest number of species being maintained in vitro collections is India, followed by Germany and Czech Republic. In average there are two aquatic species being maintained by country in in vitro conservation programs.

Table 46. Countries and number of species maintained *in vitro* collections

Country	Count of species in in vitro collections	Country	Count of species in in vitro collections
India	34	Tonga	2
Germany	14	Ukraine	2
Czech Republic	9	Belize	1
Colombia	8	Brazil	1
Senegal	6	Chile	1
Malaysia	3	Costa Rica	1
Thailand	3	Iran (Islamic Rep. of)	1
Kiribati	2	Kenya	1
Korea, Republic of	2	Latvia	1
Philippines	2	Mozambique	1

Table 47 and Table 48 provide the average number of species maintained per country by sub-region and by economic class. Important differences are observed between sub-regions, being the countries belonging to the South-East Asian Region the nations with the largest number of in vitro collections and the largest number of aquatic genetic resources maintained in this type of collections.

Table 47. *In vitro* collection – distribution by region and average number of species

Geographical regions	Count of species	Average number of species by region
Southern Asia	35	18
South-Eastern Asia	8	3
Eastern Asia	2	2
Western Europe	14	14
Eastern Europe	11	6

Northern Europe	1	1
South America	10	3
Central America	2	1
Eastern Africa	2	1
Western Africa	6	6
Micronesia	2	2
Polynesia	2	2

The most common uses of the conserved species in this sub-region are: direct human consumption, used as live feed for aquaculture, conservation, restocking and stock enhancement, in this order.

Regarding differences by economic class, it should also be noted that developed country have a higher average number of aquatic genetic resources per country compared to least developed or other developing countries, while the differences are not as important as between regions.

Table 48. In vitro collection – distribution by economic class and average number of species

Economic class	Count of species	Average number of species
Developed countries or areas	26	7
Least Developed Countries	9	3
Other developing countries or areas	60	5

5.5.3 Main species being conserved

Table 48 provides a summary of main species being conserved in vitro conservation programs. 20 of the 95 species listed by countries have been included. The assessment of these species shows that the principal use of the species conserved is for direct human consumption. Furthermore, Table 49 provides the list of all countries and species being maintained in each of the country. It should be noted that enormous differences are observed regarding the nature of aquatic genetic resources being preserved in different countries and regions.

The selection criteria for aquatic genetic resources of national relevance that should be preserved in in vitro collections is very heterogeneous and variable from country to country and from region to region. The assessment of surveyed country reports has shown that developed countries are preserving a certain number of species for pure research and conservation of biological diversity, while least developed and other developing countries are giving higher relevance to aquatic genetic resources of potential use/domestication, as live feed for aquaculture or devoted to direct human consumption. Detailed information on the main objectives of the *ex situ* conservation programs at global, sub-regional and by economic class levels is provided below in Section 5.6 of this chapter.

Table 49. Summary of the most important species conserved in in vitro collections

Chaetoceros mulleri	*Acipenser sturio*
Cyprinus carpio	Acipenser oxyrinchus
Silurus glanis	Scophthalmus maximus
Isocrysis galvana	Puntius carnaticus
Indigenous freshwater fish species	Oreochromis niloticus
Clarias magur	Acipenser ruthenus
Dicentrarchus labrax	*Oncorhynchus mykiss*
Huso huso	*Mugil cephalus*
Heteropneustes fossilis	*Sorubim cuspicaudus*
Horabagrus brachysoma	*Acipenser oxyrichus*

L. rohita	*Puntius chalakkudiensis*
Pangasianodon gigas	*Garra surendranathanii*
Rachycentron canadum	*Wallago attu*
Leiarius marmoratus	*Pseudoplatystoma sp*
Salmo trutta	*Chitala chitala*
Prochilodus sp	

5.5.4 Preservation mechanisms

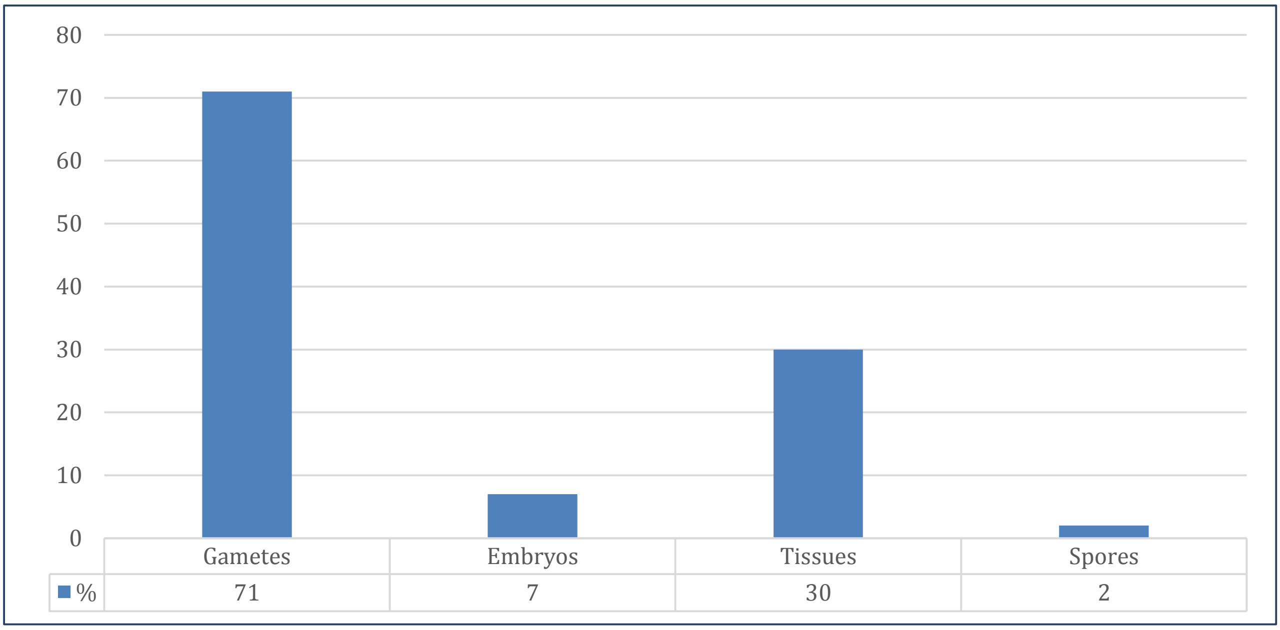
In this section countries were asked to provide information on the in vitro preservation mechanisms and strategies used for each specific species. As a result of this assessment, it was observed that:

- more than 70% of species are maintained in the form of gametes (mostly in the case of finfish species – marine, freshwater and brackish water)
- 29 % of the species are conserved as tissues (mostly freshwater finfish species)
- 7% of the species are conserved as embryos (with a wide range of genus and species, including finfish, mollusks and crustaceans, such as Artemia, oysters and mullets);
- Only 2% are conserved in the form of spores (obviously this methodology is mostly being applied in the case of microalgae).

Table 50. Summary of the number of species being maintained with each mechanisms, including the percentage (Figure 47).

Total species	95	Percentage
In vitro collection of gametes	67	71
In vitro collection of embryos	7	7
In vitro collection of tissues	29	31
Spores	2	2

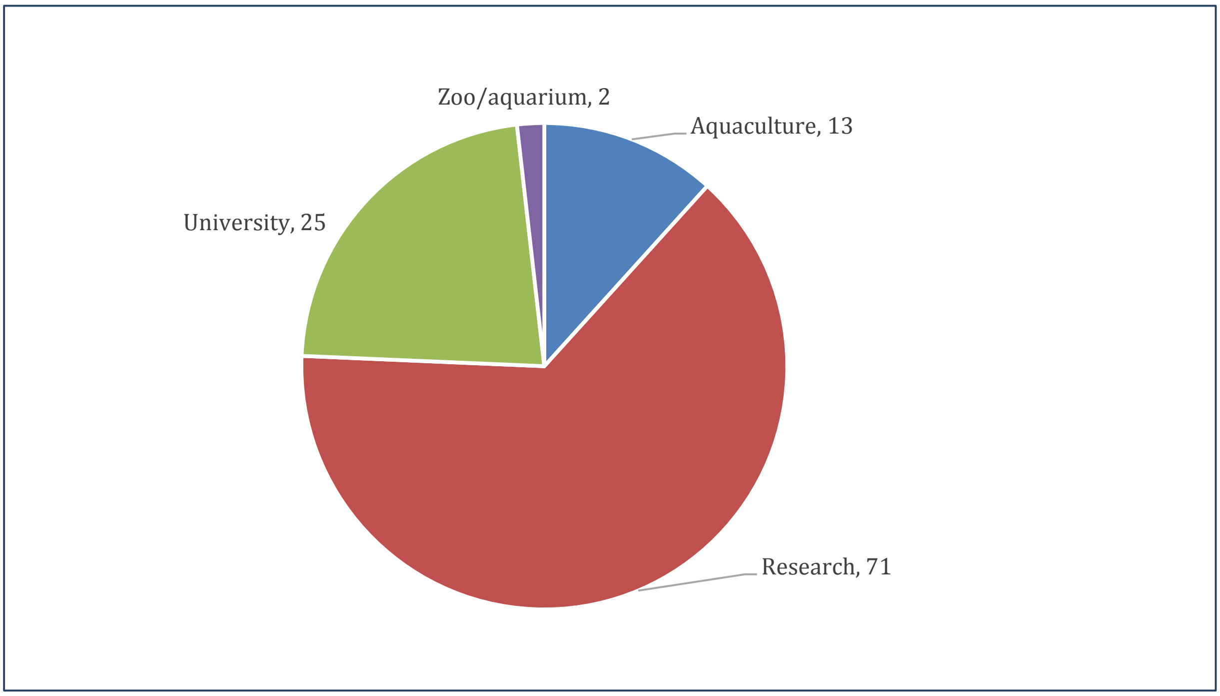
Figure 47. Number of species being maintained with each mechanisms (percent)



5.5.5 Facilities for in vitro conservation

Among the 112 facilities identified by surveyed countries, 63% of the facilities are research centers, 22 % are universities, 15% are zoo and aquaria and only 11% are aquaculture facilities (Figure 48).

Figure 48. Distribution of *ex situ* conservation facilities



5.6 Global assessment of objectives of *in situ* conservation programs in the world

Countries were requested to assess the level of importance of the following objectives of *ex situ* conservation programs in their respective countries, with special emphasis on the scope of this study, farmed species and their wild relatives:

- Preservation of aquatic genetic diversity.
- Maintain good strains for aquaculture production.
- Meet consumer and market demands.
- To help adapt to impacts of climate change.
- Future breed improvement in aquaculture.

Objectives were ranked from 1 to 10, being 1 a very important objective of the overall (covering all aquatic genetic resources) national *ex situ* conservation programs, and being 10 the less important objective of the national *ex situ* conservation program.

While all the objectives were ranked very high in the ranking, there are clear differences between them: the most important objective at global level is the preservation of aquatic genetic diversity, followed very closely with the use of these resources for future breed improvement in aquaculture and for the maintenance of good strains for current and future aquaculture production.

Table 51. Ranking of objectives of *ex situ* conservation programs

Objectives of *ex situ* conservation	Average Rank (1: very important; 10: no importance)
Other	0.43
Preservation of aquatic genetic diversity	2.07

Future breed improvement in aquaculture	2.63
Maintain good strains for aquaculture production	2.65
Meet consumer and market demands	3.82
To help adapt to impacts of climate change	3.87

The less important objective of national *ex situ* conservation programs at global level is the need to maintain these resources for future adaptation to climate change. Table 51 provides the global overview of these objectives and Table 52 provides an assessment by economic class.

Table 52. Objectives of *ex situ* conservation programs by economic class (the economic areas where the objective has been ranked with the higher score have been marked in bold)

Objectives of *ex situ* conservation	Description	Country count	Average Rank
Preservation of aquatic genetic diversity	Developed countries or areas	9	4.22
	Least Developed Countries	11	1.73
	Other developing countries or areas	26	1.46
Maintain good strains for aquaculture production	Developed countries or areas	9	4.89
	Least Developed Countries	11	1.55
	Other developing countries or areas	26	2.35
Meet consumer and market demands	**Developed countries or areas**	**9**	**5.22**
	Least Developed Countries	11	3.55
	Other developing countries or areas	**26**	**3.54**
To help adapt to impacts of climate change	Developed countries or areas	9	4.22
	Least Developed Countries	**11**	**4.82**
	Other developing countries or areas	26	3.35
Future breed improvement in aquaculture	Developed countries or areas	9	5.11
	Least Developed Countries	11	1.91
	Other developing countries or areas	26	2.08
Other	Developed countries or areas	9	0.00
	Least Developed Countries	11	1.09
	Other developing countries or areas	27	0.30

5.7 Key findings and conclusions

There are regional differences	There are significant differences regarding the number of facilities and aquatic genetic resources being maintained between sub-regions. The South East Asian region being the most important one in this regard.
There are differences between economic classes of country	Certain differences are also observed between countries belonging to different economic classes. Developed countries have the highest number of ex situ programs and collections as well as species being maintained.
The majority of conservation facilities are research centres	Among the 112 facilities identified by surveyed countries, 63% of the facilities are research centres, 22 % are universities, 15% are zoo and aquaria and only 11% are aquaculture facilities.
Ex situ conservation is widespread	70% of surveyed countries have current *ex situ* conservation programs.
	More than 344 aquatic genetic resources are the subject of *ex situ* conservation programs in 112 facilities among the 47 surveyed countries.
	The most important of objective of the current *ex situ* conservation programs at National level for the 47 surveyed countries is the preservation of aquatic biodiversity, followed very closely by the maintenance of strains, stocks and lines for future improved breeds and aquaculture development
	The less important objective of current *ex situ* conservation programs at National level for the 47 surveyed countries is the presentation of aquatic genetic resources for future adaptation to climate change.

Most of the conserved material are vertebrates	90% of the aquatic genetic resources being conserved are finfish (marine, freshwater and brackish water) while only 10% are invertebrates, mostly aquatic microorganisms such as small crustaceans, rotifers and microalgae.
The principal purpose for conservation is for human food use	Most common uses for the conserved aquatic genetic resources are (1) direct human consumption and (2) used as live feed in aquaculture.
	Other important uses mentioned by countries are: conservation of aquatic diversity, restocking stock enhancement, recreational fisheries, potential uses in aquaculture, ornamental use, research, etc.

5.8 References and key documents

Key documents and information sources being consulted include:

- Country reports.
- CGRFA reports (14th and 15th sessions).
- CGRFA working documents, information documents and background study papers.
- FAO Fisheries Glossary.
- Convention on Biological Diversity.

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6 STAKEHOLDERS WITH INTERESTS IN AQUATIC GENETIC RESOURCES OF FARMED AQUATIC SPECIES AND THEIR WILD RELATIVES WITHIN NATIONAL JURISDICTIONS

PURPOSE: The purpose of Chapter 6 is to provide an overview of the perspectives and needs of the principal stakeholders who have interests in aquatic genetic resources of farmed aquatic species and their wild relatives for food and agriculture within national jurisdictions. Specific objectives are to:

- Describe the different principal stakeholder groups with interests in aquatic genetic resources of farmed aquatic species and their wild relatives;
- Identify the type(s) of aquatic genetic resources of farmed aquatic species and their wild relatives in which each stakeholder group has interests and why;
- Describe the roles of stakeholder groups and the actions they are taking for the conservation, sustainable use and development of the aquatic genetic resources in which they have interests; and
- Describe the actions that stakeholder groups would like to see taken for the conservation, sustainable use and development of aquatic genetic resources in which they have

KEY FINDINGS

- Responses were received across the world, with greater response rates from developing countries than for developed countries.
- Some differences were observed among regions in terms of how they viewed stakeholder participation in the conservation, management and use of AqGR of farmed species and their wild relatives.
- Twelve key stakeholder groups were identified
- Marketing people, policy makers and donors were found to play the greatest role in conservation management and use
- Production, conservation and marketing activities were the most common of the 12 stakeholder types
- Stakeholder interests decline according to the level of genetic diversity(e.g. species, stock, breed, DNA)
- The importance of indigenous communities in conservation and protection of aquatic biodiversity and aquatic ecosystems of relevance for wild relatives of farmed aquatic genetic resources is recognized by nearly all countries
- Women are important in the aquaculture sector in both developed and developing countries
- Global coverage by the questionnaire is needed to improve the resolution of the analysis

6.1 Background

Many stakeholders have interests in the conservation (policy makers, aquatic resources managers, even fish farmers), management (e.g. fishers, hatchery operators, fish farmers, marketing people, NGOs, IGOs, donors), or use (fishers, fish farmers, hatchery operators, marketing people, etc.) of aquatic genetic resources (AqGR) of farmed aquatic species and their wild relatives, either because it comes within the ambit of their jobs or for livelihood and income generating purposes. And yet we know little about where specifically these interests lie or what they entail.

