

A Deductive Approach to the Relationship between Climate Change and Aquaculture Sector

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Abstract

This paper addresses the relationship between climate change and aquaculture sector through comparing the contribution of developed and developing countries in gas emission (CO₂) and aquaculture production. As long as aquaculture industry is vital source of food and revenue for most developing countries, their livelihood presumably would be affected negatively by global warming. Examining data of FAO suggested that despite slight role of developing countries in total global gas emission, their economies in aquaculture sector are more prone to losses in contrast to developed countries that emit large portion of greenhouse gases.

Keywords: *Economic effect, Climate change, Aquaculture, Developing countries, Developed countries.*

1. Introduction

Aquaculture or underwater agriculture has developed scientifically during the past three decades but, as a way of obtaining more food and source of protein, has been practiced for about 4000 years (Stickney, 1990).

This was because the demand for fish and shellfish was more than ocean supply, so this need stimulated for rapid growth in fish farming or aquaculture (Naylor et al., 2000).

Fish farming or aquaculture has been the fastest growing sector of animal food production in the world since 1970. Due to stagnating wild fisheries and a growing human population, aquaculture is expected to fill the gap in supplies of fish as food for

humans, while demand continues to increase (Naylor et al., 2000; AskarySary et al., 2012). As well as providing a valuable protein complement to the starchy diet common among the global poor, fish is the main source of protein, essential vitamins, minerals and fatty acids for people worldwide (World Fish Center, 2007).

Fisheries and aquaculture play an important role in human feeding but often unsung role in economies around the world, in both developed and developing countries.

Today, the contribution of aquaculture in fish food consumption is estimated around 45 percent which shows the importance of this subsector (De Silva and Soto 2009). Although, fisheries and aquaculture sector has little role to greenhouse emission and climate change, they are among the

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first sectors that would suffer directly and indirectly from climate change and global warming (Williams and Rota 2001, FAO 2009) after sea level rise, change in monsoonal rain pattern, extreme climate events (Fig. 1) and water stress (De Silva and Soto 2009).

The importance of fisheries and aquaculture and their future prospects has been documented by many researchers from different perspectives at different

local, regional and continental scale (De Silva and Soto 2009; Handisyde et al., 2006; Williams and Rota 2011; Moth-Poulsen 2007, Hovhannisyann et al., 2011, Khavtasi et al., 2010, Kalbassi et al., 2013), however, information on the relationship between climate change and aquaculture sector is lacking. This paper addresses such relationship through comparing the contribution of developed and developing countries in gas emission (CO₂) and aquaculture production.

