Study on the Potential of Aquaculture in ACP countries
An Overview Report of the Three Regions

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Cover Photos: Clockwise from top left: The (Mud) Crab Company Fiji July 2014, Yalelo Cage Tilapia Producer Siavonga, Zambia July 2014, J Hunter Fiji Pearls Savusavu Fiji July 2014, Herman Lee King Tilapia, Valencia River, Arima, Trinidad and Tobago August 2014.

Contents

Acronyms and List of Key Stakeholders

ACP	African Caribbean Pacific Programme	http://www.acpfish2-eu.org/
CDE	Centre for the Development of Enterprise	https://www.cde.int/
CRFM	Caribbean Regional Fisheries Mechanism	http://www.crfm.int/
CTA	Technical Centre For Agriculture and Rural Cooperation (EU-ACP)	http://www.cta.int/
EDF	European Development Forum	
FAO	Food and Agriculture Organisation	http://www.fao.org/aquaculture/en/
NACA	Network of Aquaculture Centers in Asia- Pacific	www.enaca.org/
NEPAD	New Partnership for Africa's Development	http://www.nepad.org/
OIE	Organisation Internationale des Epizootics	http://www.oie.int/
SARNISSA	Sustainable Aquaculture Research Networks in Sub Saharan Africa	www.sarnissa.org
SPC	Secretariat of the Pacific Community	http://www.spc.int/aquaculture/
WFC	WorldFish Center	http://www.worldfishcenter.org/

Figures

Tables

Executive Summary

- The evidence base for successful examples of aquaculture development and then its evolution across the ACP regions and more widely on a global scale show a relatively small range of "immanent"(investor funded) and "interventionist "(donor supported) examples/models (Belton 2011).
- The approaches for encouraging and then replicating these models are by their nature quite distinct and different for the private, government and research sectors in each case.
- Recognising these specific approaches and focussed use of resources is key to the success of their implementation and future sustainability in any aquaculture development project including the proposed ACP programme.
- Three target countries, one for each ACP region, were chosen for short scoping visits between July – August 2014 for this report to obtain quick overview of aquaculture development in each. Countries were chosen where aquaculture was not yet well developed but had potential to do so (Zambia, Fiji and Trinidad and Tobago).
- From these three countries 3 X 2 illustrative case studies were completed for this report.
- The scoping visits also included attending the first ever Caribbean Aquaculture Working Group (AWG) meeting for 2 days in Georgetown, Guyana, and also a visit to the NEPAD southern African node at Bunda College, University of Malawi for discussions with key ACP partners.
- UoS from the findings of this study and report also took on the role of producing a draft 5 year ACP Integrated Aquaculture Plan across the 3 regions. This is a first draft and working document which can be the basis for further discussion and modification towards a final 5 Year ACP Aquaculture Development Plan and detailed Description of Work.
- World aquaculture production and trade has for the last 15-20 years been dominated by Asian countries particularly China, with three ACP regions producing a small % of global production. Asian aquaculture imported products (at competitive prices) now permeated and for sale in range of ACP countries with associated knock on effects for ACP countries aquaculture production.
- Sub Saharan Africa in last ten years now beginning to increase its aquaculture production in certain countries such as Zimbabwe, Nigeria and Ghana (finfish), Madagascar and Mozambique (Shrimp), associated in former with growing national peri-urban demand and population growth, and latter for shrimp for export into European markets.
- Whilst Pacific and Caribbean countries (often small island states) have lower production levels, and restricted home demand due to their natural geography, population demographics. However for Caribbean due to proximity to lucrative US markets, previous history of export of aquaculture products ie tilapia Jamaica, but not sustained commercially for tilapia as export market collapsed. Presently Belize leading Caribbean in commercial shrimp and tilapia production still supplying US export markets.
- Impacts from first two years ACP aquaculture programme training based activities not clear. More effective evaluation should follow and measure subsequent activities and performance of those who were involved in training as to how they are individually impacting on improving aquaculture production and associated infrastructure and capacity building.
- Recognising differences in language and communication methods as a key to the bringing together and success of any ACP regional aquaculture development programme which is made up of so many different countries and cultures is vital

- And then developing an effective, fit for purpose online communication and information sharing network which is beneficial for its members, across countries , borders, regions and seas is the first step and cornerstone towards this ACP aquaculture development programme , learning from each other, from others; empowering people (existing producers and new prospective ones) in a multi-lingual, multidisciplinary network of individuals not organisations.
- Then using this network to build up a membership and database of registered members from a wide range of disciplines who have access to and also contribute to daily updated information, publications, videos, media news, employment and research opportunities to form we would envisage after two years an "Online Community of Practice".
- This growing network of individuals would then be valuable to give feedback and inform the ACP programme on the specific areas and activities which would need to be addressed in order for aquaculture to develop further in their regions. Thus the network would be a mechanism for were necessary shaping and modifying the 5 year ACP Aquaculture Plan.
- Alongside and complementing this network within the draft five year plan the authors have proposed a series of other targetted activities and outputs which they believe will further empower individuals, organisations and even countries to develop sustainable aquaculture across the 3 ACP regions.
- These include a working aquaculture internship scheme, setting up of working groups on key aquaculture issues including new potential aquaculture species and renewable energy use in aquaculture, publication of illustrative lessons learning case studies, development of mobile phone messaging services and smart phone mobile apps, development of 3 regional aquaculture development conferences and associated trade fairs, short online training videos produced, internet and networking training workshops for producers and value chain.
- Six case studies were prepared and included in this report , two for each ACP region. They were chosen to illustrate different scales and types of commercial and group related aquaculture production systems, as well as a novel government based aquaculture training facility.
- Some of the take home messages from these include: - Access to affordable quality feed and seed (fingerlings , juveniles) is crucial for aquaculture to develop in any country. – Hatchery production and supply of fingerlings should be the sole remit for the private sector not the government. - For smaller island states producing and selling to niche markets can be key ie mudcrab cultivation in Fiji. - At planning stage recognising this and not trying to produce species or products which can be produced or collected elsewhere at lower prices. – For effective and sustainable group aquaculture projects and enterprises, the groups and individuals therein have to be chosen carefully originally; they have to be supported well in first years, not necessarily financially but with regular communication and advice preferably from a commercial producer who is integral to the groups development. – Effective, hands on aquaculture training can be provided by governments in other ways than conventional Fisheries Department Extension services ie YTEPP Trinidad and Tobago. – Cage culture has been the main production system which is responsible for the last ten years increase in tilapia production across sub-Saharan Africa. Is this message applicable to the other ACP regions?

Introduction and Rationale

The Brussels Briefing n. 32 on Fish Farming: "The New Driver of the Blue Economy" was held on the 3rd July 2013 and co-organised by the CTA, DG DEVCO from the European Commission, the ACP Secretariat and Concord. This was part of the bimonthly briefings on key issues and challenges for rural development in the context of ACP-EU cooperation, and generated considerable interest from the audience resulting in an overall consensus to further develop the ACP aquaculture programme.
Following a range of presentations by experts (including Professor David Little co-author of this report) and from the Regional organisations in the ACP (NEPAD, CRFM and SPC), the ACP group of ambassadors recommended a focussed follow-up action on defining specific needs for support of the ACP group to be presented at the 11th EDF in September 2014.

Figure 1: Brussels Briefing Document 32: Fish Farming: The Driver for the Blue Economy

As a result the authors based at the Institute of Aquaculture, University of Stirling, Scotland, UK (www.aqua.stir.ac.uk) were contracted through CTA to compile an overview report of the Potential for Aquaculture for the three regions, whilst each of the three regional partners, NEPAD for Africa, SPC for Pacific and CRFM for the Caribbean, were tasked to produce their own specific regional reports. Stirling's overall report has been targeted with particular reference towards potential commonalities and synergies for sustainable aquaculture development between the three regions and a combined way forward without reiterating the specific content from the three regional reports. As well as the overall report from the findings of the three regional reports and Stirling's scoping trips to visit ACP and associated stakeholders

in each of the three regions, a summary 5 year Aquaculture Development Plan integrated for the three ACP regions has been produced, including specific targeted activities, timescale, resources and an approximate estimate of budget required. This is a constructive and targeted way forward within the ACP aquaculture development process and "A Plan for Work" document for discussion and refinement towards the next 5 years ACP Aquaculture support programme in the three regions.

The potential for aquaculture to fulfil a range of societal objectives depends on a range of factors integral to the three geographic regions that incorporate socio-economic, market value chain, human resource development (training and education), and policy as well as the need for new knowledge (research) or knowledge transfer from elsewhere. Our assessment will unpack the knowledge needs and potentials for interventions that could support sharing within and between the regions and aquaculturally advanced economies (AAE) elsewhere. AAE can be identified across a range of development and are not mapped in terms of simplistic OECD/LDC definitions but rather defined in terms of the rate of development of aquaculture and importance to the overall economy and household livelihoods therein.

The ACP "Fish Farming: The new driver of the blue economy " publication outlines the potential roles and importance of aquaculture in enhancing food security, poverty reduction, especially for lower income stakeholders in each of the regions. The distinction made between donor supported ("Interventionist") and private sector commercial investor funded ("Immanent") aquaculture development will be a focus for this study also clarifying the importance of differentiating between these two categorisations in relation to the evidence base of aquaculture development and its sustainability in the three ACP regions (Belton 2011). This report will also assess aquaculture within a broader framework incorporating its links with in other non-food-consumptive sectors such as tourism, ornamental fish, extraction of high value compounds, rather than considering it as a narrow technical development model.

Although not directly within the remit of this study, being also very aware that the ACP programme is EC funded and as such has European interests much at heart, we consider it important to identify specific sectors where European commercial and other organisations with the appropriate expertise can look for opportunities within the three ACP regions, and where they also can benefit and develop sustainable aquaculture development with local stakeholders. Experience gained from previous Asian and now Sub Saharan African aquaculture development show the increasing importance of transfer of small to mid-scale entrepreneurial and business based skills to build durable local aquaculture production and market chain capacities.

In terms of language(s) used, although the Study will be written in English, we would recommend that there is also a French language translated version made available online by ACP which will significantly increase the impact and readership not just across the French speaking aquaculture sectors including francophone sub Saharan Africa, but also to the likes of Haiti, St Lucia, Dominican Republic, Tahiti, New Caledonia, French Polynesia and Vanuatu.

Methodology for the Study

The Methodology for the production of the overall report and 5 year ACP Aquaculture Development Plan is outlined below in Figure 2:

Days	Activity	Outcome
1-3	Information Collection: Initial literature and online review.	Necessary primary information and data collected.
4-7	Individual contact by email and skype with CRFM, NEPAD and SPC individuals	More specific data, information and also key perceptions collected from range of stakeholders.
8-14	Visit to NEPAD representative in Malawi for feedback & further inclusions/modifications to draft study then visit to Zambia for overview of aquaculture sector and two specific short illustrative case studies.	
15-21	Visit to Fiji to gain overview of aquaculture development producing two short case studies, also meeting SPC representative(s) for feedback and further inclusions/modifications to draft study	
22-27	Attendance at Caribbean Regional Aquaculture Working Group Meeting Guyana with CRFM representative(s) for feedback and further modifications to draft reports (Caribbean and Overall). Then visit to Trinidad for overview of aquaculture sector and two specific short case studies	Following these visits data and information in draft triangulated and assessed.
28-32	Final Report/Study writing	Final study report and 5 year ACP Aquaculture Development Plan completed and submitted

Figure 2: Methodology of Study and Final Report

In planning the necessary information and data collection required for the report within the budget allocated it was decided to identify and carry out scoping visits to one illustrative country in each of the three ACP regions. This was to give a relatively rapid overview of aquaculture in each by spending 5-6 days visiting a range of production, value chain, government, research and input supply stakeholders and then from each to choose two sites/stakeholders to produce short illustrative, lesson learning case studies for this report. It should be added for the Caribbean we were also able to attend the first meeting of the Caribbean Aquaculture Working Group in Georgetown, Guyana, at which we met a range of CRFM country representatives from across the Caribbean in order to discuss further the aquaculture status and levels of development in their particular countries.

The selection of three countries to visit was carried out as follows: It was decided that the most effective use of time and resources was to visit those countries where aquaculture was not fully developed but having the potential to do so, rather than the more well-established larger producers such as Nigeria, Jamaica and Belize where aquaculture development was well documented for key species ie African catfish (*Clarias gariepinus*), tilapia (*Oreochromis niloticus*) and marine shrimp (*Litopenaeus vannamei)* respectively. For these reasons Zambia, Fiji and Trinidad were chosen. From each of these a total of six illustrative case studies were compiled and included in this report which then led on to formulating some of the key areas and recommendations for inclusion of activities in the 5 year Aquaculture Development Plan.

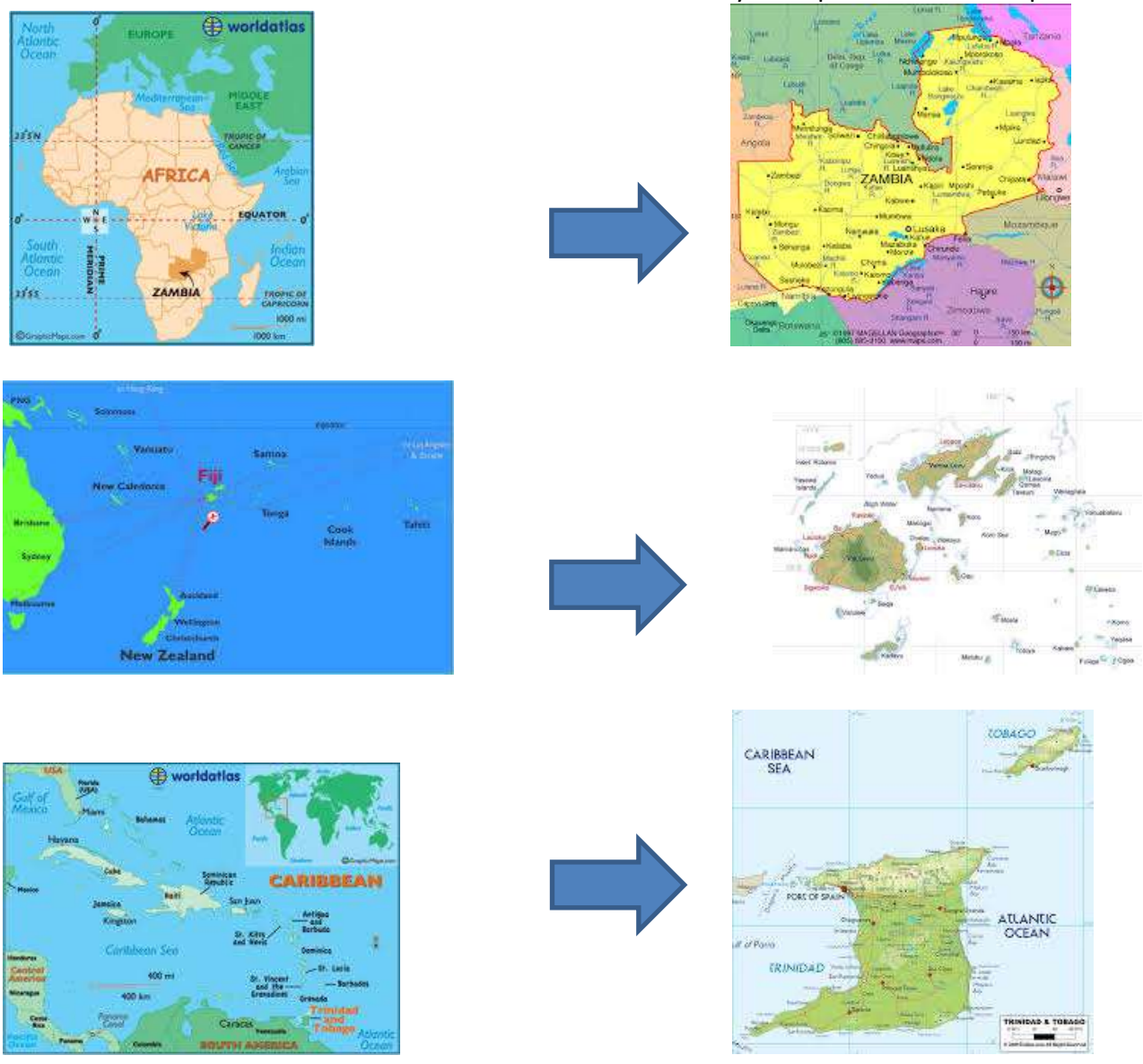

Figure 3: Three ACP countries (Zambia, Fiji and Trinidad and Tobago) visited as part of study report.

Chapter 1: Initial overview of overall global aquaculture sector, its recent growth, key trends in production and value chains, policy and regulatory mechanisms.

"*Aquaculture is the fastest growing food production system in the world. The industry has grown at a steady 8-10% over the past 30 years, and this is set to continue." (WWF 2012)*

1.1 Global Production and Species

With the global supply of wild capture fisheries having peaked (FAO 2012), and total global capture fisheries production reaching 91.3 million tonnes in 2012, a decrease of 2.6 percent compared with the previous year, aquaculture, the farming of aquatic animals and plants, has recently been described as the fastest growing global food production sector (WWF 2012). For the first time by 2012 it was producing over 50 % of all fish and aquatic products for human consumption globally with an estimated value of USD 137.7 billion. Since the turn of the millennium aquaculture production has continued to grow significantly, increasing at an average annual growth rate of 6.1 percent from 36.8 million tonnes in 2002 to 66.6 million tonnes by 2012. Pre 2000's during the 1980s and 1990's it achieved high average annual growth rates of 10.8 percent and 9.5 percent respectively although starting from lower base rates. It should be noted that aquaculture also includes the production of molluscs, and aquatic plants, mostly seaweeds, 23.8 million tonnes in 2012, with carrageenan seaweeds ie *Kappaphycus alvareezii* and *Euchemia spp* (8.3 million tonnes) followed by Japanese kelp (5.7 million tonnes) being the main cultured species. 2012's figures show 44.2 million tonnes (66%) were finfish, 15.2 million tonnes molluscs (23%), 6.4 million tonnes of crustaceans (10%), and 0.9 million tonnes of other aquatic species (1%). Inland aquaculture produced 38.6 million tonnes of finfish, this being 58% of global food fish aquaculture in 2012.

In terms of both countries and species, China predominates in the production of freshwater carps primarily to meet huge home population market demands. However in terms of global aquaculture production and value chains farmed marine shrimp (*Penaeus monodon, Litopenaeus vannamei*), Tilapia (*Oreochromis niloticus*) and increasingly Pangasius (*Pangasius hypophthalmus)* have now become globally traded commodities produced primarily in south Asia but also in south and central America. These species are generally cultured in two types of production system: either earth or lined ponds or cages. Although in recent years their production has been increasingly intensified using high capital water recirculation and filtration systems in response to a range of factors including environmental concerns, increasing competition for water and land use, and biosecurity towards minimising risk against aquatic animal diseases. In both Europe and US aquaculture developed and increased its production during the 1980s -1990's based primarily on salmonids (salmon and trout) in northern Europe, northern US, Canada and Chile), seabream *Sparus aurata,* and seabass *Dicentrarchus labrax* in the Mediterranean, and channel catfish (*Ictalurus punctatus*) in southern US. However into the 2000's this expansion has notably slowed and stabilised to remain at a consistent level of production over the last 10-15 years, as Europe and the US have increasingly imported farmed aquatic products from Asia.

Aquaculture's contribution to global fish production has risen steadily across the other continents, especially in Asia which has been producing more farmed than wild-caught fish since 2008. As a result Asia's aquaculture share of total fish production reached 54 percent in 2012, leaving Europe at 18 percent and other continents well below 15 percent. In terms of production by 2012 the top ten producers (excluding aquatic plants and non-food products) were dominated by China (41.1 million tonnes) followed by India (4.2 million tonnes), Vietnam (3.1 million), Indonesia (3.1 million), then Bangladesh, Norway, Thailand Chile, Egypt and Myanmar. These 10 countries contributed 88% of global aquaculture production by quantity in 2012. It should be noted that none of these are in the ACP countries with only Egypt from the African continent included due to its well-developed tilapia and mullet farming sectors. Whilst this very much

emphasizes the strength of Asia globally, in aquaculture terms it also illustrates that for each of the African, Caribbean and Pacific regions there is the potential to expand and develop its own aquaculture sectors in the countries and locations where the appropriate sites, resources, and markets are available.

