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RESEARCH PAPER

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A Prelimnary Survey on Perception of Turkish Aquaculture Stakeholders on Climate Change-Aquaculture Interactions

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Abstract

Climate change is expected to have direct and indirect impacts on aquaculture sector. Significant socio-economic role of aquaculture in terms of job and income generation as well as food security and economic development calls the need for a proactive approach for development of adaptation and mitigation policies towards climate change and aquaculture interactions. Awareness building and understanding the perceptions of aquaculture stakeholders regarding the impact of climate change on aquaculture are important pillars of developing adaptation and/or mitigation policies. This study is a preliminary assessment of Turkish aquaculture stakeholders' perception regarding climate change-aquaculture interactions, which was carried out within the activities of EU funded CERES project (Climate Change and European Aquatic Resources). A semi-structured questionnaire developed by CERES project for this purpose was used to collect data through face to face interviews. For statistical analysis of the collected data, both descriptive and inferential methods were used. Majority of stakeholders participating in the survey believed that most of the performance parameters including feed conversion ratio (FCR), fish health, survival rate and production costs, will potentially be affected negatively by climate change.

Introduction

Turkey is a leading producer of marine and freshwater farmed products in the Mediterranean region. Turkish aquaculture production is dominated by rainbow trout (*Oncorhynchus mykiss*), European seabass (*Dicentrarchus labrax*) and gilthead sea bream (*Sparus aurata*). There are currently 2308 aquaculture farms in Turkey operating in marine (427) and freshwater environment (1881) (BSGM, 2017). In terms of socio-economic impact, Turkish aquaculture sector is not only contributing to food security at national level but is also creating employment and income. Turkey is also a net exporter of aquaculture products mainly rainbow trout, European sea bass and gilthead sea bream contributing to seafood trade and generating foreign currency.

Turkish aquaculture sector has enjoyed an upward trend in terms of overall production ever since late 1990s; reaching a production level of over 235 000 mt in 2016 (BSGM, 2017). Its widely acknowledged that climate change would have direct and indirect impact on aquaculture (De Silva & Soto, 2009; Cochrane, Young, Soto, & Bahri, 2009; Handisyde, Ross, & Allison, 2014; FAO, 2016) and as in the other parts of the world, one of the challenges for sustainable aquaculture production in Turkey is the impact of climate change. According to Callaway *et al*. (2012) technological developments in aquaculture sector overshadows the impact of climate change. Nevertheless; they state that broader aquaculture literature reviews do suggest that over the next

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century climate change has the potential to directly affect aquaculture industry. On a global scale, aquaculture production will be challenged by climate change through gradual warming, ocean acidification, changes in sea surface water temperature, sea level rise, increased frequency of extreme events (e.g. storms, floods, drought), water stress, changes in other oceanographic variables such as wind velocity, currents and waves (De Silva & Soto, 2009; Cochrane et. al., 2009; Callaway *et al*., 2012; Handisyde et. al., 2014; FAO, 2016). Being in the Mediterranean, the climate change patterns and variation in this region is of prime importance for the future of Turkish aquaculture industry. It is widely acknowledged that Mediterranean is a sensitive ecosystem and potentially vulnerable region to climate change with consequences for aquaculture industry in the region (Turley, 1999; Giorgi & Lionellao, 2008; Rosa, Marques, & Nunes, 2012). The direct impact of climate change on Mediterranean aquaculture can be summarized as the rise in water temperature, eutrophication and harmful algal blooms, sea level rise, extreme events and water stress, acidification, increase in outbreak bacterial and viral diseases as well as fish parasites (Rosa et. al., 2012).

Significant socio-economic role of aquaculture in terms of job and income generation as well as food security and economic development calls the need for a proactive approach for development of adaptation and mitigation policies towards climate change and aquaculture interactions. In this regard, Intergovernmental Panel on Climate Change IPCC, (2014) stresses adaptation and mitigation as complementary strategies for reducing and managing the risks associated with climate change. Gray et. al. (2014) draw attention to barriers to the adaptation process and focus on “understanding”, “planning” and “management” as the three broad barriers. Marshall, Park, Howden, Dowd and Jakku (2013) underline the importance of climate change awareness as a potentially important factor influencing the capacity to cope with and adapt to climate change. They further point out that higher climate change awareness results in higher adaptive capacity. Several other studies also draw attention to importance of awareness building and understanding the perceptions of aquaculture stakeholders regarding the impact of climate change on aquaculture for developing adaptation and/or mitigation policies (Aphunu & Nwabeze, 2012; Fleming et. al., 2014; Ahsan & Brandit, 2015; Lebel, Whangchai, Chitmanat, Promya, & Lebel, 2015).

