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Impact of aquaculture on the livelihoods and food security of rural communities

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Abstract

Aquaculture production has prospered rapidly since the 1970s and is considered as a part of the rural development program in many countries. The impacts of aquaculture on the rural communities in terms of livelihood and food security are assessed in this paper. Aquaculture contributes to the livelihood of the poor through improved employment and income. Aquaculture creates job opportunities for rural communities, especially for illiterate women to earn side income for the household. With increased financial ability, household manage to reflect stronger purchasing power and have better access to the resources. However, there is a controversy among the researchers whether that aquaculture in rural communities is showing a pro-poor growth due to imbalance in resource distribution. In terms of food security, aquaculture of small indigenous fish in the small farmer system in rural areas provides a high quality of animal protein and essential nutrients, such as vitamin B12, calcium, and potassium. Unfortunate cases like child blindness, infant mortality and non-communicable disease (NCDs) have substantively decreased with the help of rural aquaculture. In Pacific Island Countries and Territories (PICT), locally-canned tuna turned out as an affordable and non-perishable food source for the remote inland residents, helping them to achieve self-sufficiency. However, when aquaculture involves farming of large-sized commercial species, problem of food insecurity resurfaced as these commercial large fish species does not bring same quantity of nutrition as compared to small fishes.

Keywords: Livelihood, food security, aquaculture, rice-fish farming, Beche-de-mer

1. Introduction

Aquaculture production has prospered rapidly since the 1970s, and was the fastest growing food production industry in many countries for the past two decades, overtaking terrestrial farm animal meat production and landings from capture fisheries (Tacon, 2001) ^[41]. For the past centuries, aquaculture has been introduced in many parts of developing countries, such as Africa and Asia, with the objective to open up opportunities for the local rural communities to improve their standard of living and a way to escape from poverty (Edwards, 2000) ^[19]. It is believed that aquaculture is one of the fastest ways for the poor to earn a living meanwhile, serves as a valuable foreign exchange for the national development. On top of that, aquaculture has slowly integrated as a vital part of rural livelihood when it turned out as the solution for intensifying population pressures, environmental degradation or loss of access, the decline in catches from the wild fisheries (Halwart, Funge-Smith and Moehl, 2003) ^[26]. While the global wild capture diminished at the rate of more than 0.5 million tonnes per year, aquaculture has been growing at roughly 2.5 million tonnes annually between 2004 and 2011 (Cleasby *et al.*, 2014) ^[16].

According to Edwards and Demaine (1997) ^[17], *rural aquaculture* is generally explained as 'aqua farming practices in extensive to semi-intensive scale with relatively low production cost and technologies'. Targeting low-income consumer groups, this small-scale household activity adopted off-farm agri-industrial inputs and organic fertilizer, without relying on any formulated feed to supply low-value production. Aquaculture development is often part of the rural development program since most of the aquaculture was widely promoted in rural areas. However, the development mentioned here is ambiguous and highly debatable, which whether it follows its traditional dichotomy between rural or agricultural and urban or industrial areas (Yap, 1999) ^[50].

It is absolutely not an easy task to establish a successful aquaculture industry, not to mention in a rural context where access to resources is pretty limited.

Till today, there are plenty of real life cases, happened in mostly Africa and some other underdeveloped countries, where introduced aquaculture have failed. A typical example for this would be the cage culture of carp in Bangladesh. The cage culture was officially introduced to Bangladesh during the 1980s in the Kaptai Lake (Ahmed and Saha, 1996; Edwards, Little, and Demaine, 2002) ^[1, 18]. The carp industry soon collapsed due to the inability of local people to inject capital cost and inputs to afford cages (Bulcock, Beveridge and Hambrey, 2000) ^[12]. The reasons behind an aquaculture failure might be the lack of access to capital and resources, vulnerability, and aversion in villagers to take the risk (Asian Development Bank, 2005) ^[6]. The absence of technical skills and knowledge in operating fish farms by the local villagers are also an important obstacle to overcome. The insufficient financial support from the government and the villagers has put rural aquaculture to a more difficult spot (Edwards, Little, & Demaine, 2002) ^[18].