7.1 Identification of stakeholders

Stakeholder groups were identified on the basis of institutional knowledge, from sectoral and sub-sectoral consultations conducted during the country reporting process and where necessary from expert opinions. Gender issues pertaining to the conservation, sustainable use and development of aquatic genetic resources of farmed aquatic species and their wild relatives are considered, as well as the perspectives and needs of indigenous peoples and local communities.

In almost all countries, multi-stakeholder workshops or meetings were convened to assess the involvement of different stakeholder groups in key areas associated with aquatic genetic resources use, management, development and conservation. The approach followed by respondent countries towards this chapter of the questionnaire differed from country to country and from region to region, but it should be noted that most countries followed a participatory and inclusive strategy, involving a wide range of stakeholders with interests in aquatic genetic resources, either through national consultative process such as workshops or seminars, or through the establishment of national committees or national task forces composed of key players.

As an illustrative example, it should be mentioned that countries such as Germany or Mexico have provided the details of the consultative and participatory processed followed to conduct the stakeholder assessment, involving the aquaculture industry, hatchery managers, policy makers and research/academia among others.

In the following sections, data were extracted from the database containing country reports from 47 countries, and it is presented in a series of figures and tables in order to communicate the key findings.

6.2 Global level analysis

6.2.1 Roles of Stakeholders in AqGR conservation, management and use

Through a process of national consultation, supported by regional capacity building workshops and advice, countries identified 12 stakeholder groups with interests in the conservation, management and use of aquatic genetic resources of farmed species and their wild relatives.

The 47 reporting countries concluded that all stakeholder groups played at least one role in the conservation, management and/or use of aquatic genetic resources of farmed species and their wild relatives.

Analyzing the global scores, which were derived from summing all scores submitted by all reporting countries on the roles accorded to each stakeholder group for each of the nine categories associated with the conservation, management and use of AqGR, (maximum score = 47 (countries) x 9 (roles in conservation, management and use of AqGR) = 423) determined that marketing people (314), policy makers (259) and donors (221) played the greatest roles, while hatchery operators (103), IGOs (118) and government resource managers (121), with less than half the scores of those who topped the rankings, came bottom (see Figure 49).

Figure 49. Total scores (responding countries x roles in the conservation, management and use of AqGR of farmed species and their wild relatives. Data derived from Table 53. Maximum score = 47 x 9 = 423.

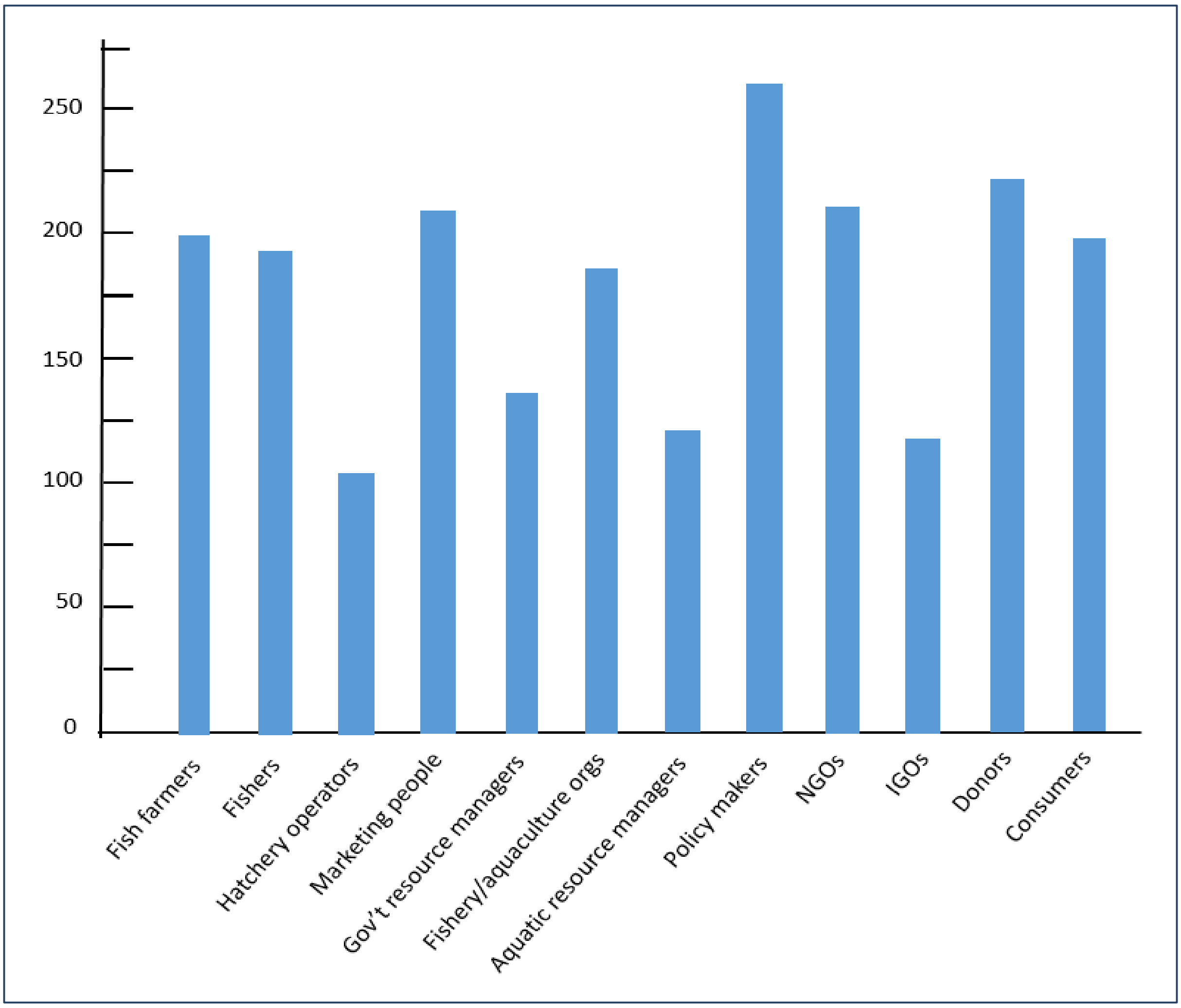

Table 53 summarizes the data for each stakeholder in terms of their roles - numbers (and percentages) – as determined by countries who assessed that they played a role in each of the nine categories of conservation, management and use of AqGR[23].

In terms of the categories in which the majority of countries (i.e. >50%) believed the stakeholder played a role, the greatest, at six out of eight categories, was accorded to policy makers. There follows a cluster of seven stakeholder groups whom the majority of countries concluded played a role in around half (i.e. four or five out of nine) of the different categories of AqGR conservation, management and use.

Four stakeholder categories were assessed as only playing roles in only one or two categories (see Table 53).

If the results are ranked in terms of the top three stakeholders by type of AqGR conservation, management and use (Table 54), then policy makers were assessed as playing the greatest number of roles (five out of nine categories), followed by fish farmers and marketing people (score = four), then fishers, fisheries/ aquaculture organizations, NGOs and consumers (score = three).

Three types of stakeholder – hatchery operators, government resource managers and IGOs – were not ranked in the top three of any category of AqGR conservation, management and use.

It was concluded by the majority of countries that fish farmers played a role in five categories of AqGR conservation, management and use of farmed species and their wild relatives: conservation (75% of countries agreed that fish farmers played a role in conservation), production (62%), research (69%), advocacy (58%) and extension (53%) (Table 53).

[23] We exclude category 'others' from the analysis.

The majority of countries agreed that fishers played roles in conservation (64%), research (60%), outreach/extension (51%) and advocacy (51%), while the majority of countries viewed hatchery operators as only being active in one category, marketing (60%).

Most countries agreed that marketing people engaged in production (96%), breeding (82%), marketing (78%) and processing (56%), compared to their view of government resource managers, who it was concluded were active in three categories (production, 64%; marketing, 62%; conservation, 51%).

Fishing/aquaculture organizations were found by the majority of countries to be involved in breeding (91%), production (84%), research (60%) and conservation (60%), while it was concluded that aquatic area managers were active in only in one area of AqGR conservation, management and use - marketing (80%).

Most responding countries found policy makers played roles in conservation (90%), research (76%), breeding (76%), outreach/extension (73%), production (73%) and advocacy (71%) and NGOs were active in five: production (91%), marketing (69%), processing (56%), breeding (51%) and feed manufacture (51%).

IGOs featured in only two categories (conservation, 71%; advocacy, 58%) according to the majority of countries who responded, while donors were seen as having interests in conservation (80%), production (64%), research (58%), outreach/extension (51%), and advocacy (51%).

Consumers played roles in conservation (78%), production (64%), outreach/extension (62%), advocacy (60%) and research (58%).

Table 53. Roles of different stakeholders in the conservation, management and use of AqGR of farmed species and their wild relatives, as determined by the global numbers (percentage) of all respondent countries that agreed on the particular role of a stakeholder (see text).

	Roles									
	Advocacy	**Breeding**	**Conservation**	**Feed manufacturing**	**Marketing**	**Outreach/ extension**	**Processing**	**Production**	**Research**	**Other**
Fish farmers	26 (55)	18 (38)	34 (72)	6 (13)	19 (41)	24 (51)	11 (23)	28 (60)	31 (67)	2 (4)
Fishers	23 (49)	25 (45)	29 (64)	13 (27)	16 (34)	23 (49)	14 (30)	22 (47)	26 (58)	5 (11)
Hatchery operators	12 (26)	2 (4)	10 (21)	2 (4)	25 (53)	6 (13)	19 (40)	17 (37)	2 (4)	8 (17)
Marketing people	6 (13)	37 (79)	15 (32)	22 (47)	32 (68)	11 (23)	14 (54)	43 (92)	13 (28)	1 (2)
Government resource managers	9 (20)	4 (9)	23 (49)	4 (9)	28 (60)	7 (17)	21 (45)	29 (62)	5 (11)	2 (4)
Fisheries/aquaculture organizations	9 (20)	41 (87)	27 (58)	32 (68)	15 (32)	14 (30)	2 (4)	38 (82)	27 (58)	1 (2)
Aquatic area managers	8 (17)	7 (15)	3 (6)	8 (17)	36 (77)	12 (25)	22 (47)	17 (35)	7 (14)	1 (2)
Policy makers	32 (69)	34 (73)	40 (85)	17 (35)	18 (39)	33 (71)	17 (35)	33 (71)	34 (72)	1 (2)
NGOs	17 (35)	23 (49)	20 (43)	23 (49)	31 (67)	20 (43)	25 (52)	41 (87)	7 (15)	3(6)
IGOs	32 (69)	10 (21)	32 (68)	2 (4)	2 (4)	17 (35)	1 (2)	7 (15)	21 (44)	0
Donors	23 (49)	20 (42)	36 (77)	21 (44)	21 (44)	23 (49)	19 (40)	29 (62)	26 (55)	3 (6)
Consumers	29 (62)	17 (35)	35 (75)	9 (20)	16 (33)	27 (57)	11 (23)	27 (57)	26 (55)	0
TOTALS	**228**	**224**	**304**	**139**	**266**	**219**	**187**	**314**	**236**	**27**

Table 54. Summary of top three stakeholder scores (in parenthesis) against roles in AqGR conservation, management and use. The last column gives total scores (see footnote 2).

Roles in AqGR conservation	Top three stakeholders[1] (number of countries concluding the stakeholder plays a role)	Total scores[2]
Advocacy	Policy makers (32) Consumers (29) Fish Farmers (26) Fishers (26)	228
Breeding	Fishing/aquaculture associations (41) Marketing people (37) Policy makers (34)	224
Conservation	Policy makers (40) Donors (36) Consumers (35)	304
Feed manufacturing	NGOs (23) Marketing people (22) Donors(21)	139
Marketing of AqGR	Donors (36) Consumers (35) Fish farmers (34)	266
Outreach/extension	Policy makers (33) Consumers (28) Fish farmers (24)	219
Processing	Marketing people (25) NGO (25) Aquatic area manager (22)	187
Production of AqGR	Marketing people (43) NGOs (41) Fishing/aquaculture organisations (38)	314
Research	Policy makers (34) Fish farmers (31) Fishers (27) Fishing/aquaculture organisations (27)	236
Other	-	27

[1]Unless two categories of stakeholder have the same score.

[2]Sum of all countries that determined a stakeholder played a role in a particular aspect of AqGR conservation, management and use. Maximum score for each type of role = 47 (i.e. number of respondent countries) x 12 (number of stakeholder types) = 564 – see text.

6.2.2 Analysis of conservation, management and use of AqGR categories

Data on the number of countries that found different stakeholders to be involved in each of the nine categories associated with the conservation, management and use of AqGR of farmed aquatic species and their wild relatives were summed, providing a simple global indicator of where stakeholder activity is greatest.

Out of a possible maximum score of 564 (i.e. each of the 47 responding countries agree that each of the twelve types of stakeholder are involved in a particular category of AqGR conservation, management or use), highest scores are found for production (314, equivalent to 56% of the maximum score), conservation (304 or 54%) and marketing (266 or 47%) (Table 53).

6.3 Regional and Country level analysis

6.3.1 Response rate by region and economic class

Table 55 sums up data on regional responses. Countries in nearly three quarters (73%) of the 22 regions responded, with greatest levels of response being from Central America (75% of countries) and South-Eastern Asia (55%).

Table 55. Number (percentage) of countries per region that responded.

Region	Number of Countries	Number of Countries responding (%)
Polynesia	11	3 (27)
Micronesia	7	1 (14)
Australia and New Zealand	6	0
Melanesia	5	1 (20)
Caribbean	29	0
South America	15	7 (47)
Central America	8	6 (75)
Northern America	5	0
Eastern Africa	23	5 (22)
Western Africa	17	4 (24)
Middle Africa	9	0
Northern Africa	8	1 (13)
Southern Africa	7	0
Western Asia	19	1 (5)
South-Eastern Asia	11	6 (55)
Southern Asia	9	2 (20)
Eastern Asia	8	2 (25)
Central Asia	5	0
Southern Europe	18	1 (6)
Northern Europe	17	3 (18)
Western Europe	11	1 (9)
Eastern Europe	11	2 (18)

Some 47 (24%) of member countries responded, more than half of responses being from 'other developing countries or areas' (27) and fewest responses (8) from 'developed countries'. In percentage response terms, by economic class, twice as many responses came from 'least developed countries' (21%) and 'other developing countries or areas' (20%), than from 'developed countries' (11%) (Table 56).

Table 56. Number of responding countries in each economic class.

Category	Number of countries	Number of respondents (%)
Developed countries or areas	73	8 (11)
Least Developed Countries	53	11 (21)
Other Developing Countries or Areas	134	27 (20)

Although the number of surveyed countries at this stage is very limited, some differences were observed among regions in terms of how they viewed stakeholder participation in the conservation, management and use of AqGR of farmed species and their wild relatives.

Generally, and as an example, fish farmers are considered to be more highly involved in production and conservation in least developed and other developing countries than in developed countries, where fish farmers are seen as active players in a wide range of roles, including marketing, breeding, extension, outreach and research. Further, hatchery people are seen by least developed and other developing regions (Central America, Latin America, South East Asia) as key players in breeding and marketing of aquatic genetic resources (marketing of seed, fry, fingerlings, spat), while hatchery people are considered as highly involved in conservation and research in developed countries.

In certain cases, responses are very similar in all regions, independent of economic status, as is the case of aquaculture and fishing organizations that are considered by all regions as key stakeholders in a broad range of roles, including production conservation, advocacy, breeding, marketing, research and extension.

Capacity building, sensitizing and communication actions are and will be implemented in order to increase the number of country reports that will be analyzed for the final State of the World's Report. This first draft is devoted to provide a clear and precise picture to the delegates regarding the type of data and information that will be included in the final report.

6.4 AqGR of key interest to stakeholders

For the purposes of determining the types of AqGR of farmed species and their wild relatives that are of greatest interest to the various stakeholder groups, data are summed in raw numbers (and percentage terms) in Table 57.

Out of a maximum score of 564 (i.e. 47 x 12; if all countries decide that all stakeholders are interested in a particular AqGR), the total global scores fall from 368 (species) to 286 (stock, breed, variety) and then to 88 (DNA), suggesting that the interests of stakeholders are greatest at the highest level of genetic diversity i.e. species level, and decrease as one moves to the stock, breed or variety level, and ultimately to the level of DNA variation. However, the notable exception to this is fish farmers, whose greatest interest, responding countries report, is at the stock, breed or variety level.

