Impacts of Climate Change on Snakehead Fish Value Chains in the Lower Mekong Basin of Cambodia and Vietnam

Marketing, Economic Risk Assessment, and Trade/Study/13MER03UC

Hap Navy[1], Truong Hoang Minh[2], and Robert Pomeroy[3]

[1]*Inland Fisheries and Research Development Institute, Phnom Penh, Cambodia*
[2]*College of Aquaculture and Fisheries, Can Tho University, Cantho, Vietnam*
[3]*University of Connecticut-Avery Point*

ABSTRACT

The productive fisheries of the Lower Mekong Basin of Cambodia and Vietnam are essential to the food security and nutrition of 60 million people. Yet these fisheries, both culture and capture, are susceptible to the impacts of climate change. This paper reports on a study undertaken to examine the vulnerability, as perceived by snakehead (*Channa striata*) fish farmers in Vietnam and fishers in Cambodia, to the impacts from climate change. Perceived impacts on various actors in the value chain are identified, as well as adaptation strategies currently being utilized and planned for the future. Recommendations are suggested to contribute to assisting snakehead farmers and fishers in adapting and preparing for the impacts of climate change.

INTRODUCTION

The productive Mekong fisheries are essential to the food security and nutrition of the 60 million people of the Lower Mekong Basin (LMB). Fish, from capture and culture, are a significant source of income and food security in Cambodia and Vietnam. Freshwater fish consumption in Cambodia and Vietnam ranges up to 40 kg/person/year, placing them amongst the top three countries in the world. Fish contributes 81% of the population's protein intake in Cambodia and 70% in Vietnam. Mekong inland fisheries provide employment to 1.6 million of the 14 million Cambodians. In the Mekong Delta in Vietnam, 60% of the people are part-time fishers and 88% of the 'very poor' households depend on fisheries. Freshwater fish and fish products are traded throughout the LMB countries and internationally, and markets for many products are well developed. Women play a very important role in fisheries sector, including capture and aquaculture. More than 80% of the fish traders and processors in the LMB are women. However, many capture fisheries resources have been largely over exploited and, as a result, development of aquaculture has been encouraged to provide the protein, income, employment, and export earnings for Cambodia and Vietnam. The combination of high fish biodiversity, high productivity, high exploitation rate, long-distance migrations, and fish trade make protecting these fisheries and aquaculture of great importance. However, they are highly vulnerable to climate and nonclimate (specifically water development such as hydropower dam development) related drivers of change. This includes increased temperatures; changes in rainfall patterns; changes in the hydrological regime (water levels, duration of flooding, timing of flooding); changes in run-off or sediment load/movement; and increased instances of extreme weather events (storms, floods and droughts) (Keskinen et al. 2010; Hoanh et al. 2010; Västilä et al. 2010; Lauri et al. 2012). Saline water intrusion in the Mekong River was about 20km at the end of the 20th century and is now up to 50km. These drivers of change will be felt throughout the fish value chain and will pose significant challenges for fisheries and aquaculture production; food security and the nutrition and health of people, especially poor households; household income; livelihoods; markets and trade; and gender issues in the LMB of Cambodia and Vietnam. However, a complete understanding of the impacts of each individual driver and combination of drivers is only just beginning. Adaptation is urgently needed to foster there salience of the fisheries and aquaculture sectors. Adaptive strategies can

take the form of processes, actions, or outcomes in order to better adjust to, cope with, and manage changing conditions (Smit and Wandel 2006). Adaptation mechanisms can be differentiated along several dimensions: by the purpose of adaptation (whether the adaptation is planned or unplanned), by the timing of implementation, by spatial and temporal scale, by sector of activity, or by which actors are designing and implementing the mechanisms (Adgeret al. 2007; Smit et al.1999). It will be important to identify a suite of potential adaptation options for the various biophysical and technical conditions of capture and culture fisheries in the LMB.

This paper will present the results of a study which examined the vulnerability, as perceived by snakehead (*Channa striata*) fish farmers in Vietnam and fishers in Cambodia, to the impacts from climate change. Since there is a ban on snakehead aquaculture in Cambodia, data was collected on the actors in the snakehead capture fisheries value chain. Perceived impacts on various actors in the value chain are identified, as well as adaptation strategies currently being utilized and planned for the future. Recommendations are suggested to contribute to assisting snakehead farmers and fishers in adapting and preparing for the impacts of climate change.