Although still relatively small, African aquaculture production has significantly increased its % of total global production from 1.2-2.2% over the past 10 years, led by the development of inland finfish culture in the countries Egypt, Nigeria, Ghana and Zimbabwe. Whilst the Pacific has a very small % of global aquaculture production made up primarily from marine molluscs and finfishes, it increased between 2005-2012 in both production (1,213 – 9,478 metric tonnes) and value (692,000 – 1,243,000 USD) with French Polynesia and New Caledonia leading the way (Fishstatplus FAO). Likewise the CARICOM Caribbean region's aquaculture production is still comparatively small with an estimated 11,000 metric tonnes in 2010, which accounted for only 6.2% of the total fishery production for the region. Leading producers are Belize, Jamaica and Guyana.

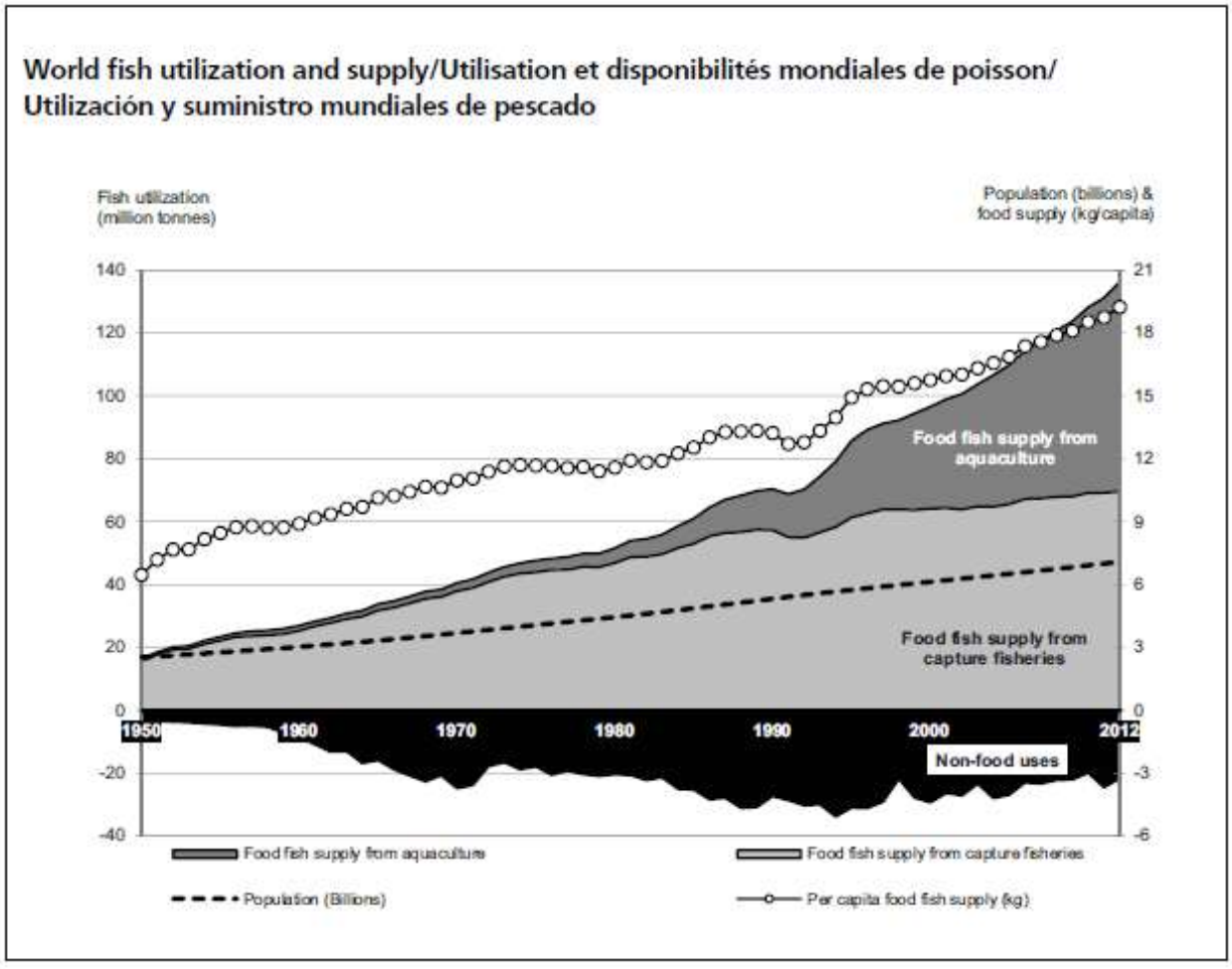

Figure 4: World Fish utilisation and supply (Source FAO Fisheries and Aquaculture Statistics Yearbook 2012)

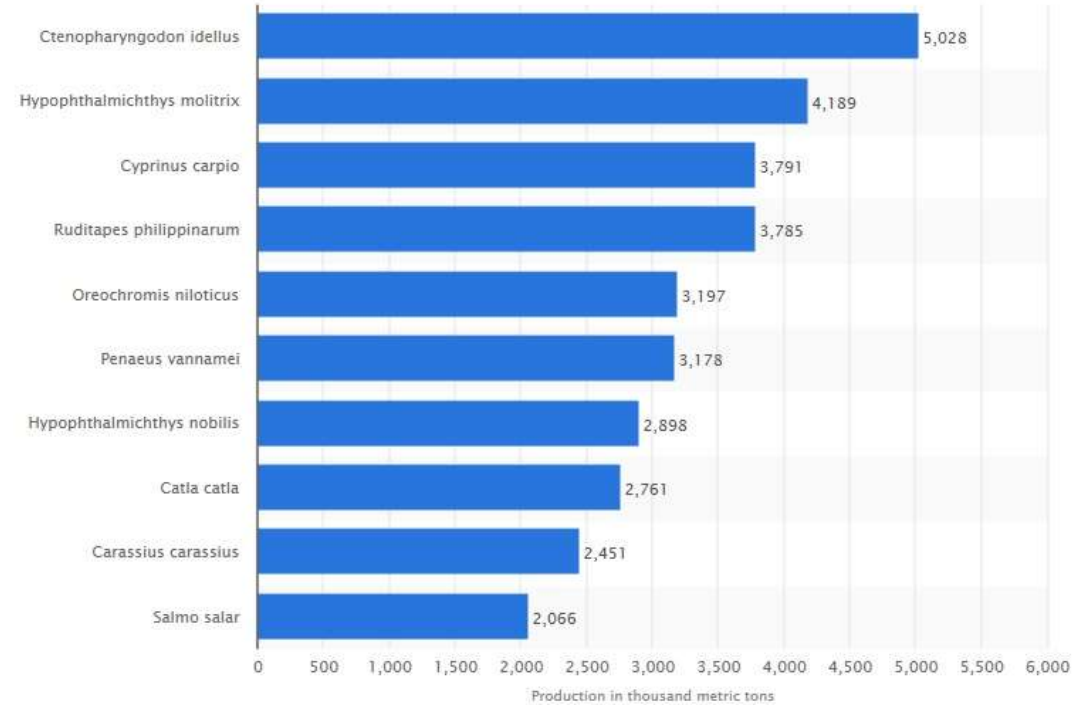

Figure 5: Top 10 species in global aquaculture production in 2012 (in 1,000 Metric Tonnes) Noting predominance of freshwater carps from China. Source: FAO Stat through @Statistica 2012

In terms of global fish consumption in 2011 Asia was responsible for over two thirds with 21.4kg per capita per year, which was similar to Europe (22.0kg) and North America (21.7kg). Africa and Latin America were much lower at 10.4 and 9.9kg respectively, whilst Oceania (FAO Pacific and Australasia grouping) – were highest at 25.1kg per capita per year.

1.2 Global Trade: World Markets

In terms of world trade in Fisheries products, a significant proportion (37% of total production in 2012) was exported entering international marketing channels, with global exports of fish and fish products reaching USD 129.2 billion , up 16.4% since 2010 (FAO 2012a). The USA and Japan were the largest importing countries in 2012 by value with 27% of total global imports, with developed, higher income level countries accounting for 73% of total fisheries imports in value. The European Union (EU) as a regional block is the world's largest market representing 36% of total global imports in 2012. If inter-regional trade between the 28 EU member countries is excluded this declines to 23%, which still made it the worlds largest market for fish and fisheries products in 2012.

In terms of nations China is by a considerable margin the main exporting country by value, followed by Norway, Thailand, and Vietnam. The net value of developing countries fisheries products (exports vs imports) has continued to improve over the last 25 years, increasing from USD 11.5 billion in 1992, to USD 17.4 billion in 2002, and then to USD 35.1 billion in 2012. These figures are significantly higher than for other globally traded agricultural commodities ie rice, coffee and tea. With global wild caught fisheries production no longer increasing during this period, it has primarily been the growing aquaculture sector in certain developing countries which has brought about these export import surpluses (FAO 2012a). However it should be noted that these are totalled figures for export vs import statistics for fisheries products and will by their nature be distorted by the likes of China with its large aquaculture production and huge population, growing middle class and associated market demand for fisheries products. For certain other developing

countries within the ACP regions by 2012 they were still having to import considerably more fisheries products than they exported including in Africa eg Nigeria, Ghana.

In terms of value marine shrimp was still the most commonly traded fisheries product in 2012 comprising of 15% of globally traded fisheries products. Whilst salmonids (salmon and trout) were the next group at 14%, with groundfish (eg hake,cod, pollack) 9% , and tuna 8% following.

In the future the World Bank has estimated that global demand for farmed fish will increase to 93 million metric tonnes by 2030 due to global population increases, changing demographics and socioeconomic dynamics with former developing countries undergoing rapid urbanisation and developing into mid income nations (World Bank 2013). To meet this demand the further growth of aquaculture will depend on a range of factors related to resource availability and sustainability including water and land access, inputs availability ie fish meal and its inevitable substitution and replacement in aquaculture feeds, lower energy costs, innovation and technological improvements, potential new aquaculture species, intensification of production systems (?) and control of aquatic animal diseases (HLPE 2014). In the mid to longer term to achieve durable financially viability in global aquaculture value chains they will have to move towards the right combinations of environmentally sustainable production systems (the Ecosystems Approach) also including other agricultural food production systems.

1.3 Policy and Regulation

Global aquaculture production has significantly increased in the 2000's due to wild capture fisheries production peaking, population growth and increased demand through commercial market value chains and mechanisms. However this growth has also occurred within specific national country based policy and regulatory infrastructures. These vary to a considerable extent in their complexity, implementation and effectiveness, often related to the individual country's GDP, per capita incomes and government resource and budgets availability. Most are primarily based on original government sector Fisheries Departments set up in the 1950's and 60's which began to formulate the first national legislative and regulatory mechanisms as aquaculture began to become more important. For certain regions and countries ie in Europe, United States and China, national aquaculture strategies and plans, often for up to five year periods, were produced. In the 1980s, 90s and 2000's national aquaculture plans began to be produced by others particularly in the growing Asian and African developing country aquaculture sectors as government Fisheries Ministries developed more specialised aquaculture departments and related staff capacities. These national plans, although providing recommendations and guidance tended to be relatively non-specific in their content and proposed activities, also in most cases not related to any specific or estimated budgets. In the 1970's and 80's in Europe and the US specific supportive government monitoring, regulatory institutional and legislative infrastructures were set up in key areas related to their national aquaculture sectors ie food safety, aquatic animal health, live fish introductions, aquaculture site and business registrations, and environmental impact assessment and monitoring. These have tended to follow slowly in other countries as aquaculture is increasingly producing globally traded commodities which are demanding certain standards. However for certain developing countries budgetary constraints and the lack of government political will to foresee the increasing potential for aquaculture have led to delays in providing the necessary infrastructure to promote and help aquaculture to develop. In developing countries there has also been a tendency for government aquaculture regulation, monitoring and support to be housed within a continually changing myriad of government ministries and departments, these often repeatedly changed as new governments come and go eg Ghana, Kenya, Malawi. Also there are further examples from Africa where the different components related to aquaculture regulation and support have been actually co-divided between a range of different ministries often leading to confusion and lack of communication. Neither of these two have led to even mid-term stability within the aquaculture sector of these countries

and these institutional fragilities and lack of capacity have in a number of ways acted as barriers for further aquaculture development.

Over and above national infrastructures, the European Union is an example of a trading block and member organisation which also sets and implements strategic aquaculture legislation and regulation for its member countries. This is particularly effective in areas of food safety and aquatic animal health setting standards for both inter EU trade in aquaculture products, as well as international trade to and from outside of the EU. It is also now addressing the recent non-increase in EU aquaculture production in the last 10-15years, highlighting and then trying to mitigate key constraints to increasing its production in the future.

In recent years certification of aquaculture products has become increasingly prevalent across global value chains, with a range of different schemes based on setting specific standards and best practices at different points along the input supply, production, and associated market chains to the consumer eg Global Gap, Global Aquaculture Alliance, WWF , ASC, MSC, Freedom Foods etc. Excepting ASC which had a more participatory stakeholder engagement programme, the others were originally set up with a more prescribed, top down approach with it must be said varying vigour and consistencies within their procedures. Although these different certification schemes have arguably raised standards and best practices across global aquaculture value chains, it should be noted that they were all developed and now run by private sector organisations (which are to a large extent in competition with each other) and are currently regulated minimally through national government or international bodies.

Regionally and internationally there are a number of other key organisations which support, influence, and to varying extents indirectly regulate aquaculture. FAO being an example which, other than having the responsibility for collecting national and global aquaculture production statistics annually, also provides support, publications, training and targeted funding. The CGIAR WFC (WorldFish Center) carries out similar roles internationally through its regional centres across Asia and Africa. The OIE (Organisation Internationale des Epizootics) also fulfils this international role for a range of notifiable aquaculture and other livestock related pathogens and diseases. Regional examples of such organisations are many but include NACA and SEAFDEC in Asia, and SARNISSA in Africa, each of which act as networks primarily for individuals providing and sharing key information and contacts required to develop aquaculture across and between the regions.

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Chapter 2: Overview of aquaculture development in ACP countries. Findings and impacts of ACP aquaculture programme so far.

"To ensure that ecological well-being is compatible with human well-being, and to make long-term sustainable prosperity a reality for all, it is necessary to strike the right balance between seizing opportunities and addressing threats in the use of technology and natural resources, in applying sound economic and policy decisions and in preserving environmental integrity and social license."

Árni M. Mathiesen, Assistant Director-General, United Nations Food and Agriculture Organization 2014

2.1Introduction and background to ACP

It has already been stated in the original introduction that this report does not aim to reiterate or repeat the specific content of the three ACP regional reports for Africa, the Pacific and the Caribbean which each provide in detail overviews for aquaculture development and potential in each ACP region and also the individual countries therein, and should each be referred to in this context. For this reason this section contains only brief overviews for aquaculture development in each of the three regions and then goes on to examine the activities and impacts of the ACP Fish programme in aquaculture so far.

As a grouping the African, Caribbean and Pacific Group of States (ACP) is a group of countries from Africa, the Caribbean, and the Pacific that was first created by the Georgetown Agreement in 1975. The group's main objectives are sustainable development and poverty reduction within its member states, as well as their greater integration into the world's economy. ACP as a grouping is composed of 79 African, Caribbean and Pacific states, with all, except Cuba, signatories to the Cotonou Agreement, also known as the "ACP-EC Partnership Agreement" which binds them to the European Union. There are 48 countries from Sub-Saharan Africa, 16 from the Caribbean and 15 from the Pacific.

2.2 Smaller Island States: Constraints and Advantages towards Aquaculture Development

Since many of the small island developing states are found in the three ACP regions states, the fourth Lomé Convention was revised in 1995 in Mauritius to give special attention to island countries in this agreement. This is perhaps the best way to enter this aquaculture summary of the three regions, since, especially for the Pacific and Caribbean regions, aquaculture and its development has very much been molded by the geographical, socio-economic and markets chain context of a number of smaller island states. These island states can be viewed in aquaculture development terms in both positive and negative lights. Isolated island status can present natural barriers to the unwanted introduction of a range of potentially financially important aquatic animal pathogens which can, as the evidence base for farmed shrimp in Belize and also across south Asia illustrates, significantly affect a country's main income earning aquaculture sector. It can also act as an effective barrier to introductions of unwanted, non-indigenous aquatic animal species which can potentially adversely affect the biodiversity of existing flora and fauna within the country. On the negative side, they have relatively smaller land and freshwater resources and with the exception of smaller island states like Singapore, Hong Kong etc, and have relatively smaller rural and peri-urban based populations which equate to relatively low market demand for farmed aquaculture food products, especially where in some cases their marine wild caught fisheries are still providing the necessary volumes of competitively priced marine fish for the majority of the populations concerned.

Africa due to its huge continental land mass, varying climate and water and resource availability, overall greater number of countries, significantly higher and increasing populations, and thus market demand has to be viewed in a different light related its aquaculture development. Although there are certain commonalities with the other two regions with Africa having its own island states eg Madagascar, Mauritius, Reunion, Cape Verde and Sao Tome and Principe having a number of similarities to their fellow Pacific and Caribbean ACP island compatriots.

2.3 Languages and Communication between and within the ACP regions

One other issue which is significant across all three ACP regions is language, both politically, culturally and commercially and as a result affecting aquaculture development through the (perceived) limited extent of information and contacts sharing across the three regions and equally within member countries within each region. Either English or French is spoken as the main national language in many of the 79 ACP states. The evidence base from sub Saharan Africa shows since the colonial introduction and promotion of aquaculture from the 1950's onwards, its development in francophone and English speaking countries has moved along different paths (Lazard, pers com 2013) with often neighbouring countries aquaculture sectors totally unaware of the aquaculture development of their different language speaking neighbours. Portuguese is also spoken in the five lusophone African countries Angola, Cape Verde, Guinea Bissau, Mozambique and Sao Tome and Principe. Spanish and to a lesser extent Dutch are also spoken in the Caribbean eg Cuba, Dominican Republic and Aruba. Whilst in the Pacific English and French are the national languages of a number of the island states eg Fiji, Cook Islands and Tonga, and French Polynesia and New Caledonia respectively.

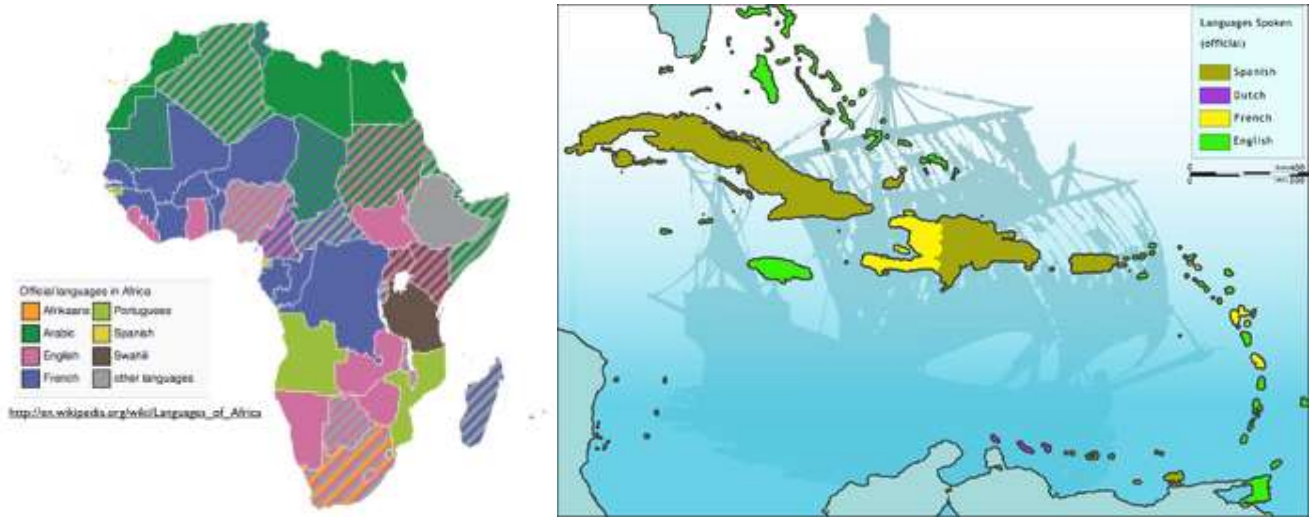

Figure 6: Maps of Africa and Caribbean Official languages. *Source:http://geocurrents.info/place/subsaharan-africa/african-country-names-in-indigenous-languages#ixzz3AgwPUhoP*

The issue of languages became highlighted as a present constraint in terms of aquaculture development across the three ACP regions as part of this study. The meeting for the first time of the Caribbean Aquaculture Working Group in Georgetown, Guyana in August 2014 was a very positive step for the future and it is hoped that ACP will continue to support its development, but in attending the meeting it became apparent that cross communication between the English and French speaking Caribbean could be further developed especially outside governments in the private, NGO and commercial sectors in order to further build bridges and develop aquaculture. Unfortunately the Spanish speaking countries ie Cuba were not present at the meeting. This issue with languages was also noted during the author's scoping visit to the Pacific and Fiji where certain commercial shellfish producers were experiencing environmental and potential disease problems leading to severe financial losses in their stocks. Having difficulty finding the necessary specialist scientific and research based support and advice in their own country they were aware of commercially well-developed shellfish sectors of the same species in other neighbouring francophone pacific states. However they were unable and unsure of how to contact them following previous attempts which had been met with minimal or no response. Although there can obviously be some level of commercial competition and confidentiality here, following discussing with relevant stakeholders in both

Fiji and New Caledonia there are definite mechanisms, official channels and setting up of bilingual information sharing networks that can be incorporated constructively within the ACP next 5 year Aquaculture Plan to ameliorate this situation and undoubtedly other similar examples occurring across the ACP aquaculture sectors.