Looking more closely at stakeholder interests in the species level of AqGR of farmed and wild relatives, all groups, other than fish farmers, show very high levels of interest (64-80%), with only 5% of countries indicating that this was a resource of particular interest to fish farmers.

Table 57. Summary of genetic resources of interest of different stakeholder, by number of countries responding (max – 47) and percentage (in parenthesis).

Stakeholder	Genetic resources of interest			
	DNA	**Stock, breed, variety**	**Species**	**Other**
Fish farmers	8 (17)	24 (51)	2 (5)	1 (2)
Fishers	11 (23)	21 (44)	29 (62)	4 (9)
Hatchery operators	11 (23)	21 (45)	29 (62)	4 (9)
Marketing people	2 (4)	30 (64)	34 (72)	6 (13)
Government resource managers	0	14 (30)	33 (70)	0
Fisheries/aquaculture associations	10 (21)	32 (68)	35 (75)	5 (11)
Aquatic protected area managers	4 (8)	15 (32)	32 (68)	5 (11)
Policy makers	15 (31)	30 (64)	35 (74)	7 (15)
NGOs	2 (4)	25 (53)	36 (77)	3 (6)
IGOs	6 (13)	23 (49)	33 (70)	1 (2)
Donors	13 (28)	27 (58)	35 (75)	4 (9)
Consumers	6 (13)	24 (51)	35 (74)	4 (9)
TOTAL	**88**	**286**	**368**	**44**

Summed country responses show that only fish farmers (51% of countries) have greatest interest in the stock, breed or variety level of AqGR, although the summed data also show that other stakeholders – marketing people (64%), fisheries/aquaculture associations (68%), policy makers (64%) and donors (58%) – have even higher scores (Table 57).

While stakeholders interested in AqGR at the DNA level had the lowest aggregate score (88), for fish farmers, it was the second highest genetic resource of interest, and several other stakeholders – policy makers (31%), donors (28%), fishers and hatchery operators (23% each) and fishery/ aquaculture organizations (21%) were accorded higher scores than fish farmers.

As mentioned above, in the specific case of fish farmers it has been observed that more than half of the surveyed countries considered this stakeholder to have specific interests in strains/ lines/ breeds as well as in species, with some minor differences between economic classes, as can be seen in table 58 below.

Table 58. Assessment of genetic resources of interest for fish farmers by economic class

Description	% of countries	Genetic resource of main interest
Developed countries or areas	48	Species
	37	Stock, breed or variety
	10	DNA
Least Developed Countries	52	Species
	44	Stock, breed or variety
Other developing countries or areas	12	Other
	42	Species
	38	Stock, breed or variety
	2	DNA

6.5 Indigenous communities

All countries apart from European developed countries highlight the extremely important role of indigenous communities in conservation and protection of aquatic biodiversity and aquatic ecosystems of relevance for wild relatives of farmed aquatic genetic resources.

There is a general consensus that indigenous communities are mostly involved in conservation, protection, management of aquatic protected areas, and community-based conservation actions, than in real production, harvesting or marketing of aquatic genetic resources. Major roles of indigenous peoples and communities are listed in table 59 attached below.

Table 59. Assessment of major roles of indigenous communities in use, conservation and management of aquatic genetic resources

- Conservation of aquatic biodiversity
- Protection and conservation of aquatic ecosystems
- Protection of endangered/threatened species
- Management of aquatic protected areas
- Small scale seed production of key native species
- Small scale aquaculture production of key native species
- Marketing
- Processing

There are no significant differences in roles between economic classes or regions. It should be noted that certain least developed countries, such as Kiribati or Guatemala indicated the important role of indigenous communities in specific types of small scale aquaculture of native species, such as giant clam farming in the case of Kiribati and native freshwater finfish species in the case of Guatemala.

Other countries, such as India or the Philippines, noted the important role of indigenous communities in small scale hatcheries/backyard seed production.

A country example of the important role of indigenous communities in conservation of genetic resources for food and agriculture of relevance at national level is Brazil, which mentions that *"Indigenous and local communities' knowledge usually make sustainable use of natural resources. The relationship between such people and environment pass on through generations are an important source of information of the distinct uses of biodiversity. Fish and other aquatic organisms are not different. The fighting of the indigenous groups against power plant construction in Brazil is an example how the fish resources are important for them and indirectly for the whole population. Long term conservation of genetic resources rely mainly on aquatic environment preservation".*

6.6 Gender

Most of the least developed and other developing countries mention the important role of women in harvest, post-harvest, processing and marketing activities directly related to the aquaculture sector, but not so directory linked with the use, conservation and management of aquatic genetic resources.

By contrast developed countries indicated that women are fully integrated in the aquaculture sector and play a crucial roles at all levels and in all stages of the production chain, from broodstock management, seed production, grow-out, harvest, processing, research, academia and policy making action. Therefore, it should be noted that there are significant differences between the roles identified for women by developing, least developed and developed countries, as is shown in table 60 below.

Table 60. Major roles of women identified by surveyed countries by economic class

Developed countries	Least developed countries	Other developing countries
Production		
Hatchery work/seed production	Seed production	Seed production
Breeding		
Harvest	Harvest	Harvest
Processing	Processing	Processing
Marketing		Marketing
		Production of fish byproducts
Policy making		
Academia		
Research		

Furthermore, around 60% of the countries mention the important role of women in seed production and broodstock management, playing a crucial role in fish breeding and in larvae rearing systems and protocols.

Certain countries, such as the Philippines, noted that *"the participation of women before and after fish harvest in the aquaculture industry has been given little importance, leading to the near invisibility of women as contributors to this sector. However, these pre- and post-production activities are significant in terms of their economic and social value. These include: net mending, sorting fish upon landing, fish vending, trading and market retailing, (handling the small scale marketing that involves inexpensive fish varieties), processing and preservation (salting or drying) which are considered tasks for women".*

6.7 Discussion and Conclusions

6.7.1 Introduction

While the results from the questionnaire are sometimes as expected, there are other more puzzling responses and inexplicable inter-country and region differences that cannot be readily explained other than by a closer consideration of questionnaire design and process. It is thus worth reviewing what was done and how in collecting the data.

6.7.2 Terminology

The list of stakeholders assembled for the purposes of this study is not exhaustive but nonetheless is fairly comprehensive. Prior to the study beginning, a regional stakeholder consultation workshop was help in Bangkok, Thailand, during which it was decided to merge some of the stakeholder types and to discard others. Arguably, the list should have included scientists, regional fisheries management bodies and aquaculture networks, and indeed future consideration should be given to the list of stakeholders used, although the question remains as to whether their roles are important or would change the overall picture very much.

In the end, twelve stakeholder types were chosen. Some are relatively unambiguous; others, however, may be open to a degree of interpretation. For example, the regional stakeholder workshop in Bangkok, Thailand, initially found it difficult to distinguish between the role of a 'government resource manager' and how it differed from that of a 'policy maker'. Similarly, the various possible roles of stakeholders in the conservation, management and use of AgR of farmed species and their wild relatives are open to interpretation. Post-hoc definitions are provided in Tables 61 and 62.

Table 61. Brief description of stakeholders

Stakeholder	Description
Fish farmer	A professional involved in raising aquatic organisms commercially by controlling the entire or parts of the aquatic organism's life cycle.
Fisher	A fisherman or fisher is someone who captures fish and other animals from a body of water,
Hatchery operators	Professionals involved in running and/or management of a place for aquatic organisms artificial breeding, hatching and rearing through the early life stages of these organisms, with special emphasis on finfish and shellfish in particular.
People involved in marketing	Professionals involved in the action or business of promoting and selling products or services related to aquatic genetic resources, including market research and advertising.
Fisheries and aquaculture associations	Professional society of fish farmers, fishermen or both, which is registered and legally recognized at national, regional or international levels.
Aquatic protected area managers	A person responsible for controlling or administering protected areas of seas, oceans, rivers or lakes; these areas usually restrict human activity for a conservation purpose, typically to protect natural or cultural resources
Policy makers	A person responsible for formulating policies and other types of regulatory frameworks and instruments.
NGOs	A non-governmental organization (NGO) is any non-profit, voluntary citizens' group which is organized on a local, national or international level.
IGOs	An intergovernmental organization or international governmental organization (IGO) is an organization composed primarily of sovereign states (referred to as member states), or of other intergovernmental organizations.
Consumers	A person who purchases goods and services (in this case related to aquatic genetic resources) for personal use.
Others	-

Every individual consulted or directly involved in completing a country questionnaire belonged to at least two stakeholder groups. Everyone, for example, is a consumer; some fish farmers also own and operate their own hatcheries or processing facilities, while some fishers may also be aquaculturists. This should have helped foster an understanding of stakeholder roles and types of conservation, management and use of AqGR among respondents.

Table 62. Brief description of roles in conservation, management and use of AqGR.

Role	Definition
Advocacy	Individual or group activity that aims to influence decisions within political, economic and social systems and institutions
Breeding	Mating and reproduction of offspring by animals
Conservation	Preserving, guarding or protecting wise use.
Feed manufacture	The production of aquaculture feeds from plant and animal-based feedstuffs
Marketing	The management process responsible for identifying, anticipating and satisfying customer requirements profitably1
Outreach/extension	The application of scientific research and new knowledge to aquaculture practices through farmer extension
Processing	The processes associated with aquatic animals and aquatic animal products between when they are caught or harvested and the time the final product is delivered to customers
Production	The elaboration of aquatic animal biomass in aquaculture systems, through maintenance of good growing conditions and the provision of food
Research	The systematic investigation of scientific theories and hypotheses.
Others	-

[1]Official definition from the Chartered Institute of Marketing; source: http://www.CIM.co.uk.

Excluding 'others' nine types of AqGR conservation, management and use were distinguished for the purpose of this first attempt to capture stakeholder roles. Most are self-obvious – e.g. advocacy, breeding, conservation, marketing, outreach/extension, production, research – but two are not: feed manufacture and processing. With no other guidance, it is concluded here that the former refers to the use of wild fish in the form of fishmeal and fish oil, the fisheries that form the basis not always being sustainably managed.

Similarly, processors of farmed aquatic species by definition use AqGR. Nevertheless, these two categories recorded the lowest scores, suggesting a degree of uncertainty among respondents.

The category 'other', which was included both for AqGR conservation, management and use and for AqGR of interest to stakeholders, being something of a catch-all, is of limited value, other than to signal that stakeholders had roles and interests in areas other than those included in the study.

Little attention was, however, paid to defining roles beyond the categories developed for the purposes of the present questionnaire, leaving exactly what stakeholders did in fulfillment of these roles being very much open to interpretation.

Take the issue of conservation of AqGR, for example. Almost 90% of responding countries believed policy makers were involved in conservation of AqGR, although no supporting evidence is provided. It may simply have been assumed that policy makers develop policies that conserve AqGR. But do they, and are the assertions supported by evidence? Are the policies being implemented, are they effective?

Fish farmers will often also claim to be managing ex-situ AqGR. But are they sufficiently knowledgeable to manage these in such a way that creates more productive farmed strains whilst effectively avoiding inbreeding?

Various studies point to mismanagement of ex-situ AqGR for aquaculture purposes as being the norm. Brummett et al. (2004), for example, show that the growth performance of African catfish (*Clarias gariepinus*) sourced from commercial hatcheries, and derived from 3rd or 4th generation fish taken from the wild, was inferior to that of fry obtained from wild brood stock, indicating poor hatchery management of brood stock.

6.7.3 Country and regional responses

Ideally, all countries in all regions would have completed the questionnaire at the time of this first analysis. But the reality is that more than 25% of regions didn't respond (Table xx). Among those that did, the response rate ranged from 75% (Central America) to 5% (West Asia), invalidating any inter-regional analysis, especially when other sources of variability are factored in. The paucity of responding countries has also skewed representation among economic classes (Table xx), particularly between 'developed countries' and the rest, limiting analysis of responses to between 'least developed countries' (21%) and 'other developing countries or areas' (20%).

6.7.4 Composition and capacities of country respondents

Although further data have yet to be analyzed, it is clear that some of the inter-country variability in responses is due to the composition of the country teams completing the questionnaires, how much they know about the different stakeholder groups and, indeed, how they have defined them (see above), as well as their understanding of the different AqGR of interest.

The only guidance provided was for country focal points to consult with or involve stakeholders in completing questionnaires. And yet it seems likely that a country team, say, composed of 50% fish farmers, would have answered questions differently from a team dominated by country resource managers.

As well as inter-country differences in team composition, influencing collective country team knowledge of the roles of stakeholders in AqGR conservation, management and use, there are undoubted differences in interpretations of what the roles mean. These were not clearly defined in the guidance on completing questionnaires, as became apparent at 3 regional training workshops and several stakeholder workshops and meetings conducted at national levels. Although less open to interpretation there was nonetheless some ambiguity around the AqGR terms.

Three regional workshops, held in Thailand, Uganda and Guatemala, were completed prior to the present data analysis exercise. Both illustrated the need for stakeholder consultation and capacity building to develop a good understanding of the terminology used in the questionnaires and an appropriate level of consensus.

Taken together, then, all of the above factors introduce an unquantifiable, but nonetheless substantive, degree of variability, explored further below, which means the results from this first survey of AqGR conservation, management and use must be issued with a health warning. That we urge caution here is supported by the fact that there are some very difficult to explain results.

6.7.5 The roles of stakeholders in AqGR conservation, management and use

At a global level the results from the questionnaire show clear differences between stakeholders in terms of their roles, actual and perceived, in conservation, management and use of AqGR of farmed aquatic species and their wild relatives. If one interprets the roles accorded by the majority of responding countries to stakeholders, then one third of all stakeholder types – policy makers, NGOs, donors, consumers – are seen as being involved in the majority (>5, excluding 'others') of roles around AqGR conservation, management and use.

The majority of responding countries concurred that fish farmers play roles in conservation, research, production, advocacy and extension. Leaving aside the issue of how exactly they implement these roles and whether or not they are effective, the results are not surprising. Some critics of aquaculture, for example in those countries with wild stocks of Atlantic salmon, might point to the conflicting roles of fish farmers in both developing ex-situ genetically improved strains and, through the inadvertent introduction of feral farmed fish to the environment, increasing the risk of introgression of alien genetic material, with consequent effects on fitness.

While some results are unsurprising, others are puzzling. Why, for example, did only 40% of responding countries concur that fish farmers play a role in conservation of AqGR through breeding? Is this due to inter-country differences in types of aquaculture or in interpretation of the term 'breeding' (or, indeed, of 'fish farmer')? In yet another example the majority of responding countries see fishers as important in the conservation of and research into AqGR, despite this being less than immediately obvious. Why did the majority of responding countries only agree that hatchery operators and aquatic area managers had only a single role in AqGR conservation, management and use; and why in both cases via their role in marketing?

Such discrepancies and less than obvious allocation of stakeholder roles in different types of conservation, management and use of AqGR of farmed species and their wild relatives – and there are many, as is readily apparent in Table xx – may be due to inter-country differences in their aquaculture sectors but are also likely due to differences in understanding and/or interpretation of stakeholder roles, as discussed above.

6.7.6 Genetic resources of interest

The results here posed fewer surprises than with regard to the role of stakeholders in different types of conservation, management and use of AqGR of farmed species and their wild relatives. The most striking result is that interest among stakeholders still resides primarily at the species level.

And yet the results from the questionnaires also provide some interesting insights. Fish farmers, for example, are seen as being particularly interested in AqGR at the stock, breed and variety level (although less so than fisheries/aquaculture marketing associations, marketing people, hatchery operators, policy makers and donors, and only as much as consumers).

Few aquaculture sub-sectors – most notably Atlantic salmon and possibly tilapia – currently have access to such varieties and understanding of their impact on production, growth and profitability by most fish farmers remains limited. Perhaps the greater interest among users of AqGR residing at the stock, breed and variety level might have been more apparent if a greater number of developed countries had responded. Similarly, few stakeholders are yet interested in AqGR at the DNA level (although why hatchery operators, fishers and policy makers are more interested than fish farmers is inexplicable).

As the importance of marker-assisted selection and of the importance of conserving genetic diversity of AqGR at the population level in the wild becomes more apparent then interest at this level can be expected to increase.

6.7.7 Indigenous communities and gender

It is recommended that a further analysis at global, regional, sub-regional and by economic class of country reports be carried out on these topics. It is also advisable to clarify to national focal points in charge of the preparation of country reports the main objectives and expectations of this question are, in order to obtain a comprehensive and useful analysis of data.