METHODS

The value chain approach is a useful tool to study specific challenges facing a sector resulting from various drivers of change, such as climate change, including small firms' and fishers' competitiveness in changing markets. Critically, such analyses can reveal context- and sector-specific adaptation strategies to enhance a sector. A value chain is defined as "the full range of activities which are required to bring a product or service from conception, through the different phases of production, delivery to final consumers, and final disposal after use" (Kaplinsky and Morris 2001). A value chain approach can be used to examine both micro and macro aspects, including the complex networks of production and trade comprising the fisheries and aquaculture sector. The value chain perspective is important because it offers insights that would not surface in studies focused on individual economic agents or particular policy frameworks.

The value chain analyses conducted for snakehead fish through a previous study served as the foundation for this current analysis (Sinh et al. 2014). The previous study described the value chains of captured (Cambodia) and cultured (Vietnam) snakehead in the Lower Mekong Basin (LMB). The important actors involved in the value chain of cultured snakehead in Vietnam were seed producers, farmers, traders and processors (Figure 1). The important actors involved in the value chain of captured snakehead in Cambodia were fishers, traders and processors (Figure 2).

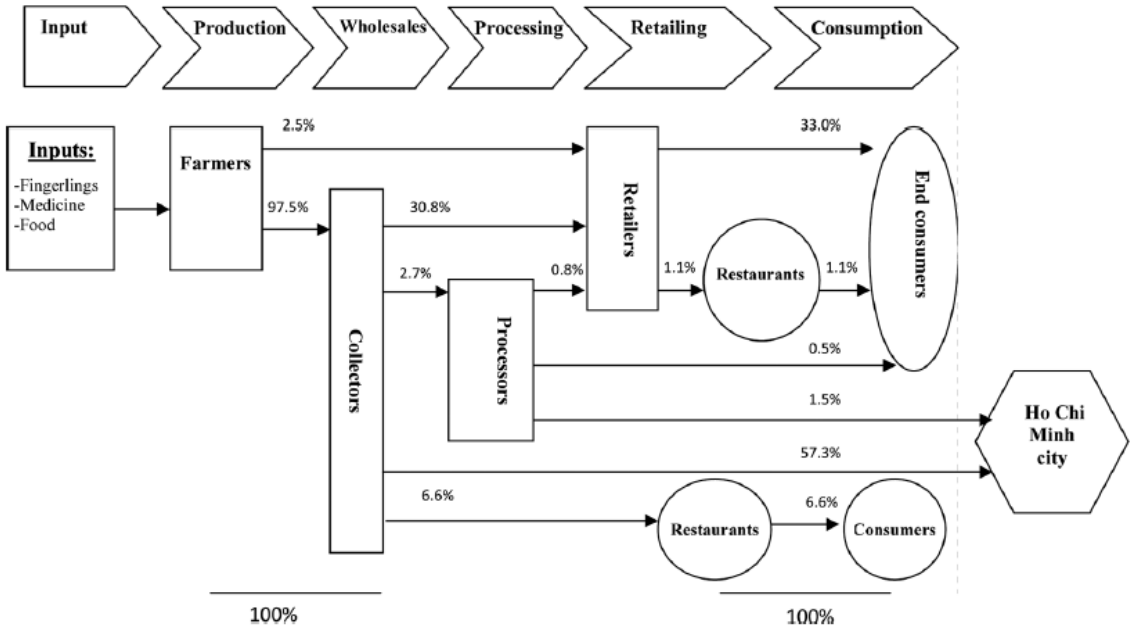

Figure 1. Value chain for cultured snakehead in Vietnam.