Although most of the time aquaculture farms operated by the rural communities are in the mission of improving the life standards in terms of alleviating poverty and securing food availability, a successful aquaculture does not guarantee the earlier terms nor comes along with all the benefits. Without careful management, rural aquaculture might also be a weapon that threatens the poor. Every coin has two faces. In other words, aquaculture carried out by the rural communities does bring negative consequences as well besides the positives to the villagers. Hence, the objectives of this paper are to examine the positive and negative impacts of aquaculture on the rural communities. However, in order to have an in-depth insight view of the topic, only specific social impacts in terms of livelihood and food security of the communities will be focused and studied.

2. Impact of Aquaculture on the Livelihood

Aquaculture contributes to the livelihood of the poor through improved employment and income. Due to its smallholder operating size and free from high advanced-technology machinery, rural aquaculture is labour intensive. Account to this, villagers who do not have access to land can at least earn a living by providing manpower to other aquaculture farms (Ahmed & Lorica, 2002) ^[2]. Rural aquaculture creates an 'own enterprise' employment, where the entire family devote to the business (Edwards, 2000) ^[19]. Occasionally, during harvesting season or net changing period, extra hands are needed from casual or occasional labourers (Ahmed & Garnett, 2010) ^[5]. Aquaculture then creates job opportunities for illiterate women to earn side income for their household. According to the recent study of Number of fishers and fish farmers in selected countries ^[32], it is reported that every single individual who get involved in this sector, has three family members to support financially. This phenomenon can be clearly seen in developing country like China, whereby more than 100,000 of citizen employed in fisheries, contributing 3.7% of the nation GDP. Table 1 shows the number of people employed and the value of aquaculture industry in China and a few developing countries in Asia. Nevertheless, this statement is debatable as employment effect created by household aquaculture is not consistent and might not be significant in upgrading the livelihood of the rural communities. For instance, in Bangladesh, it was argued that less than 1% of the total hired labour were employed by aquaculture industry, whereas aquaculture sector in the Mekong Delta of Vietnam contributed employment to roughly 37% of their local well-renowned university (Ahmed, Rab and Bimbao, 1993; Berg, 2002) ^[3, 10].

Table 1: Fisheries and aquaculture economics figures in a few selected countries in Asia

	Number of people employed	Value of the industry
China	12, 594, 654 (Green Facts, 2015)	61 million tons (China aquaculture industry report 2015-2018) ^[15] . Fishing and aquaculture contribution to GDP is 3.7% (FAO, 2006) ^[42]
Indonesia	4, 496, 680 (Green Facts, 2015)	8.9 million tons (FAO). Value of fishing and aquaculture contribution to GDP is 3.9% (FAO, 2006) ^[42]
Philippines	1, 500, 000 (FAO, 2006)	3.9 million tonnes (FAO). Fishing and aquaculture contribution to GDP is 4.8% (FAO, 2006) ^[42]
India	2, 500, 000 (FAO, 2006)	9.6 million tons (FAO). Aquaculture contribution to GDP is .5% (FAO, 2006) ^[42]

A recent follow-up study carried out by Ahmed & Garnett (2010) ^[5] has discovered that after the rise of the integrated farming of prawn industry in Bangladesh over the decades, some closely linked sectors has also developed. These include seed industry, feed industry, fertiliser trading and prawn marketing. With the establishment of these fish farming related network, it has opened up more opportunities for employment upon the limited aquaculture field.