6.8 Key findings and conclusions

Responses were received across the world, with greater response rates from developing countries than for developed countries.	47 (24%) of member countries responded
	Countries in nearly three quarters (73%) of the world's 22 sub-regions responded, with greatest levels of response being from Central America (75% of countries) and South-Eastern Asia (55%).
	Responses from 'least developed countries' (21%) and 'other developing countries or areas' (20%) we nearly double that of 'developed countries' (11%).
Some differences were observed among regions in terms of how they viewed stakeholder participation in the conservation, management and use of AqGR of farmed species and their wild relatives.	Although the number of surveyed countries at this stage is limited,
	Inter-country differences are considered to be due to the composition of the teams completing the questionnaires, and the limited consensus around definitions of stakeholders, their roles and the genetic resources of interest.
Twelve key stakeholder groups were identified	All were found to play at least one role in the conservation, management and use of aquatic genetic resources of farmed species and their wild relatives.
Marketing people, policy makers and donors were found to play the greatest role in conservation management and use	Based on a scoring system derived from summing all scores submitted by all reporting countries on the roles accorded to each stakeholder group (maximum score = 423)
	Most important were: marketing people (314), policy makers (259) and donors (221)
	Least important were: hatchery operators (103), IGOs (118) and government resource managers (121), with less than half the scores of those who topped the rankings
	In terms of the categories in which the majority of countries (i.e. >50%) believed the stakeholder played a role, the greatest, at six out of eight categories, was accorded to policy makers.

Production, conservation and marketing activities were the most common of the 12 stakeholder types	Country reports indicate that of the 12 stakeholder types stakeholders involved in a particular category of use of AqGR The predominant activities were: production (56%), conservation (54%) and marketing (47%).
Stakeholder interests decline according to the level of genetic diversity(e.g. species, stock, breed, DNA)	The interests of stakeholders are greatest at the highest level of genetic diversity i.e. species level
	Interests are less at the stock, breed or variety level, and ultimately at the level of DNA variation,
	The notable exception to this are the fish farmers, whose greatest interest is at the stock, breed or variety level.
The importance of indigenous communities in conservation and protection of aquatic biodiversity and aquatic ecosystems of relevance for wild relatives of farmed aquatic genetic resources is recognized by nearly all countries	All countries apart from European developed countries highlight the extremely important role of indigenous communities in conservation and protection of aquatic biodiversity and aquatic ecosystems of relevance for wild relatives of farmed aquatic genetic resources.
	Indigenous communities are primarily involved in conservation, protection, management of aquatic protected areas, and community-based conservation actions.
	Indigenous communities are less involved/concerned with (aquaculture) production, harvesting or marketing of aquatic genetic resources.
Women are important in the aquaculture sector in both developed and developing countries	Most of the least developed and other developing countries highlight the important role of women in harvest, post-harvest, processing and marketing activities directly related to the aquaculture sector
	By contrast developed countries indicate women are both fully integrated in the aquaculture sector and play crucial roles at all levels and in all stages of the production chain, from broodstock management, seed production, grow-out, harvest, processing, as well as in research and policy making.
Global coverage by the questionnaire is needed to improve the resolution of the analysis	Many of the results from the questionnaire are as might be expected
	there other responses that are less intuitive and some inexplicable differences between countries and regions
	From the regional and socio-economic perspectives, this is due in part to the relatively small and unbalanced number of responding countries

As mentioned above, more regional stakeholder workshops are planned for 2016, which will undoubtedly yield submission of more completed questionnaires that can then be included in the final report. Hopefully, too, the workshops will benefit from the learning developed in this first round of interpretation (see also Table 63).

Table 63. Key issues identified during the collection and analysis of preliminary respondent country data and proposed means of addressing them.

Issue	Proposed means of addressing
Inter-country differences in range of stakeholders consulted and in composition of respondent teams	Guidelines on stakeholder composition to introduce greater consistency/uniformity

Overly complicated questionnaire, with possibly too many stakeholder types, types of involvement in AqGR conservation management and use	Revise stakeholder categories and roles and, where possible, reduce
Confusion and inter-country differences with regard to stakeholder definitions, in areas of AqGR conservation, management and use and in genetic resources of interest	Revised and robust definitions of stakeholder and AqGR of interest, field tested at stakeholder workshops
Limited understanding of roles of stakeholders in AqGR conservation, management and use	More stakeholder workshops
Lack of guidance notes in questionnaire	Notes developed and attached to questionnaire
'Others' difficult to interpret	Remove
Gender and indigenous sections are very vague and certainly incomplete	Further assessment of gender and indigenous sections in country reports Clear definition of main objectives and expectations regarding these two sections

6.9 References

Brummett, R E, Agnoni, D E & Pouomogne, V. 2004. On-farm and on-station comparison of wild and domesticated Cameroonian populations of *Oreochromis niloticus*. *Aquaculture* 242, 157-164.

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联合国粮食及农业组织 | Food and Agriculture Organization of the United Nations | Organisation des Nations Unies pour l'alimentation et l'agriculture | Продовольственная и сельскохозяйственная организация Объединенных Наций | Organización de las Naciones Unidas para la Alimentación y la Agricultura | منظمة الأغذية والزراعة للأمم المتحدة

7 NATIONAL POLICIES AND LEGISLATION FOR AQUATIC GENETIC RESOURCES OF FARMED AQUATIC SPECIES AND THEIR WILD RELATIVES WITHIN NATIONAL JURISDICTION

PURPOSE: The purpose of Chapter 6 is to review the status and adequacy of national policies and legislation, including access and benefit sharing, concerning aquatic genetic resources of farmed aquatic species and their wild relatives. The specific objectives are:

- To describe the existing national policy and legal framework for the conservation, sustainable use and development of aquatic genetic resources of farmed aquatic species and their wild relatives;
- To review current national policies and instruments for access to aquatic genetic resources of farmed aquatic species and their wild relatives and the fair and equitable sharing of benefits arising from their utilization; and
- To identify any significant gaps in policies and legislation concerning aquatic genetic resources of farmed aquatic species and their wild relatives.

KEY MESSAGES:

- There are gaps in national policies the genetic level, but good examples of comprehensive national policies do exist.
- Policies exist at the species level and policies relating to the National Biodiversity Strategic Action Plans under the CBD.
- Policies also include fisheries management, fishing closures and restrictions on import/export of a variety of types of AqGR.
- Some national policies are in conflict with international obligations, e.g. the local trade of threatened and endangered species.
- Monitoring and enforcement of national policies is often constrained by lack of human and financial resources.
- Access and benefit sharing regimes will be different for AqGR than for GR of crops and livestock.
- Genetic improvement of farmed aquatic species often done by large companies or international institutions with modern breeding facilities, and in areas outside of the center of origin for many species. Thus farmer rights' and breeders' rights not relevant in many cases and not included in national policies.
- Countries have taken steps to facilitate access to AqGR that address primarily access to living specimens.
- Countries have encountered obstacles in accessing or importing AqGR that are primarily a result of their own restrictive national legislation.

7.1 Introduction

The FAO Code of Conduct for Responsible Fisheries (Code) lays out a series of guiding principles and recommendations on which national legislation and policy could be based (FAO 1995). The Code was adopted by the FAO Council in 1995 and includes sections on fishery management, fishing operations, coastal area management, aquaculture development, post-harvest and trade, international cooperation and research; there are articles on the special needs of developing countries. Whereas each biennium countries report to the FAO Committee on Fisheries (COFI) on their progress on implementation of the Code, very rarely have countries specifically reported on AqGR at the level below the species.

The 31st Session of COFI established the Advisory Working Group on Aquatic Genetic Resources and Technologies in order to advise the organization and increase international cooperation on AqGR. The first meeting of the working group (FAO 2016) agreed to develop a road map to assist countries in managing their aquatic genetic resources and noted that often it is the lack of specific national policies that constrain effective use and conservation of AqGR.

The range of the policies relevant to the management of AqGR food and agriculture is extremely large because it encompasses farming, fishing and conserving aquatic species. National legislation governing aquatic genetic resources are generally lacking in most parts of the world (Pullin et al. 1999). Policies are better developed at the species level in capture fisheries and aquaculture, for example for setting catch limits and seasons for capture fisheries (FAO 2003), or for allowing the import/export of certain species considered to be invasive (Bartley and Halwart 2006).

Often ministries and policies promoting fishery and aquaculture development, i.e. the use and exchange of AqGR, are in conflict with those promoting conservation (see chapter 3). The terrestrial agriculture sector is largely based on non-native species that were domesticated thousands of years ago and moved around the world with little regard for environmental risks. The relatively recent development of aquaculture and the domestication of aquatic species are occurring within a background of environmental awareness and an existing food production sector (Bartley et al. 2007).

The precautionary approach (FAO 1996), environmental impact assessment and risk analysis provide a means to balance the risk/benefit of proposed actions (Arthur et al. 2009).

Recommendations have been made stating that policies and legislation should be decentralized to the extent possible to take into consideration the needs and capacities of local communities. However, local practices may often be inconsistent with international treaties or instruments (Chapter 8; Bartley et al. 2016). For example local trade of species listed on the CITES appendices would be legal within a country, but would require special permits if the species were to be traded internationally.

This chapter reviews the status and adequacy of nation policies and legislation on aquatic genetic resources. Access to and the sharing of benefits derived from the use of AqGR is also presented.

7.2 Overview of national policies and legislation

The majority of country reports were submitted by signatories to the Convention on Biological Diversity (CBD). Under that convention countries are required to develop National Biodiversity Strategic Action Plans (NBSAP) that set policies for the sustainable use and conservation of biological diversity and the fair and equitable sharing of benefits. The emphasis of the NBSAP is primarily on the species level for aquatic organisms. Other national legislation has opportunities for protection of genetically distinct segments of a species that are of special evolutionary importance (Box 7).

Box 7. US Endangered Species Act recognized genetically important stocks of Pacific salmon as a 'species' and therefore eligible for protection under the act

Verbatim text to be rewritten:

http://www.nmfs.noaa.gov/pr/pdfs/species/sacramentoriver_winterrunchinook_5yearreview.pdf

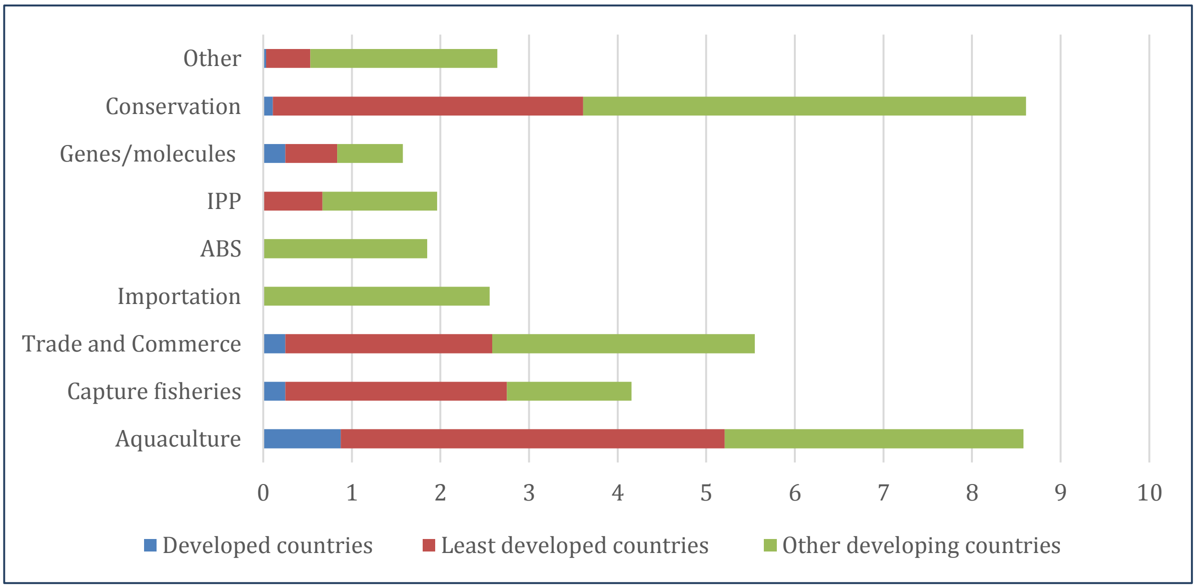
Many West Coast salmon and steelhead (*Oncorhynchus* sp.) stocks have declined substantially from their historic numbers and now are at a fraction of their historical abundance. There are several factors that contribute to these declines, including: overfishing, loss of freshwater and estuarine habitat, hydropower development, poor ocean conditions, and hatchery practices. These factors collectively led to the National Marine Fisheries Service (NMFS) listing of 28 salmon and steelhead stocks in California, Idaho, Oregon, and Washington under the Federal

Endangered Species Act (ESA).

Under the ESA, a species, subspecies, or a distinct population segment (DPS) may be listed as threatened or endangered. To identify the proper taxonomic unit for consideration in an ESA listing for salmon we draw on our "Policy on Applying the Definition of Species under the ESA to Pacific Salmon" (ESU Policy) (56 FR 58612). According to this policy guidance, populations of salmon substantially reproductively isolated from other con-specific populations and representing an important component in the evolutionary legacy of the biological species are considered to be an ESU. In our listing determinations for Pacific salmon under the ESA, we treated an ESU as constituting a DPS, and hence a "species."

Countries reported on a variety of policies and legislation that address aquatic genetic resources for food and agriculture (Figure 50)[24].

Figure 50. Scope of national policies (Number of responses/number of countries reporting)



Many countries have fishery management plans that regulate the time and quantity of fishing activities. The Philippines for example lists several national policies regulating the use of amphibians, fish and shellfish. These are primarily aimed at the species level (but see Box 7).

Countries reported that lack of awareness of national policies, lack of technical capacity and insufficient resources as key gaps in effective policy implementation. Additionally, significant problems in monitoring and enforcing national polices arise from lack of human resources and finances. Often countries' wetlands and coastal areas are expansive, e.g. Brazil and Indonesia, and prevents effective oversight of national policies.

7.3 Access and benefit sharing policies

Access to AqGR and the sharing of benefits derived from that use present special considerations in aquaculture and fisheries. Unlike terrestrial agriculture where domestication and stewardship of improved breeds and varieties was often the result of farmers using and improving genetic resources over millennia, the domestication and genetic improvement of many commercial aquatic species, did not take place in centers of origin, or as the result of the efforts of local aquaculturists (Bartley et al. 2009). Often genetic improvement of aquatic genetic resources was the result of large-scale private industry with advanced breeding programmes.

[24] Graph was normalized to account for the differences in number of reports received from countries in different economic classes for better comparison. To be revised on receipt of more country reports.

For example the establishment of the strain of Specific Pathogen Resistant shrimp took place in a bio-secure part of the Hawaiian Islands; improvements in the Pacific oyster native to Japan took place in North America; the genetic improvement of farmed tilapia native to Africa, the GIFT fish, took place in the Philippines (Bartley et al. 2009).

Thus, some of principles such as farmers' rights and breeders' rights (Andersen and Winge 2003) are less relevant to aquaculture than to agriculture.

7.3.1 Principles guiding access to AqGR

Principles have been established in some areas guiding access to native genetic resources. Key principles regarding access include prior informed consent and clearly defined benefit arrangements. A famous example of a bilateral ABS agreement concerns Costa Rica and the international pharmaceutical company Merck. Guiding principles to promote access to native biodiversity in Costa Rica included:

- Genetic Resources Access permits
- Registration of interested parties
- Access request
- Formulation and management of their prior informed consent agreement between providers and stakeholders.[25]

The arrangement between Costa Rica and Merck may not be reproducible in many areas; it relies on a very strong financial donor (Merck) and many groups wishing to access AqGR are not as wealthy.

Material Transfer Agreements (MTA) have also been established on a case by case basis that outline the general conditions and obligations associated with accessing genetic resources.

The World Fish Center of the Consultative Group on International Agriculture Research requires MTAs before distributing their genetically improved farmed tilapia (GIFT) (Table 56). These principles and obligations have been promoted by FAO et al. (Bartley et al. 2008) and would apply regardless of whether the entity seeking the genetic resource was national or foreign.

Table 56. Indicative elements of Material Transfer Agreements for accessing AqGR (WorldFish Center (www.worldfish.org and Bartley et al 2008).