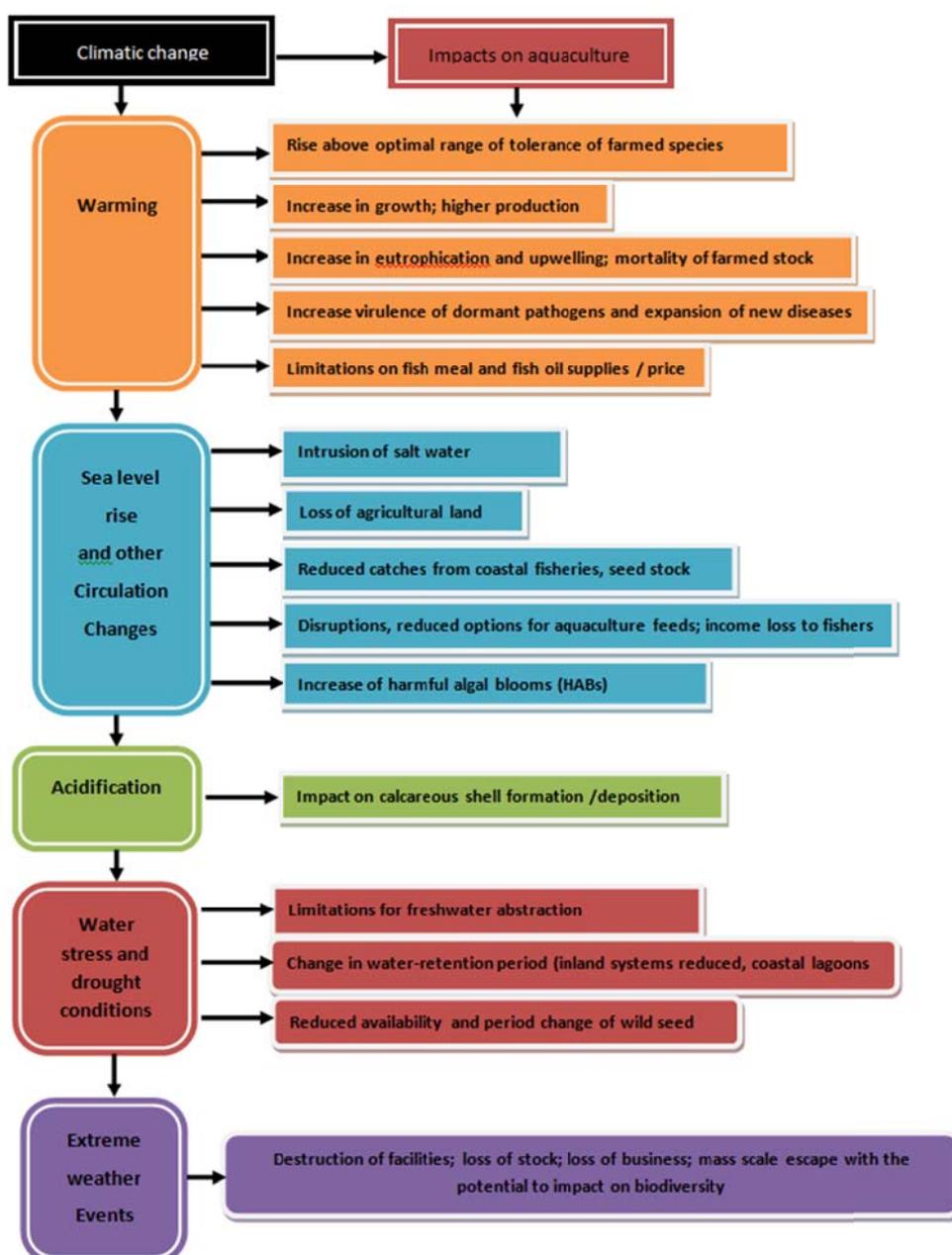


Fig. 1: Climate change element effects on aquaculture (FAO, 2008).

2. Methodology

First, contribution of developed and developing countries in gas emission and aquaculture productions were defined using published data by FAO and then economic factors such as total product and employment rate in aquaculture subsector were considered between developed and developing countries. For measuring the economic effects of climate change in aquaculture in developing and developed countries, we considered effects on production and consequently in income and in employment between these categories.

According to FAO among top-20 aquaculture producer countries of aquaculture products in 2010 and 2011, two were underdeveloped, five developed and the rest developing countries (FAO, 2012). In this study, share of developed and developing countries in gas emission and aquaculture production for 2010 was determined. Microsoft office Excel 2010 was used for statistical analysis.

According to aquaculture production in top-20 producer countries, the share of developing countries in producing aquaculture was more than the other countries (FAO, 2012). In most of the developing countries fish, is the top foreign exchange earner and very important for ensuring food security at the aggregate level (De Silva and Soto 2009). On the other hand, developed countries have the vital role in greenhouse gas emission but developing countries are affected in fisheries sector more than developed countries. In this regard, China was an exception because it was the biggest producer of aquaculture products and also the biggest greenhouse gas emitter. So, we considered two scenarios in the analyses, data from and without China.

3. Perceptive Results and Discussion

3.1. Effects of Climate Change on Aquaculture

Easily overlooked and often underreported that

effects on aquaculture could be positive or negative, arising from direct and indirect effects on the natural resources. Aquaculture requires namely water, land, seed, feed and energy. Figure 1 shows the elements of climate change that have different consequences on aquaculture via different ways. The climate changes could increase physiological stress on farmed fish of cultured stock. This would not only effect productivity but also increase vulnerability to diseases and in turn, impose higher risks and reduce returns to farmers. Interactions of fisheries, aquaculture and climate changes in the subsectors could create collateral often cascade effects. Fisheries and aquaculture located in the high latitudes and those that rely on climate changes susceptible systems, such as upwelling or coral reef ecosystems, appear to have most potential exposure to effects.