Overview of Aquaculture in the Caribbean

The sixteen CARICOM/ CARIFORUM ACP group of countries composing of both island and continental mainland states are part of the 2.6 million km² area of the Caribbean Sea with an estimated overall population of between 60-70 million persons in 2012. Belize (5,290 MT Annual production in 2011), and Jamaica (5,140 MT in 2011) are the two main aquaculture countries specialising in larger scale marine shrimp and tilapia production respectively. Classification of the other countries in terms of aquaculture can be outlined as below:

Table 1: National level of aquaculture development for ACP Caribbean countries (categorisation from Myvett et al 2014)

Aquaculture Category - National level of development	Countries
Early Industrial Commercial phase	Belize, Jamaica
Intermediate Developing phase	Dominican Republic, Guyana, Haiti, Suriname
Initial Experimental Pilot phase	Bahamas, Barbados, Dominica, Grenada, St Lucia, St Vincent, Trinidad and Tobago

There are no current figures available for employment levels in the Caribbean aquaculture sector however in 2010 direct employment in all Caribbean Fisheries was estimated at 182,000 persons, this from a total fisheries production of 176,200 metric tonnes, of which 11,000 MT was made up from aquaculture production (ie 6.25% of total fisheries production). Demographics show by 2012 the majority of the Caribbean population were under 50, with aquaculture production being primarily male dominated, whilst females were more prevalent in the post-harvest and fish processing sectors.

Original attempts to develop freshwater aquaculture in the Caribbean go back to the 1950's when species like *Tilapia mossambicus and Cyprinus carpio* were introduced to Jamaica and a number of the other island states. An FAO Technical Assistance project started government hatchery and aquaculture station development in Haiti in 1954. However after early promise production declined through the 70's and 80's in Haiti despite further outside donor support. Perhaps one of the most influential projects and interventions in the earlier years in the Caribbean was the USAID tilapia project starting in 1976 in Jamaica which involved technical support from Auburn University, US. Starting originally based on small scale pond culture and local markets consumption with a few hundred kg of *Oreochromis niloticus* in 1977, it developed and consolidated through the 80s and early 90s into a smaller number of larger scale vertically integrated tilapia producers to produce over 5,000 MT of processed fish, mainly red hybrid tilapia, by 2002, most of which was exported to US and European markets (NAGA 2002). However into the new millennium, fluctuations in global tilapia commodity prices due to increased supply from other new competitive producers in Asia and South and Central America caused export sales to decline rapidly. This was not helped by increasing local feed prices and the Jamaican tilapia industry by 2003-2007 basically being composed of one large vertically integrated producer relying solely on export markets. As a result it was unable to react to these changes in world

markets and the lower input costs of their competitors with Jamaican tilapia production then declining from 5,000MT in 2007 to just 500 MT by 2013 (Wright, V. 2014 pers comm). In some ways this example of Jamaica has been a macrocosm for attempts to develop tilapia as an aquaculture species across the Caribbean where it has obtained footholds on a number of the island states but has not as yet been able to develop further due to many of the factors outlined above. Up to the present day there are further beginnings of commercial tilapia production in Belize (25 acre earthpond systems and Recirculation Aquaculture Systems- RAS) and Trinidad and Tobago (tank RAS, monosex hatchery and raceway systems). There are also two examples of culturing tilapia in marine or brackish water: a commercial company with cage culture of tilapia in St Kitts since 2006, and a Swiss based company trialling salt water tilapia production in pump onshore concrete tanks in south west Jamaica.

In terms of mariculture development other than the aforementioned commercial shrimp production in Belize there have been a range of more pilot type experimental attempts to develop different production systems across the Caribbean with not great uptake rate to commercialisation. For the molluscs from the early 1970's mangrove oysters (*Crassostrea rhizophorae)* have been produced semi intensively on line and raft systems across the Caribbean, more specifically in Cuba and Jamaica, but only ever at a local levels to supply small scale hotel trade (Jory, D. E. 1985). Industrial pollution and environmental issues especially on the sites selected in Cuba caused fluctuations in local spat production and adversely affected seasonal harvests and supplies of final product to local markets. Further experimental trials have been set up in Turks and Caicos, Bahamas and St Lucia with different molluscan species including the pacific oyster (*Crassostrea gigas*), hard shelled clams (*Mercenaria mercenaria*) and top shell (*Cittarium pica*) but have not yet progressed beyond their respective pilot stages.

Seaweeds cultivation have a similar history with *Gracilaria spp* rope or longline pilots having been trialled in St Lucia with limited uptake commercially. Smith et al 2002, concluded that seaweed development projects in the Caribbean had been effective in solving most of technological aspects of cultivation eg propagation methods and equipment , site requirements, plot maintenance and initial post-harvest processing. However in order to realize the full potential for seaweeds cultivation in the Caribbean this transfer of technology needed to be supported by a better understanding of the institutional, socio-economic factors that are critical to its success, research on which had noticeably been lacking in the planning and implementation of previous interventionist projects.

In terms of finfish mariculture there have been similar attempts to set up pilot cage culture sites some of which were associated with onshore hatcheries for species including cobia (*Rachycentron canadum),* Florida pompano (*Trachinotus carolinus)*, dolphinfish *(Coryphaena hippurus)* and red drum (*Sciaenops ocellatus)* . Of these Florida pompano culture has recently been scaled up into commercial business in the Dominican Republic in 2012, and is now one of the largest aquaculture projects in the Caribbean. It has a commercial hatchery facility in Santo Domingo and a large grow-out site in the Salinas region on the southwest coast with a business plan targeting the North American retail and food service markets (Reuters 2012). Cobia has been described as a species with great aquaculture potential in the Caribbean, and in the last few years the research and private sectors have been collaborating to demonstrate the viability of hatchery reared cobia in newly designed submerged cages in more exposed sites off Puerto Rico and the Bahamas. Hatchery and grow out of cobia is also currently been trialled in the Dominican Republic. For pompano and cobia these are quite significant capital based investments, and it is still relatively early days before any solid judgements can be made on their commercial viability and environmental sustainability's. For more extensive coastal brackish water channel fish culture, traditional systems based on tidal exchange on the Guyana coastline have been in operation for a number of years based on the extensive cropping of local indigenous species such as Hassar (*Micropogonias furnieri*), Lukanani (*Chicla ocellaris*), Cascadura (*Hoplosternum littorale*) and Mullet

(*Mugil cephalus*), with the Caribbean white shrimp (*Penaeus schmitti*) and Mexican brown shrimp (*Penaeus aztecus*) also being valuable by-catch.

Overview of Aquaculture in the Pacific

In terms of scale and value of production, aquaculture in the Pacific island states is still relatively insignificant compared to capture fisheries and in fact to global aquaculture production with its total annual aquaculture production being 9,478MT by 2012. Over the last decade the two main species which have headed production in terms of USD value and kg were the black pearl oyster (*Pinctada margaritifera*) in French Polynesia, New Caledonia and Fiji, and commercial scale marine shrimp culture (*Litopenaeus stylirostris*) primarily in New Caledonia. FAO annual figures show French Polynesia with the highest annual production (kg and value USD) in 2012 at 2,654 MT and USD 80,540 respectively (FishStat 2012). It was followed by Papua New Guinea (1,825MT and USD10,033) and New Caledonia (1,663MT and USD 16,915). Certain island states like the Solomon Islands (1,300MT and USD 534) and Kiribati (829MT and USD6,280) in 2012, have relatively larger kg production compared to their production values since they have specialised in seaweeds and other lower value products. In terms of incomes and employment it is estimated by 2014 more than 7,000 people are employed full or part time in coastal aquaculture, with 5,000 jobs in French Polynesia, and 200-600 in each of Fiji, Cook Islands, New Caledonia and Solomon Islands (Pickering 2014).

Figure 7: The black pearl oyster (*Pinctada margaritifera*) and blueshrimp (*Litopenaeus stylirostris*), key aquaculture products in the Pacific.

Seaweeds cultivation (*Kappaphycus alvareziii*) although a relatively lower value product has developed in a number of states including Kiribati, Fiji, Papua New Guinea and Solomon islands. Annual production across the region was 3,100MT dry weight in 2013 which was mainly exported to New Zealand, European and US markets.

Tilapia (*Oreochromis mossamibus, Oreochromis niloticus*) had originally been introduced in the Pacific in the 1950's for aquaculture and since has been developed mainly as a small scale, pond based income earning activity primarily as part of the subsistence economy. Although by 2014 still small scale the main producers are Papua New Guinea (PNG), Fiji, Vanuatu, Solomon Isles, Samoa, American Samoa, and Guam with national state's policies aimed towards developing tilapia for poverty alleviation, as a lower cost farmed fish which can address food security in more remote (inland) rural areas. There have been a number of donor funded programmes supporting tilapia culture in the Pacific including more recently the CGIAR WorldFish Center

Inland aquaculture development project in the Solomon Isles (WorldFish 2012). The EU through its European Development Fund (EDF) have also been supporting small scale business and value chain improvement programmes for tilapia culture through the European Increasing Agricultural Commodity Trade (EIACT) programme including strengthening tilapia cluster farmers and small scale tilapia cage culture in hydroelectric scheme dams. There are also current training and capacity building initiatives focussing on tilapia hatchery production ie in Fiji and Guam, especially towards developing and making available good quality monosex, all male tilapia fingerlings for the small but growing number of producers.

Other cultured species which are still at pilot/ early entrepreneurial stages include the Freshwater prawn (*Macrobrachium rosenbergii)* in Fiji, Vanuatu and PNG, mud crab (*Scylla spp*) also in Fiji, milkfish (*Chanos chanos*) in Palau, Kiribati, Solomon Islands and French Polynesia, giant clam (*Tridacna and Hippopus spp)* in Palau, Republic of the Marshall Islands (RMI), Federal States of Micronesia (FSM), and French Polynesia. For marine finfish culture WFC ACIAR have been active in supporting applied research for the Pacific island states in developing various species of higher value Grouper culture ie hatchery, fingerling and grow out production, fish health, and the development of an Asia Pacific Grouper network . They have also supported economic and markets analyses of live reef food fish trade across the Asia- Pacific. Related marine ornamentals including coral are sold for export from Tonga and Fiji.

Species with comparatively low set up and input costs which have potential for future aquaculture development especially for lower income coastal communities include Trochus or Topshell (*Trochus niloticus*) and Sea cucumber (*Holothuria scabra).* The Secretariat of the Pacific Community (SPC) have been at the forefront of looking to develop new species for commercially viable aquaculture in the Pacific an example of which being a joint SPC - ACIAR Tropical Sea Cucumber Aquaculture Symposium held in Noumea, New Caledonia in February 2011.

Aquaculture is still at relatively low levels in the Pacific with its expansion in the future dependent on a range of factors. The testing and provision of financially viable improved technological production models (both intensive and extensive) for species currently being farmed allied to associated value chain analyses to assess demand is still sadly lacking and an area where donors and governments Fisheries Departments can constructively focus on. These should be simple and flexible so that they are relevant to the context of the Pacific Islands environment and to the important market chains for sale of their products. Otherwise the geographical isolation and transport costs to and from outside markets for both inputs and export, cyclones and adverse weather heightening risk for uptake and investors, land and water tenureship, and access to and availability of land and freshwater are all key in shaping the direction aquaculture will take in the Pacific in the future.

Overview of Aquaculture in Sub Saharan Africa (SSA).

As an ACP region SSA is in many ways different from the smaller island based economies of the Caribbean and Pacific. It is the second largest by land area and 2nd most populous continent in the world, with a total land area of over 24 million km² which constitutes 20.4% of the earth's total land area. By 2012 It was composed of 48 countries with Nigeria being the most populous (173.6 million) and Seychelles the smallest population (89,000) (World Bank 2013). In terms of freshwater it has huge natural water bodies with about one-third of the world's major international water basins (basins larger than 100,000 km²), however about 66% of the African continent is arid or semi-arid with more than 300 million of the 1.1 billion people in sub-Saharan Africa living in water-scarce environments by 2010 (United Nations 2013). The total African continental coastline stretches for over 26,000km.

Some form of aquaculture has been practised on the African continent for over 2,500 years, with the Egyptians growing nile tilapia in ponds clearly shown in the hieroglyphics of tomb friezes (Bardach 1997).

More extensive brushpark acadjas (Lalaye, P. 2000) have also been used to produce food for hundreds of years by coastal communities in Benin and Togo. However for Sub Saharan Africa, in more recent times aquaculture began to develop from the 1950's onwards primarily in the colonial English, Francophone and Belgian administered countries. These were normally through the construction of government based fish farm and hatchery stations which were planned to supply fingerlings and also act as demonstration sites for promoting uptake by others. However through the 1960's overall inland aquaculture production remained low and with many countries gaining their independence during these times their administrations, limited budgets and more pertinent priorities were focussed elsewhere. From the 1970's to the 1990's there followed a period of "Interventionist", international donor funded support for aquaculture development across SSA. This was primarily based on the subsidised promotion of small scale, livestock and crop integrated rural aquaculture models, most of which had emanated from southern Asia. The donors and collaborating government Fisheries Departments also put strong emphasis on these being the way forward towards poverty alleviation and food security across the continent. Excepting the now growing Egyptian aquaculture sector in the north, and despite the considerable donor funds allocated, the sustainability, financial viability and overall production of these systems were very limited. Into the new millennium a change began with more "Immanent" commercial scale inland production and value chains developing in Nigeria for African catfish (*Clarias gariepinus),* in Zimbabwe, Uganda and Ghana for tilapia (*Oreochromis niloticus*), and Mozambique and Madagascar for marine shrimp (*Penaeus monodon*). Between 2006-2010 the growth rate for African aquaculture production increased from 12.6 -18.6%, reaching 1,301,400 MT by 2010 representing 2.2% of global aquaculture production (FAO 2012a). By 2011 FAO estimated 920,400 people (95.2% male 4.8% female) were employed in aquaculture across Africa, with Egypt (586,000), Nigeria (136,000) , Uganda (52,000), Madagascar (12,200) and Ghana (11,900) the leading employing nations (De Graaf 2013).

Up to the current day these three species: tilapia, African catfish and marine shrimp constitute the majority of the production both in MT and value. It is interesting and intuitive to note that for farmed tilapia despite the previous 30 years promotion and donor funds being towards earthpond based systems it is commercial cage culture which in the last fifteen years has developed to produce the majority of farmed tilapia across SSA led by Zimbabwe, Ghana, and Uganda, and now being taken up in earnest by other countries including Zambia and Nigeria. The Nigerian catfish farming sector has very much developed within its own private sector entrepreneurial context, some may say independently of state support, concentrating production in peri-urban areas with good access to still unfilled demand in Lagos and Abuja markets, with production reaching 253,900MT in 2012 making it the largest Sub Saharan African producer by weight.

Figure 8a and b. 8a Typical peri-urban *Clarias gariepinus* catfish farm including hatchery building in background, Abuja, Nigeria March 2013. 8b Commercial tilapia cage producer Volta Lake June 2014. Note levels of locally employed staff.

In terms of other freshwater species and aquaculture in SSA different carps have been introduced since the 1960's especially in southern Africa however production and sales haven't developed mainly due to cultural and lack of market acceptance of these species. Whilst different *Macrobrachium spp* have been trialled and piloted all over SSA but never made transition as in countries like Bangladesh into a commercially farmed commodity. Potential "new freshwater species" for aquaculture include *Heterotis niloticus ,* and the Bagrid catfish *Chrysichthys nigrodigitatus* in West Africa, and the lungfish *Protopterus aethiopicus* in East Africa, with well documented research based literatures available for both the hatchery and growout stages of these three species.

Mariculture although far less developed in SSA than its inland counterpart offers great potential for the future especially as the competition for freshwater with the continents growing population is only likely to escalate. As previously mentioned commercial marine shrimp production has in the last decade stabilised in Mozambique and Madagascar despite disease issues. The main companies concerned are Francophone based with selective certification and niche marketing into primarily European markets to avoid competition with Asian products. Finfish mariculture is still very much in its infancy however the cage culture of dusky kob (*Argyromus japonicas*) in South Africa, and the more research based and pilot scale cage production of "tropical ombrine" or red drum *Sciaenops ocellatus* , and goldlined seabream or "sage dore" *Rhabdosargus sarba,* has been developing in Reunion and Mauritius. French based researchers at ARDA in Reunion also on Mauritius have been refining the reproduction and hatchery phases of these species in order to scale up and determine the economic viability for commercial ongrowing in cages and wider sale locally or for export (ARDA 2012)

Figure 9: Video: ARDA Reunion Mariculture research and scale up of hatchery and cage growout of finfish species Red drum *Sciaenops ocellatus* and Goldlined seabream *Rhabdosargus sarba* https://www.youtube.com/watch?v=lrp1_SrGT-k

Marine species cultured at lower but still significant volumes include a cluster of mainly womens groups producing seaweeds in Zanzibar for now over ten years, commercial oyster and mussel cultivation in Namibia, more artisanal women's groups producing mangrove oyster in The Gambia, Senegal and Tanzania, and the beginnings of sea cucumber culture in coastal communities in Mozambique and Madagascar. Other "new marine species" which hold promise for the future include the marine halophytic plants *Salicornia spp* already trialled in coastal fish-shrimp-plant integrated systems in Eritrea, and brackishwater and marine cultivation of halophilic tilapia species trialled in Senegal (in greenwater RAS and cage systems) also in South Africa.

Due to its predicted future population growth, huge environmental and cultural diversity, past history, availability of resources, and range of existing aquaculture systems the future of aquaculture in SSA is a challenging but exciting prospect. If we can learn from the past, certain key components must be in place for it to move forward ie proximity and access to markets, hatchery fingerling supplies and (commercial) feeds, an applied, focussed, and contributing research base, and national environments and infrastructures which encourage and support all levels of commercial investment and entrepreneurship.

Impacts of ACP programme in aquaculture so far

The ACP FISH 2 Programme is a 4.5-year programme financed by the European Development Fund on behalf of ACP (African, Caribbean and Pacific Group of states) countries which since its inception in 2009 has primarily been aiming at improving fisheries management in ACP countries in order that fisheries resources of these countries are exploited in a sustainable manner. However the programme has also recognised the increasing importance of aquaculture across the three regions to fill the gap in the growing demand for aquatic food for their increasing populations, especially as their capture fisheries sectors and associated production are no longer increasing or for some fisheries actually in decline.

A series of workshops and trainings related to aquaculture primarily in areas of national and regional planning and value chains have already been completed as part of the ACP programme across the three regions. Details of these can be found at on the ACP website at http://acpfish2-eu.org/index.php?page=projets-par-region . Some examples of these are shown below from southern Africa:

Component 1: Improved policies and fisheries management plans

REVISION OF NATIONAL POLICY FOR FISHERIES AND AQUACULTURE IN MALAWI AND NATIONAL FISHERIES POLICIES IN SWAZILAND

Countries	Status	Amount (thousand euros)	Duration	Implementor
Malawi and Swaziland	Finished	EUR 135.580	3 months -02/2011 to 05/2011	MEGAPESCA Lda

SUPPORT FOR THE DEVISING OF THE AQUACULTURE DEVELOPMENT STRATEGY FOR BOTSWANA AND DEVELOPMENT OF OUTLINES FOR THE FISHERIES MANAGEMENT PLAN OF THE OKAVANGO DELTA

Botswana	EUR	5 months		SOGES s.p.a.
Finished	170.505	From 12/2010-05/2011		

Component 3: Reinforced national and regional research strategies and initiatives

Support for the Devising of the Aquaculture Development Strategy in Caia and Gorongosa Districts

Mozambique	Finished	EUR 85.546	5 months 6/13 - 11/13	IBF International Consulting

Component 4: Developed business supportive regulatory frameworks and private sector investment

REGIONAL TRAINING ON VALUE CHAIN ANALYSIS

Angola, Botswana, Comoros, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, Swaziland and Zambia	Finished	EURO 76.097	6 months 05/2012-10/2012	PESCARES

The specific impacts from these mainly strengthening of national and regional government plans and training workshops are not readily available although there are some related more general impacts shown on the ACP Fish II website http://acpfish2-eu.org/index.php?page=programme-results . The content shown therein lists numbers of national and regional strategies implemented and also numbers of training workshops including numbers of people trained. However these are not direct indicators of concrete impacts, in that it is the resultant specific actions and activities from these and in the end leading to specific increases in aquaculture production, sales, food and income generation and employment for lower income classes,

which are the true measurements of success or not. This of course for implementation of new more effective national aquaculture plans and strategies will be time dependent, with often a one up to five year intermediate period before the new national plans start to produce positive outcomes. Similarly this time delay can be the case for training of individuals through workshops or other means. However for more accurate and meaningful post-intervention assessment of such training programmes, it is not about the number of people trained or number of workshops, rather what happens to these individuals afterwards and how they individually improve, perform and produce (or not) in their particular employment sectors, which are much more accurate measurements and an informed evidence base for assessing and measuring specific impacts and cost effectiveness of such training programmes.