A country planning to import new or exotic species has to sign a Material Transfer Agreement which states that the recipient agrees to:
Abide by the provisions of the Convention on Biological Diversity and the FAO Code of Conduct for Responsible Fisheries
Preclude further distribution of germplasm to locations at which it could have adverse environmental impact
Not claim ownership over the material received, nor seek intellectual property rights over the germplasm or related information
Ensure that any subsequent person or institution to whom they make samples of germplasm available is bound by the same provision
Comply with the country's biosafety and import regulations and any of the recipient country's rules governing the release of genetic materials
Follow quarantine protocols

[25] http://www.inbio.ac.cr/en/component/content/article/20-inbio/services/catalogo-bioprospeccion/121-research-and-genetic-resources-access-permits.htm

Abide by international guidelines in case germplasm is transferred beyond the boundaries of the country (http://www.fao.org/nr/cgrfa/cgrfa-global/cgrfa-codes/en/) (see chapter 8)

7.3.2 Facilitating and restricting access to AqGR

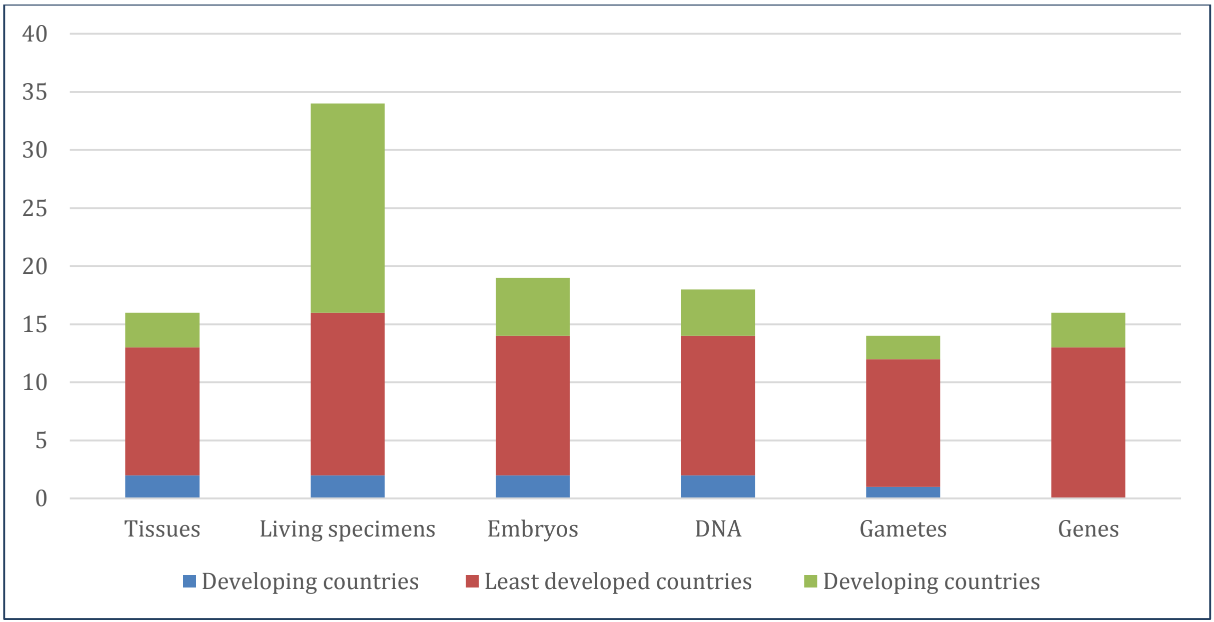
Countries have sovereign rights to restrict access to AqGR. At the DNA, stock/strain and species levels there is a complete range in level of restriction from no restriction to severe restriction. For example in Germany, there is no legislation restricting access to genetic resources in line with CBD Article 15 or the Nagoya Protocol. Whereas for Malawi there is highly restricted access unless national approval is obtained.

Certain countries identified specific species where access was restricted, e.g. Thailand restricts access to *Botia sidthimunkii, Probarbus jullieni, Catlodaio siamensis, Scleropages formosus, Pangasianodon gigas, Datnioides microlepis* (several of these species are on CITES Appendix 1 and international trade would be restricted as well).

Countries have also been proactive in facilitating access to genetic resources outside their national border (Figure 51). Living specimens were the group of organisms reported where access was most facilitated.[26]

Figure 51. Number of actions taken to enhance access to AqGR (number of country responses)

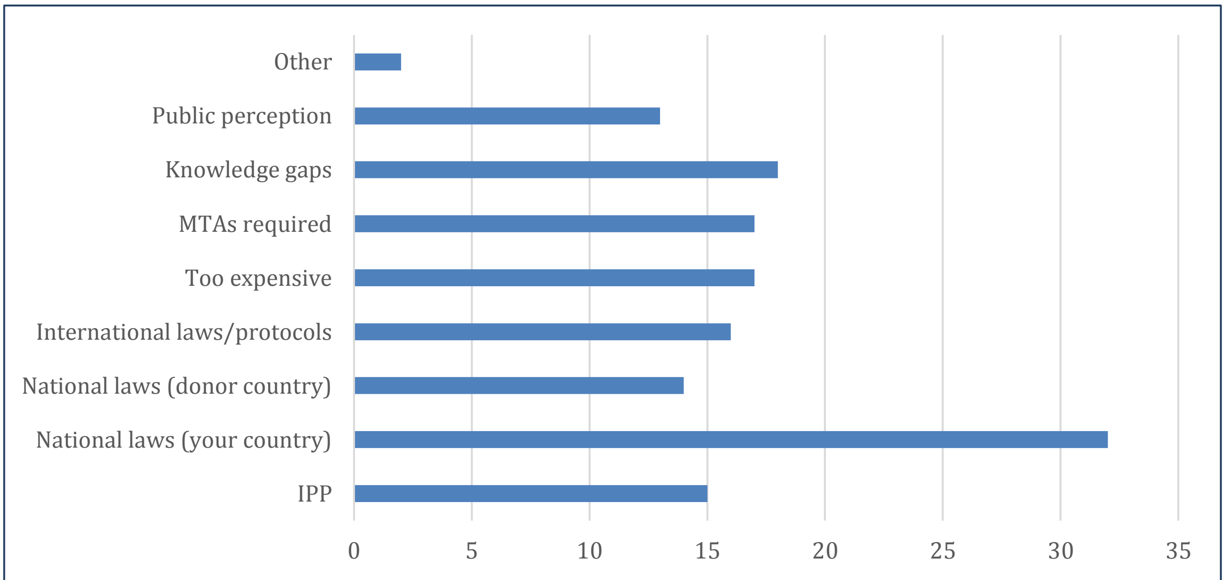
[26] The high number of actions taken by developing countries is a reflection of the greater number of country reports received. Figures will be revised on receipt of additional country reports.



7.3.3 Obstacles to accessing AqGR

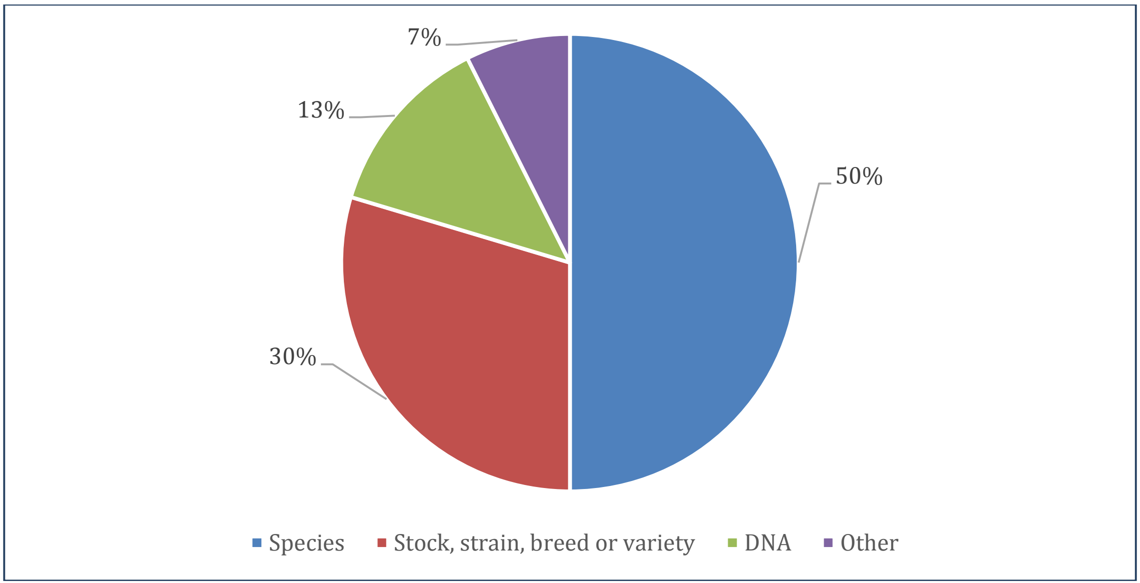
Countries seeking to access AqGR have also encountered obstacles (Figure 52). The most widely reported obstacle was national legislation. Lack of knowledge, expense, intellectual property protection and requirement for MTAs were also identified as obstacles by numerous countries.

Figure 52. Types of obstacles in accessing AqGR (Number of country responses)



Living specimens were the type of AqGR where most obstacles to access were encountered (Figure 53), but obstacles in accessing breeds, strains and varieties were also encountered in almost 1/3 of the responses.

Figure 53. Types of AqGR where obstacles to access were encountered (% responses)



7.4 Key findings and conclusions

Policy	There are gaps in national policies the genetic level, but good examples of comprehensive national policies do exist.
	Policies exist at the species level and policies relating to the National Biodiversity Strategic Action Plans under the CBD.
	Policies also include fisheries management, fishing closures and restrictions on import/export of a variety of types of AqGR.
	Some national policies are in conflict with international obligations, e.g. the local trade of threatened and endangered species.
Implementation and enforcement	Monitoring and enforcement of national policies is often constrained by lack of human and financial resources.
Rights and access	Access and benefit sharing regimes will be different for AqGR than for GR of crops and livestock.
	Genetic improvement of farmed aquatic species often done by large companies or international institutions with modern breeding facilities, and in areas outside of the center of origin for many species. Thus farmer rights' and breeders' rights not relevant in many cases and not included in national policies.
	Countries have taken steps to facilitate access to AqGR that address primarily access to living specimens.
	Countries have encountered obstacles in accessing or importing AqGR that are primarily a result of their own restrictive national legislation.

7.5 References and key documents

- Aichi Targets
- Convention on Biological Diversity www.biodiv.org
- Convention on International Trade of Threatened and Endangered Species of Fauna and Flora www.cites.org

- Country Reports
- InBio National biodiversity Institute of Costa Rica http://www.inbio.ac.cr/en/
- National Biodiversity Strategic Action Plans www.biodiv.org
- Nygoya Protocol www.cbd.int/abs/
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8 RESEARCH, EDUCATION, TRAINING AND EXTENSION ON AQUATIC GENETIC RESOURCES WITHIN NATIONAL JURISDICTION: COORDINATION, NETWORKING AND INFORMATION

PURPOSE: The purpose of Chapter 7 is to review the status and adequacy of national research, education, training and extension, coordination and networking arrangements and information systems that support the conservation, sustainable use and development of aquatic genetic resources of farmed aquatic species and their wild relatives for food and agriculture. Specifically to:

- Describe the current status, future plans, gaps, needs and priorities for research, training, extension and education on the conservation, sustainable use and development of aquatic genetic resources of farmed aquatic species and their wild relatives
- Describe existing or planned national networks for the conservation, sustainable use and development of aquatic genetic resources of farmed aquatic species and their wild relatives.
- Describe existing or planned information systems for the conservation, sustainable use and development of aquatic genetic resources of farmed aquatic species and their wild relatives.

KEY MESSAGES:

- 83% of countries noted that research on AqGR (conservation, use and/or management) is covered under their national research programs.
- Certain surveyed countries within America and Africa don't have a component related to AqGR in their national research programs.
- 95% of countries have at least one research institution dealing with use, conservation and management of AqGR.
- 244 research centers were identified by 46 countries. 76% of these centers are focused on basic knowledge on aquatic genetic resources, being this area of research the most covered one at global level; only 30% of the research centers are focused on economic valuation as one of their research areas, being the less covered at global level.
- The most important capacity need identified by countries regarding research is actually the improvement of capacities on the economic valuation of AqGR of relevance.
- 131 training and education centers dealing with use, conservation and/or management of AqGR were identified by the 47 surveyed countries. The main area of training at global is genetic resource management.
- Around 30% of the training courses reach a postdoc level.
- 100 inter-sectoral collaboration mechanisms were listed by the 47 surveyed countries.
- 93 national networks were listed by the 47 surveyed countries, being the most important objective of these networks the Improvement of basic knowledge on aquatic genetic resources.
- 78 information systems on AqGR were listed by the 47 surveyed countries.
- Main users if national information systems on AqGR are universities and academia, followed by government resource managers. The less relevant users are donors.
- The type of information stored in these information systems is mostly (1) species names; and (2) production data on AqGR. Very few information systems are devoted to DNA data and Genes or genotypes information.

8.1 Definitions

Research	The systematic investigation into and study of materials and sources in order to establish facts and reach new conclusions.
Education	The process of receiving or giving systematic instruction, especially at a school or university.

Training	The action of teaching a person a particular skill or type of behaviour.
Outreach	The extending of services or assistance beyond current or usual limits
Network	A group or system of interconnected people or things.
Collaboration	The action of working with someone to produce something.

8.2 Introduction

Appropriate current capacities, knowledge and skills on aquatic genetic resources use, conservation, management and development at country, sub-region or regional levels are keys to better characterize, use and develop available genetic resources of importance for food and agriculture; and therefore, for livelihoods and national economies.

Appropriate knowledge and skills are also key to ensure sustainable utilization and development of these resources for future generations. It is globally accepted and known that both knowledge and institutions focused on the study and research of important aquatic resources for food and agriculture are relatively limited in most regions of the world.

This chapter therefore aims to clarify some of the Global notions about education and training situation regarding aquatic genetic resources, and to promote the development of concrete actions to enhance their better knowledge. It is globally accepted that if we do not know what we have, what we culture, or what we intend to culture in the near future, hardly be able to use it in an efficient, effective and sustainable manner.

8.3 Research on AqGR

Countries were asked whether their current and respective national research programs support the conservation, sustainable use and development of aquatic genetic resources of farmed aquatic species and their wild relatives or not. 83% of surveyed countries answered yes and 17% no, as it is shown in Figure 54 below.

Figure 54. Coverage of AqGR in national research programs

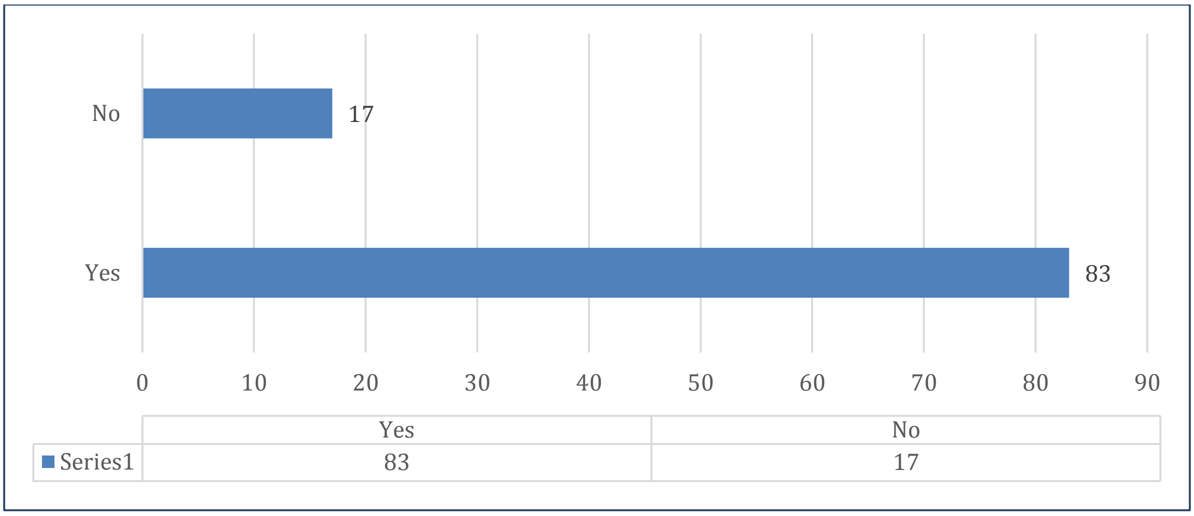


Table 57 and Table 58 present the geographical and economic distribution of these answers. It should be noted that the majority of countries that don't have research programs or areas devoted to use, conservation and management of aquatic genetic resources to a certain extent belong to "other developing countries " and "least developed countries".