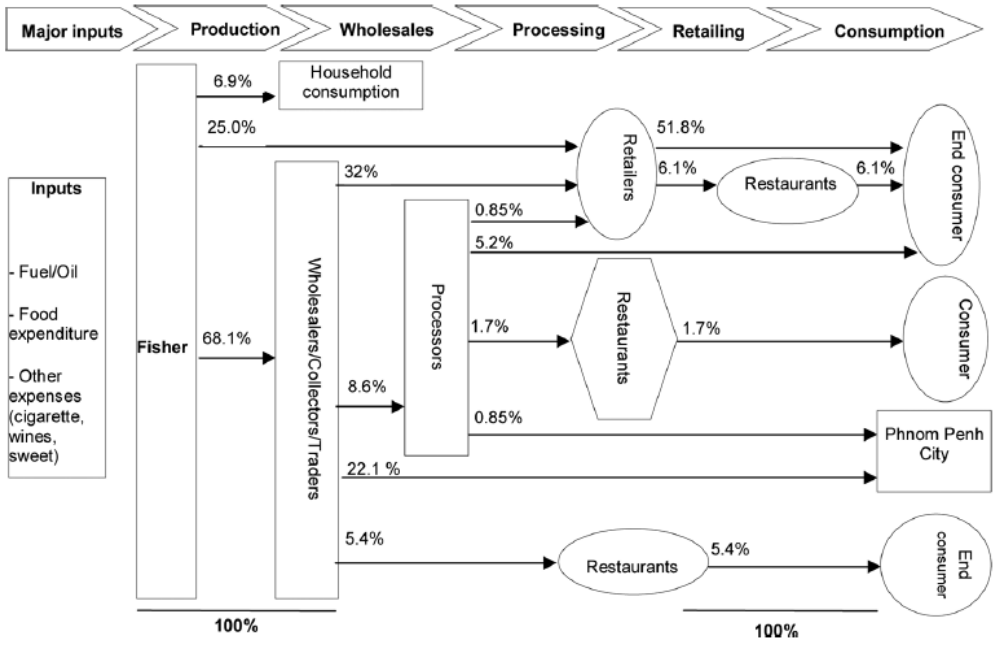

Figure 2. Value chain for captured snakehead in Cambodia.

Respondents were asked questions on climate change impacts, vulnerability, and adaptation strategies along the major capture and culture snakehead fish value chains. The study was structured using the vulnerability assessment framework of Allison et al. (2009) to understand the vulnerability of actors in the fish value chain to the key drivers of climate change. Vulnerability is defined as "a combination of the extrinsic exposure of groups or individuals or ecological systems to a hazard, such as climate change, their intrinsic sensitivity to the hazard, and their lack of capacity to modify exposure to, absorb, and

recover from losses stemming from the hazard, and to exploit new opportunities that arise in the process of adaptation" (Allison et al. 2009). The key drivers of vulnerability in this system will be changes in rainfall and wind, flooding, drought, air temperature, water temperature, storm and salt water intrusion (Tra Vinh province in Vietnam), the principal expected impacts of climate change on fisheries and ecosystems in the Lower Mekong basin region (Keskinen et al. 2010; Hoanh et al. 2010; Västilä et al. 2010; Lauri et al. 2012).

This study was conducted in both countries between February to November 2014. The study was conducted in five provinces in Cambodia including Kandal, Kampong Chhnang, Kampong Thom and Siem Reap, and Phnom Penh city. Secondary data was collected from reports of the Fisheries Administration and the Inland Fisheries Research and Development Institute (IFReDI). The primary data was collected through interviews of 52 fishers, 36 traders, and 15 processors in the study provinces through semi-structured questionnaires. The sample size is reported in Table 1.

The study was conducted in five provinces in Vietnam including An Giang, Dong Thap, Tra Vinh, Vinh Long and Hau Giang. Secondary data were collected from reports of five Departments of Agriculture and Rural Development in the study Provinces and Districts, as well as related research on snakehead. The primary data was collected through interviews of 75 snakehead seed producers, 152 farmers, five traders (large scale traders) and 22 processors in the study provinces through semi-structured questionnaires. The sample size is reported in Table 2.
An Access software and Excel database was developed and data were analyzed using EXCEL and SPSS. The vulnerability assessment was conducted based on data on exposure, sensitivity, potential impact, adaptive capacity, and vulnerability and analyzed using two formulas (Glick, Stein and Edelson 2011):

- Potential Impact (PI) = Exposure (EX) + Sensitivity (SE)
- Vulnerability = PI + AC (Adaptive Capacity)

RESULTS

Snakehead culture in Vietnam. Ninety-two percent (92%) of seed producers, 74% of farmers, 83% of traders, and 82% of processors reported that they were aware of climate change (Figure 3). The respondents reported that the main events that they consider as climate change in their area were changes in rainfall patterns, drought, and water and air temperature changes. The climate change events of most concern to seed producers and processors was changes in rainfall patterns, while of most concern to farmers and traders was drought. All of the respondents reported that they felt that the major changes to occur from climate change over the next ten years will be drought and hotter weather.