During the third meeting of the ACP Ministers responsible for Fisheries held in Nadi (Fiji) on 18th June 2012, which addressed partnerships for sustainable development across the fisheries sector in ACP countries, a five year strategic plan of action (SAPFA) was drawn up for implementation to invigorate the ACP Ministerial Fisheries Mechanism. This plan set in place five strategic priority areas to build on the initials workshop and training programme:

- Effective Management for Sustainable Fisheries
- Promoting Optimal Returns from Fisheries Trade
- Supporting Food Security in ACP Countries
- Developing Aquaculture
- Maintaining the Environment

Although only the fourth point specifically mentions aquaculture development, it can be seen very clearly that three out of the remaining four directly relate to it.

This meeting was then followed by the drafting and production of the aforementioned Brussels Briefing Number 32 document on Fish Farming: "The New Driver of the Blue Economy" which was prepared by CTA to inform a bimonthly briefing on 3rd July 2013 in Brussels on key issues and challenges for rural development in the context of ACP-EU cooperation and the ACP programme so far. The meeting was attended by key persons from DG DEVCO from the European Commission, the ACP Secretariat, Concord, and CTA. Also participating and giving a range of presentations were key aquaculture specialists from the European Union and also the three ACP regions. Considerable interest was generated across the meeting resulting in an overall agreement to move forward to further develop the ACP aquaculture programme in a focussed manner. It was agreed that the first priority should be up to date reviews on the current status and future potential for aquaculture development in each of the three regions (drafted by SPC, NEPAD and CRFM respectively), as well as an overall review identifying the key mutually beneficial synergies and potential collaborations towards developing a joint aquaculture mechanism/strategy across the three ACP regions (from Stirling University i.e. this report). The University of Stirling also took on the role, from the findings of these reports, of compiling the first draft of a Five Year Integrated Strategic Plan for Aquaculture across the three ACP regions. These (4X) reports and the 5 year strategic plan will then be presented at the 11th EDF (European Development Forum) in October 2014 for further ratification towards implementation.

Chapter 3: Evidence base for contribution of aquaculture to food and nutrition security and poverty alleviation in developing countries

"Ultimately, food is both a symptom and a symbol of how we organize ourselves and our societies. It is both a vignette and a microcosm of wider social realities." (Lang, T. 2000)

Introduction

Presently it is capture fisheries and aquaculture which provide 3.0 billion people with almost 20 percent of their average per capita intake of animal protein, and a further 1.3 billion people with about 15 percent of their per capita intake (HLPE 2014). Among the 30 countries in the world where fish contribute more than one-third of the total animal protein supply, 22 were officially referred to as Low Income Food Deficient Countries (LIFDCs) in 2010 (Kawarazuka and Béné, 2011). This equates to a number of the countries in the three ACP regions where fish and aquatic products provide lower income individuals and households with a significant proportion of their annual protein intakes. It has already been described in previous chapters that global capture fisheries are at the most optimistic no longer increasing their production, at the worst actually declining, whilst aquaculture is now one of the fastest growing food production sectors in the world, and increasingly filling the gap in supply from traditional fisheries.

This chapter, through a literature review and primary information from the authors, examines the evidence base for aquaculture positively affecting and impacting upon nutritional security and poverty alleviation in primarily developing countries including those in the ACP regions. It is well known for those working in the research, government and even commercial sectors to see in the media, in the literature, in donor funded project reports, in government reports, and in other publications, the continual assertion that aquaculture can and actually is increasing nutrition security and poverty alleviation for lower income communities, households and individuals in developing countries. However on looking more closely at many of these publications the actual evidence base (statistical quantitative and qualitative) to corroborate these assertions is often either completely absent or unclear.

Relationship between aquaculture, fisheries, food security and poverty alleviation

On looking more deeply into the relationships between aquaculture, food security and poverty alleviation it becomes apparent that they are complex and often dynamic, continually changing. Figure 10 below shows the myriad of pathways and linkages of how fish production, through both aquaculture and wild caught fisheries can contribute to food security and nutrition directly through availability of nutrient-rich food both at the household and at local, provincial, and national market levels. Whilst it also highlights the indirect benefits at household level or higher national levels in terms of generation of incomes and employment not just at production but increasingly at post-harvest levels along the processing and market value chains.

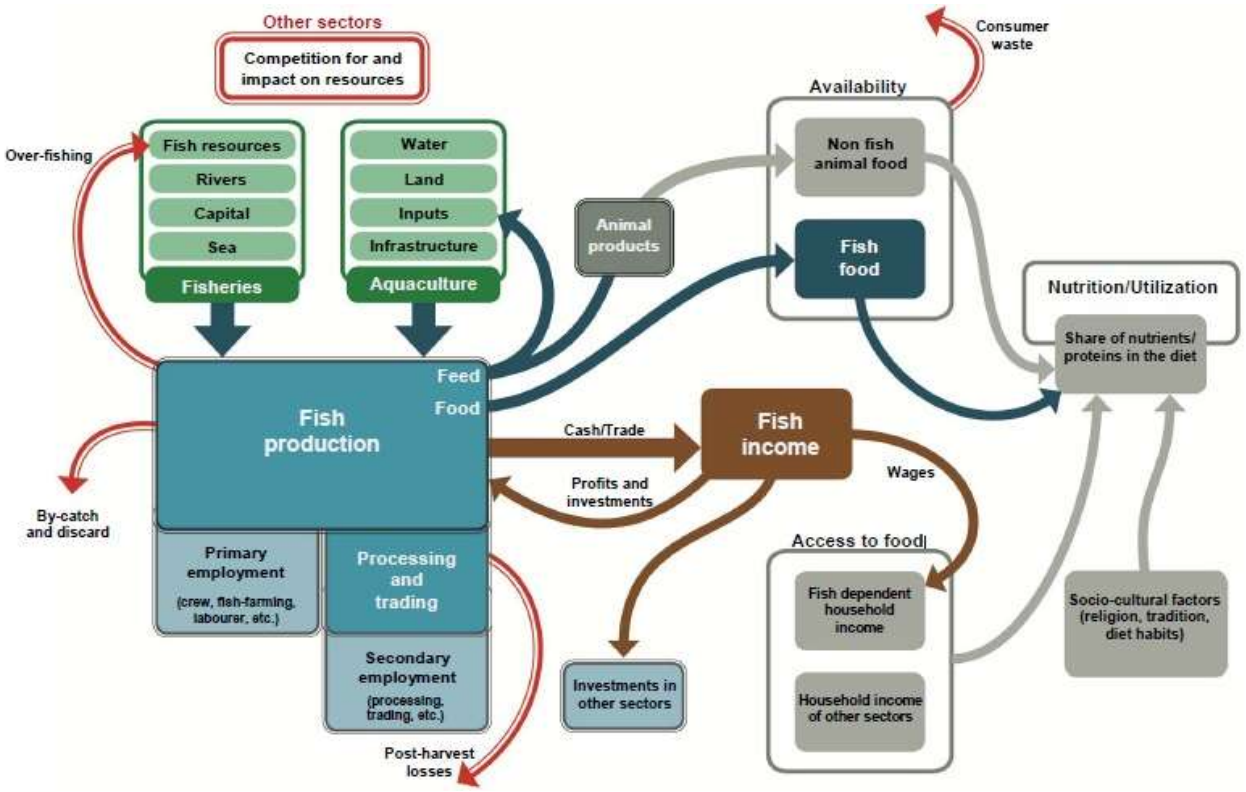

Figure 10 Conceptual representation of the different pathways between fish and food security and nutrition (HLPE 2014)

In the past from the 1950s, as aquaculture became a perceived vehicle for alleviating poverty and providing protein in LIDC s the more conventional "interventionist" and donor driven view was this could be achieved through short term 1-3 year projects promoting smaller scale rural aquaculture to provide food within rural areas and villages. These were often based on recycling inputs and outputs (based on integrated systems

in S Asia) and a numbers led approach where large numbers of rural farmers were trained in aquaculture techniques (irrespective of the suitability of their sites or backgrounds) then provided free or subsidised inputs such as feed and fingerlings. This almost blanket approach to aquaculture development, particularly implemented across SSA, did not bring about significant increases in production and tended after two – three years or when the projects finished, to have a very small % of the original participants still actively farming and harvesting fish. The evidence base for this is quite clear throughout the 80s 90s 2000s in countries like Malawi, Ghana, Kenya where donors project reports can be accessed documenting the 2-3 years of the project; however few if any go on to produce and publish evaluations to show the post project performance and fate of the participant fish farmers. The peer reviewed literature, where it is available, tends to also reflect this short term approach and lack of critical but constructive assessment of the projects impacts and also value for money (Dey 2010). Dey is quoted here in relation to Malawi but there are a number of other examples.

In more recent years there have appeared more critical publications which tend to question this interventionist approach (Pant 2013) and also analyse in more detail the question of scale in aquaculture production in relation to sustainability and the economic viability of the systems. Belton (2012) discusses scale in relation to the recent considerable growth of the aquaculture sector in Bangladesh based on small to mid scale pond production of pangasius and also river cage production of tilapia. This in the context of a previous history of small scale rural integrated aquaculture type development focussing on more traditional indian carps. The growth of these new commercial scale pangasius and tilapia models in Bangladesh have also been aided by commercial formulated feed now being produced and also a technically proficient private hatchery sector which is now producing fingerlings in the millions rather than thousands. Brummett (2011) also looked at scale of production in relation to the economic viabilities of pond aquaculture systems in Cameroon. His conclusions were that for the type of systems and inputs they were using, ponds or farm sizes had to be above a certain area and volume before they would be economically viable. For lower income Cameroonian households in such cases they would be better using the land and /or water for other agricultural purposes. This may seem a harsh conclusion however is backed up by thousands of small abandoned fish ponds across the African continent which tell a similar tale.

The relatively recent growth of commercial scale aquaculture production in Zimbabwe, Nigeria and Ghana is not well documented or reviewed in the peer reviewed literature. It appears many researchers still wish to write about more traditional small scale and perhaps as they perceive it "pro poor" aquaculture systems. However this stance could be perceived as ignoring both the economic and social benefits which have accrued from these new commercial systems. Companies like Lake Harvest in (Zimbabwe and Uganda) by 2014 now employ over 800 staff, Tropo Farms in Ghana nearly 600 staff throughout their operations. Over 90% of these staff are in country nationals often from rural areas and district towns, a significant proportion of whom are employed in the post harvest, processing and distribution sectors (De Wilde Pers comm 2014) . It is also interesting to note for each Lake Harvest staff employed in Zimbabwe, they are on average actually supporting 9 other extended family members from their individual salaries (Pasipimire Pers comm 2012). From a Caribbean perspective the experience and benefit to local communities so far with commercial scale (tilapia) aquaculture has been far less successful. Significant numbers were employed in the early to mid 2000s during the heady days of Jamaican commercial tilapia production when 5000-7000MT per year were achieved and sent for export markets. Again similar to the African examples it was in the post harvest and processing sectors where most persons were employed, also not forgetting the fish feed mills and distribution. Sadly many of these jobs along with the associated production have disappeared now primarily due to competition in export markets and higher costs for inputs, leaving us with the question: could such systems at some time in the future become economically viable again ? Perhaps one of the issues here was basing a whole production sector on what will always be volatile export markets and a key objective being earning foreign currency, also not having the flexibility to switch supply to other more local markets during difficult times.

Belton (2011) also concluded from the empirical evidence from the literature for Bangladesh that at smaller to mid production levels it is usually better-off farmers or individuals who have the capability to adopt new practices and technologies and thus obtain the benefits. The reasons for this include education, income and access to credit and information, but also more structural issues, such as ownership or rental of land and water resources. He also concluded similarly to Brummett (2011) that fish-farmers located in peri-urban areas are more likely to generate higher incomes and longer-term financial viability than similar producers in more remote rural areas due to access to both inputs and higher value markets. This illustrates the importance of access to urban markets for both the sale of fish as well as access to key inputs such as feed and fingerlings. However it is again the gaps in the literature on comparative analyses between the production and performances of urban, peri-urban and rural producers in specific country contexts , whilst also the uncertainty and different perceptions of what constitutes "urban", peri-urban or "rural " in terms of aquaculture site and associated markets chains locations (Kassam, 2014).

Aquaculture and its contribution to National Economies

Bene (2013) carried out a detailed literature review on the evidence base for aquaculture and wild caught fisheries impacting positively on poverty alleviation and food security. In this review he and co-authors scored (using a standardised format) a carefully selected number of peer reviewed papers which described various levels of impact. His findings for aquaculture were similar to above, finding very little direct quantitative or qualitative evidence showing direct impacts of aquaculture on poverty alleviation and food security. In the review he also looked at how aquaculture benefits national economies and hence contributes to poverty reduction. Here he found little direct evidence, due to where datasets were described they were often aggregated and no clear conclusions could be made on how the benefits of this trade was distributed potentially to benefit lower income people. Studies on the distribution and taxation revenues from domestic aquaculture trade are few and far between thus how much and in what way aquaculture contributes to national economic development remains unclear for many developing countries. Definitions and measurements of poverty across developing countries can also be quite diverse and make inter country comparisons difficult. There is therefore the need for inter-country comparisons based on well-designed research studies that acknowledge the variability of production systems in their different local/regional contexts. Amongst this mainly negative discussion there are certain countries where national level data is available online for Vietnam and Nigeria which indicates that commercial aquaculture systems in particular have generated considerable domestic and export revenue, and account for a significant share of national Gross Domestic Product (GDP). This is fairly common knowledge in the case of the huge growth of the Vietnamese pangasius farming sector over the last ten years, with the associated export earnings and significant employment generated especially in the post-harvest processing sectors, and likewise but to a lesser extent for the Nigerian Clarias industry. However the quality of this particular evidence is not very robust as it does not give further data to illustrate the effects of derived tax revenues and foreign exchange earnings on the welfare of lower income households. As a result, the quality of this body of evidence is relatively low, essentially due to the lack of disaggregation and the lack of substantial evidence of how revenues contribute to the national economy and/or pro-poor outcomes at the local and household level for both these directly involved and the rest of the population.

Conclusions

The recorded evidence base in the literature is very limited in showing the direct and indirect impacts of aquaculture development on food security and poverty alleviation in developing countries. We should then

ask is this because it is actually factually the case that aquaculture has limited beneficial effects for lower income people or in the authors view more likely researchers and academics have not yet focussed their research and publications on areas where aquaculture has made positive impacts in developing countries? What is clear from the review is that scale of production is an issue which affects the different ways in which food security and poverty alleviation can be impacted upon. And not necessarily concluding that the new emergent "immanent " commercial scale aquaculture is the only model which will significantly impact on poverty alleviation through employment and income generation rather than producing fish in local villages to eat. Rather both "immanent" commercial and "interventionist" more extensive donor funded systems can be successful in benefitting poorer people in their different ways, however the developmental, promotional and resources use approaches to both are quite different, and in any development programme or commercial context there should be a clear focus on what is required to move them towards longer term sustainability. In the long term for each of the different approaches environmentally sustainable aquaculture production will depend on the right combination of production systems resource use (e.g. land water, energy), farming species low on the food chain, use of appropriate inputs (feeds, seeds, labour, infrastructure) and management of production (e.g., husbandry best practices diseases), given trade-offs with other uses of the resource bases (water, land) improved
marketing/distribution systems.

Chapter 4: Selected case studies of successful and durable aquaculture development (of different scales) across each of the three ACP regions.

Introduction and Methodology

In the formulation of this overall comparative report the authors decided that it would be instructive to include two short case studies from each of the three ACP regions. This was firstly to show specific examples where aquaculture development and associated value chains had been successful or offered promise for the future across the three regions, and secondly illustrated a number of key outcomes which were relevant to the compilation of the ACP 5 year Aquaculture Development Plan.

The subjects for these case studies were identified and chosen following the authors scoping visits to Zambia, Fiji and Trinidad and Tobago, where in each country a range of different private sector aquaculture production, value chain, research, and government sites/organisations were visited. The countries themselves were chosen to visit firstly as in the time frame only one country in each region could be visited. But secondly and more importantly we wished to look at countries where aquaculture was presently not well developed but had the characteristics and resources to do so in the future.

Case Study 1: The Crab Company, Fiji.

Figure 11a and b: 11a The Crab Company, producing Mud crab (*Scylla serrata)* for local Fijian markets July 2014. 11b Harvested mud crabs ready for sale

Introduction

The beginnings of this company were initiated in 2004 when former natural resources consultant Wilco Liebregts met Colin Shelley an aquaculture scientist who had previously worked in barramundi and crustaceans in Northern Territory, Australia. Following discussions including the local overharvesting of crabs resulting in declining stocks, the ready market in urban areas and the tourist industry, and a wish to involve local Fijian communities in aquaculture, they decided with the relatively new technology which enabled the commercial breeding and ongrowing of crabs that there was a future in Fiji for mud crab (*Scylla serrata*) culture.

Towards a commercial business

Initially finding capital to set up was a problem but by 2007 part funding was secured from CDE (Centre for the Development of Enterprise) to carry out a feasibility study on a potential site of an old shrimp farm and also a markets survey to combine towards a full business plan. It was estimated that then latent market demand for mud crabs in Fiji was between 70-150MT per annum.

By 2009 the option of leasing the former shrimp ponds and associated packing building was taken up, then an agreement obtained to set up a mud crab hatchery at the University of South Pacific Marine Science Department. The Crab Company (Fiji) was then registered and set up in 2011. Five hectares of the former shrimp ponds were renovated in 2012 and the first breeding cycles began in the hatchery. Following some low survival rates with the first hatchery cycles, modifications to the filtration systems and more rigid disinfection of tanks in between cycles were carried out, hatching and survival rates then improved considerably to allow a continual process for stocking the earthponds.


Figure 12a and b 12a Mud crab hatchery primary tanks. 12b Outdoor nursery facility

Into Commercial Phase

By 2013 13 ponds (largest 1.3 hectares) including 2 nursery ponds totalling 9 hectares had been renovated and stocked with 4" crablets at 5,000 per hectare. Grow out ponds were furnished with plastic hides (approximately 0.5 per m^2) and the crabs were fed 2 times daily with locally available fish waste from a nearby processing plant. A Philipino farm manager was employed with previous experience in mudcrab culture and by the end of the year the farm had a working staff of 15 persons. Each pond was test weighed on monthly basis with harvesting occurring after 6-8 month cycles.
Sales then began to develop to local wholesale, hotel and tourist trade with prices varying from USD 14.50 for 500g crabs to USD 21.00 for 1-1.5kg animals ($Fiji 1 = USD 0.54). For first harvesting cycles the crabs averaged 550 g after 6 month cycles. The crabs were also categorised for quality into A and B grades: A with both claws and all legs present, B with claws or legs missing, this also having an effect on price. In 2014 the company obtained funding through EU, SPC and AusAid to renovate its packing shed facility which now has a walk in freezer and is awaiting HACCP approval.


Figure 13a and b. 13a Growout pond prepared for stocking. Note plastic hides. 13b Growout pond stocked and with aeration.

Future Plans

In the next 5 years the company has plans for the following:

- Already identified potential site to develop new purpose built hatchery
- Renovate and construct further ponds on grow out site up to 40 hectares
- Trial commercially imported specialised feed from Philippines to compare growth rates and economic viability
- Increase from current 30MT production per year in 2013-2014 up to 200MT on present site by 2017
- Follow up potential export markets in Australia, and more efficient live transport in boxes to increase post-harvest quality
- Set up out growers scheme - growout pens for mud crab with carefully selected local communities, supplying them with juveniles, support and advice. Once up to market size buy back to sell through own specialised value chain.
- More detailed plan - in next four years to develop franchise social enterprise grow outpens IN (not destroying) 50 hectares of local mangrove with local communities - little or no environmental footprint – Early days yet but estimating up to 200 local persons can benefit directly or indirectly.
- Already there has been considerable outside interest in this model from other Pacific islands including Kiribati and Marshall Islands. Opportunities to replicate….