Table 57. Regional distribution of answers regarding National research programs supporting use, conservation and management of AqGR

Geographical regions	Country count	Response
South America	6	Yes
Central America	3	No
Central America	3	Yes
South America	1	No
Northern America	1	Yes
Eastern Africa	4	Yes
Western Africa	3	Yes
Northern Africa	1	Yes
Western Africa	1	No
Eastern Africa	1	No
Polynesia	2	Yes
Micronesia	1	Yes
South-Eastern Asia	6	Yes
Southern Asia	2	Yes
Eastern Asia	2	Yes
Western Asia	1	Yes
Northern Europe	2	Yes
Eastern Europe	2	Yes
Northern Europe	1	No
Southern Europe	1	Yes
Western Europe	1	Yes

Table 58. Economic distribution of answers regarding National research programs supporting use, conservation and management of AqGR

Economic class	Country count	Response
Other developing countries or areas	20	Yes

Least Developed Countries	10	Yes
Developed countries or areas	8	Yes
Other developing countries or areas	5	No
Least Developed Countries	1	No
Developed countries or areas	1	No

8.3.1 Research institutions

Countries were asked to list main institutions, organizations, corporations and other entities in their respective countries that are engaged in field and/or laboratory research related to the conservation, sustainable use and development of aquatic genetic resources of farmed aquatic species and their wild relatives. 46 countries out of 47 surveyed countries mentioned that there are institutions focused on research on AqGR conservation, use, development, management, etc present in their respective countries.

A total of 224 institutions were identified by these 46 countries as main research centres at National Level, which gives an average of around 5 institutions per country. Table 59 presents the number of research institutions identified by each sub-region and the ratio of institutions per country depending on the number of surveyed countries by region.

The two regions with the higher number of institutions per country are North America, with 8 research centres/country (Canada is the only surveyed country in this region) and South East Asia, with 14 research centres/country. It should be noted that there are clear differences between sub-regions, as it is shown in Table 59 .

Table 59. Regional distribution of research centers on AqGR

Geographical regions	Count of institutions	Surveyed countries per region	N. of institutions per country
South America	37	7	5
Central America	19	6	3
Northern America	8	1	8
Eastern Africa	21	5	4
Western Africa	22	4	6
Northern Africa	6	1	6
South-Eastern Asia	43	6	7
Southern Asia	28	2	14
Eastern Asia	5	2	3
Western Asia	2	1	2
Northern Europe	9	3	3
Eastern Europe	9	2	5
Western Europe	6	1	6
Southern Europe	3	1	3
Polynesia	4	3	1
Micronesia	2	1	2

Table 60 shows the distribution of research institutions by economic class, including the ratios. Other developing countries is the economic class with the highest number of research centres per country, with a total of 5 research centres/country.

Table 60. Economic distribution of research centers on AqGR

Economic class	Count of institutions	Surveyed countries per region	N. of institutions per country
Developed countries or areas	38	8	4
Least Developed Countries	44	12	3

Other developing countries or areas	142	27	5

8.3.2 Major areas of research

Main areas of research of the 224 listed research centers were provided by countries. From this assessment, it should be noted that most institutions are focused on "Basic knowledge on aquatic genetic resources" (76%), while the rest of the areas of research are not so well covered by identified research centers.

The less covered area of research is the "Economic valuation of aquatic genetic resources", which is the focus of 30% of the research institutions only. Table 61 below shows the exact number of institutions dealing with each area of research and the ratios or % of institutions focused on each research area. The assessment of the main areas of research at global and sub-regional levels is relatively complex because each research center can be focused on many research areas.

Table 61. Main areas of research of institutions focused on AqGR

Area of research institutions	Number of institutions devoted to the area of research	%
Genetic resource management	112	50
Basic knowledge on aquatic genetic resources	171	76
Characterization and monitoring of aquatic genetic resources	129	57
Genetic improvement	92	41
Economic valuation of aquatic genetic resources	69	30
Conservation of aquatic genetic resources	127	57
Communication on aquatic genetic resources	122	54
Access and distribution of aquatic genetic resources	98	43

Table 62 shows the percentage of research centers focused on each research area by economic class. It should be mentioned that "Basic knowledge on aquatic genetic resources" is the main focus of research in all countries, without regional or economic distinctions.

Certain differences are observed in table 62, for example "Conservation of AqGR" is as important as "Basic knowledge on AqGR" in developed countries, while it is not so relevant for least developed and other developing countries, where "Characterization of AqGR", "Management of AqGR" and Communication on AqGR" are better covered research areas.

Table 62. Main areas of research by economic class

Description	Response count	Area of Research	%
Developed countries or areas	29	Basic knowledge on aquatic genetic resources	4
	28	Conservation of aquatic genetic resources	4
	27	Characterization and monitoring of aquatic genetic resources	3
	24	Genetic resource management	3
	21	Communication on aquatic genetic resources	3
	19	Access and distribution of aquatic genetic resources	2
	17	Genetic improvement	2
	13	Economic valuation of aquatic genetic resources	2
Least Developed Countries	36	Basic knowledge on aquatic genetic resources	3
	34	Communication on aquatic genetic resources	3
	24	Conservation of aquatic genetic resources	2
	24	Characterization and monitoring of aquatic genetic resources	2

Description	Response count	Area of Research	%
	17	Genetic resource management	1
	13	Access and distribution of aquatic genetic resources	1
	13	Genetic improvement	1
	10	Economic valuation of aquatic genetic resources	1
Other developing countries or areas	106	Basic knowledge on aquatic genetic resources	4
	78	Characterization and monitoring of aquatic genetic resources	3
	75	Conservation of aquatic genetic resources	3
	71	Genetic resource management	3
	67	Communication on aquatic genetic resources	2
	66	Access and distribution of aquatic genetic resources	2
	62	Genetic improvement	2
	46	Economic valuation of aquatic genetic resources	1

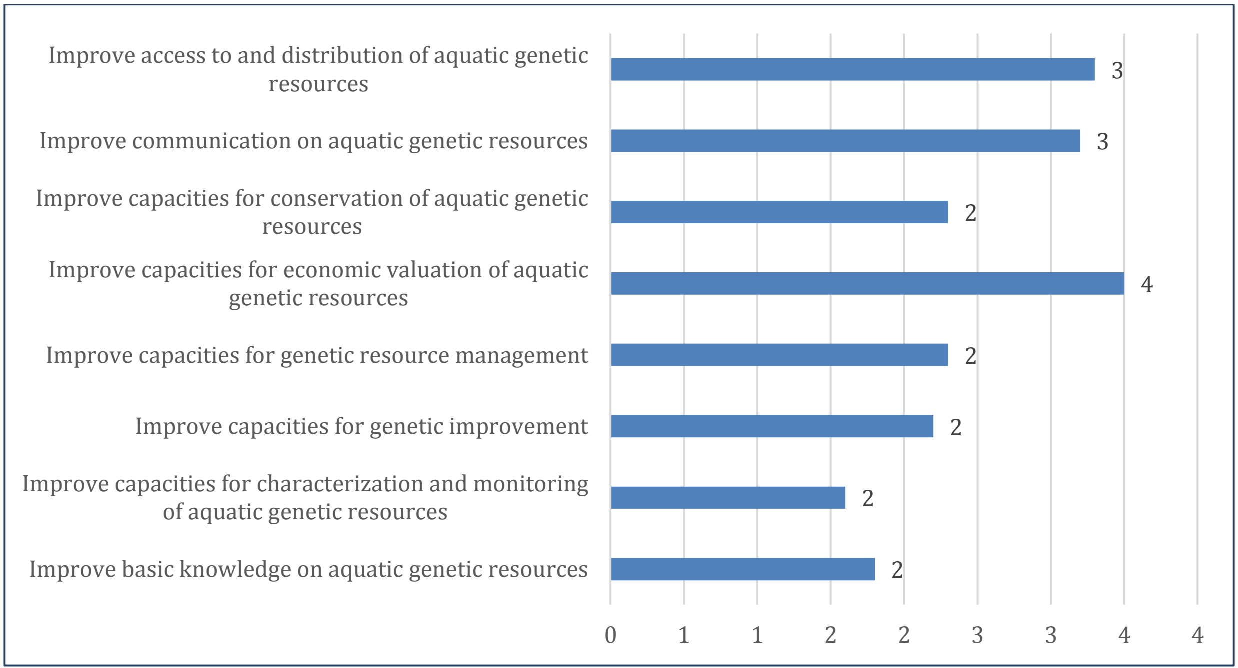
8.3.3 Capacity needs

Countries were requested to identify main capacity strengthening needs, in order to improve national research in support of the conservation, sustainable use and development of aquatic genetic resources of farmed aquatic species and their wild relatives.

The following capacities were assessed by countries, ranking them from very important (1) to not important at all (10). Figure 55 shows the global ranking of these capacities by all surveyed countries.

- Improve basic knowledge on aquatic genetic resources
- Improve capacities for characterization and monitoring of aquatic genetic resources
- Improve capacities for genetic improvement
- Improve capacities for genetic resource management
- Improve capacities for economic valuation of aquatic genetic resources
- Improve capacities for conservation of aquatic genetic resources
- Improve communication on aquatic genetic resources
- Improve access to and distribution of aquatic genetic resources

Figure 55. Ranking of capacity needs regarding research on AqGR



8.4 Education, training and extension on AqGR

8.4.1 Institutions, areas of work and type of courses

Countries were requested to indicate the extent that education, training and extension in their respective countries covers the conservation, sustainable use and development of aquatic genetic resources of farmed aquatic species and their wild relatives, listing the main institutions involved and the types of courses offered by these institutions.

All surveyed countries (47 countries in total) indicated that there are specific institutions involved in education, training and/or extension on aquatic genetic resources (use, conservation and/or management and development). **A total of 131 training institutions** were identified by the 47 surveyed countries, giving an average of around 3 training centers per country.

Table 63 provides a summary of training centers on AqGR per region, including the number of training centers per country for each sub-region. North America and Western Europe are the two sub-regions with the largest number of training centers per country, and the Pacific region (Melanesia, Micronesia and Polynesia) are the three sub-regions with the lowest number of training centers per country.

Table 63. Number of training centers on AqGR by sub-region

Geographical regions	N. of training centres	N. of centres per country
South America	24	3
Central America	14	2

Northern America	6	6
South-Eastern Asia	16	3
Eastern Asia	7	4
Southern Asia	5	3
Western Asia	2	2
Western Africa	15	4
Eastern Africa	14	3
Northern Africa	2	2
Northern Europe	7	2
Western Europe	6	6
Southern Europe	5	5
Eastern Europe	3	2
Polynesia	3	1
Melanesia	1	1
Micronesia	1	1

Table 64 provides a summary of training centers by economic class, including the number of training centers per country. Developed countries have more than 4 training centers/country while other developing countries only 2 training centers/country.

Table 64. Number of training centers on AqGR by economic class

Economic classes	N. of training centres	N. of training centres per country
Developed countries or areas	33	4
Least Developed Countries	31	3
Other developing countries or areas	67	2

Countries identified a total of 753 training courses on aquatic genetic resources use, conservation and/or management being currently implemented in their respective countries by the 131 training institutions listed above. Main subject areas of these training courses and the % of postdoctoral studies that are available for each subject area is provided in Table 65.

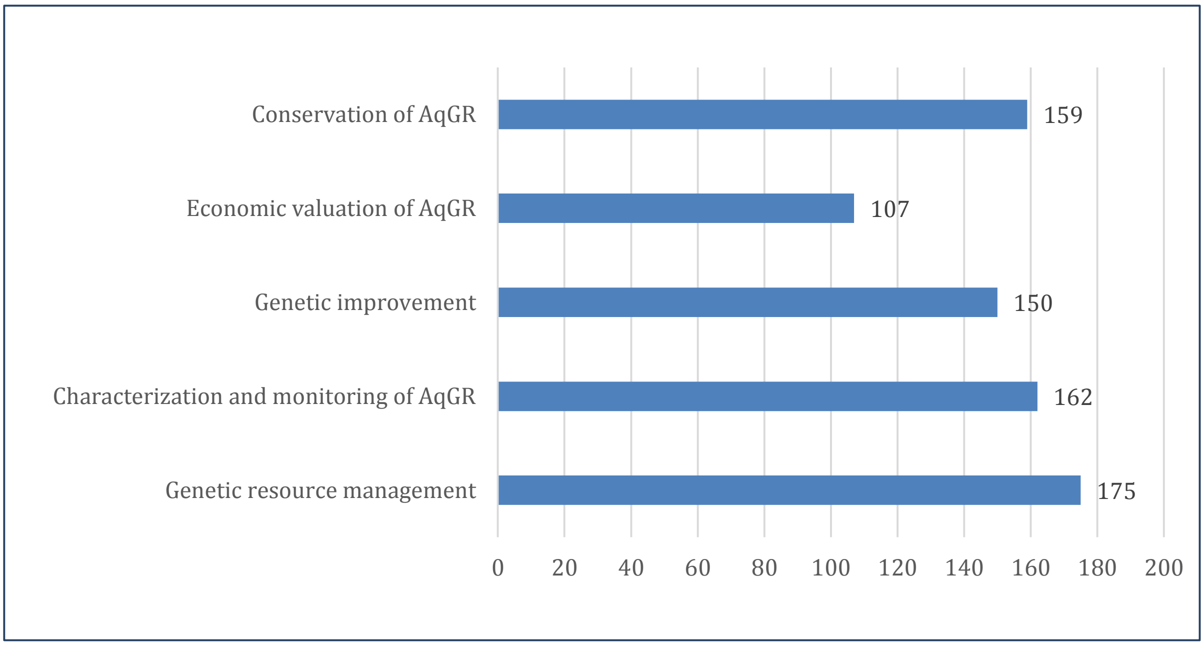
Table 65. Training courses available for each subject area and PhD courses available

Topic of the training course	Number of training courses	% of each thematic area	PhD courses	% Post-doctoral
Genetic resource management	175	23	45	26
Characterization and monitoring of AqGR	162	22	53	33
Genetic improvement	150	20	48	32
Economic valuation of AqGR	107	14	31	29
Conservation of AqGR	159	21	45	28

Total number of training courses	**753**

Figure 56 shows the summary of training courses available for each subject area. Regarding postdoctoral studies, it should be mentioned that very limited training courses are available for all subject areas, including basic knowledge on aquatic genetic resources such as general characterization of aquatic genetic resources of relevance for aquaculture and/or capture fisheries. This trend is very similar for all regions and sub-regions and for all economic classes, which denotes that this specific area of knowledge is still in its infancy in many countries.

Figure 56. Main areas of coverage of training courses on aquatic genetic resources



Training courses were classified by countries as (1) training; (2) undergraduate; (3) post-graduate; and (4) extension. A common trend for all regions and sub-regions, without distinction by economic classes, is the limited availability of "Extension courses" and "post-graduate" courses (as it has been mentioned above) available for all thematic areas. Table 66 shows the number of training courses per country and by region on basic genetic resource management, as an example of this specific trend.

Table 66. Number of training courses on genetic resource management per country and by region

Geographical regions	Response count	Type of courses	N. of training courses per country
South America	11	Post-graduate	2
	10	Training	1
	8	Extension	1
	8	Undergraduate	1
Northern America	6	Post-graduate	6
	6	Undergraduate	6
	1	Training	1
Central America	5	Training	1
	3	Undergraduate	1
	2	Post-graduate	0

	1	Extension	0
Western Africa	9	Training	2
	8	Undergraduate	2
	4	Post-graduate	1
	1	Extension	0
Eastern Africa	8	Undergraduate	2
	7	Post-graduate	1
	6	Training	1
	2	Extension	0
South-Eastern Asia	8	Training	1
	6	Undergraduate	1
	6	Post-graduate	1
	5	Extension	1
Southern Asia	4	Training	2
	4	Extension	2
	3	Post-graduate	2
	1	Undergraduate	1
Eastern Asia	2	Undergraduate	1
Northern Europe	4	Undergraduate	1
	3	Post-graduate	1
	2	Training	1
	1	Extension	0
Eastern Europe	2	Post-graduate	1
	2	Undergraduate	1
	1	Training	1
Southern Europe	2	Undergraduate	2
	1	Training	1
	1	Extension	1
Western Europe	1	Undergraduate	1
	1	Post-graduate	1
	1	Training	1
Polynesia	3	Undergraduate	1
	2	Training	1
Melanesia	1	Undergraduate	1
Micronesia	1	Undergraduate	1
	1	Training	1

8.5 Coordination and networking on AqGR

8.5.1 Networking mechanisms

Countries were requested to list any mechanisms within their respective countries that are responsible for coordinating the aquaculture, culture-based fisheries and capture fisheries subsectors with other sectors that use the same watersheds and coastal ecosystems and that have impacts on aquatic genetic resources of wild relatives of farmed aquatic species (e.g. agriculture, forestry, mining, tourism, waste management and water resources). 100 different mechanisms of inter-sectoral and intra-sectoral coordination were identified by the 47 surveyed countries. All countries identified at least one mechanisms of this kind. This give us an average number of around 2 mechanisms per country.