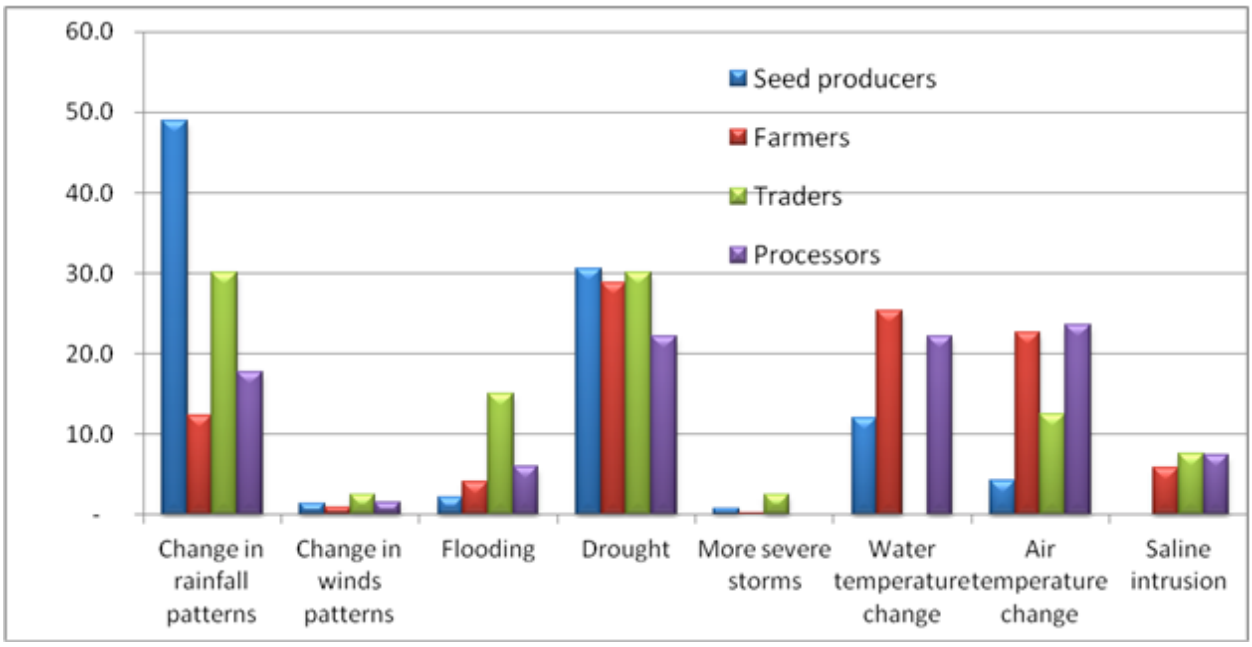

Figure 3: The percentage distribution of climate change events for actors in snakehead culture in Vietnam.

Seed producers reported that the main impacts of climate change on their business has been reduced seed production and disease. More specific impacts have been that fish get disease easier, overall decrease in productivity and lower survival rate (Figure 4). The responses were consistent across all five change in the next ten years will be a decrease in seed quality and disease provinces studied. Seed producers reported that they expect the impacts of climate. A vulnerability assessment for seed producers identified higher air and water temperature, and drought as having the strongest impact and causing the greatest vulnerability. Flooding and wind change factors had a lower impact and vulnerability (Figure 5). All the identified factors can cause low egg hatching rates and seed production. It also impacts on reproduction of snakehead brood stock and leads to low seed production.