Case Study 2: Beginnings of a small scale monosex Tilapia Hatchery Kerrys Farm, Western Viti Levu, Fiji.

Figure 14 Jiosese Vodowaqavuka developing first private sector commercial tilapia monosex hatchery in Fiji August 2014

Introduction

Since its first introductions in the late 1940's to mid-1950's tilapia culture in Fiji has historically been a livelihoods improvement, subsistence based activity practiced on smaller pond scale level in rural areas where freshwater is available, with production being mostly for home and also local consumption. In more recent years, because of changing dynamics, availability and prices of fish in local markets, there has been an increasing interest in developing tilapia pond culture on a more commercial basis. Two main issues which are commonly the key to the development of tilapia culture, ie availability and access to good quality fingerlings and also formulated feed, are constraints to its future development in Fiji. As regards to feed there are by July 2014 several local livestock feed companies producing tilapia feeds, whilst some is also imported from outside. As for fingerlings the local government sector although providing mixed sex tilapia fingerlings free of cost, have struggled to maintain regular even small numbers of *O. niloticus* fry to the now 180 small scale tilapia farmers throughout Fiji. It is with this historical background that SPC (Secretariat for the Pacific Community) recognised the need for private sector hatchery development to produce good quality all male tilapia fingerlings which would give ongrowers a better chance of achieving economic viability. From 2012 onwards they assessed the capabilities, sites and locations of existing small scale tilapia producers and identified one, Jiosese Vodowaqavuka, as a good candidate for developing a specialised tilapia hatchery.

Training and Development

Jiosese had set up his 1.8 hectare site 3 years previously with a series of 7 earthponds (70M X 30M each) fed from a pumped water supply from a nearby river. In the earlier days he already had aspirations to produce fingerlings in the ponds but had been knocked back by a once in 30 year flash flood which swept away his original *O. niloticus* broodstock. SPC then decided to support him towards a more focussed small scale ("incubator") hatchery model, and as a result using EC-IACT project funding took him to attend the hands on monosex tilapia hatchery course at the Asian Institute of Technology, Bangkok, Thailand. Whilst in Thailand he learnt and practiced at first hand the hapa, RAS (Recirculating Aquaculture System) incubator and tray based hatchery system which is now widely used commercially around the world.

Figure 15 Jiocese and his RAS hatchery system including incubators August 2014

Early days

On his return home in September 2013 with the help of SPC Josese set up a smaller scale replica of this model hatchery within the yard of his house using primarily locally available equipment and materials. In terms of staff, he employed one other person and also benefitted from support from other family members. Larger jumbo sized hapas were made and installed in the ponds and stocked at ratio of 1 male to 2 females. The broodfish were fed on a formulated tilapia diet from a Fijian feed company, whilst locally available 100% ground up fish meal was used for the masculinising hormone feed for the swim up fry. The breeding

hapas were checked on a weekly basis for eggs and yolk sac fry. Fertilisation and maintenance of greenwater in the ponds was a positive experience, with minimal use of external fertilizers, rather relying on recycling nutrients supplied from the broodstock and fingerlings wastes. Between January – May 2014 the hatchery produced 77,000 fingerlings with the first batches of these all male fingerlings being stocked into his ponds. Initial sales were 3-8g fingerlings however these first cycles of production were very much learning from mistakes, ie pump failures, power outages, and relating what Jiosese learnt at AIT into his own local farm and site context. The site has a seasonal range in water temperatures from 30˚C in December/ January - 18 ˚C in June. Practically this means under the current set up that broodstock can only produce viable fry for sale 8 months of the year between September to the following June. The hatchery is still very much in its infancy and a surplus of 2-3g all male fingerlings is now being produced with fingerlings being sold to tilapia farmers in Western Viti Levu and Tailevu clusters at USD 0.03 each. Repeat orders have already been placed. As temperatures rise again into September 2014 Jiosese will go through another cycle further developing his experience and skills towards what is hoped will be Fiji's first commercial monosex tilapia hatchery supplying and meeting the needs of Fiji's nascent but growing tilapia farming sector.

Future Plans

In the future Jiosese plans to:

- Scale up present pilot hatchery set up to a larger volume RAS and filtration system with more incubators and trays to increase its capacity.
- Reduce risk by installing back up pumps and alternative power supply in case of power failure
- Install channel gravity fed water supply from 1km spring located above farm to reduce current electricity costs for pumping river water into ponds.
- Depending on customer demand also nurse up a proportion of fingerlings to sell at larger 18-20g size.
- Examine options for heated/insulated facilities ie polytunnels, for holding broodstock at warmer temperatures between June to September in order to produce fingerlings all year round.
- **Case Study 3: Yalelo: Commercial tilapia cage farming in Zambia**

Figure 16 Feeding time at Yalelo's Siavonga cage site July 2014

Introduction

Aquaculture in a landlocked but resource rich country such as Zambia has developed from earlier times primarily based on smaller scale tilapia pond culture, with some larger commercial pond based set ups funded through national food and sugar companies having limited success. There have also been several durable and financially viable integrated tilapia livestock (especially fish pig) units which have stood the test of time and are still operating after 20 years in operation in Zambia. These based their production and profitability on reducing costs for commercial fish feed through careful management of livestock fertilised ponds to produce nutrient rich greenwater systems. In more recent years in the new millennium with the advent and development of what is now Africa's largest commercial fish farming company, Lake Harvest across the waters of Lake Kariba in neighbouring Zimbabwe, Zambia has now begun to develop its own cage culture. This case study describes the early days of one particular company Yalelo who have set up their cage production site on the shores of Lake Kariba at Siavonga.

Setting up towards commercial production …….

Following the recent trend across SSA for larger scale tilapia production being based on cage culture systems in both Zimbabwe and Ghana, and also the relatively buoyant and still unfilled demand for tilapia in local Zambian and also regional southern African markets, Yalelo set up as a company in 2012. A shore based site was acquired at Kamimbi village 22km from Siavonga township on Lake Kariba, which provided good depth, water flows, and also adjacent land where hatchery ponds could be developed. An environmental impact assessment report followed in June 2012 and then by the end of the year the first 20 and 25 metre diameter high-density polyethylene ("HDPE") circular cages were constructed from imported Chinese inputs and then installed in 3 adjacent locations; these were then sequentially stocked with 130,000 and 250,000 X 10g tilapia fingerlings respectively from an outside hatchery source whilst the lined hatchery ponds were being completed.

Figure 17 Yalelo installed 20 and 25 metre diameter cages in 3 separate locations on Lake Kariba in 2012 Photo July 2014

Hatchery Development

An experienced hatchery manager joined the management team in 2012 in order to develop and scale up fingerling production to make the company self-sufficient in its hatchery requirements. *O. niloticus* fingerlings were brought in to grow up as broodstock from 2 different sources in Zambia and one outside. These were kept separately in the hatchery ponds and through production cycles so as to compare the performance of their resultant fingerlings. Towards the end of 2013 the broodstock had matured and were producing swim up fry. These were collected on a weekly basis from the ponds, carefully graded and then put through the 17-Methyl Testosterone hormone treatment to produce all male fry. The resulting fry were then transferred to the larger fertilised nursery ponds where they were on grown to fingerlings of 8-10g, graded again and then were ready to be stocked out into the cages. Water supply for the hatchery ponds is pumped from an extended inlet into the lake, with aeration provided by paddlewheel aerators, and up to date a compressed air pipe system is presently being installed and extended to all of the ponds. .

Figure 18a and 18b a. Broodstock ponds with hapas and paddlewheel aerators b. Installation of piped compressed air aeration system.

Inputs, production cycle and sales

Feed for both the hatchery and grow out cages has initially been sourced from 3 Zambian and one outside commercial feed producer in order to again compare performance, growth and survival rates, since the company has already had some issues related to the quality of feeds, and effects on both the fish and local environment. By 2014 the company now employs 58 local Zambian staff at the Siavonga site, 19 of who are involved in fingerling production. The production cycle takes 6 months from stocking the cages to produce and harvest 400-450g tilapia. These are then sent in the company's two refrigerated trucks as mainly whole chilled fish with some fillets to Yalelo's wholesale/retail outlet in the capital Lusaka, a 3-4 hour drive from the cage site. From there they are purchased chilled and also distributed further around the capitals many different retail outlets including Lusaka's main Soweto market.

Figure 19 a and b Markets and value chain 19a. Yalelo's refrigerated trucks, 4 hours drive to Lusaka. 19b. Soweto Market, central Lusaka

The Future ……..

Yalelo has been in operation for two and a half years now and is steadily building up both its hatchery, cage and staff production capacities. In its original five year business plan it projected from the first full year of operation a production of 400MT tilapia employing 60 persons, to increase in year two to 4600MT, up to 7,000MT by the end of year five, by this stage employing 260 staff. By year 5 to achieve this production it was projected to require a total of 48 cages (8 X 20M, and 40X 25M diameter) and a production of 27.5 million fingerlings (2.3 million per month) from 50 hatchery ponds.

The plan also proposed from year two onwards:

- The establishment of a 15,000 tonnes per annum extruded floating pellet feed manufacturing plant on site.
- An expected yield of 30 to 35 kg of fish per cubic metre from 11.6 ha of cage water surface area
- Full processing (filleting, canning, flavouring etc.) of fresh and frozen fish.
- Expansion of sales to other major Zambian cities and export to neighbouring countries

As of July 2014 Yalelo are now moving into the year two phase of their plan. The market for fish (tilapia) sales in Zambia is now being affected by growing volumes of imported Chinese and Zimbabwean tilapia which are having an effect on market prices. However national and regional demand for fish still remains largely unfulfilled particularly in the growing peri-urban populations of Lusaka, Ndola, Kitwe, Harare, Lilongwe, Blantyre etc, which provide ready markets for Yalelo to diversify their sales, particularly if they can maintain good post-harvest quality, and branded and recognisable products which clearly differentiate themselves from the frozen Asian imported competition. In terms of timescale for reasonable assessment of such cage farming businesses, the experiences from both Zimbabwe and more latterly Ghana, show that it takes at least 5 years for such companies to develop and stabilise their production, infrastructure, staff and associated value chains from the initial 300-400MT production per year up to 3000 - 4000 -5000MT levels annually.

Case Study 4: Buyantanshi (Siavonga) Womens Cage Farming Group Zambia.

Figure 20 Buyantanshi women's cage farming group July 2014

Introduction

The Buyantanshi womens cage farming group was set up originally in 2012 through the Zambian National Human Nutrition Group (NHNG) securing funding for 24 months to develop two women's groups in small scale cage culture of tilapia on Lake Kariba. The Nutrition Group had previous experience since 1982 developing income earning activities for women's groups in the Siavonga, Kariba and Simamba wards including backyard vegetable production, livestock, pig weaning and goat rearing. In July 2014 NHNG were overseeing 27 separate women's groups in their area of operation. A focussed selection process for cage culture was undertaken in 2012 concentrating on communities bordering the lake, where local women had a traditional culture of buying and selling wild caught fish. NHNG also contacted and interacted with local commercial fish farming companies including Lake Harvest and Savannah Streams in order to develop mutually beneficial collaborations for the future.

Figure 21 Siavonga Nutrition Group, a subsidiary of the National Human Nutrition Group who have initiated and supported the women's cage farming groups

Setting up towards first production

Two women's community groups were selected at Buyantanshi (15 women) and Kabiobio (23 women) villages who had previous histories of group income earning activities. They were then invited to attend a 5 day small scale business and technical training workshop, one of the outputs being the joint drafting with the facilitators of a business plan for small scale cage culture in their particular villages. This plan and associated cash flow projected that they could begin to make a profit after five to six X 6-8 month production cycles. Each group were then given training in small boat handling, small scale cage construction and farming tilapia in cages and also an outboard motor to be used on each of their own boats for fish farming work. Following this 4 square metal framed cages of different dimensions (2 @ 3 X 3 X 3M, 1 @ 3 X 3 X 4M, and 1 @ 6 X 6 X 6M, were built in each of the two villages and installed in good locations in the lake close to the villages. They were then stocked with 2.5g fingerlings from a local fish farm at 200 fingerlings per M^3 for the 2 smaller cage sizes and 85 per M^3 for the 6M cages

Figure 22a and b a. Construction of the cages using local materials. b Feed supplied from local commercial fish farming company.

Table 2: Stocking densities of cages for the two womens groups

Dimensions of cages (M)	**Total volume ()**	**Number of 2.5g fingerlings stocked**	**Stocking density of fingerlings per M^3**
3 X 3 X 3	27.0	5,400	200
3 X 3 X 4	36.0	7,200	200
6 X 6 X 6	216.0	18,000	84

There were significant losses in some of the cages after the first stockings. The two groups then settled down to feed their fish 3 times per day using a national Zambian company feed and a six month production cycle followed. There were some further issues with mortalities with the women saying they noticed dull white marks on the sides and tails of the fish which appears to have been secondary fungal infections. The first cycle harvests after six months for the cages were disappointing with it appeared a significant decrease in numbers of fish at harvesting and the Buyantanshi group harvesting 550kg total tilapia from all their cages, with the fish averaging around 250g. Local prices around Siavonga for tilapia of this size in June 2014 were around USD 2.0 per kg (USD1 = 6 Zambian KW). However NHNG advertised the harvests on Kariba FM radio which resulted in the women selling some of the harvest outside Siavonga at USD 3.10 per kg. An agreement was also made with Lake Harvest (commercial tilapia farming company) to buy some of the harvest also at this higher price. The fish were sold whole and on ice over a period of 2 weeks. However the resultant

income of this harvest was not enough for the group to break even. There followed a series of meetings and discussions between the women, NHNG and a larger scale local commercial tilapia cage farming company assessing what had happened and then deciding on the steps they needed to take to improve for the second cycle. This process very much benefitted from having a commercial company present who could contribute from their own experiences.

Figure 23 Daily working rotas set up between the women for feeding, security and regular cage maintenance

The second cycle and moving towards the future

A second production cycle was then started with new fingerling stockings this time reducing stocking densities in the smaller cages, changing their feed supplier, and the fish now being fed four times per day compared to three previously. Mortalities in this cycle were noticeably lower and after 6 months the Buyantanshi group harvested again to this time produce 1,200kg from their 4 cages, with fish average weights increasing to 280g. The resulting harvest was where possible sold outside of Siavonga with again a proportion of the larger fish being sold through Lake Harvest. The resulting income from this 2nd phase harvest was more than double their previous one, this time just about paying off their 6 months running costs, 75% of which was their feed. The results enthused the group and there again followed joint tripartite discussions with NHNG and the mentoring commercial fish farm to assess the second production cycle, and look to areas and factors which would further increase the production of the cages in order to move towards a fully economically viable income earning activity.

Some Reflections

The history and success rate of fish farming groups or cooperatives across SSA has been a chequered one, with since the 1960's outside donors and associated government Fisheries Departments often promoting and championing their causes. The evidence base for their success and durability however has been limited across the continent with only few examples which have persisted and stood the test of time ie Walimi Fish Farmers Cooperative in Uganda and RENAPIB Fish Farmers Societe in Benin. Both of these were actually

originally set up more as fish farmers marketing and input (ie feed and fingerlings) support organisations, and were set up once there were a number of established producers who could then go on to contribute to and benefit from the services they were offering.

It is currently early days for the Buyantanshi women's cage farming group, and from the above it can be seen that they are improving their production and performance over the 18 months they have been in operation. However they have only been able to do this with the original grant and subsidies from associated donors and the also the support of organisations like NHNG and local commercial fish farming companies. On a positive note they have demonstrated within 2 production cycles they are able to almost cover their flexible running costs (excluding their own labour), with the payback period for all of their original fixed costs ie cages, outboard motor nets, and other equipment being between four to five years at their current projected growth and improvement (similar as predicted in their original business plan) .

There are a number of issues and take home points here which are common for many such fish farming groups or cooperatives:

- The process and vigour of the original selection of the groups and the individuals within are crucial to their survival towards economic viability
- The period to reach such economic viability (for this small scale cage farming model in Zambia) is likely to be a minimum of 4-5 years, during which time such groups have to be supported and subsidised financially.
- As is well known most grants and donor support on such schemes last up to a maximum of three years - this one originally had two years funding.
- Having the support, technical and marketing advice and mentoring of a local commercial cage farming company has been an extremely beneficial factor for the development of this group.
- Developing the marketing of their product outside of their locality is important towards economic viability of their business model.
- Even though for these groups of women this cage farming activity is relatively part time with the groups (of 15 and 23 women respectively) working in rotas there is still the issue of when the activity breaks even and begins to make profits after 4-5 years how these are then divided between the women? Within these 15 individuals do they all equally contribute towards the activities of the group?
- Would these profits when divided between 15 or even 23 women be enough for them individually to remain motivated to keep contributing their labour and time to the group?
- Should this original model be at some stage modified so that individuals or two or three women go on to own and be responsible for their own individual cages ?
- Could such a project where small scale cage culture starts up as an introductory subsidised group activity, then after 2-3 years moving into individual cage ownership be a viable model for future replication elsewhere?

Case Study 5: Epilimnion Aquaculture Ornamentals and Aquaponics, Cascade, Port of Spain, Trinidad and Tobago

Figure 24 Christian Young Sing: Ornamental fish house Epilimnion Aquaculture August 2014

Introduction

Following graduating in 2007 with a Diploma in Aquaculture from Vancouver Island University and returning to his home in Cascade, a suburb on the outskirts of Port of Spain, Christian Young Sing wanted to put into practice what he had learnt by setting up his own aquaculture business in Trinidad. He had been particularly drawn to the RAS (Recirculating Aquaculture System) set ups he had seen in Canada used primarily in commercial salmonid hatcheries, and thought that they might be well suited to his home island where available land, freshwater and suitable sites for aquaculture were relatively limited.

Options for production, importance of market surveys.

On the terraced slopes of his garden he firstly set up a standard pilot RAS system and stocked 12 X 2M circular tanks with locally obtained tilapia fingerlings. Going through several six month growth cycles he developed sales of the resultant 300-350g fish to local restaurants, business canteens and live to other local suburban domestic customers. However on doing his figures and cash flows he became aware that the economic viability of this system was marginal at the market prices he was getting for his final product, with the feed and energy costs overweighing the gains he was making from semi intensively growing tilapia in a limited water volume RAS.

He concluded that for such systems to be viable he had to look towards much higher value species and modify the layout on his site to make the most efficient use of the limited land area and resources he had available. Having read much on the internet about the growing aquaponics sector he decided to informally survey the local demand for green vegetables and herbs in and around Port Of Spain with the previous restaurants he had supplied with tilapia. The responses were almost unanimous, with the chefs and

restaurants finding it difficult to source and buy on a regular basis specialised salad leaves, green garnishes and particular herbs from their wholesale or other suppliers. Being an ornamental fish hobbyist for many years he also rang round a wide range of specialist shops, wholesale and retail buyers and found that there was an unfulfilled demand for specialised Trinidadian produced freshwater ornamentals such as fantails, comets, oranda *Carassius auratus auratus* etc. Christian then reworked his original business plan based on his survey demand figures for a joint ornamental fish aquaponics set up, finding that potential margins and a far more regular cash flow made the proposition a much more valid one. On the basis of his modified business plan he then decided to go ahead and develop aquaponics in conjunction with switching part of his production towards breeding specialised ornamental goldfish, ie fantail, comet, oranda, bubble eye. Christian went on to construct and fit out an ornamental fish breeding house and a vertical stacked shelf based aquaponics system for the larger original tilapia tanks. In all his new set up consisted of three separate RAS systems which allowed him flexibility and also reducing risks and potential costs from disease and mechanical /technical failures.

Into commercial production and building market sales

Christian finished the construction work in September 2013 and soon found that for his aquaponics system the floor area, growth, labour and also sales required for the plant side of the operation compared to the fish was up to 80% to 20%. He concentrated on high value green and variegated leaves such as arugula, other microgreens, herbs including specialised oriental mint and basil as well as other fast growing plants such as amaranth and mustard, initially using the waste from his twelve tilapia tanks. In terms of operating the system efficiently on a day to day basis maintaining optimum nutrient balances for his aquaponics system was initially problematic especially if he wished to harvest and sell the tilapia when they reached 350-400g. However once in operation he was soon cropping and selling his leaves and herbs 3-4 times per week to a steady and reliable demand from 7-8 restaurants in Port of Spain. In order to keep up with this demand he employed another person part time three half days per week working almost entirely on the plants. Once he had sorted out some initial teething problems with his ornamental fish breeding set up by March 2014 he was selling ornamentals to a range of specialist buyers, retail and wholesale across Trinidad and Tobago. His sales price varied depending on strains and sizes from USD2.40 up to USD 50.00 per individual fish (USD 1.00 = 6.40 Trinidadian dollars) for top of the range. By July 2014 his gross income from plant and ornamental fish sales had reached USD 2,400 per month, with his main feed and energy plus PT staff labour costs reducing this gross to net monthly income of USD 1400 per month.