The share of aquaculture in overall Turkish production of aquatic products has been steadily increasing during past years, raising from about 14% in 2000 to 43% in 2016. In this respect, Turkish aquaculture industry is an important contributor to food security, exports of seafood, income generation and employment in Turkey. To meet the challenges and risks associated with climate change, aquaculture industry needs to develop appropriate adaptation and/or mitigation policies with the engagement of all sectoral stakeholders at national level. To this end, the first and most fundamental step would be to have a clear understanding of perceptions of sectoral stakeholders with respect to aquaculture and climate change interactions. This study is a preliminary assessment of aquaculture stakeholders’ perception on impact of climate change on aquaculture in Turkey, which was carried out within the activities of EU funded CERES project (Climate Change and European Aquatic Resources). CERES objectives include awareness building concerning climate change and its potential impacts on aquaculture at sectoral level (Stakeholders) and understanding and anticipating the impact of climate change on aquaculture production systems to formulate appropriate adaptive management measures.

Material and Methods

This study is based on data gathered from two stakeholder workshops in two most important aquaculture production regions in Turkey namely Elazığ (rainbow trout farming) and Muğla (European sea bass and sea bream farming) provinces. Both workshops shared common objectives of introducing CERES project (scope, methodological approach and objectives) and promoting stakeholder engagement in CERES activities, contributing to awareness building on climate change and aquaculture interactions at sectoral level and finally collecting information on opinion, perception and experience of stakeholders regarding impact of climate change on aquaculture sector and their management plans.

First two objectives were achieved through presentations and focus-group meetings held during two sessions, while the last objective was achieved through voluntary face to face interviews using CERES semi-structured questionnaire. The questionnaire was prepared in collaboration with all CERES Project Partners and internally disseminated to use in project related activities. Questionnaire consisted of structured and open-ended questions to gather data on stakeholders’ opinions about the possible impacts of climate change on the Turkish aquaculture sector and their strategies (if any) to manage the impacts of climate change.

A broad range of stakeholders, ranging from farmers to policy makers, civil society representatives, scientists and aquaculture logistics sector were invited to participate in these two workshops. Among workshop participants, 20 stakeholders were volunteered to participate in the questionnaire survey. Of these 20 questionnaire participants, 12 were aqua-farmers while 8 are non-farmers. Detailed profiles of questionnaire participants are given in Table 1.

As for the statistical analysis of the collected data, both descriptive and inferential methods are used. Regarding scale, collected data (through questionnaires) was mainly nominal and ordinal data. Statistical analysis of nominal and ordinal data usually requires non-parametric methods. In this study, collected data was analyzed using frequency distributions, mean ranks and Mann-Whitney U Test. Mean ranks are simply the average of importance ranks given to an item by the participants. It is a well-known descriptive statistic used for comparing the items in the case of ordinal data. Mann-Whitney U Test is known as a non-parametric hypothesis test to explore significant differences in dependent variable scores between two distinct groups. Its non-parametric nature allows the dependent variable scores being non-normally distributed or ordinal. Although Table 1 shows more, questionnaire participants in this study can be classified into two distinct groups as; those engaged in trout sector (Group 1) and those engaged in sea bass/bream sector (Group 2). For each item (i.e., dependent variable) in the questionnaire, mean ranks are used for comparing them with respect to ranking scores given by the participants (regardless of the sectors engaged) and Mann-Whitney U Test was used to assess if there are any significant differences in these two sector groups regarding perceptions on climate change-aquaculture interactions.

Results

In the first part of the questionnaire, participants were asked to rank the several core objectives according to their importance for the future performance of their organization/enterprise. Results are reported in Table 2.

Table 2 shows the importance ranks (i.e., 1 for the most and 5 for the least important) of the core objectives. Fish health and quality is ranked as the most important (i.e., 1) core objective by 8 participants while 2nd, 3rd and 4th important core objective by 3, 6 and 3 participants, respectively. In similar manner, employment is ranked as the most important (i.e., 1) core objective by only one participant while 2nd, 3rd, 4th and 5th important core objective by 3, 4, 2 and 5 participants, respectively. To compare the importance of core objectives in general, mean ranks are also reported in the last column. Mean ranks show that fish health and quality seem to be the most important (mean rank = 2.20) core objective while employment seems to be the least important (mean rank = 3.79) core objective for the future performance of aquaculture sector in Turkey. Sustainable production, competing markets and coherent policy are ranked as 2nd, 3rd and 4th important core objectives, respectively.