According to Ahmed & Garnett (2011) ^[4], the Bangladesh farmers has received approximately, a US\$125 increase in their average annual net income after integrating aquaculture in their rice farm. Rice farmers in Bangladesh are often considered as the poorest of the poor. But rearing fish or prawn in the rice field has turned out as a win-win solution for the farmers as they are able to add an extra income besides from the rice production with least other resources invested. The other excellent resources Bangladesh could provide are wild post-larvae, low-lying rice field, warm climate, fertile soil and abundant labour (Ahmed & Garnett, 2010) ^[5]. Ahmed & Garnett (2011) ^[4] have reported that after the farmers'

income has increased, they reflected stronger purchasing power than before and have better access to the resources, which includes sanitary, transportation, housing, health services, and communication technologies, all are credited to integrated farming. The successful aquaculture in Bangladesh has significantly improved the living standards of the locals.

Apart from Bangladesh, striking examples of sustainable aquaculture in ranching the rural communities' livelihood could also be seen in Pacific Islands and Territories (PICT). In Fiji, sandfish or better known as Beche-de-mer was cultured by the locals after trained by the experts. Due to its high value in the Asian market and its ecological behaviour that inhibits inshore waters, sandfish is an easy target for fishers and later ended up as over-harvested (Hair, 2012) ^[25]. Hence, culturing sandfish in remote rural areas like Fiji not only benefits the locals but also contributes to the conservation as well. Sandfish is an easy species with short larval phase and requires no specialised technology or refrigeration in the entire process of harvesting, processing and storage (Battaglione and Bell, 2004) ^[7]. Combined with

Fiji's traditional management, sandfish culturing provided long-term opportunities for the local communities, which later branched out to education, health, food, so on and forth. The enormous export production and economic profit of the sandfish exportation in Pacific Island is illustrated in Figure 1, using the price of USD 90 for per kg dried weight of sandfish. The exportation amount and value from the countries increased almost ten times after sandfish sustainable aquaculture being introduced in the 1990s (Carleton *et al.*, 2013) [14]. According to Kinch *et al.* (2006)'s [30] finding, villagers in Marovo Lagoon, Solomon Island managed to earn annual income of SBD 166 to 2920 (USD 21 to USD375)

from jobs associated with sandfish farming.

Similarly, pearl culture is integrated as a sustainable development for the rural communities when it was brought over to Mafia Island Marine Park (MIMA), Tanzania under Worldwide Fund for Nature (WWF) initiatives. Local participants were able to have a 6 times growth in their average household income with the culturing and valuable products made (Troell *et al.*, 2011) [48]. Whereas in Cook Island, pearl farming industry has contributed US\$18 million, which equivalent to 20% of the country's gross domestic product (Southgate, 2007) [40].

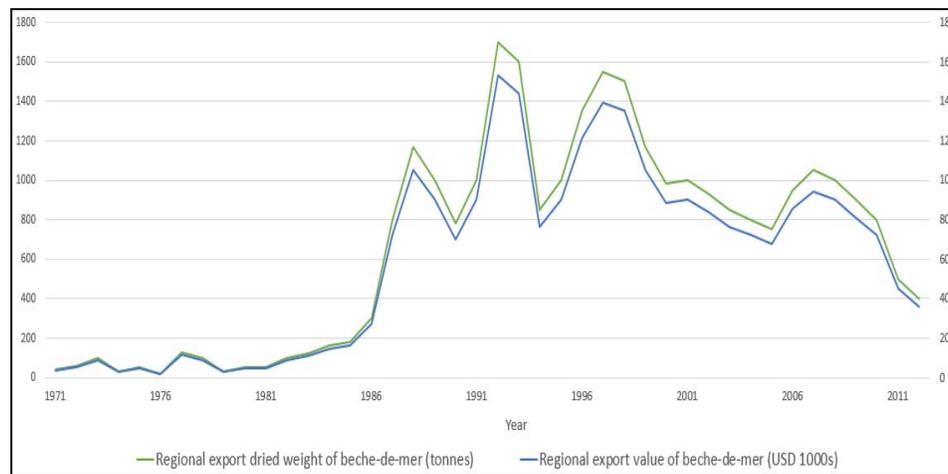


Fig 1: Regional export dried weight and export value of beche-de-mer from Fiji, Papua New Guinea, Solomon Island, Tonga & Vanuatu between the year 1965 to 2012 (Carleton *et al.*, 2013) [14].