Figure 25 Aquaponics system Epilimnion Aquaculture. From September 2014 tilapia will be replaced with ornamental goldfish to provide necessary nutrients

The future…….

Christian explained that by July 2014 his system was currently working to only 35% of its capacity for both the plants and ornamentals as it had only been in operation 9 months and was still improving. As such to increase production of both plants and fish would not be an issue for him, other than needing to take on his current staff full time to meet the necessary workload. His main future time and efforts to develop his business in the next 12 months he believed would have to be in marketing and developing a wider sales base for his products. For the plants and herbs as he was currently only selling within Port of Spain, he had already identified a number of other markets across Trinidad and also in Tobago, particularly in higher value restaurants and tourist resorts for which a maximum transport time of 3 hours would not be a problem for the perishability and freshness of the products. In terms of the ornamentals he now wanted to begin exporting fish to other countries in the Caribbean where he identified good markets where he could sell his fish with a local Caribbean branding.

In looking more closely at the contribution the original and now remaining tilapia made to his cash flow, net income and operational efficiency he concluded that he should not continue growing them. Rather instead using the 12 X 2 M tanks to expand his ornamental goldfish production capacity, a fish which from the same m^3 water volume he could earn at least double the income also with a faster turnover period. By July 2014 Christian had decided to sell off his remaining tilapia and concentrate solely on ornamental goldfish to provide the effluents and nutrient base for his aquaponics systems. He also wanted in the next months to bring in a "fresh stock" of different goldfish from the US, which he would then breed from to compare the resulting progeny in terms of quality with his present broodstock.

In terms of payback period for his total capital outlay on the new ornamental fish house and associated system, and the aquaponics growth beds and equipment, he estimated it would take him a further 2 years at his present rate of growth.

Case Study 6: The Youth Training and Employment Partnership Programme (YTEPP) Aquaculture Training Course, Waterloo, Trinidad and Tobago.

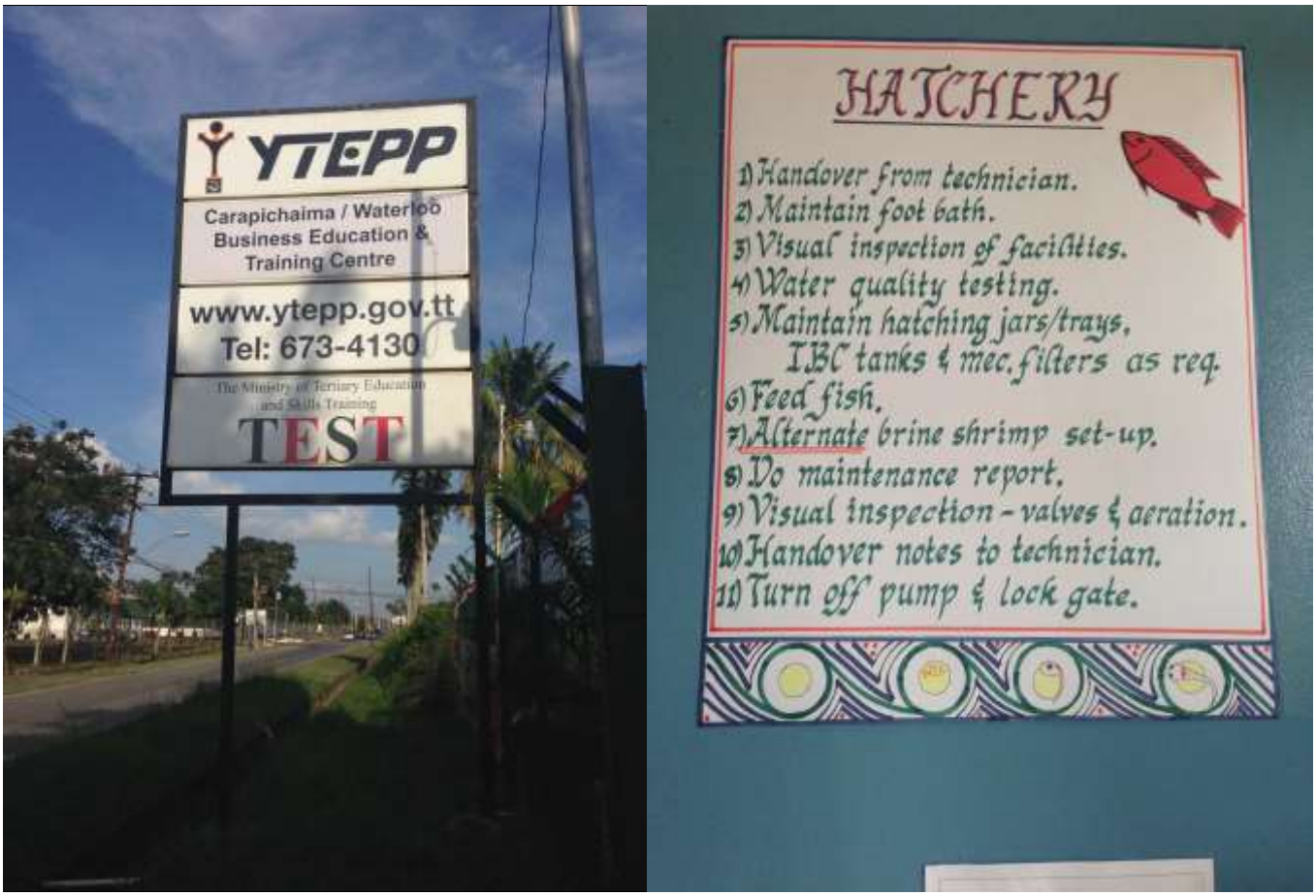

Figure 26 The YTEPP Business Training and Aquaculture Training Centre, Waterloo, Trinidad August 2014

Introduction: The History of YTEPP

YTEPP as an organization began in 1988 through World Bank funding as a national response to the growing problem of unemployed youth in Trinidad and Tobago (T and T). It was originally set up as an emergency, temporary program to prepare young people for the sharp rises in unemployment during the economic crisis of the 1980s, which saw a decline in output, reductions in real per capita income, and employment across the Caribbean.

In addition to providing the necessary vocational skills training to the unemployed youth, another aim of the program was to impress upon the minds of its participants, the need for continuing education and self-sustainability throughout their lives even if they had been made redundant. To accomplish this, a Pilot Personality and Confidence Development Module made up of five (5) supportive sections was introduced in early 1988. These were: Self Awareness; Drugs and Unemployability; Physical Fitness and Productivity; Developing Positive Attitudes to Work; and Going into Your Own Business. This initial pilot project attracted over 2,600 young persons.

Following this pilot the first cycle of YTEPP was initiated in 1988, and attracted over 12,000 unemployed young people, and a number of cycles followed. During the third cycle of training, in October 1990, YTEPP was formed into a limited liability company with its own Board of Directors. The company focused its training

on Vocational Skills, Career Enhancement and Micro Entrepreneurship and particularly the growing IT sector. At the end of World Bank funding in 1998, the financial responsibility fell squarely on the shoulders of the Government of Trinidad and Tobago. YTEPP was firstly under the Ministry of Education and would later be transferred to the Ministry of Information, Communication, Training and Distance Learning. Eventually that Ministry became the Ministry of Science, Technology and Tertiary Education, and today YTEPP now falls under the auspices of the Ministry of Tertiary Education and Skills Training.

YTEPP moving into aquaculture training

Following the beginnings of aquaculture in the 1990's across the Caribbean, especially the then burgeoning growth of tilapia culture in Jamaica, as a serious income earning and food production sector, and also the absence of any associated vocational training across T and T, YTEPP decided to add aquaculture to their growing portfolio of taught courses. Training in aquaculture began as a new module (1 cycle per year) in 2003, with 25-45 year olds targeted who were in in need of employment or retraining due to redundancies and job losses. The first courses were more theoretical and classroom based but including field visits, with specialized aquaculture experts hired in as training advisors, with ornamental fish culture being the main study area on the first courses due to it being the specialty of the first training specialist. Whilst on the aquaculture module students were also able to access and participate in a range of other related modules including IT, plumbing, film and video production, woodworking, horticulture, agro processing, automotive maintenance, electrical installation and seamanship. This range of trades and activities were ideal for giving future aquaculture employees and managers the necessary all round skill base to be employable individuals within the Caribbean aquaculture sector. These courses continued through the first decade of the new millennium, and although the aquaculture module curriculum was broadened to include other species, YTEPP noted that in terms of follow on jobs for their students, tilapia hatchery and also grow out farms were after 2010 more likely future employers in T and T. They also noted from previous students feedback that YTEPP should develop its own working hatchery and farm facilities where the students could benefit daily from hands on , practical training, rather than the irregular field trips to existing commercial and government farms where they were often "just shown round" rather than being able to practice themselves.

Design, construction and running of specialized aquaculture facility

Figure 27 Construction of new tilapia training hatchery and renovated classroom with records keeping an integral part of the training course

Following an internal review in 2012 YTEPP recognized there was spare capacity at their Waterloo site in terms of old underutilized buildings and also associated land which could be used for developing a more specialized tilapia culture training facility. At this time they were also approached by an ex Stirling University

aquaculture graduate, Rhea King Julien, who was then taken on to design a purpose built tilapia hatchery, ongrowing units, renovate the existing teaching facilities and also update the course curriculum. Based on her experiences working and studying at a commercial tilapia farm in Thailand Rhea along with other YTEPP staff drew up plans for the redevelopment of the site. At this stage an ex YTEPP aquaculture student Darian was employed to support in the construction and then the running of the new facility. By mid-2013 one of the older buildings had been renovated and inside a commercial scale tilapia hatchery had been built. Also within the same building block a classroom had been renovated and a feed and equipment store also added. Outside a series of concrete water tanks were upgraded and stocked with tilapia broodstock and also another larger concrete pond used for ongrowing. By February 2014 Darian, the now resident Aquaculture Unit Technician, had produced the first monosex tilapia fingerlings and the first new aquaculture training course started up on the site. The first new intake of students totaled 14 persons ranging from 25 - 50 years of age (50:50 male /female). The specialized set modules included:

1. Starting up a fish farm, business plan, environmental impact assessment….
2. Site, System and Species Selection
3. Hatchery Operations
4. Anatomy and Physiology of Tilapia
5. Feeds and Feeding Programme
6. Management and Care of Fish
7. Water Quality, Filtration and Environmental Pollution
8. Business Management
9. Diseases of Tilapia
10. HSE concerns regarding Aquaculture-based activities
11. Harvesting Processes
12. International, Regional and Local markets and marketing.

There is a USD 16.00 registration fee for enrolling on the course, otherwise all other costs including teaching and also use of the facilities is met by YTEPP. “Work Experience “Internships are arranged by YTEPP as an integral part of the course with different private and government sector farms or associated commercial suppliers ie feed companies. The qualification they receive if they complete the 500 hour 7 month course successfully is the Caribbean Vocational Qualification (CVQ) in Inland Aquaculture Operations: Tilapia Production Level 1. To earn a CVQ award, the students must demonstrate competence in reaching CARICOM approved occupational standards developed by practitioners and employers (i.e. industry experts). These standards are organized in the units or modules as above. Students as they progress through their course earn units awards towards achieving a complete CVQ.

Figure 28 A hands on training experience at YTEPP towards commercial uptake

The Future……..

The Aquaculture Training Unit in Waterloo has now gone through its first new revised cycle of training with 9 students successfully completing the course. Plastic circular nursery tanks are now been added outside the hatchery and suitable land has been acquired nearby to construct further ongrowing ponds on land with a good external water supply which will further enhance the hands on training.

From their experiences so far YTEPP are reviewing their current policy of providing the course almost completely free of cost. There are obvious tradeoffs here to be met between attracting the more serious individuals who are willing to pay and who will go on and complete the course, against providing a recognized training and certificate for those lower income individuals who are keen but cannot afford to pay high course fees. The hatchery through Technician Darian has already started generating external income since May 2014 by selling 5,000 all male tilapia fingerlings per month to outside fish farmers at USD 0.32 per fingerling = USD1,600 income per month. Although it is foreseen in the future that income earning activities within the unit will continue to expand to support the costs, it remains an official Retraining Centre within the Ministry and will always be to some extent at least partially funded through government

The current age range of students on the course is also under review with some opinion that it should be lower in order to encourage individuals to enter commercial productive aquaculture rather than as for some older persons as a hobby and part time activity. This also has obvious implications towards the financial operating costs and budget for the Waterloo unit, which presently mainly relies on governmental and other outside funding to run. In future the YTEPP board would wish to move more towards developing the income generating activities of for example fingerling sales as above, which can at least cover some of the operational costs and also salaries.

Having just completed the first cycle of students on the new course it is early days yet to assess its success

or value for money in terms of its students finding full or part time jobs within the aquaculture sector in T and T or elsewhere. As of August 2014 tilapia is the main farmed fish on T and T however is still relatively small ~ 200 MT per year with aside from government facilities currently around 20 small scale commercially run tilapia growout sites and 4 small size commercial hatcheries. Although there are employment prospects in other sectors, including ornamentals and aquaponics, in the next 3-5 years there is going to have to be growth in tilapia and other production across the islands, for future cycles of YTEPP students to be employed or even to encourage them to set up their own businesses

Such innovative models for aquaculture training as this YTEPP unit at Waterloo, T and T are as yet unproven. However it provides an interesting alternative model for training compared to the more conventional and widespread government Fisheries Department Extension models whose concrete impacts and related value for money in terms of increasing aquaculture production, related employment and incomes generation have been debatable. Such focused training models can also benefit from an holistic, small business, entrepreneurial approach in which (often younger) individuals develop a much wider skill base set which equips and also encourages them to either look towards starting up their own productive businesses or at least managing and running aquaculture sites on behalf of others.

Chapter 5: Key factors in addressing the longer term sustainability of the sector in the 3 ACP regions.

Potential for commonalities and mutually beneficial shared actions across the ACP regions.
Potential areas for European Community Organisations to work with and benefit from within the ACP regions.

Introduction

This chapter is divided into a series of threads or sectors where commonalities between regions are firstly identified and described which can affect aquaculture development either positively or negatively. Then they are discussed as to how they can be addressed to produce mutually beneficial shared actions which will benefit aspects of aquaculture development across the regions and can be incorporated into the ACP 5 year Draft Programme Plan. These are based on a wide range of sectors from geographical, environmental and physical related resource availabilities, through technical and institutional capacities and value chains, to communication and information sharing across languages and borders. These shared actions will then go on to form the basis of the ACP five year strategic plan. At the end of the chapter is a further section on future potential inclusion and benefit of EU organisations (commercial, research, other) into the future ACP aquaculture development programme.

Geographical… Small island states

Two out of the three regions, the Caribbean and Pacific, are primarily composed of smaller island states, with their geographical locations and demographics having significant effects on the ways and scales aquaculture develops in each. Africa to a much lesser extent also has five smaller island states, all of which except Madagascar, are classified as small islands under the UNESCO classification system for all islands under 2,000 square kilometres (770 square miles). Madagascar, in contrast, at 587,041 square kilometres (226,658 square miles) is the fourth-largest island in the world. In line with most characteristics of small islands, the islands of Africa with the exception of Madagascar are almost all volcanic in origin, high in structure, with low coral elevation, with limited surface water resources and undergoing variable weather conditions, with occasional destructive tropical cyclones.

In terms of aquaculture development such small island states share the following characteristics:

Table 3 Characteristics of small island states for aquaculture, SWOT Analyses

Strengths	Notes	Weaknesses	Notes
Surrounded by sea Opportunities for Mariculture……..	Evidence base for Caribbean (C) Pacific (P) and SSA shows mariculture hasn't greatly developed due to range of factors	Limited land and freshwater resources limited sites for fw aquaculture	
Wild fisheries catch and processing still supplying low cost processing wastes - trash fish and fish meal	Low cost fish meal - lower costs of aquaculture feeds	Relatively smaller populations thus lower local market demand	Limited local markets prevents scaling up commercially except where export is viable
More remote locations provide pristine pollution free production sites	Can be used advantageously in export branding and marketing	Distances from export markets (especially P) Transport and freight costs – same also for costs of required imported inputs for aquaculture	(C) can have opposite advantage here with access to north central and south American consumer markets
Island states if well managed have natural barriers for introduction of new exotic		Perishability and short shelf life of products	Also not conducive for exports

species also reduced risk of disease introductions			
Small island states traditionally fish eating therefore strong consumer demand for all aquatic products		Still productive commercial wild fisheries supplying fish at lower costs than aquaculture production cost per kg	
		Poor communication /information sharing between island states	Also applies across African (SSA) continent
		As a result of above repeated regional replication of resource use and expenditure across many sectors	Eg Research, specialised laboratories, Commercial inputs ie feed mills, aquaculture equipment supply etc
Opportunities	**Notes**	**Threats**	**Notes**
Mariculture	Range of not just finfish culture but also crustaceans, shellfish, molluscs, macrophytes	Tropical cyclones adverse weather conditions	Increased risk especially for mariculture Barrier to investment. Also even with less severe can hold up transport of products for export and also essential inputs feed and equipment.
Tourist higher value markets for niche products	Eg Cultured oyster pearls Fiji New Caledonia, oyster shell jewellery Maldives	Imports of low cost marine and fw fish eg farmed Chinese tilapia	Local production systems ie Jamaica cannot compete on price – also now applies to many African countries eg Chinese tilapia in Zambia and Malawi. Noting some countries like Ghana have banned imports of Chinese tilapia to protect its own industry.
Improving online communication and networking	Needs to be multilingual to be effective and also clearly benefitting individuals so that they become involved	Global warming climate change rising sea levels loss of land salinization of fw supplies	Noting some climate change can also have positive outcomes
Incorporation of renewable energies into aquaculture	Eg Haitian US funded photovoltaic tilapia hatchery. Chinese photovoltaic industry reducing costs by 10% per year over last 5 years	Smaller island states can become isolated from mainstream developments in aquaculture production and markets	This relates back to lack of communication networks to outside.
Development of brackish water culture of euryhaline species	Eg St Kitts Cage culture tilapia. This potentially has great promise - Larger scaled up tilapia brackish water cage farms successfully established in Mexico – Market advantage ? Taste?	Political instability. Can be an issue also affecting outside investors	A number of examples in small island states but also across SSA continent with countries like Cote D'Ivoire and DRC have repeatedly had their aquaculture sectors decimated by political unrest.
Development of non-food aquaculture production	Eg Artisanal oyster production – shells for jewellery, ornamental fish, seaweeds chemical extraction	Increasing and restrictive energy costs especially for electricity and oil can make certain types of aquaculture non-viable	This depends as some smaller islands have oil eg Trinidad and Tobago and as a result conversely have lower fuel costs .

Development of cost effective RAS and aquaponics for land and fw limited small islands	These still commercially unproven globally. RAS requires high value product(s) for economic viability.		

For smaller island states all of the above in either positive or negative ways have in the past and will continue to influence aquaculture development in the Pacific and Caribbean regions.

The sections below now go into more specialised areas where commonalities between the three regions can be developed jointly for the benefit of ACP as a whole.

Information sharing and networks

This has been identified as a key issue constraining aquaculture development across all three regions. Each region has its own particular communication issues eg SS Africa – sheer scale of a continent and its diversity, 46 countries, 4 main languages, hundreds of traditional languages, Caribbean up until recently low levels of institutional and aquaculture stakeholder interaction, Pacific – in the past reliant on outside Australian, New Zealand, French and Hawaiian organisations and networks to broker and drive inter-island communication. It could also be said in the past that all three regions especially SS Africa have been slow to develop their access to the worldwide web, however this is now very much not the case as internet access increases and developing lower cost mobile phone technology now opens up online communication for millions in rural areas.

The shared solution…. An Aquaculture Network cornerstone for ACP.