However, low adaptive capacities are important as they elevate the vulnerability of least developed countries even though greater warming is predicted to be greater at higher latitudes. Communities located in deltas, coral atolls and ice dominated coasts would also be particularly vulnerable to sea level rise and associated risks of flooding, saline intrusion and coastal erosion, the loss of agriculture productivity due to salination from sea level rise and seawater intrusion, could have an important effect and lead to aquaculture taking a major climate change adaptive role as an alternative livelihood, compensating for income and some aspects of food supply.

Indirect effects arising from adaptation by other sectors and from climate change mitigation activities, such as use of alternative energy sources, could be significant and might even overshadow the direct effects of climate change. An ecosystem approach would be required and system-wide evaluation and planning of mitigation and adaptation strategies will need to include downstream effects on other sectors (FAO, 2008). Share of greenhouse gas emission between countries are shown in Table 1.

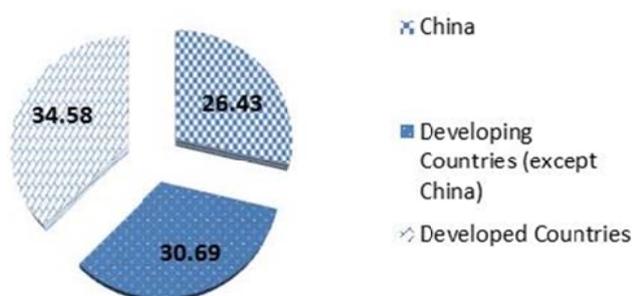
Table 1. Contribution of developed and developing countries by 2010 in gas emissions (percent)

Developing Countries		% of world emissions	
Albania	0.01	Korea, Demo. P. Rep. of	0.23
Algeria	0.39	Latvia	0.02
Argentina	0.58	Lebanon	0.07
Armenia	0.01	Libya	0.19
Azerbaijan	0.15	Lithuania	0.04
Belarus	0.2	Macedonia	0
Belize	0	Malaysia	0.69
Bolivia	0.05	Mauritius	0.01
Bosnia and Herzegovina	0.1	Mexico	1.42
Botswana	0.02	Morocco	0.16
Brazil	1.34	Namibia	0.01
Bulgaria	0.14	Nicaragua	0.01
Cameroon	0.02	Nigeria	0.25
Chile	0.23	Pakistan	0.51
China (ROC)	26.43	Panama	0.03
Colombia	0.24	Papua New Guinea	0.01
Costa Rica	0.02	Paraguay	0.02
Côte d'Ivoire	0.02	Peru	0.18
Dominican Republic	0.07	Philippines	0.26
Ecuador	0.1	Romania	0.25
Egypt, Arab Rep.	0.65	Russian Federation	5.55
El Salvador	0.02	South Africa	1.47
Fiji	0	Sri Lanka	0.04
Gabon	0.01	Sudan	0.05
Georgia	0.02	Suriname	0.01
Ghana	0.03	Syrian Arab Republic	0.20
Guatemala	0.04	Thailand	0.94
Guyana	0.01	Tunisia	0.08
Honduras	0.03	Turkey	0.95
India	6.41	Turkmenistan	0.17
Indonesia	1.38	Ukraine	0.97
Iran, Islamic Rep. of	1.82	Uruguay	0.02
Iraq	0.37	Uzbekistan	0.33
Jamaica	0.02	Venezuela	0.64
Jordan	0.07	Vietnam	0.48
Kazakhstan	0.79	Zimbabwe	0.03
Kenya	0.04		
Total	57.12		
Total except China	30.69		