The impact of rural aquaculture can be also seen in Philippines where caragenophyte seaweed, such as *Eucheuma* spp. and *Kappaphycus alvarezii* being cultivated under Integrated Coastal Management program (ICM). With the lowest net income of PHP36,791 (USD 793) being generated in every ha of seaweed farm per year, seaweed farming has contributed enormous employment to the country, with more than 30,000 involved in the industry throughout the entire the nation (Yap, 1999) [50]. The ICM program also practised in northern Indonesia, where households that involved in seaweed culturing in some places, like Tumbak, increased from 23% to 93%, providing 70% more employment opportunities (Sievanen, 2005) [38].

The prominent effect of rural aquaculture also can be seen in Assam, India where commercial freshwater species, such as *Labeo rohita*, *Catla catla* and *Hypophthalmichthys molitrix*, being introduced to the rural community for farming. Under the community fish culture program, the revenue increased four-fold from RS15,591 (USD 230) to RS62,500 (USD 923) (Jana and Jana, 2003; Rout and Tripathi, 1998) [28, 36]. On top of bringing economic benefits to the poor, the socio-economic of aquaculture is also undeniable. Local infrastructure, for example school building, library and herbal medicine garden were built to enhance the livelihood of the locals. Workshop and community activities also conducted to upgrade the local aquaculture practices and develop labour (Goswami and Sathiadhas, 2000) [21].

In China, due to status classification, aquaculture generally limited to small-scale, done by communities or state-run enterprises. As a whole, Chinese aquaculture is on the traditional rural aquaculture (Guang, 1993) [23]. Hence, when China aquaculture underwent expansion, the enormous job

opportunities created is remarkable. Employment in the aquaculture sector of the year 1997 hit 3.29 million, which increased almost trice of its number in the year 1989, 1.53 million (Qian, 1994) [34]. In the same year, the per capita net income of fish farmers was 2090.13 yuan (USD 317). Song (1999) [39] has reported that approximately 64% of the income spend on living expenses, communication, medical care and sanitary purpose, which can shed the light that the living standards of people in China that associated from rural aquaculture have benefited in their livelihood.

However, there is a controversy among the researchers whether that aquaculture in rural communities is showing a pro-poor growth. Kakwani *et al.* (2003) [29] explained Pro-poor as a means economic growth that benefits the poor proportionally more than the non-poor. Well, some might interpret pro-poor as the other way round: 'a growth episode that gives every rich person \$1 million but 1 cent to a single poor person' (Grinspun, 2004) [22]. This later is believed because in Bangladesh for example, the proportion of landlessness stands majority in the communities and has obstructed the poorest to gain from aquaculture (Toufique and Belton, 2014) [46]. The result from that, the poor and middle-income communities in Bangladesh could only manage to enjoy the benefit indirectly from the job opening arose from the commercial aquaculture, while a very big part of the gain still goes to the wealthy landowners (Toufique and Gregory, 2008) [47]. Similar findings are also reported in the Philippines where the aquaculture accounts only half as much of the income for the poor, as for the non-poor. The land ownership in Visayas region was heavily imbalanced and the average salaries for labourers were low (Irz *et al.*, 2007) [27].

Besides, as reported by Irz *et al.* (2007)^[27], respondents in the Philippines has described fish farming as a gamble, where a large amount of intermediate inputs has to be invested in with high uncertainty of its returns. Thus, this rich man's game only can be afforded by those with strong financial status who can take the risk, making the rich much richer. Although aquaculture provides fewer advantages to the poor rural communities in absolute terms, it definitely benefits much more in terms of relative terms via poverty reduction and relative inequality (Irz *et al.*, 2007)^[27]. Thus aquaculture growth has a strong influence on the distribution of income in developing countries and effectively narrowed the income inequality gap.