The SARNISSA African aquaculture network, originating from an EC FP7 project in 2009 is an example of how such networks if correctly set up and administered can be successful in bringing thousands of people working across all ranges of aquaculture together for their mutual benefits. Through a range of bilingual online resources and activities, email fora, web and social network sites it now has over 2300 registered members across 46 African and 48 other international countries. As a core first cornerstone activity of the ACP 5 year strategic plan we propose to develop similar sister bi-lingual model networks for the Caribbean and also Pacific which are then linked together under one larger network "ACP Umbrella" which will incorporate all three. Thus as well as significantly increasing communication and information sharing within the Pacific and Caribbean regions it will also encourage the flow of information sharing between all three regions across borders and languages. As with SARNISSA this will also involve developing a simple database of individuals (registered network members) across the three regions which will then be searchable for different areas and disciplines eg seaweeds producers, fish feed manufacturers, government policy etc (SARNISSA database already has over 2300 individuals and is growing weekly) . It will also involve a main bilingual website which will act a repository of information, publications, manuals, case studies , contacts, videos, photos, ACP programme outputs etc from all three regions, basically a one stop resource for the wide range of ACP members. This resource base will be updated regularly from an ACP Facebook site – as in SARNISSA - which is daily updated with media news, publications, videos etc. The SARNISSA experience showed that allying a strong email discussion fora, with daily updated Facebook/Twitter linked site and main information repository store website is an effective model for increasing numbers of relevant individuals to join and benefit.

Regional Aquaculture Conferences

These networks will then be in operation for 24 months of the 5 year programme, during which time the Caribbean and Pacific networks will build up a significant increase in the number of members, who will have

been communicating and sharing with each other towards potential collaborations. At this stage (Month 24) we then propose to hold the first ACP Regional Aquaculture Development Conference in the Caribbean. This three day conference will be open to all sectors and disciplines (commercial, research, government, value chain) and will bring together network members often for the first time, for a programme of presentations, series of focussed side meetings, and an equipment/inputs and suppliers Trade Fair. We would also wish to invite key speakers from the other two ACP regions, commercial producers etc where there is the potential for technology transfer and information sharing. Then in Month 36 we would repeat but this time holding the conference in the Pacific region with the same format and outside invited guests; and again in Month 48 a conference for the SS African region. In each case before the conference an organising committee from within each region will be set up to not just organise the event, but also to identify and then develop different income earning strategies for the conferences ie affordable registration fees, commercial sponsorship, revenue from Trade Fair stands. This will be with the aim of covering at least some of the running costs and working towards repeating the conferences on a three yearly basis when they will further be able to generate income through increased numbers of participants and also more international recognition and sponsorship. It should be noted that although there were some previous aquaculture conferences – in Caribbean in 2002 – these will be firsts for each of the three regions and through the ACP programme will very much be set up to run every 3 as self-income generating events bringing together a wide range of commercial, research , government and other sectors.

Most if not all of the further threads below will be directly influenced, informed and in many cases actually driven by this network and associated database, a network which is based on individuals rather than institutions or organisations.

Key Species/Groups….. production and value chains ……

There are particular aquaculture species which are produced and sold across either two or all three ACP regions. Also for each region certain indigenous new potential species deemed possibilities for aquaculture development. In most cases each region remains largely unaware of what the others do and especially for private sector existing or potential producers and also it may be said for government Fisheries Department staff. Through improved communication, and targeted activities in the five year plan we (and also our network members) wish to determine which technologies / production systems and associated value chains would be specifically suited (economic viability, environmental sustainability) to the particular contexts within each region. Then implement specific technology transfers and build multi stakeholder working relationships towards this end.

It is important to firstly identify from the four ACP reports (3 Regions and overall) and secondary literature evidence base the specific culture species and related production systems for each region and specific countries which the next 5 year ACP programme wishes to develop and allocate time and resources towards. This initial consultation process in the first year of the five year plan should for example ask the following questions: Firstly can commercial tilapia culture in smaller island states like Jamaica and Fiji, or African countries like Namibia or Angola be financially viable and provide concrete impacts and value for money for the ACP programme to develop? Or…….. can semi - extensive sea cucumber production best be developed on New Caledonia with the development of a state of the art hatchery to supply other neighbouring island states? If the answers to questions such as these for individual countries are a provisional yes, then at what scale or levels? Which proven specific production and value chain model(s) should be provided with resources and activities to develop? And conversely if the answers are no for specific ACP island states or other countries then the ACP programme should move on and devote its resources and plans to specific aquaculture models and species which have the best chances of success in each of the countries within the budgets allocated. We propose that through a Working Group consisting

of partner staff this review exercise is carried out in the first year of the ACP 5 year plan by the 3 ACP partner organisations, Stirling University and also CTA to produce a guideline report which will by Month 12 focus the following 4 years workplan.

Tilapias

This cichlid is farmed in all three regions, however it is Africa where the increases in total production of this fish has been most pronounced. The main species for aquaculture across the regions is *Oreochromis niloticus* however *Oreochromis mossambicus* is equally widespread being introduced into both the Pacific and Caribbean earlier in the 1950's. Advances in African tilapia culture in the last ten years particularly in countries like Ghana, Zimbabwe, and Zambia offer sharing and learning opportunities for the other two ACP regions particularly as has been pointed out it is cage culture (with the exception of Egypt) which has produced the majority of significant increases in tilapia production across the continent. The experience of commercial tilapia development and then decline in Jamaica is also relevant in terms of lessons learning particularly in identifying which production and value chain models that can work in the future. Tilapia hatchery development particularly for monosex all male production has been scaled up in countries like Ghana and Zimbabwe so that hatcheries are producing millions of fry per month rather than thousands, which has led to a proliferation of grow out production sites. The Caribbean is currently at an interesting stage of development in its tilapia hatchery production with a number of the islands using and paying for "super male" tilapia technology through a European company and university. Although there are no hormones involved in the direct production of the fingerlings there are a number of potential issues related to this type of tilapia hatchery production being used across a whole region as it appears to be in the Caribbean which can affect the future sustainability of the tilapia sector. The authors would recommend the ACP programme particularly looks to examine the economic and environmental viability of brackish or full marine water culture of tilapia especially in the Pacific and Caribbean island states with now examples of commercial uptake of saline tolerant strains of tilapia in the Philippines, Mexico, Taiwan, whilst there are at least two smaller scale cage production sites in the Caribbean.

Marine Shrimp *Litopenaeus vannamei and Penaeus monodon* . Freshwater prawn *Macrobrachium sp*

Marine shrimp are farmed in all three ACP regions with Madagascar and Mozambique, Belize, and New Caledonia taking the lead in terms of commercial production of the two main species *L. vannamei and P. monodon.* A number of unsuccessful attempts have been made over the years to set up large scale shrimp farms in each of the ACP regions ie South Africa, Fiji , the Gambia, Jamaica. The authors are of the opinion that due to the scale and investment involved in such ventures the ACP 5 year programme will be much more suited and effective in not looking at setting up but trying to increase information sharing between existing shrimp farming companies and potential new investors particularly in terms of disease, production and also value chain issues. We would also wish to examine the transferability to other ACP countries of a much smaller French backed community based shrimp and Macrobrachium production models which have been successful over the last 5-6 years in Cameroon.

African Catfish *Clarias gariepinus*

This species again are found in each of the three regions however aside from Nigeria, the biggest producer in Africa, and more latterly Kenya and Uganda, they have not been successfully produced and sold in the other two ACP regions for a number of reasons. There has been considerable success for catfish culture in Nigeria in what are in essence intensively stocked, secure, peri-urban backyard tank and raceway systems co-located close to large urban populations for which catfish culturally are widely accepted as a regular daily food item. Although there are obvious differences in cultural and international acceptance of this fish,

the authors see potential for the ACP programme supporting commercial entrepreneurs to set up several similar commercial peri-urban demonstration units in the other two ACP regions (Caribbean and Pacific) allied to hatchery production of juveniles. Nigerians are now beginning to develop more intensive RAS systems for Clarias, which can well have economic impact when transferred to other ACP regions. In the end the potential for expansion of Clarias production into other countries not just in SSA but also other ACP regions will depend on market and cultural acceptance. Interestingly European (Dutch) commercial Clarias RAS systems have been successful for over ten years now, but based on a strong processing component adding value to the product by filleting, and steaking as well as incorporation into ready meals, a marketing strategy which at first went down well with thousands of Dutch ethnic minority consumers, but has now entered more mainstream consumer markets across the country and into Germany. Interestingly Pangasius (*Pangasius hypopthalmus)* another air breathing catfish from Vietnam is now present in certain Caribbean and SS African countries with rather unclear legislation as regards to it being developed as an aquaculture species. This species also potentially can have applications in such peri-urban intensive RAS and backyard systems although as yet this has not been trialled.

Shellfish oysters

This group again cross over the ACP regions but have had varying success in terms of commercial viability. For the Pacific - Pearl oyster production (*Pinctada margaritifera and Pinctada maxima)* has proven economically successful, despite the long 5 year growing cycle, in Fiji and French Polynesia, selling to higher value tourist markets and to a lesser extent on Zanzibar Tanzania in more community based projects. Whilst Namibia has developed an export based edible oyster and mussel production sector backed up by a private sector commercial oyster hatchery near Swakopmund. The Gambia, Gabon and Senegal each have nascent artisanal (mangrove) oyster production however are constrained from expanding by relatively low demand and in country value chain issues. In terms of environmental footprints many of these systems are very attractive and do offer the opportunities of both larger commercial and smaller scale artisanal set ups. The ACP programme would aim to increase awareness of the pros and cons of the different systems between the different regions, and also the key practical post-harvest food safety/hygiene, depuration, shellfish health and market chain issues towards increasing demand in local and other markets.

Figure 29 Fresh Oysters for sale Swakopmund Supermarket Namibia 2012

Marine Finfish

This sector as described earlier is still relatively underdeveloped across the three regions but offers potential for the future. In terms of commonalties certain species such as red drum and cobia are beginning to be produced in hatcheries and then cage grow out at research and pilot scales in the Caribbean and also East African ocean eg Reunion, Mauritius. Other than raising awareness of the production and value chains of these species for potential new uptakers, ACP can especially increase information sharing and contacts related to cage culture, design, materials, site selection, mooring, installation etc. This is a particular area where European companies and organisations have a competitive advantage and can offer beneficial services and advice.

Seaweeds

Tanzania Zanzibar in SSA and Kiribati lead the way in seaweeds production across the ACP regions with both concentrating sales to export markets in Europe and Australasia respectively. The current evidence base shows that the producers end up with a relatively low sales prices per kg often due to an extended value chain of a number of individuals through to the final extracted products in higher income importing countries. The ACP programme could certainly provide support for producers, whether groups or individuals to better access the different levels of the value chain through providing internet and other networking training. Also for selected SS African and Pacific producers to travel to the Caribbean region (to the country/countries with the most promising sites) to share their knowledge and skills. In recent years there has been increasing interest and research to pilot stages in IMTA - Integrated Multi-trophic Aquaculture systems , which often include seaweeds cultivation, in conjunction with cage finfish culture and shellfish. The jury is presently out about the commercial viability of such systems however this would be another production system discussed in ACP's first years review which would be assessed for potential in specific ACP countries for the future.

Sea cucumber Holothurians

Sea cucumber cultivation has in the last 5 years become more of a commercial proposition in tropical countries, with hatchery technology now well researched and documented. This is also being driven by the strong demand from Asian markets for this product often at very attractive prices even after transport costs are included. New Caledonia, Mozambique and Madagascar within the ACP countries are the main producers, however especially in SSA it is still mainly at coastal community level. This species aside from the original hatchery set up capital, has relatively low start-up costs for grow out systems and as such can offer an alternative income for individuals or groups within lower income coastal communities. Having already held a special workshop on sea cucumber cultivation in 2012 in New Caledonia, the ACP programme can effectively follow on from this with similar events on the East African coast and in the Caribbean where the main producers, potential producers and researchers are invited also key Asian value chain individuals. ACP can then build on the relationships made at these workshops to develop mutually beneficial collaborations during the remaining 5 year ACP programme. As sea cucumber production and sales are currently relatively low across the three regions, it is an area where ACP can make concrete measurable impacts over the five year period of the ACP programme.

Potential New Species for Aquaculture?

There are a number of these across the different ACP regions and countries, some of which have been mentioned earlier. The past and current "state of play" tends to continue where these species are talked about both in country and internationally and even some preliminary research implemented towards completing their hatchery reproductive cycles and also their market potential and acceptability. However in most cases the lack of funding and also capital to take these "new species" to or beyond pilot stage tends to hold back their development. There are examples where particular donors and also investors have taken the plunge ie USAID currently developing pilot lungfish *Protopterus aethiopicus* systems in Uganda, and a commercial company developing dusky kob *Argyrosomus japonicas* culture in South Africa.

Figure 30A and B ….. New potential species for aquaculture? A. Lungfish *Protopterus aethiopicus* in Uganda, and B. Dusky kob *Argyrosomus japonicas* in South Africa.

Within the first year of the ACP programme the authors propose a Working Group to be set up after careful considerations and communications between the three ACP partners and UOS , each ACP country comes up with a well-researched standardised justification for 3 potential "new species" for aquaculture in their individual regions. From these reports the partners, UOS and the ACP Programme Advisory Committee will then meet in a series of "virtual" online meetings to decide on one species for each region. The ACP programme in the following 5 years will then concentrate on each of these "new" species in a clear, step by step process to move forward the current "State of the Art" towards assessing commercial viability for each species. Although there will be some commonalities this process is likely to differ between the three species and regions depending on a range of factors including their current research and production base and how far they each are towards a proven juvenile/hatchery and grow out. However common outputs through ACP would include for each species publications: A markets and value chain assessment, A hatchery /juvenile production manual, A specific country or region "Site Evaluation Map" which would assess and rank specific geographical locations for the best hatchery and grow out stages for each species.

Research and Government Sectors

These two already have some commonalties between them across the 3 ACP regions, with ACP itself being in itself an example of cross communication here.

Research and Academic Sector

The research and academic communities in each of the regions tend already to have good communications and networks internationally particularly at senior researcher and academic level due to the nature of their research however for lower levels particularly diploma, BSc and Masters levels the communications and links are far more limited. Other than connecting individuals through the email discussion fora the increasing power of social networks Facebook/Twitter in the 18-35 year old age group has already been illustrated through SARNISSA. Within the ACP Programme this social networking will be developed further for the Caribbean and Pacific regions to develop a "Community" where individuals can both contribute or if they wish just receive the daily updates and new information. Within this younger student/ research sector we also propose the ACP programme to set up a Working Internship Scheme" which will match students and other young persons with short term employment opportunities in the different commercial and other stakeholder sectors of the ACP network membership. There are already successful working examples of this model in south Asian academia from the Asian Institute of Technology in Bangkok. We also propose to include a Case study writing component to the ACP programme, again particularly targeting young up and coming researchers who have not published previously, to produce short, lessons learning case studies on particular aquaculture topics in their regions. These could be about particular commercial or smaller scale farms, input suppliers feed mill companies, particular disease occurrences, markets and value chain, national government aquaculture planning or any relevant agreed topics of their choice. The authors will be supported through the writing and editing of the case study which when completed will be published up as programme outputs on the ACP Aquaculture site and across the ACP regional networks. We would aim for ten case studies per year, fifty over the five year programme divided into English and French language versions.

The Government Sectors

Here there is probably less communication than above between individuals even between states within each region, although there are examples where the ministerial and higher levels do from time to time meet ie the Abuja NEPAD Fisheries and Aquaculture Summit 2006, FAO COFI meetings, however the outputs and concrete outcomes from such meetings have been largely disappointing. In addition to our proposed Regional Aquaculture Conferences the ACP five year plan would wish to concentrate on joining up more junior staff in Government Fisheries Departments between countries and regions to share their knowledge and particularly identify and address any areas where they need to increase their knowledge and skillbases. Such government staff would also be eligible under the right circumstances to participate in the ACP working internship scheme as for the majority they have not set up or even worked on commercial fish farms or hatcheries, or in the value chain throughout their careers. The ACP programme will also commission several case studies on examples of how governments through policy and lower levels, as well as the working activities of their staff can more proactively and effectively support the development of aquaculture in their countries.

Aquaculture Nutrition/Feed Sectors

This includes the wide range of feeds which are and can be used for farmed aquatic species, for finfish, shellfish, crustacea, and mollusca. In a wider context but equally importantly this sector also includes so called (Indirect feed inputs) mainly fertilisers (organic and inorganic) which are used to promote and sustain production of phyto and zooplankton primarily in pond systems but also equally importantly in

hatchery sector of juvenile living feeds. Feeds can be commercial formulated as a complete diet for the farmed species concerned, or on farm made local diet used as a supplementary feed to enhance already fertilised more extensive systems. Across the three ACP regions this sector is both hugely diverse but also showing commonalties and scope for improvement through information sharing and joint actions.

For such commonly farmed species across the ACP regions as tilapia, African catfish and shrimp, it is only in certain countries in SS Africa (Zimbabwe, Ghana, Uganda , Zambia for tilapia, Nigeria for catfish, Mozambique and Madagascar) and in the Caribbean (Jamaica and Belize) where commercial formulated feeds for these species have been produced in significant quantities. The opening and operation of the first specialised commercial fish feed mill in any country in terms of aquaculture development is often described under "the chicken and egg scenario" i.e. aquaculture production will only start to increase significantly in a country when a proper commercial fish/shrimp feed is available at a competitive cost. Whereas a commercial feed company will only consider opening a new Feed Mill in a country when its aquaculture production reaches 4,000 – 5,000 MT in order to make it financially worthwhile for initial investment and set up costs (Magne, J. 2013 pers comm). For a number of ACP countries the evidence base over the last years shows production remaining low since they are not able to achieve one without the other. However conversely there are proven examples where specialised feed mills have kick-started tilapia and catfish commercial production. In SS Africa Nigeria is an example where aquaculture production (of catfish) was initially increasing due to imported specialist feeds from Europe and also the middle east. Although relatively expensive their quality and the resulting low (good!) Food Conversion Ratios (FCR's) made them economically viable for Nigerian catfish farmers to use. Whilst some still use imported feeds, there are now four home owned major specialist fish feed producers in Nigeria supplying feeds across the country to this growing sector. In recent months a large multi-national fish feed conglomerate has expressed an interest in opening up another mill there. Its near neighbour Ghana had struggled for many years in the development of its aquaculture sector for a number of reasons, including its rudimentary poor quality local fish feed production through non-specialised poultry and livestock feed mills. Around 12 years ago the first of Ghana's large scale commercial cage culture producers began on the Volta Lake. Within their business plan and projections they were well aware of the lack or absence of specialised feeds in the country therefore for the first 5-7 years of operation they imported a good quality commercial formulated tilapia feed from Brazil. This arrived in the port of Tema, close by to their hatchery and cage culture operations. And as in Nigeria this imported feed allowed aquaculture production in Ghana (mainly through two larger scale cage tilapia producers) to grow upwards to over 7-8000MT by the mid 2000's. It was then at this stage that an Israeli commercial fish feed producer expressed its interest in opening up a feed mill in Ghana. Following consultations with the main producers and also a wide range of other stakeholders it went ahead to build the first specialised commercial tilapia feed mill in Ghana, located again in close proximity to the port of Tema for feed ingredients required to be imported in and also close to its future customers the growing number of tilapia cage producers on the Volta Lake. By 2012 the company employed over 40 local Ghanaians and were selling tilapia feed throughout southern Ghana and also a specialised commercial catfish feed into Lagos and Abuja Nigeria (an 8-10 hours lorry drive eastwards). This model of originally importing feed into a country has been repeated in the Caribbean in Jamaica in the late 1990's as the commercial tilapia sector developed based on importing the bulk of its production to higher value overseas markets. Again once the industry reached 4-5000MT tilapia in the 2,000's the largest producer starting up its own specialist feed mill, thus becoming vertically integrated. The Pacific region up to the present day has never had the volumes of finfish production to necessitate the opening of a specialist fish feed mill. Also with the majority of the countries being small island states the logistics and viabilities of each country opening up their own specialist feed mill is unlikely in the future. However there are exceptions with a specialised fish and shrimp feed mill having been set up on Mauritius, islands off the east African coast. This mill produces shrimp (and fish) feed which supplies the surrounding commercial shrimp (and growing tilapia) farming sectors in Mozambique, Madagascar and smaller finfish mariculture in Reunion, and has potential to move feed through good rail and road links from Mozambican ports into neighbouring Malawi and

Zimbabwe. This illustrates for both the Pacific and Caribbean regions that there can be a fish feed model company set up to supply aquaculture on a regional location basis as long as transportation/shipping links are regular and also reasonably priced. In the Pacific region fish meal is relatively widely available with costs still significantly low. This is a good precursor to developing one specialised fish and shrimp feed mill in the right location in the Pacific in order to supply the whole region. Within the ACP programme we would propose in Years 1 and 2 sending (two) carefully selected individuals working already in the fish/shrimp feed sectors in the Pacific and Caribbean to visit and spend time with a major specialised commercial fish feed mill either in Ghana or Mauritius. These individuals and the companies they worked for will be chosen very carefully so that on their return following their visits they and their respective companies will be in a position to implement positive changes from what they have seen and learnt from SSA.