In addition to frequency distributions and mean ranks shown in Table 2, Mann-Whitney U Test was also applied to test if importance ranks of core objectives significantly differ between those engaged in trout and sea bass/bream sectors (engaged either

Table 1. Profiles of Questionnaire Participants

Field of Activity	# of Participants
Trout Farmer	5
Sea Bass / Bream Farmer	7
Policy Maker	4
Civil Society	2
Research / Education	1
Aquaculture Logistics	1

Table 2. Importance Ranks of Core Objectives

Core Objectives	# of Participants Who Ranked					Mean Rank
	1st	2nd	3rd	4th	5th	
Fish health / quality	8	3	6	3	0	2.20
Competing markets	2	8	2	6	2	2.90
Sustainable production	8	3	5	2	2	2.35
Employment	1	3	3	4	8	3.79
Coherent policy	5	3	4	2	5	2.95

as producer, researcher or policy maker). Test results are reported in Table 3.

Table 3 suggest that for all core objectives, importance rankings of participants show no significant difference between those engaged in trout or and sea bass/bream sectors, since all p values are greater than 0.05. In other words, for both groups, core objectives are in a similar order.

In another question, participants were asked to rank the signs of climate change by their notability. Results are reported in Table 4.

Table 4 shows the ranks of the climate change signs according to their notability. The most notable sign is ranked 1st while the least notable sign is ranked 5th by the participants. Mean ranks show that climate change signs are mostly observed in water quality and water temperature (both have the same mean rank = 2.05) while the least observed sign of climate change is in sea level rise (mean rank = 3.16). Extreme weather conditions and growth rate of fish / nutrition are ranked as the 2nd and 3rd, respectively.

To test if the notability rankings of climate change signs significantly differ between those engaged in trout and sea bass/bream sectors, Mann-Whitney U Test was applied to the collected data. Test results are reported in Table 5.

Table 5 suggest that for all signs of climate change, notability rankings of participants show no significant difference between two groups, since all p values are greater than 0.05. These results mainly suggest that both groups rank the notability of climate change signs in a similar order.

In another part of the questionnaire, participants in the survey were also asked about their opinion regarding the potential impacts of climate change on several aquaculture performance parameters. Results are presented in Table 6.

Numbers in Table 6 shows the number of participants who think that the climate change has either negative impact, no impact or positive impact on aquaculture performance parameters shown in the row. For instance, 9 participants think that climate change will have potentially negative impact on fish growth performance, while 2 and 9 participants think

Table 3. Mann Whitney U Test for the Importance Ranks of Core Objectives Between Participants engaged in Trout and Sea bass/Sea bream Sectors

Core Objectives	Mann-Whitney U Test Statistic	Z Value	p Value
Fish health / quality	12.0	-0.973	0.331
Competing markets	10.0	-1.290	0.197
Sustainable production	8.5	-1.491	0.136
Employment	12.0	-0.586	0.558
Coherent policy	13.0	-0.376	0.707

Table 4. Notability Ranks of Climate Change Signs

Signs of Climate Change	# of Participants Who Ranked					Mean Rank
	1st	2nd	3rd	4th	5th	
Water quality	8	6	4	1	1	2.05
Water temperature	7	6	6	1	0	2.05
Sea level rise	3	1	5	10	0	3.16
Growth rate of fish / nutrition	3	3	5	5	3	3.11
Extreme weather conditions	5	4	3	5	3	2.85

Table 5. Mann Whitney U Test for the Notability Ranks of Climate Change Signs

Signs of Climate Change	Mann-Whitney U Test Statistic	Z Value	p Value
Water quality	17.0	-0.085	0.932
Water temperature	16.0	-0.260	0.795
Sea level rise	13.5	-0.316	0.752
Growth rate of fish / nutrition	7.0	-1.488	0.137
Extreme weather conditions	10.5	-1.159	0.246

that climate change will have no impact or positive impact, respectively. It can be concluded from the Table 5 that most of the performance parameters will potentially be affected negatively by climate change, except fish growth performance and employment in the sector. For these two parameters, participant opinions are not very clear since they are evenly distributed over the choices.

To test if participant answers for potential impacts of climate change shown in Table 6 significantly differ between those engaged in trout and sea bass/sea bream sectors, Mann-Whitney U Test was used and the results are reported in Table 7.