3. Impact of Aquaculture on the Food security

Food security is the situation where all the people existing, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life, as claimed by the definition of Food and Agriculture Organization (FAO) (Schmidhuber and Tubiello, 2007)^[37].

Aquaculture in small farmer system in rural areas provides a high quality of animal protein and essential nutrients, especially for nutrition vulnerable groups, such as pregnant and lactating women, infants, and pre-school children. In fact, almost half of the child deaths around the globe are linked to malnutrition. In numerical reading, it is around 3 million young lives every single year ("UNICEF STATISTICS 14", 2015)^[49]. It was proven that after supplied with sufficient needed nutrition which can be found in fishes, such as vitamin B12, calcium, and potassium, unfortunate cases like child blindness and infant mortality has substantively decreased (Ahmed & Garnett, 2011)^[4]. In rural aquaculture context, most of the time farmers' household tend to eat the small fish which fails to meet the market size and left the bigger one which can fetch higher prices (Ahmed & Garnett, 2011)^[4]. Occasionally, some rural communities do practice by giving out fishes as a type of payment to labourers working in the farms (Irz *et al.*, 2007)^[27]. These small fishes are eaten together with their head and bones, added more micronutrients, vitamins and mineral that could not be found in larger fish (Ahmed & Garnett, 2011)^[4]. Indirectly, the practice of collecting 'free fish' from fishponds has contributed as the main nutrient source to the poor families in rural areas, and helped in reducing malnutrition among young children.

The contributions of aquaculture to food security to the public health enhancement were clearly illustrated in Pacific Island Countries and Territories (PICT) through diversification of tuna farming. Apart from the economic gains, the tuna resources are impressive in a way that they assisted in resisting the high and rising prevalence of non-communicable disease (NCDs) of the regional people over the region (Bell *et al.*, 2015)^[8]. NCDs such as heart disease and obesity could happen among the poor. This was due to their high dependency on imported and processed foods as their net food production per capita which often severely destroyed by extreme natural climate disaster (Bell *et al.*, 2009)^[9]. In the midst of raising nutrition and health implication, tuna farming managed to provide stable food supply and fulfil food security of the poor in all three utmost dimensions: stabilised food availability, provided the villagers sufficient access to it and ability to utilise it. Locally-canned tuna turned out as an affordable high quality and non-perishable food source for the

remote inland residents, helping them to achieve self-sufficiency without dependent on imported goods which are subjected to fuel prices fluctuations that added more pressure to the low economic status group population (Pilling *et al.*, 2015)^[33].

Additionally, aquaculture by rural communities helps in increasing the availability of fish in both local rural and urban markets. According to the law of supply and demand in economics, when the supply of an item increase, automatically the price for the item will go down, provided there are no external constraints (Gale, 1955)^[20]. The same ideology applies to fisheries. As the supply of fish production increase, the unit prices of the fishes will then definitely drop to lower prices which more household could manage to afford. Table 2 clearly illustrates the increment in the fish consumption per capita of least-, developing countries, and low -income food-deficit countries, in the year 2007, 2009, 2010. The economic grouping shown in the figure are the main three grouping where rural aquaculture being introduced.

Economic grouping	Per capita food fish supply (kg/year)		
	2007	2009	2010
Least-developed countries ¹	9.5	11.1	11.5
Developing countries ²	16.1	18.0	18.9
Low-income food-deficit countries ³	9.0	10.1	10.9

¹Least-developed countries include Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Kiribati, Lao People's Democratic Republic, Lesotho, Liberia, Madagascar, Malawi, Maldives, Mali, Mauritania, Mozambique, Myanmar, Nepal, Niger, Rwanda, Samoa, Sao Tome and Principe, Senegal, Sierra Leone, Solomon Islands, Somalia, Sudan, Timor-Leste, Togo, Tuvalu, Uganda, United Republic of Tanzania, Vanuatu, Yemen, Zambia

²Developing countries include all countries in Africa except South Africa, all countries in Asia except Israel and Japan, all countries in Oceania except Australia and New Zealand, and all countries in North and Central America except Canada and USA, and all countries in South America.