Developed Countries		% of world emissions	
Australia	1.19	Ireland	0.13
Belgium	0.35	Italy	1.3
Canada	1.59	Japan	3.73
Cyprus	0.02	Malta	0.01
Czech Republic	0.36	New Zealand	0.1
Denmark	0.15	Norway	0.18
Estonia	0.06	Poland	1.01
Finland	0.20	Portugal	0.17
France	1.15	Spain	0.86
Germany	2.38	Sweden	0.17
Greece	0.28	Switzerland	0.12
Hungary	0.16	United Kingdom	1.57
Iceland	0.01	United State of America	17.33
Total	34.58		

Source: United Nation Statistics Division

Developed countries were responsible for about 34.5 percent of CO₂ emission and this share was about 30 percent for developing countries excluding China (Fig. 2).



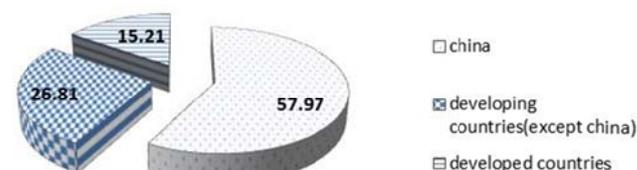
Source: United Nation Statistics Division

Fig. 2: Ratio of CO₂ emission among developed and developing countries (excluding China) and China.

Data in Table 2 indicated that developing countries were dominant in producing aquaculture product.

More than 85 percent of aquaculture productions occurred in Asia and in developing countries (De Silva and Soto 2009).

Share of aquaculture products among developed and developing countries (excluding China) and China is shown in Figure 3. Among developing countries China is really dominant in aquaculture production and has the most share of market. About 85 percent of the supply side of the market is produced by developing countries.



Source: Based on FAO 2011.

Fig. 3: Ratio of aquaculture products among developed and developing countries (excluding China) and China

Table 2.1. Contribution of developed and developing countries by 2010 in aquaculture products (percent)

Developing Countries		% of world aquaculture products	
Albania	0.0020	Korea, Demo. P. Rep. of	5.6356
Algeria	0.00075	Latvia	0.00328
Argentina	0.0021	Lebanon	0.000666
Armenia	0.0131	Libya	0.000409
Azerbaijan	0.0087	Lithuania	0.0199
Belarus	0.043	Macedonia	0.00519
Belize	0.0015	Malaysia	0.408
Bolivia	na	Mauritius	0.00051
Bosnia and Herzegovina	0	Mexico	0.136
Botswana	na	Morocco	0.00379
Brazil	0.1528	Namibia	0.0001127
Bulgaria	0.0417	Nicaragua	0.000307
Cameroon	0.00029	Nigeria	0.0875
Chile	0.5957	Pakistan	0.0645
China (ROC)	57.97	Panama	0.0196
Colombia	0.1229	Papua New Guinea	0.000056
Costa Rica	0.0115	Paraguay	0.00038
Côte d'Ivoire	0.0016	Peru	0.02819
Dominican Republic	0.0042	Philippines	3.7727
Ecuador	0.5978	Romania	0.126
Egypt, Arab Rep.	0.3273	Russian Federation	0.5379
El Salvador	0.00276	South Africa	0.0219
Fiji	0.00174	Sri Lanka	0.0104
Gabon	0.000256	Sudan	0.00102
Georgia	0.0054	Suriname	0.0000153
Ghana	0.0022	Syrian Arab Republic	0.0262
Guatemala	na	Thailand	1.9006
Guyana	0.00044	Tunisia	0.0044
Honduras	0.0292	Turkey	0.0465
India	7.179	Turkmenistan	0.00999
Indonesia	3.3064	Ukraine	0.3427
Iran, Islamic Rep. of	0.1117	Uruguay	0.000035
Iraq	0.243	Uzbekistan	0.0960
Jamaica	0.0166	Venezuela	0.0107
Jordan	0.00011	Vietnam	0.08858
Kazakhstan	0.0170	Zimbabwe	0.00067
Kenya	0.00582		
Total	84.78		
Total except China	26.81		