Test results reported in Table 7 shows that for all potential impacts of climate change participant assessments show no significant difference between those engaged in trout and sea bass/sea bream sectors, since all p values are greater than 0.05. In other words, participants agree upon the direction of climate change impacts regardless of species/sectors. Moreover, both groups have complete agreement on potential impact of climate change over fish health, weather conditions, availability and price of fish meal/oil and market opportunities (p values = 1).

Participants were asked if their company/institute have any strategy or plan for managing the impacts of climate change. Results show that only 3 participants' company/institute (15%) have a strategy or a plan, while remaining 17 participants' company/institute (85%) have no strategy or plan to adapt or to mitigate the impact of climate change on aquaculture. The only tangible adaptation strategy mentioned by participants with a strategy or plan for meeting the challenges imposed by climate change was the use of aquaculture recirculated system (RAS).

Table 6. Potential Impacts of Climate Change on Performance of Aquaculture

Potential Impact of Climate Change	Negative Impact	No Impact	Positive Impact	Don't Know
Fish growth performance	9	2	9	0
Fish health	19	0	1	0
Feed conversion ratio (FCR)	12	1	7	0
Reproductive performance	14	2	3	1
Fish survival	18	0	1	1
Weather conditions	19	0	1	0
Availability and price of fish meal / oil	19	0	1	0
Production costs	18	1	1	0
Employment in the sector	9	5	4	2
Community depending on the sector	15	2	3	0
Competition for space	13	1	3	3
Competition with fish substitutes	10	3	6	1
Sustainability	17	1	1	1
Market opportunities	10	1	4	5

Table 7. Mann Whitney U Test for the Potential Impact of Climate Change

Potential Impact of Climate Change on	Mann-Whitney U Test Statistic	Z Value	p Value
Fish growth performance	9.5	-1.418	0.156
Fish health	17.5	0.000	1.000
Feed conversion ratio (FCR)	16.0	-0.324	0.746
Reproductive performance	15.5	-0.428	0.669
Fish survival	14.0	-1.183	0.237
Weather conditions	17.5	0.000	1.000
Availability and price of fish meal / oil	17.5	0.000	1.000
Production costs	15.0	-0.845	0.398
Employment in the sector	11.5	-1.051	0.293
Community depending on the sector	12.0	-1.073	0.283
Competition for space	13.0	-0.959	0.337
Competition with fish substitutes	14.5	-0.586	0.558
Sustainability	17.0	-0.125	0.901
Market opportunities	17.5	0.000	1.000

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In subsequent open-ended questions, participants were asked to suggest strategies or plans (if any) for managing the impacts of climate change. Among the very few answers, the most notable strategies included;

- Identification of possible risks associated with climate change for aquaculture,
- The use of technology (e.g. submergible cages, artificial wave-breakers),
- Species diversification and use of warm-water species,
- Polyculture of warm-water species and
- Identification of suitable sites for aquaculture under different climate change scenarios and relocation of existing marine aquaculture farms.

Another question was regarding the possibilities of collaborations between public and private sectors for development of adaptation and mitigation policies. All the participants in the survey underlined the need for close collaboration between the stakeholders including; universities/research institutions, producers, policy makers, professional organizations and NGOs for formulating adaptation and mitigation policies to meet the challenges by climate change. The establishment of a specific institute, focusing on research and technology development (RTD) towards climate change and aquaculture interactions and adaptation and mitigation policies, was also proposed. What was also evident from the answers given by participants was the call for more active role of public sector on issues related to forecasting climate changes, climate change scenarios, identification of risks for aquaculture sector associated with climate and development of adaptation and mitigation policy and strategies.

Discussions

The outcomes of this survey reveal that Turkish aquaculture stakeholders participating in our exercise were aware of risk associated with impact of climate change on aquaculture sector. Similar studies assessing the awareness level of aquaculture stakeholders in other countries and regions also report that overall level of awareness regarding climate change and aquaculture interaction among aquaculture farmers and stakeholders is high (Fleming et.al., 2014; Lebel et.al., 2015). Nevertheless; it should be underlined that regardless of high level of awareness among stakeholders with respect to risk associated with climate change only 15% of respondents had a strategy or plan for adaptation to climate change or mitigation of the risks. Lack of any adaptation or mitigation strategy among aquaculture enterprise is probably due to the fact the aqua-farmers perceive climate change as a long-term challenge and regard developing such strategies as the responsibility of public institutions.