³Low-income food-deficit countries: Benin Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Comoros, Côte d'Ivoire, Democratic Republic of the Congo, Djibouti, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Somalia, South Sudan, Sudan, Togo, Uganda, United Republic of Tanzania, Zimbabwe, Haiti, Honduras, Nicaragua, Afghanistan, Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Kyrgyzstan, Mongolia, Nepal, Syrian Arab Republic, Tajikistan, Uzbekistan, Yemen, Papua New Guinea, Solomon Islands

Table 2: Per capita food fish supply by economic grouping in the year 2007, 2009 and 2010 (FAO, 2010; FAO, 2012; FAO, 2014)^[43, 44, 45].

Nonetheless, some argue that the introduction of large commercial fish types in the polyculture farms has negative consequences on food security of the rural communities. Before any aquaculture has being started in the rural, fish only

can be accessed through the wild captures of small indigenous fish. For instance, *Amblypharyngodon mola*, or better known as *mola* by the local in Bangladesh. The rich nutrition found in small fishes, as discussed earlier, has played a vital role in fulfilling the nutritional requirement of the rural poor. Unfortunately, due to habitat degradation and overfishing, the catches are declining and rural poor are forced to switch to large-sized fish species which they reared in their rice farms (Mazumder, 1998) [31]. Bouis (2000) [11] argued that despite these commercial fish species large in sizes but does not bring the same quantity of nutrition as compared to small fishes. A clear comparison can be seen between *mola* (*Amblypharyngodon mola*) and other large introduced species, such as tilapia and some common carp species. 100g of edible *mola* parts carries more than 1,500 retinol equivalence (RE) of vitamin A content whereas large introduced species carries less than 100 RE (Roos, Islam & Thilsted, 2003) [35]. Thus, it can be said that aquaculture development in rural areas does not guarantee food securities, but alleged inequity and imbalance in the supply of good quality nutrition. However, the issue could be minimised through appropriate government legislation via elimination of market monopolies and proper resource distribution.

For an example in Vietnam the government has launched the Cooperative Law on year 2003 with the objectives of giving out support for shrimp farmers, which includes funding assistant of VND 2 (USD \$112359) billion start-up capital loan with 12% interest rate per annum and technical training on shrimp farming (Ha and Brush, 2010) [24]. Besides, Vietnamese government also set up series of programme, such as Shrimp Aquaculture Export Promotion Program that loosens restriction on land conversion policy to align with the shrimp aquaculture industry (Buu & Phuong, 1999) [13]. The assistance from the government has effectively helped rural communities to overcome financial and technical constraints they are facing in starting up aquaculture, and later prompted them moving out from poverty.

4. Conclusion

In summation, the benefits of aquaculture far outweigh the risks in enhancing the livelihood and food security of the rural communities. Aquaculture helps the nation in earning valuable foreign exchange, increases the food production, and later in diversifying the economy and results in job creation in the countryside. Small scale aqua farming also assists the remote population to be self-sufficient without relying much on imports. Yet, more proportion of these gains goes to the non-poor rather than the poor due to the imbalance in resources allocation in the current stage. Therefore, there is a soaring need for government policies to implement holistic strategies which include the poor in the aquaculture development as part of their national development to ensure that entire population of the country would be benefited. Account to that, institutional and infrastructure aid are urgent in need from the government for diversification of production and trade, execution of ethical aqua farming techniques and development of backward and forward linkages, with resource-poor household as the core nucleus, in order to fight with disease, drought, floods, high production cost and other social crisis.

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