On farm or lower quality supplementary feeds are also produced across the ACP regions with mixed results. There are not many examples across SSA, Caribbean or Pacific of production systems using this feed which have ultimately been successful due to its lower performances and Food Conversion Ratios (FCR's) which more than negate the benefits of its lower costs compared to more commercial specially formulated feeds. In Zambia two well managed commercial pig fish greenwater tilapia systems have been financially viable for over 20 years supplementing the productive green water with a 17% lower protein level supplementary feed. Although relatively rare across Africa these are examples of where naturally fertilised integrated fish livestock greenwater systems are successful in reducing fish feed costs in order to achieve financial viability It should be noted that pigs in these systems produce around 65% of total income , with 35% from the fish.

Both the capital and technology and expertise necessary to produce live feeds especially for the hatchery sectors of a range of farmed species has been lacking within certain ACP countries and has held up the production of juveniles for particular species. These are primarily for mariculture including shrimp , shellfish and finfish although African catfish and Macrobrachium are examples in fresh and brackish water. We wish to share out expertise in these sector across the ACP networks using a range of methods including special evidence based case studies and also new and existing effective online training videos.

Hatchery and Juvenile Production Sector

Figure 31 A and B Small scale backyard commercial tilapia hatchery Siparia Trinidad and Tobago. Recently set up – Now producing hundreds of thousands of monosex tilapia fry July 2014.

This to some extent has already been covered in the Species section above. However there is much scope here across the three regions to help support its further development within the ACP programme. Again the sector is diverse, specialised, technically challenging, and often based on high capital initial start-up costs. The evidence base continually shows that for developing the numbers and quality of seed required for take-

off of different production sectors it must be the private sector which takes the lead in hatchery production. In some countries in the Pacific and also SSA "free" fingerlings are given out to some fish farmers from government stations or through donor funded projects, often going back to the 1960s and 70s. This practice may seem positive to some, however it unfortunately does not encourage private sector individuals to go into hatchery production, whilst the stations themselves tend to struggle to produce the necessary numbers and quality of fingerlings to meet even the most modest in country demands. This scenario has been repeated across the three regions for many years now, however there are some shining lights for the future. The larger scale commercial tilapia producers in SSA have built and run hatcheries which produce millions rather than thousands, whilst the Nigerian private sector have, despite many challenges, developed a network of small to mid-scale catfish hatcheries which supply their growing industry. Private sector pearl oyster and shrimp hatcheries have sustained in the Pacific, whilst the Fijian case study on the start-up of a small scale private sector monosex tilapia hatchery in this report gives pointers in the direction to go. It must be added that there were also several very impressive small scale backyard tilapia hatcheries visited by the author in Trinidad and Tobago with dynamic owners and the potential for developing further see Figure 28 above. Similarly to feed here for groups of smaller island states in terms of economic viabilities it would be prudent for the ACP programme to support the development of one or two carefully selected private sector regional hatcheries for tilapia , shrimp, Macrobrachium and even sea cucumbers, not necessarily financially, but as SPC have done effectively in the Pacific by strengthening their knowledge base, technical and marketing skills, and also with the development of their broodstock. Within ACP we would propose cross visits for carefully selected individuals to commercial hatcheries in other regions and a hatchery focus in the case studies programme to produce valuable lessons learning outputs. Within the programme we would also wish to have a specific focus on aquatic animal health and its prevention and also treatment at the hatchery stage. Again from the evidence base aquatic animal diseases are becoming increasingly economically significant at the seed production level, especially as is well known internationally for shrimp, but lesser known for Clarias catfish and tilapia. We would also wish through the ACP programme to carefully select and then "champion" the cause of one specialised aquatic animal health laboratory in each of the three regions in order that their facilities and services would be available to all across each region.

Finally in terms of government Fisheries Department based hatchery infrastructure across the regions we would propose an important role that they would be well suited for and which we could develop within the ACP programme would be as National and Regional Broodstock Centres which carefully maintain and also develop the different species and strains which are required by the private sector to replenish their stocks. Again the evidence base from the vibrant aquaculture sector in Vietnam shows that this National Broodstock Centre model works very effectively, and develops a particularly strong working relationship between government and private sector.

Value Chains and Markets

From previous funded aquaculture programmes (either donor or government based) this is probably the most underestimated in terms of its importance and under resourced in terms of budgets, activities and outputs. Of the three regions, SS Africa due to its geography and population demographics, can be reasonably considered different to the island states of the Pacific and Caribbean. Countries such as Nigeria have huge market demand for farmed fish as the most populous country in SSA. Whilst others such as Ghana, Kenya, Uganda and Zambia where aquaculture is now developing have strong home market demand for farmed fish as well as potential for regional export within the ECOWAS (West African) and Eastern African Community (EAC) trading blocks respectively. It is interesting that Lake Harvest in Zimbabwe, the largest commercial tilapia producer on the continent, originally set up with a business plan specifically targeted towards producing fillets for export to the European Community. Whilst this lasted for the first five years as the company increased its production, it soon became obvious that the company could sell virtually all of its production to local and regional markets across southern Africa at equally competitive prices. For

these nascent African aquaculture producing countries the message has been to get their fish farming produce out of the village into far more lucrative peri-urban markets to make higher margins. This is also about the producers themselves realising the importance of being well informed and understanding their different market options. For the Pacific and Caribbean in country market chains are far more limiting due to lower populations and alternative lower value imports and for the Pacific in particular still availabilities of wild caught marine fish at affordable prices. The Caribbean has export market potential in being located close to the US, and south and central American centres of population.
With this background in mind the ACP programme will throughout the five year programme ensure the regular monthly publishing and exchange of key market prices for the main aquaculture species across its networks. It will also concentrate on sharing information towards better post-harvest handling and transport of aquatic products to their point of sale, an issue which is currently adversely affecting quality and also potentially consumer acceptability in a number of countries across the three regions. As mobile phone use and technology is becoming increasingly mainstream across the ACP regions with countries like Kenya now leading the way in mobile phone applications related to agriculture, the programme will also look to develop a regular messaging service and also an app informing stakeholders of market prices and availability of different species in key sales outlets.

Aquaculture and Renewable Energy?

As renewable energy technologies continue to develop this sector is increasingly being discussed globally for its viability to be incorporated into aquaculture at all different levels. This can be for potentially reducing longer term energy bills, and also the sites environmental and carbon footprints, and also enabling certain aquaculture production sites to be located in areas which are not on national grids or which have intermittent or unreliable mains electricity supplies. In the end currently the main research and socio-economic questions can these technologies first be appropriate and secondly economically viable for specific aquaculture production systems and geographical locations?

For the ACP countries there are already some examples of solar photo-voltaic systems being used in fin fish hatcheries and grow out sites in Haiti and Senegal. The well-publicised work of Ivorian, Auburn graduate Abe Valentin developing small scale tilapia production in Haiti has been backed financially by several US funders including the Clinton Foundation . A tilapia hatchery site (Lashto Farm) was constructed to improve the supply of quality fingerlings to a range of small scale fish farmers across the country. This was then followed up on the site two years ago with the incorporation of photo-voltaic panels and associated battery storage infrastructure which now has the capacity to run most of the energy needs of the farm, pumping water, filtration, aeration, lighting and other light equipment usage. Figure 31 below also shows solar panels on the roof of a small scale catfish/tilapia hatchery in Senegal where they supply aeration, some small volume water pumping and also security lights at night. This system was again installed with a grant from an outside donor. It is unknown to the authors the payback time for each of these systems. The Haitian example involved a significant USD 100,000 grant from US donors which the hatchery itself would be unlikely to be able to pay back in at least twenty years of commercial operation. For the smaller Senegalese hatchery systems payback times are likely to be far less. However these both illustrate the important question above of the commercial viabilities of such systems and the scale at which they can effectively be used in aquaculture

Figure 32 A and B. A. Photovoltaic panels above the fish tanks at Lashto Fish Hatchery Haiti (2012). B Solar panels on roof of catfish and tilapia hatchery Senegal (2013)

Due to the potential importance for aquaculture of these technologies in the ACP regions in the future and the current lack of practical studies and information available to the wider public the authors propose to set up a Renewable Energies Working Group in the 5 year programme. This group will collect and develop information and resources on the economic viabilities of these systems which will then be shared out on the ACP network. At least one case study will be published on a working example of such systems and for both the working internship scheme and the exchange visits sites and businesses using renewable energy technologies will be targeted. By the end of the 5 year programme we will hope to have gathered and disseminated out a comprehensive information base on the (economically viable) use of renewable energies in aquaculture.

Environmental Issues and Sustainability

Although the final section in this thread, environmental sustainability in terms of aquaculture development across the regions has to inform and underpin all, and will be a key component within the ACP 5 year programme. Again commonalties, probably the most relevant being that environmental regulation, licensing and monitoring of both existing and new aquaculture sites is extremely variable across the three regions. For the most part this is due to individual country government's departments having diverse priorities and limited budgets in this area. As a result a significant number of existing aquaculture sites are rarely routinely monitored for their environmental impacts, effluent water quality, sediments analyses below and around cage sites, biological and chemical analyses on effects of chemicals or chemotherapeutants. This only tends to happen in response to a pollution, fish kill or other reported instances. The emergence of a range of certification standards linked towards value chains and consumer acceptability in the last 5-10 years has begun to address these issues but for smaller producers, and there are many in the ACP regions, their standards are often set too high for them to join and benefit from such schemes.

Due to the scale and size of environmental issues across the three regions the ACP programme can and should concentrate on using its resources and budgets in focussed ways and activities in order to achieve realistic but important outcomes. We would firstly propose that a similar review process and a working group set up, as for the new indigenous aquaculture species, takes place in Year 1 between the ACP programme partners on identifying one member state in each ACP region which the programme can work with the government and private sectors constructively over the next four years in order to develop a "Model Aquaculture Environmental Sustainability infrastructure". Again this selection should be made carefully so that each country selected is able to make measurable improvements over the 5 years of the programme.

This particular activity could also be linked into developing an effective national aquaculture statistics collection framework through aquaculture site and business registration; and then allying this with a series of incentives for private sector aquaculture producers to maintain and then submit their annual records and returns to a government collection point; then the resultant data anonymised, aggregated and then published up online with open access to all. Again the evidence base from countries like Vietnam and China where these national aquaculture statistics are made available online clearly show they are a valuable and well used resource for existing producers, value chain and government planners as well as new potential entrants and investors. A key factor in the success of setting up any national aquaculture environmental sustainability monitoring and regulation infrastructure is getting the buy in and approval of the private sector at all scales of production. As with the other sections above there are considerable opportunities here through the ACP networks to share and learn from each other on environmental regulation and monitoring across the ACP countries.

Potential areas for European Community Organisations to work with and benefit from within the ACP regions

There are a number of areas where European organisations (both commercial and other) can support the further development of aquaculture in the ACP regions whilst also themselves benefitting some of which we have already mentioned above. Below is an initial scoping list which is no way exhaustive but provides an illustrative introduction. This is included in the light of European aquaculture production levelling off over the last 10-15 years and the increasing reliance of the influential EC seafood buyers or "Choice Editors" on competitively priced wild caught and farmed imports. The expertise and background experience of the European aquaculture sector developed since the 1970's has the potential to both support and benefit the future development of aquaculture in the ACP regions. The below list are not ranked in any order of importance and can undoubtedly be added to in the future :

- Cage culture both marine and freshwater - in both manufacture and supply of inputs as well as site identification and evaluation, installation and maintenance
- More general aquaculture site identification and design, including GIS mapping research base and expertise
- Aquatic animal health - research, training, biosecurity, chemotherapeutants and vaccines, government monitoring and regulation programmes, customs entry point regulation of imports and exports
- Post harvest processing/value addition, food safety and hygiene both commercial and government regulation, HACCP and movement towards certification
- Aquatic animal nutrition, commercial feed mills – already occurring in SSA
- Market/value chain information sharing systems, mobile phone technology
- Genetics and hatchery technologies, broodstock improvement programmes, supermale tilapia technology already in the Caribbean.
- Aquaculture equipment supply, fish handling, grading and live fish movement and transport.
- Skills transfers in writing and submitting successful research and development project proposals, environmental impact assessments (EIA's), business plans, applications for loans and microfinance, cost benefit analyses, cashflows, PhD and MSc applications.

The above includes a range of organisations within the EU from universities to commercial companies, from government through to national or regional trade organisations. It is planned to introduce and invite key EU aquaculture related organisations/individuals to participate in the ACP online network communications and information sharing with a view towards future mutually beneficial collaborations.

Chapter 6: Five year Draft Aquaculture Development Plan integrated for 3 ACP regions, including specific targeted activities and timescale.

Introduction

The UoS agreed, based on the report above to produce a draft integrated Five Year ACP Programme Aquaculture Development Plan for the three regions. This plan is purely a first draft and is produced with a view to be a working document to be modified towards a final plan which can be incorporated and implemented within the wider ACP Fisheries and Aquaculture programme. It is made up of a number of different components and activities which are mentioned and discussed in the above report, which aim to mutually complement each other and form a results and impact based strategy for developing aquaculture across the three regions. However the components should also be viewed and considered individually in determining whether they should or should not be included within the plan, and also whether further components also need to be added. The plan is based on the initial development of an online, bilingual communication and information sharing network and platform which the authors consider to be integral to the success of the five year plan. In terms of indicating budget, as we did not have an estimated budget available for the programme we have not included this within the plan.

Table 4: Five year Draft Aquaculture Development Plan integrated for 3 ACP regions

	Component/Activity	**Notes /Outcome**
Year 1 (Month M)		
M1	Programme Inception Meeting Project partners attend	To discuss work ahead, produce updated workplan, set up Programme Advisory Group Committee and finalise partners Consortium Agreement
M2	Begin set up of online networks for Caribbean and Pacific including bilingual website, email fora, stakeholders database, and social network sites.	English and French speaking administrators to be identified. All to be set up and operational by M6
M3	Setting up and first online meetings for Review Working Groups on: 1. New indigenous aquaculture species 2. Aquaculture production systems evaluation 3. Aquaculture Environment/National aquaculture registration 4. Regional Aquaculture conferences organising committee 5. Renewable Energy in Aquaculture	Working Group meetings to be then held online on 3 monthly basis to develop activities
M3	First tender put out for Case Study authors	To produce 10 completed case studies by M12
M4	IT specialist taken on to develop mobile phone messaging service and also specialised ACP aquaculture app	To be completed and operational by M8
M6	ACP Aquaculture internship scheme set up and operational	By M12 2 working internships completed
M9	First Market Information/prices summary produced for each of three regions	These will be disseminated out initially through the Email fora and social network sites, but aim to also use mobile phone

		service and app when ready. To be published monthly thereafter
M9	First X3 Producers internet training workshops to be held in each region	3 workshops to be completed by M12
M10	Production of first x2 short aquaculture training videos related to case studies	To be edited, completed and online by M12. For SSA we propose to work with Univ of Kampala Film School Uganda who's students produce videos as part of their course
M12	10 Case studies completed and posted up online	
M12	First edition of bilingual 6 monthly ACP aquaculture magazine/newsletter out online and hard copies printed	This will be vehicle to inform wider audience both online and off about the programmes progress - Editions every 6 months
Year 2		
M13	ACP Programme Annual meeting partners and also members of Programme Advisory Group (PAG) attending	Partners to assess Yr1 and modify workplan for Yr2 and beyond. PAG to give independent evaluation of Yr 1 s work.
M15	First Exchange visit completed – Feed ?- Fingerlings?	Potentially for Pacific individual to visit commercial Feed mill in west Africa? Person to write post visit report on their experience
M15	Programme working groups continue meeting every three months	By M12 New aquaculture species group to have identified three species to work further on – one in each region By M12 Aquaculture Env Group to have identified 3 X countries to work with – one in each region By M12 Prod systems group to have identified 3 X specific aquaculture prod models to develop further
M18	2nd edition of bilingual 6 monthly ACP aquaculture magazine/newsletter out online and hard copies printed	
M20	Two 2 x further aquaculture training videos completed and online	
M20	First two specialist Workshops carried out	These could be for example on Seaweeds production, Marine cage culture etc
M24	3 X internet training workshops in each region =9 total	
M24	Five 5 x working internships completed for the year	Each intern will be required to write up illustrated report on their experience. If possible we would wish them also to produce online blog of their experiences
M24	Further 10 case studies produced and online	
M24	Second Exchange visit completed	Potentially Caribbean individual to visit Pearl oyster producer in Pacific
M24	First Regional ACP Aquaculture Conference and Trade Suppliers Fair for Caribbean	This will be allied to ACP programme Yr 2 Annual Meeting also for Working groups to meet. And PAG to give evaluation of Yr 2 work
M24	3rd edition of bilingual 6 monthly ACP aquaculture magazine/newsletter out online and hard copies printed	
Year 3		
M27	Third Exchange visit completed	

M28	3 X Small scale, low cost, Pilot aquaculture production systems identified and also locations and individuals chosen through tendering application system . Construction begun	Potentially periurban catfish production systems as in Nigerian models? - pilots set up in Pacific and Caribbean. For SSA potentially mud crab hatchery, or brackish water tilapia culture? These to run as commercial going concerns.
M30	1st Evaluation of ACP online aquaculture network and associated Mobile applications. Also evaluation of stakeholders database and grouping of specialists to potentially form their own associations – Fish Health? Sea Cucumber producers?	Report produced including recommendations for modifications and improvements
M30	3rd edition of bilingual 6 monthly ACP aquaculture magazine/newsletter out online and hard copies printed	
M33	Further 9X Internet training workshops	By Year 3 we would be aiming to carry out at least 50% of these in french - in francophone countries
M34	Further 2 aquaculture training videos completed	
M34	Further 2 Specialist workshops carried out	Aquatic animal health? Shellfish production ? These workshops would be rotated between the three regions
M36	Further 10 Case studies completed	
M36	ACP Regional Aquaculture Conference and Trade Fair Pacific	Plus Year 3 ACP Annual Meeting. Meeting will also discuss and formulate first draft of post ACP programme withdrawal plan. PAG evaluation of Year 3
M36	Fourth exchange visit completed	
M36	Five working internships completed	
M36	4th edition of bilingual 6 monthly ACP aquaculture magazine/newsletter out online and hard copies printed	
Year 4		
M38	3 X Pilot aquaculture systems construction completed and operational	ACP programme only to fund construction costs – Individuals concerned have to cover all other running and input costs – to run as a commercial business
M39	Fifth Exchange visit completed	
M42	Further 9X Internet training workshops started	Completed by M48
M42	5th edition of bilingual 6 monthly ACP aquaculture magazine/newsletter out online and hard copies printed	
M45	Further 2 aquaculture training videos completed	
M46	Further 2 Specialist workshops carried out	
M46	Further 10 Case studies completed	
M48	ACP Regional Aquaculture Conference and Trade Fair SS Africa	Year 4 ACP Annual Meeting. Post ACP Programme withdrawal plan updated. PAG evaluation of Year 4 .
M48	Sixth exchange visit completed	
M48	Five working internships completed	

M48	6th edition of bilingual 6 monthly ACP aquaculture magazine/newsletter out online and hard copies printed	
Year 5		
M51	Seventh Exchange visit completed	
M54	Further 9X Internet training workshops started	Completed by M60 Total 39 Internet training workshops – 13 in each region
M54	7th edition of bilingual 6 monthly ACP aquaculture magazine/newsletter out online and hard copies printed	
M57	Further 2 aquaculture training videos completed	Total 10 aquaculture training videos
M58	Further 2 Specialist workshops carried out	Total 8 Specialist Workshops
M58	2nd Evaluation of ACP online aquaculture network and associated Mobile applications.	Final Network Report produced including recommendations for modifications which can be updated in last two months
M58	Three pilot scale production systems evaluated for any modifications to be added by M60	
M60	Further 10 Case studies completed	Total 50 case studies
M60	2nd ACP Regional Aquaculture Conference and Trade Fair Caribbean	Year 5 Final 4 ACP Annual Programme Meeting. Post ACP Programme withdrawal plan updated and then put into operation. PAG evaluation of Year 4 .
M60	Eighth exchange visit completed	Total 8 Exchange visits
M60	Five working internships completed	Total 22 Working internships completed
M60	8th edition of bilingual 6 monthly ACP aquaculture magazine/newsletter out online and hard copies printed	Total 8 Magazines/Newsletters

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