When it comes to perceptions of risks and impact of climate change on aquaculture clear majority of stakeholders participating in the survey believed that most of the performance parameters including feed conversion ratio (FCR), fish health, fish survival and production costs, will potentially be affected negatively by climate change. In a survey carried out in Bangladesh and Denmark, aqua-farmers in both countries perceived that climate change will increase the oxygen-depletion and will have a negative impact on aquaculture production (Ahsan & Brandt, 2015). The results of survey conducted by Aphunu and Nwabeze (2012) reveal that fish farmers in Nigeria believed that climate change will have a negative impact on reproductive performance of fish and cost of fish production.

Ahsen and Brandt (2015) define risk perception as the perceived likelihood of negative consequences and underline that risk perception is influenced *inter alia* by personal experience. The difference in perceptions regarding risks associated with impact of climate change in different studies and countries are therefore understandable and justifiable. Nevertheless; results of statistical assessments in this study reveal that in general perceptions of stakeholders on climate change-aquaculture interactions (e.g. signs, impact) are similar between those engaged in trout and sea bass/sea bream sectors.

The proposals by participants in the survey, on possible strategies and plans to meet the challenges imposed by climate change on aquaculture sector, are reasonable and justifiable. Though Turkey has developed a “National Action Plan for Climate Change” (Anon., 2011) covering many sectors, there is still a need for an aquaculture-specific policy and strategy including action plans to identify and meet the risks associated with climate change. As underlined by Mahon (2002) and Ahsan and Brandt (2015), these policy and strategies need to be developed with active involvement of producers and all other aquaculture stakeholders.

Production of sea bass and sea bream in off-shore cage farms along the Turkish Aegean and Mediterranean coast constitute nearly half of the total Turkish aquaculture output. It is widely acknowledged by many scholars that increase in frequency of extreme events (e.g. storms) and changes in other oceanographic variables such as wind velocity, currents and waves are among the challenges caused by climate change (De Silva & Soto, 2009; Cochrane *et al*., 2009; Callaway *et al*., 2012; Handisyde *et al*., 2014; FAO, 2016). Use of more robust off-shore cages, nets and mooring systems will help the marine cage farming sector to cope with severe marine conditions caused by climate change.

As mentioned above nearly half of the Turkish aquaculture production comes from sea bass and sea bream farming. The remaining half is mainly composed of rainbow trout which is a coldwater species highly vulnerable to high water temperatures. Rosa et. al. (2012) report that by the end of 21st century an increase of 2.2 to 5.1°C in air temperature is expected in the Mediterranean region and this warming will have diverse impact on aquaculture depending on production system, species and country. Rainbow trout farming will certainly be negatively affected by expected rise in water temperatures. Species diversification and cultivation of warm-water species (e.g. *Cyprinidae spp*.) or other species with wider optimal water temperature demand will be an adaptation option with regard to impact of global warming and climate change. This option could be implemented as monoculture or polyculture.

Relocation of aquaculture farms, specifically for marine cage farms is also a potential adaption strategy which can be thought of. Turkish sea bass/sea bream farms are localized in Milas and Bodrum districts (Muğla Province) on the South Aegean coast. This region is under the influence of Mediterranean with higher water temperatures compared to North Aegean coast which more under the influence of colder waters of Black Sea. Therefore; as far as expected impact of climate change on sea water temperature is concerned, relocation of marine cage farms in suitable sites in North Turkish Aegean coast could be potential adaptation strategy. Nevertheless; allocation of marine production sites to aquaculture is a controversial and complicated issue requiring detailed environmental impact assessments, surveys and in-depth spatial planning which may limit the applicability of this strategy.

Several scholars underline the importance of revelation of stakeholders' risk perceptions on climate change for developing appropriate adaptation and mitigation policies (Mahon, 2002; Aphunu & Nwabeze, 2012; Marshall *et al*., 2013; Gray *et al*., 2014; Fleming *et al*., 2014; Ahsan & Brandt, 2015; Lebel *et al*., 2015). In this regard, this survey sheds light on perception of Turkish aquaculture stakeholders on climate change-aquaculture interactions and associated risks and reveals that there is relatively a high level of awareness on this issue. What is also clear is that Turkish aqua-farmers regard climate change and its impact on aquaculture as a long-term challenge and dealing with many daily problems throughout the production process, they are still far from foreseeing any adaptation or mitigation strategy at company level.

What seems essential is that there is an urgent need for a proactive approach by public authorities to assess the risks associated with climate change on aquaculture at national level and develop appropriate adaptation and mitigation policies. This requires a "bottom-up" approach through involvement of all aquaculture stakeholders and primarily producers, researchers and policy-makers. Capacity building for tools to meet the potential impacts of climate change specifically among small and medium-scale aqua-farmers/enterprises should also be an integrated part of any national climate change adaption and mitigation policy.

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