Table 67 shows the number of mechanisms per country by sub-region. Western Europe followed by South East Asia are the two regions with the highest number of mechanisms for sectoral coordination. There are a few sub-regions with only one mechanisms in place per country, such as Easter Africa, Eastern Europe, North America and Polynesia, among others.

Table 67. Number of inter-sectoral coordination mechanisms on AqGR by Region and per country

Geographical regions	**N. of mechanisms**	**Countries**	**N. of mechanisms per country**
South-Eastern Asia	22	6	4
Southern Asia	5	2	3
Eastern Asia	4	2	2
Western Asia	3	1	3
South America	15	7	2
Central America	10	6	2
Northern America	1	1	1
Western Africa	10	4	3
Eastern Africa	6	5	1
Northern Africa	2	1	2
Northern Europe	7	3	2
Western Europe	5	1	5
Eastern Europe	2	2	1
Southern Europe	2	1	2
Melanesia	3	2	2
Polynesia	2	3	1
Micronesia	1	1	1

Table 68 shows the number of inter-sectoral coordination mechanisms on AqGR by economic class where some differences can also be observed.

Table 68. Number of inter-sectoral coordination mechanisms on AqGR by economic class

Description	**N. of mechanisms**	**Countries**	**N. of mechanisms per country**
Developed countries or areas	20	8	3
Least Developed Countries	19	12	1
Other developing countries or areas	61	27	2

8.5.2 Capacity needs

Countries were requested to rank the capacity strengthening that could be improved in inter-sectoral coordination, in support of the conservation, sustainable use and development of aquatic genetic resources. Three different capacities were ranked from 1 (very important) to 10 (no importance) by countries.

The results are provided in Table 69 below. Increase technical capacities of institutes was identified by countries as the most important one, followed very closely by the other two, which are improve awareness and improve information sharing.

Table 69. Average rank of capacity strengthening to be improved in inter-sectoral coordination, in support of conservation, use and management of AqGR

Capacities to be improved	Average Rank (1: very important; 10: no importance)
Improve awareness in institutions	2
Increase technical capacities of institutes	1
Increase information sharing between institutes	2

8.5.3 National networking on AqGR

Countries were asked to list all national networks in their respective countries, as well as all international networks their countries belongs to that support the conservation, sustainable use and development of aquatic genetic resources. As a result of this assessment, it has been shown that 35 countries out of 47 have national networks related to use, conservation and/or management of AqGR. A total of 93 networks were identified by these 35 countries, which gives an average value of almost 3 networks per country.

Table 70 shows the number of national networks per country by region and Table 71 shows the number of national networks per country by economic class. The sub-region with the highest number of networks is North America, followed by Southern and Western Europe. Surprisingly, Easter Europe, together with Melanesia and South America are the three regions with the lowest number of national networks related to AqGR.

Table 70. Number of national networks related to AqGR per country and by sub-region

Geographical regions	N. of networks	Countries	N. of networks per country
South-Eastern Asia	20	6	3
Southern Asia	6	2	3
Eastern Asia	5	2	3
Western Africa	13	4	3
Eastern Africa	11	5	2
Central America	11	6	2
Northern America	7	1	7
South America	6	7	1
Northern Europe	6	3	2
Southern Europe	4	1	4
Western Europe	4	1	4
Eastern Europe	2	2	1
Melanesia	1	2	1

Table 71. Number of national networks on AqGR per country and by economic class

Description	N. of networks	Countries	N. of networks per country
Developed countries or areas	25	8	3

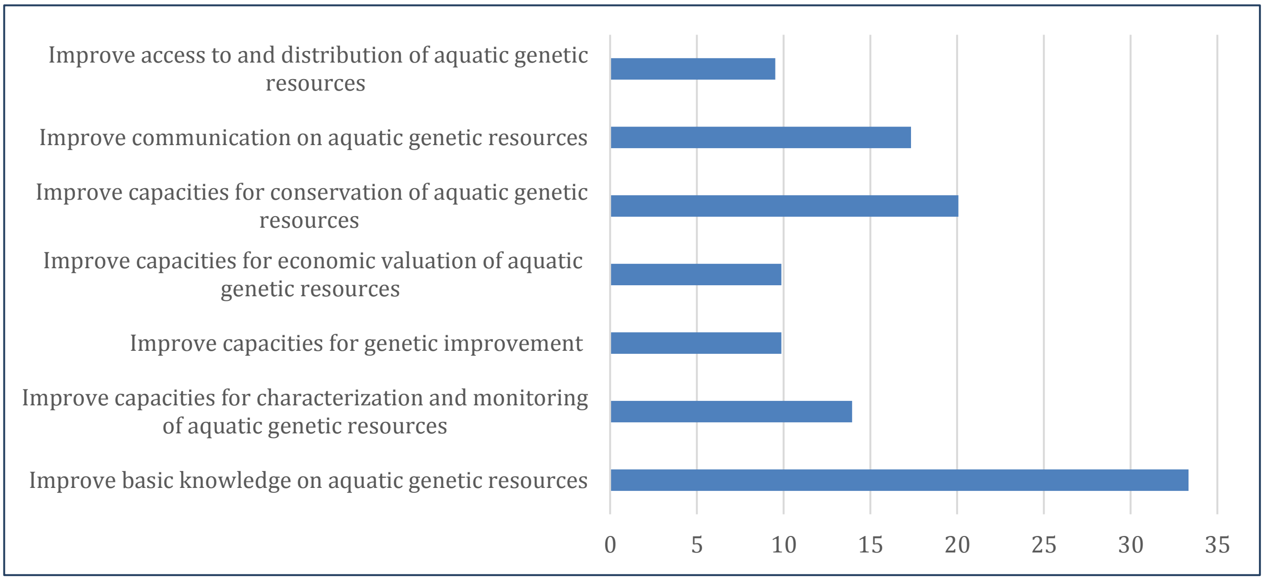
Least Developed Countries	19	12	1
Other developing countries or areas	52	27	2

The objectives of the national networks on aquatic genetic resources were assessed by surveyed countries, being these objectives:

1. Improve basic knowledge on aquatic genetic resources
2. Improve capacities for characterization and monitoring of aquatic genetic resources
3. Improve capacities for genetic improvement
4. Improve capacities for economic valuation of aquatic genetic resources
5. Improve capacities for conservation of aquatic genetic resources
6. Improve communication on aquatic genetic resources
7. Improve access to and distribution of aquatic genetic resources

Figure 57 shows the ranking of these objectives by countries at global level. It is clear that the main objective of national networks is to improve basic knowledge on aquatic genetic resources, while the economic valuation is the lowest on importance.

Figure 57. Ranking of objectives of national networks on aquatic genetic resources



8.6 Information systems on AqGR

Countries were asked to list any information systems existing in their respective countries for receiving, managing and communicating information about the conservation, sustainable use and development of aquatic genetic resources of farmed aquatic species and their wild relatives. 78 information systems were listed by 38 countries. Table 72 shows the number of information systems on aquatic genetic resources per country and by sub-region. Again, North America is the region with the highest number of information systems on this rea of knowledge, while Polynesia is the surveyed sub-region where there are no information systems.

Table 72. Number of information systems on AqGR per country by sub-region

Geographical regions	N. of information systems	Countries	N. of information systems per country

South-Eastern Asia	18	6	3
Southern Asia	5	2	3
Eastern Asia	4	2	2
Western Asia	1	1	1
Eastern Africa	9	5	2
Northern Africa	7	1	7
Western Africa	5	4	1
South America	9	7	1
Central America	6	6	1
Western Europe	5	1	5
Eastern Europe	3	2	2
Northern Europe	3	3	1
Southern Europe	1	1	1
Polynesia	1	3	0
Melanesia	1	2	1

Table 73 shows the number of information systems on aquatic genetic resources per country by economic class. Least developed countries have only 1 information system/country while developed and other developing countries have listed 2 information systems/country in average.

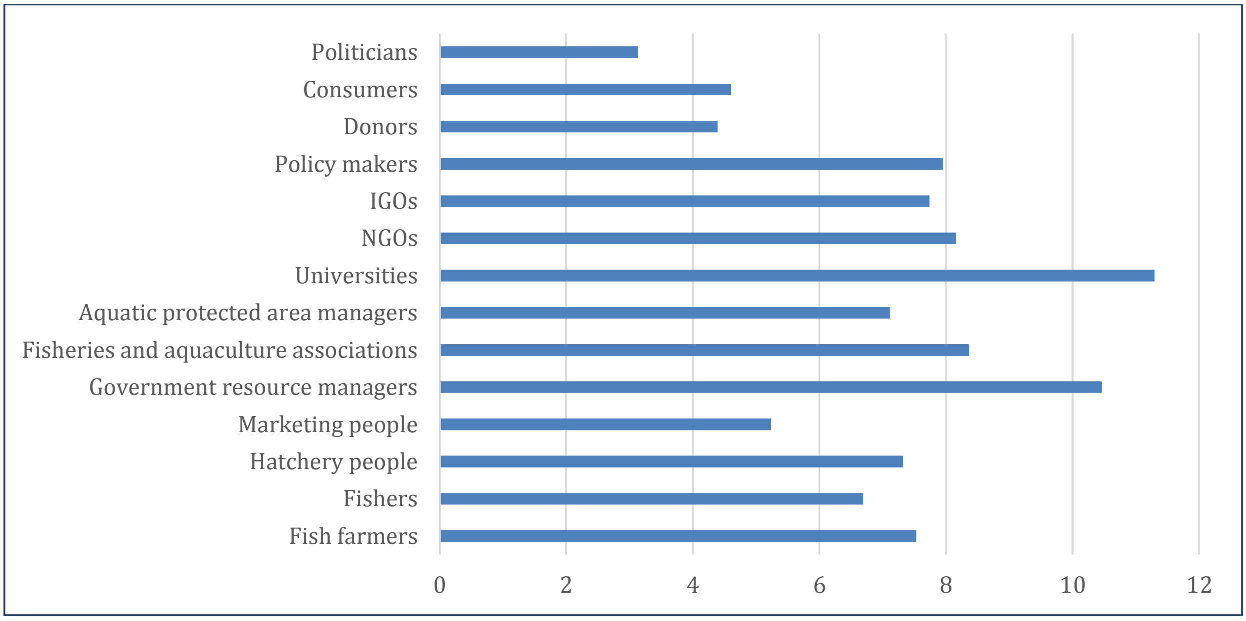
Table 73. Number of information systems on AqGR per country and by economic class

Description	N. of information systems	Countries	N. of information systems per country
Developed countries or areas	15	8	2
Least Developed Countries	15	12	1
Other developing countries or areas	48	27	2

8.6.1 Main users of information systems

Countries also assessed main users and extent of use by these users of the information systems on AqGR that are available at National level. Main users identified by countries and the extent of use of the aforementioned 78 information systems is provided in Figure 57. The main users of information systems identified by surveyed countries are Universities and Academia, followed by Government resource managers. Stakeholders with limited use of these information systems are politicians and donors. Aquaculture producers (hatcheries, farmers) also had a medium level of use of information systems.

Figure 57. Users of information systems on AqGR



8.6.2 Type of information stored in information systems on AqGR

Type of information stored in national information systems on AqGR was assessed by countries, and the results are shown in Figure 58. The type of information stored is also provided by economic class in table 74. It should be mentioned that most of the information systems available at National levels are focused on species names and production data, while very few information systems contain information on DNA, genes and genomics and strains/varieties.

Figure 58. Types of information stored in information systems on AqGR

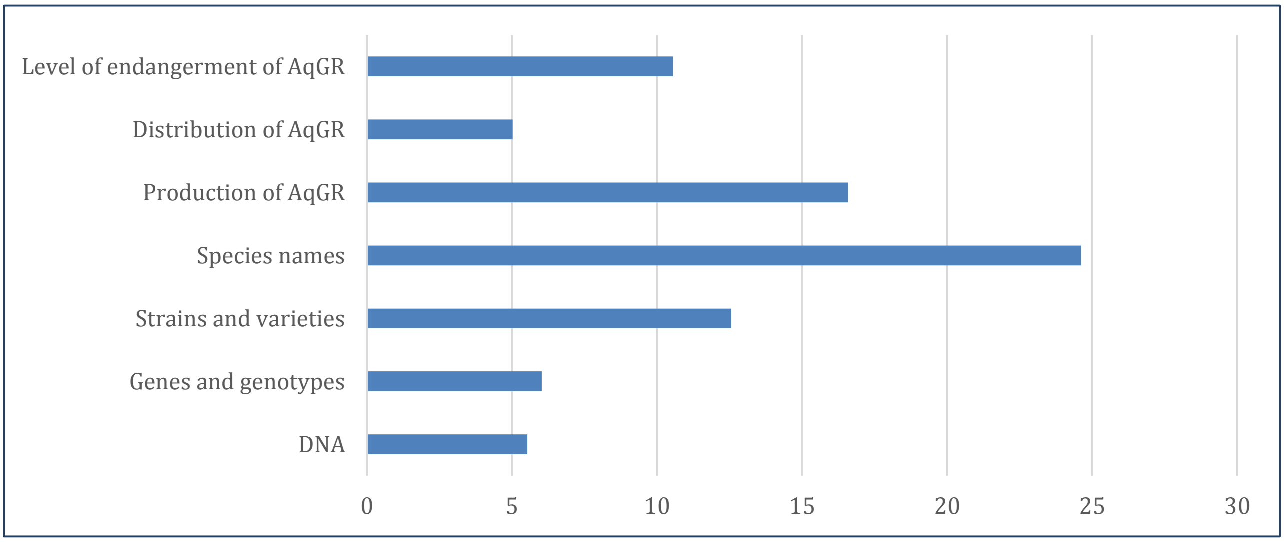


Table 74. Type of information stored in national information systems by economic class

Type of information stored	Response count	Description
Species names	24	Other developing countries or areas
	13	Least Developed Countries
	12	Developed countries or areas
Production figures	18	Other developing countries or areas
	9	Least Developed Countries

	6	Developed countries or areas
Distribution	17	Other developing countries or areas
	10	Developed countries or areas
	6	Least Developed Countries
Level of endangerment	14	Other developing countries or areas
	5	Developed countries or areas
	2	Least Developed Countries
Breeds, strains or stocks	9	Least Developed Countries
	8	Developed countries or areas
	8	Other developing countries or areas
Other	8	Other developing countries or areas
	6	Developed countries or areas
	1	Least Developed Countries
DNA sequence	7	Other developing countries or areas
	3	Least Developed Countries
	1	Developed countries or areas
Genes and genotype	6	Other developing countries or areas
	3	Developed countries or areas
	3	Least Developed Countries

8.7 Key findings and conclusions

Research	95% of countries have at least one research institution dealing with use, conservation and management of AqGR.
	83% of countries noted that research on AqGR (conservation, use and/or management) is covered under their national research programs.
	Certain surveyed countries within America and Africa don't have a component related to AqGR in their national research programs.
	244 research centers were identified by 46 countries. 76% of these centers are focused on basic knowledge on aquatic genetic resources, being this area of research the most covered one at global level; only 30% of the research centers are focused on economic valuation as one of their research areas, being the less covered at global level.
Capacity building and training	The most important capacity need identified by countries regarding research is actually the improvement of capacities on the economic valuation of AqGR of relevance.
	131 training and education centers dealing with use, conservation and/or management of AqGR were identified by the 47 surveyed countries. The main area of training at global is genetic resource management.
	Around 30% of the training courses reach a postdoc level.
Information networks and collaboration mechanisms	100 inter-sectoral collaboration mechanisms were listed by the 47 surveyed countries.
	93 national networks were listed by the 47 surveyed countries, being the most important objective of these networks the Improvement of basic knowledge on aquatic genetic resources.
	78 information systems on AqGR were listed by the 47 surveyed countries.

Information systems	Main users if national information systems on AqGR are universities and academia, followed by government resource managers. The less relevant users are donors.
	The type of information stored in these information systems is mostly (1) species names; and (2) production data on AqGR. Very few information systems are devoted to DNA data and Genes or genotypes information.

8.8 References and key documents

Key documents and information sources being consulted include:

- Country reports.
- CGRFA reports (14th and 15th sessions).
- CGRFA working documents, information documents and background study papers.
- FAO Fisheries Glossary.
- Convention on Biological Diversity.