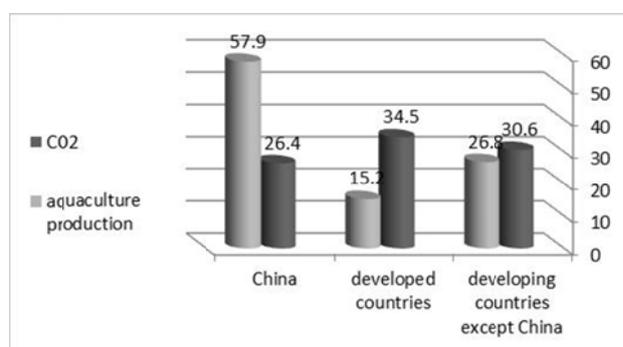
Table 2.2. Contribution of developed and developing countries by 2010 in aquaculture products (percent)

Developed Countries		% of world aquaculture products	
Australia	0.084	Ireland	0.1391
Belgium	0.0043	Italy	0.8729
Canada	0.2325	Japan	7.1574
Cyprus	0.00079	Malta	0.00256
Czech Republic	0	New Zealand	0.2688
Denmark	0.2216	Norway	0.67167
Estonia	0.0015	Poland	0.01567
Finland	0.0917	Portugal	0.0327
France	1.282	Spain	0.8646
Germany	0.4951	Sweden	0.03647
Greece	0.1040	Switzerland	0.0063
Hungary	0.02790	United Kingdom	0.2911
Iceland	0.0129	United State of America	2.1186
Total	15.21		

3.2. Economic Effects of Climate Change on Aquaculture

Employment in fisheries and aquaculture has grown in the last three decades considerably with an average of 3.6 percent per year since 1980 (World Fish Center 2011). In 2008, it was estimated that around 44.9 million people worked for aquaculture industry as full time or part time job. For each person, who was engaged in fisheries and aquaculture production, about three jobs were involved in secondary activities (FAO, 2011). Therefore, about 180 million people were employed for this industry. If each worker provided for three family members about 540 million people or 8 percent of the world population would be supplied through aquaculture subsector and expectedly, more as population increases, unlike industrialized countries in which employment in this sector has been declining (Finegold, 2012).

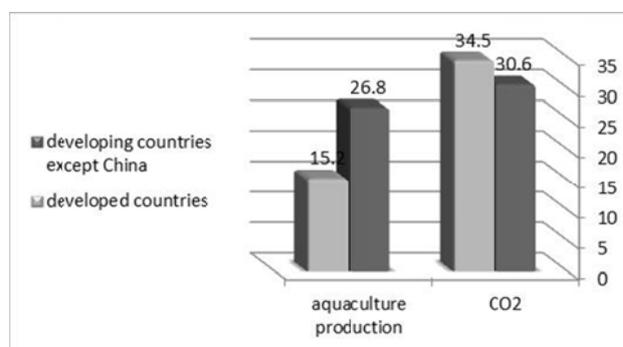
Aquaculture is a vulnerable industry to the temperature and other factors related to this event. Developing countries, except China did not contribute much to greenhouse gas emissions but are affected by global warming via decreasing aquaculture products. Developing countries contribute to about 30 percent of gas emission while this number is around 34.5 for developed countries and 26 for China. In supply side of aquaculture products, China had 58 % share of the market and this rate was 15% for developed and 26.8% for developing countries (Fig. 4).



Source: Production Based on FAO 2011 and CO2 Emission from United Nation Statistics Division.

Fig. 4: Percentage of aquaculture products and CO2 emission among developed and developing countries (except China) and China

It is concluded that even by adding China to developing countries, developed countries had 15% of aquaculture production but contributed 34% to gas emission. While developing countries produced 57% of gas emitted and 85% of production (Fig. 5).



Source: Production Based on FAO 2011 and CO2 Emission from United Nation Statistics Division

Fig. 5: Percentage of aquaculture products and gas emission among developed and developing countries

There is no access to the exact amount of vulnerability ratio of aquaculture production and employment to climate change, but any rate of decline in total aquaculture production would affect developing countries many fold compared to developed countries.

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