9 INTERNATIONAL COLLABORATION ON AQUATIC GENETIC RESOURCES OF FARMED AQUATIC SPECIES AND THEIR WILD RELATIVES

PURPOSE: The purpose of chapter 9 is to review the mechanisms and instruments through which your country participates in international collaborations on aquatic genetic resources of farmed aquatic species and their wild relatives. The specific objectives are to:

- To identify a country's current participation in bilateral, sub-regional, regional, other international and global forms of collaboration on aquatic genetic resources. List national memberships, status as a Party and other forms of affiliation in agreements, conventions, treaties, international organizations, international networks and international programmes.
- To identify any other forms of international collaboration on aquatic genetic resources.
- To review the benefits from existing forms of international collaboration on aquatic genetic resources.
- To identify needs and priorities for future international collaboration on aquatic genetic resources.

KEY MESSAGES:

- International agreements of relevance regarding aquatic genetic resources use, conservation and management vary from 1-17 agreements/country, with clear differences between regions and economic classes.
- The impact of these international agreements on sustainable use, conservation and management of aquatic genetic resources has been assessed as positive and strongly positive by more than 50% of the total countries, with specific differences as well between regions, sub-regions and economic classes.
- The impact of these international agreements on stakeholders involved in the use, conservation and management of aquatic genetic resources has been assessed in a very variable way depending on countries, regions and economic classes, from no effect to strongly positive.
- The most important priority on international collaboration in surveyed countries is the Improvement of capacities for characterization and monitoring of aquatic genetic resources of interest, followed by the Improvement of basic knowledge on aquatic genetic resources.
- The less important priority on international collaboration need in surveyed countries was the Improvement of capacities for economic valuation of aquatic genetic resources, although there are variations between regions and economic classes.
- More than 50% of the countries have assessed that the following needs are met 'to some extent' at National levels:
    - Improving information technology and database management.
    - Improving basic knowledge on aquatic genetic resources.
    - Improving capacities for characterization and monitoring of aquatic genetic resources.
    - Improving capacities for genetic improvement.
    - Improving capacities for economic valuation of aquatic genetic resources.
    - Improving capacities for conservation of aquatic genetic resources.
    - Improving communication on aquatic genetic resources.
    - Improving access to and distribution of aquatic genetic resources

9.1 Introduction

Countries participate through a wide range of mechanisms and instruments in international collaboration on aquatic genetic resources of farmed aquatic species and their wild relatives. This introductory chapter lists key international instruments including CBD and its Protocols, the CCRF, CITES, RAMSAR, UNFCCC, and UNCLOS all of which have been considered by countries as being of relevance regarding aquatic genetic resources use, conservation and management.

9.1.1 The Convention on Biological Diversity (CBD)

Opened for signature at the Earth Summit in Rio de Janeiro in 1992, and entering into force in December 1993, the Convention on Biological Diversity is an international treaty for the conservation of biodiversity, the sustainable use of the components of biodiversity and the equitable sharing of the benefits derived from the use of genetic resources. With 196 Parties (May 2016), the Convention has near universal participation among countries. The Convention seeks to address all threats to biodiversity and ecosystem services, including threats from climate change, through scientific assessments, the development of tools, incentives and processes, the transfer of technologies and good practices and the full and active involvement of relevant stakeholders including indigenous and local communities, youth, NGOs, women and the business community. The Cartagena Protocol on Biosafety and the Nagoya Protocol on Access and Benefit Sharing are supplementary agreements to the Convention. The Cartagena Protocol, which entered into force on 11 September 2003, seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. To date (May 2016), 170 Parties have ratified the Cartagena Protocol. The Nagoya Protocol aims at sharing the benefits arising from the utilization of genetic resources in a fair and equitable way, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies. It entered into force on 12 October 2014 and by May 2016 has been ratified by 74 Parties.

9.1.2 The FAO's Code of Conduct for Responsible Fisheries (CCRF)

The FAO Committee on Fisheries (COFI) in 1991 called for the development of new concepts which would lead to responsible and sustained fisheries and aquaculture. Following significant developments in international fishing, such as, inter alia, the International Conference on Responsible Fishing in Cancun (1992, Mexico), the 1992 UN Conference on Environment and Development (UNCED) in Brazil, and the UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks in New York, the FAO Governing Bodies recommended the formation of a global Code of Conduct for Responsible Fisheries which would be consistent with these instruments, and in a non-mandatory manner, establish principles and international standards of behavior for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity. The CCRF was unanimously adopted on 31October 1995 by the FAO Conference and is now the cornerstone for the work of the FAO Fisheries and Aquaculture Department. Although the CCRF is non-mandatory, countries, as members of FAO, are committed to its implementation to the extent possible. Certain parts of it are based on relevant rules of international law, including those reflected in the United Nations Convention on the Law of the Sea. The Code also contains provisions that may be or have already been given binding effect by means of other obligatory legal instruments amongst the parties (Bartley, Marttin and Halwart 2005).

9.1.3 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between governments with the aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.

9.1.4 Ramsar Convention (RAMSAR)

The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. It currently (May 2016) has 169 Contracting Parties and the number of Ramsar Sites is 2,240 distributed across the globe with a total surface of designated sites amounting to 215,240,112 ha.

9.1.5 United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Framework Convention on Climate Change (UNFCCC) has 197 Members and is the parent treaty of the 1997 Kyoto Protocol. The Kyoto Protocol has been ratified by 192 of the UNFCCC Parties. The ultimate objective of both treaties is to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system.

9.1.6 United Nations Convention on the Law of the Sea (UNCLOS)

UNCLOS is the United Nations Convention on the Law of the Sea of 10 December 1982 is the international agreement that resulted from the third United Nations Conference on the Law of the Sea (UNCLOS III), which took place between 1973 and 1982. The Law of the Sea Convention defines the rights and responsibilities of nations with respect to their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources. UNCLOS came into force in 1994 and has been ratified by 167 parties.

9.2 International agreements and their impacts on aquatic genetic resources and on stakeholders: overview by region, sub-region and economic class.

This sections deals with International, regional or sub-regional agreements, conventions and treaties concerning aquatic genetic resources of farmed aquatic species and their wild relatives. Countries were asked to summarize the most important international, regional or sub-regional agreements to which each specific country subscribes to, and that cover aquatic genetic resources of farmed species and their wild relatives. Countries were also asked to assess the impact of those agreements on aquatic genetic resources and stakeholders, such as for example on:

- Establishment and management of shared or networked aquatic protected areas as far as wild relatives of farmed aquatic species are concerned.
- Aquaculture and culture-based fisheries in transboundary or shared water bodies.
- Sharing aquatic genetic material and related information
- Fishing rights, seasons and quotas as far as wild relatives of farmed aquatic species are concerned.
- Conservation and sustainable use of shared water bodies and watercourses as far as wild relatives of farmed aquatic species are concerned.
- Quarantine procedures for aquatic organisms and for control and notification of aquatic diseases.
- International collaboration has been defined for the purpose of this report as bilateral arrangements and the sharing of particular waters and stocks of wild relatives of farmed aquatic species.

9.3 Participation in international, regional, sub-regional, bilateral and other fora of relevance for aquatic genetic resources

Reporting countries listed between one and up to seventeen agreements with relevance to aquatic genetic resources that they participate in.

Table 75. Number of international agreements by country

Country	Number of International agreements	Country	Number of International agreements
Belize	1	Lao People's Dem. Rep.	2
Benin	6	Latvia	1
Brazil	8	Malawi	6
Burkina Faso	7	Malaysia	6

Cambodia	6	Morocco	9
Chile	1	Mozambique	3
Colombia	10	Nicaragua	4
Costa Rica	8	Panama	17
Czech Republic	4	Paraguay	1
Ecuador	9	Peru	8
El Salvador	8	Philippines	12
Estonia	1	Samoa	2
Fiji, Republic of	1	Senegal	4
Germany	10	Slovenia	1
Ghana	2	Sweden	13
Guatemala	3	Tanzania, United Rep. of	6
India	5	Thailand	4
Iran (Islamic Rep. of)	8	Tonga	2
Iraq	1	Ukraine	3
Japan	3	Venezuela, Boliv Rep of	3
Kenya	1	Viet Nam	5
Kiribati	2	Zambia	11
Korea, Republic of	3		

The various agreements and mechanisms listed by countries are listed in Table 76. The CBD (74%) and its Nagoya Protocol (62%) were most often cited, followed by CITES (60%), the RAMSAR Convention (38%), the Cartagena Protocol (16%), CCRF (15%) and UNCLOS (13%). Others such as OIE, IUCN or the Kyoto Conference were below 10%.

Table 76. Most important international agreements dealing with use, conservation and management of AqGR by Region

International agreements	Total countri es	%	North America (Canada)	LA C	Europe	Asia	Oceania	Africa
CBD	35	74	1	12	5	5	3	10
Nagoya	29	62	1	12	4	5	3	5
CITES	28	60	1	8	5	5	3	8
Ramsar	18	38	1	6	4	5		3
Cartagena protocol	16	34						
UN climate change	8	17		4		2		2
CCRF	7	15		2	2		1	2
UNCLOS	6	13		2	1	2		1
OIE	2	4	1			1		
IUCN	1	2		1				
Kyoto	1	2		1				

The number of international agreements by region ranges from 5 in Oceania to 28 in Europe (Table 77), and by economic class from 11 in the least developed to 17 in the other developing countries or areas (Table 78).

Table 77. Number of international agreements by Region

Geographical regions	Number of international agreements	Total number of countries
America	27	13
North America	5	1
Europe	28	7
Asia	24	11
Africa	27	10
Oceania	5	5

Table 78. Number of international agreements by economic class

Economic class	Number of international agreements	Total number of countries
Developed countries or areas	13	8
Least Developed Countries	11	11
Other developing countries or areas	17	27

The impact of international agreements on aquatic genetic resources has generally been assessed from positive to strongly positive, with less than 10 countries observing no effect. None of the agreements have had a negative or strongly negative impact. (Table 79).

Table 79. Impact of international agreements on aquatic genetic resources (N = Number of countries)

Impact on aquatic genetic resources	N	Country (Number of agreements having impact)
Strongly positive	20	Benin (6);Burkina Faso (5);Cambodia (2);Costa Rica (7);Czech Republic (1);Guatemala (3);India (1);Japan (3);Korea, Republic of (1);Lao People's Dem. Rep. (1);Malawi (1);Malaysia (3);Nicaragua (1);Paraguay (1);Peru (6);Philippines (12);Senegal (1);Sweden (2);Tanzania, United Rep. of (4);Viet Nam (1)
Positive	30	Burkina Faso (2);Cambodia (3);Colombia (10);Costa Rica (1);Czech Republic (2);Ecuador (9);El Salvador (8);Germany (7); Ghana (2);India (4);Iran (Islamic Rep. of) (6);Kiribati (2);Korea, Republic of (2);Lao People's Dem. Rep. (1);Malawi (5);Malaysia (3);Morocco (8);Mozambique (3);Nicaragua (2);Panama (15);Peru (2);Samoa (2);Senegal (3);Sweden (1);Tanzania, United Rep. of (2);Thailand (4);Tonga (2);Ukraine (3);Viet Nam (4);Zambia (9);
No effect	11	Brazil (9);Czech Republic (1);Estonia (1);Fiji, Republic of (1);Germany (2);Iran (Islamic Rep. of) (1);Nicaragua (1);Slovenia (1);Venezuela, Boliv Rep of (3);Zambia (2);

A more detailed summary by sub-region confirms that the majority of sub-regions including Central America, Eastern Africa, Eastern Europe, South America, Micronesia, Polynesia, Southern Asia, Western Europe consider international agreements having a positive impact of the on aquatic genetic resources, whereas several including Eastern Asia, Southeast Asia, Northern Europe and West Africa consider them strongly positive. Melanesia and Southern Europe are the only sub-regions were no effect predominates (Table 80).

Table 80. Impact of international agreements on aquatic genetic resources classified by sub-region.

Geographical regions	Impact on aquatic genetic resources		
	Strongly positive	Positive	No effect
Central America	29	68	3
South America	18	54	28
Eastern Africa	19	73	8
Western Africa	63	37	0
Northern Africa	0	100	0
South-East Asia	56	44	0
Southern Asia	8	83	8
Eastern Asia	67	33	0
Southern Europe	0	0	100
Northern Europe	50	25	25
Western Europe	0	78	22
Eastern Europe	14	14	71
Melanesia	0		100
Micronesia	0	100	0
Polynesia	0	100	0

9.4 International collaboration needs assessment: overview by region, sub-region and economic class.

This section is specifically focused on International collaboration, which has been defined for the purpose of this report as bilateral arrangements and the sharing of particular waters and stocks of wild relatives of farmed aquatic species. Countries were asked to list the priority needs regarding international collaboration on sustainable use, conservation and management of aquatic genetic resources of farmed aquatic animals and their wild relatives.

Table 81. Average rank for international collaboration needs regarding aquatic genetic resources sustainable use, conservation and management

Collaboration is needed in order to:	Average rank (1: very important; 10: no importance)
Improve information technology and database management	2
Improve basic knowledge on aquatic genetic resources	2
Improve capacities for characterization and monitoring of aquatic genetic resources	2
Improve capacities for genetic improvement	2
Improve capacities for economic valuation of aquatic genetic resources	3
Improve communication on aquatic genetic resources	2
Improve access and distribution of aquatic genetic resources	3
Improve access and distribution of aquatic genetic resources	3

The information from country reports can also be analyzed by sub-region. Responses clustered at the sub-regional level can indicate the extent to the needs for collaboration on the different areas identified in Table 81 are being met.

This will provide a regional gap analysis. For instance, from the 6 responses received for the Central American region 67% of responses considered that the needs for collaboration on improving information technology and database management were not being met or only 'to some extent', indicating that there is considerable scope for improvement.

9.5 Types of collaboration established in the past years: benefits, needs.

The last section of this chapter deals with the most beneficial types of international collaboration, providing some specific examples from countries and regions which can be varied and include collaboration with Academia or international and regional organizations such as FAO, NACA, SEAFDEC, World Fish Centre.

The analysis will identify, by region, commonalities among the types of collaboration which have been most beneficial for a country and how these could be reinforced or applied in other regions.

Furthermore, this section also includes specific needs for countries to expand their collaboration concerning sustainable use, conservation and management of aquatic genetic resources of farmed aquatic species and their wild relatives, including major requirements for capacity strengthening.

The final section of this Chapter will compile important roles which countries perform within a region and globally. Interesting examples from country reports may be highlighted, citing one or several examples for each region:

- Sturgeon species – Iran
- *O. mossambicus* – Mozambique
- GIFT tilapia – the Philippines and Malaysia
- *M. rosembergii* – Thailand
- 6 broodstock centers of various species – Viet Nam

As part of this assessment, certain countries have also provided details regarding important roles the country performs within its region and globally in terms of being a keeper, user or sharer of aquatic genetic resources of farmed species and their wild relatives.

9.6 Key findings and conclusions

The number and relevance and impact of international agreements varies between countries	International agreements relevant to aquatic genetic resources use, conservation and management vary from 1-17 agreements per country
	There are clear differences between regions and economic classes.
The impact of these agreements on sustainable use conservation and management is largely positive.	50% of the total countries assessed the impact as positive and strongly positive.
	There are specific differences as well between regions, sub-regions and economic classes
The impact of these agreements on stakeholders is highly variable	The impact of these international agreements on stakeholders involved in the use, conservation and management of aquatic genetic resources has been assessed in a very variable way depending on countries, regions and economic classes, from no effect to strongly positive.
Priority for international collaboration is to improve capacity to characterize and monitor AqGR	A secondary priority is the Improvement of basic knowledge on aquatic genetic resources.
	A less important priority is the Improvement of capacities for economic valuation of aquatic genetic resources
	There are variations between regions and economic classes.
More than half the countries have their information and capacity needs met to some extent	More than 50% of the countries have the following needs met 'to some extent' at National levels:
	Improving information technology and database management.
	Improving basic knowledge on aquatic genetic resources.
	Improving capacities for characterization and monitoring of aquatic genetic resources.
	Improving capacities for genetic improvement.

	Improving capacities for economic valuation of aquatic genetic resources.
	Improving capacities for conservation of aquatic genetic resources.
	Improving communication on aquatic genetic resources.
	Improving access to and distribution of aquatic genetic resources

9.7 References and key documents

Key documents and information sources being consulted include:

- Country reports
- CGRFA reports
- CGRFA working documents, information documents and background study papers

10 CONCLUSIONS AND RECOMMENDATIONS

(To be completed)