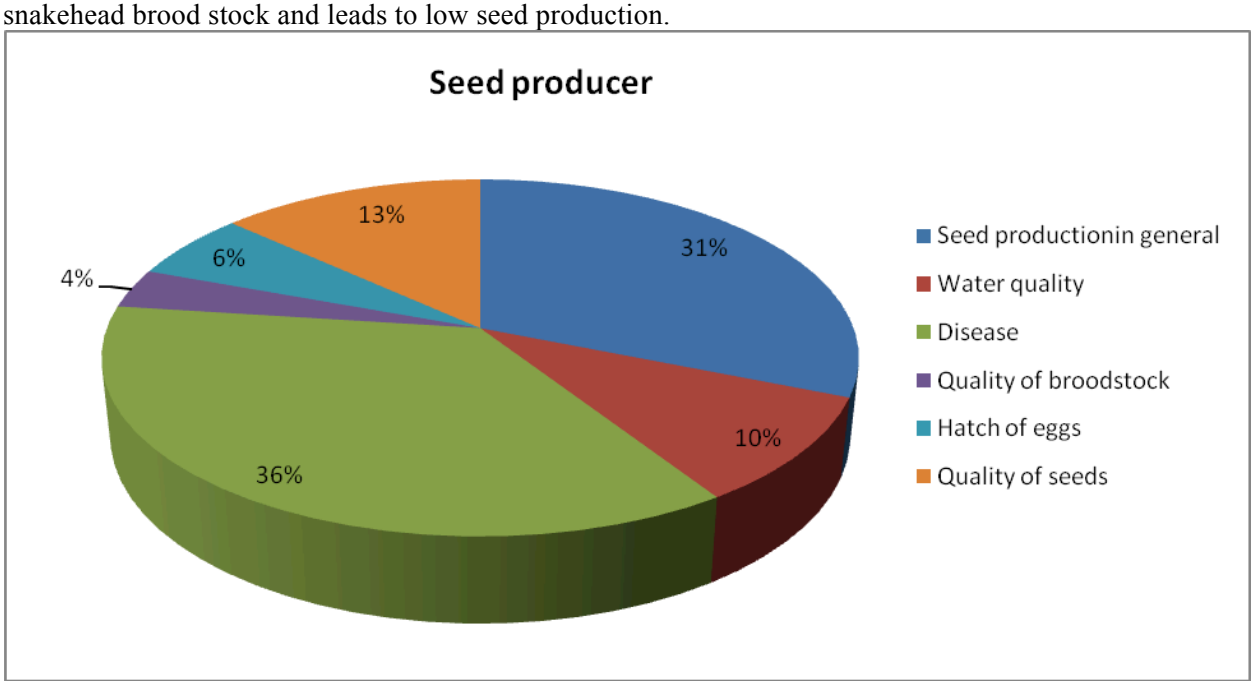

Figure 4: Main impacts of climate change on seed producer in Vietnam.

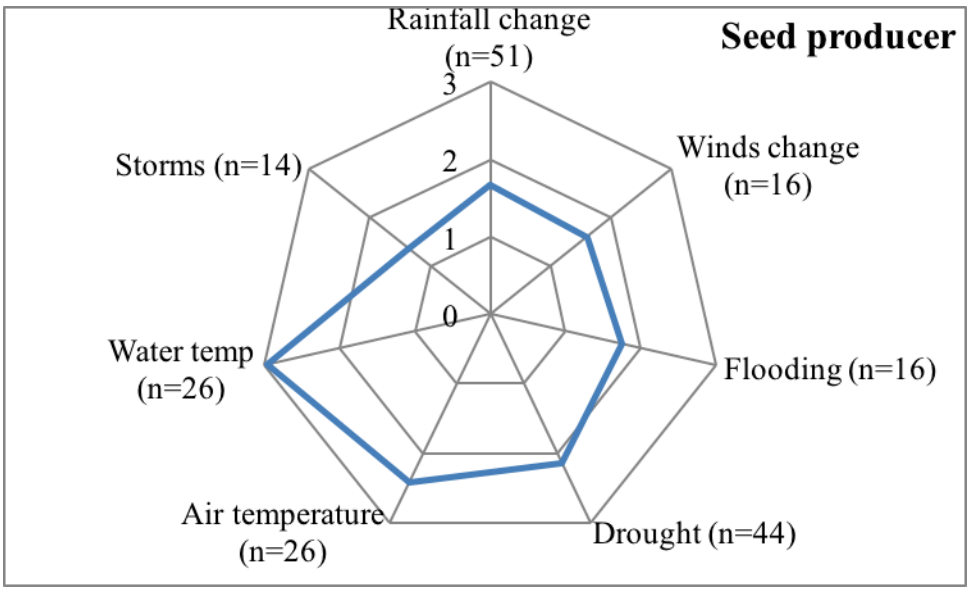

Figure 5. Vulnerability assessment matrix of seed producer in Vietnam.

Farmers reported that the main impacts of climate change on their business has been lower quality of snakehead seed, lower survival rate, water quality and disease (Figure 6). More specific impacts have been lower yields, reduction in cultured area and lower market price. The responses were consistent across all five provinces studied. Farmers reported that they expect the impacts of climate change in the next ten years will be decreased quality of snakehead seed, disease, and lower survival rate.

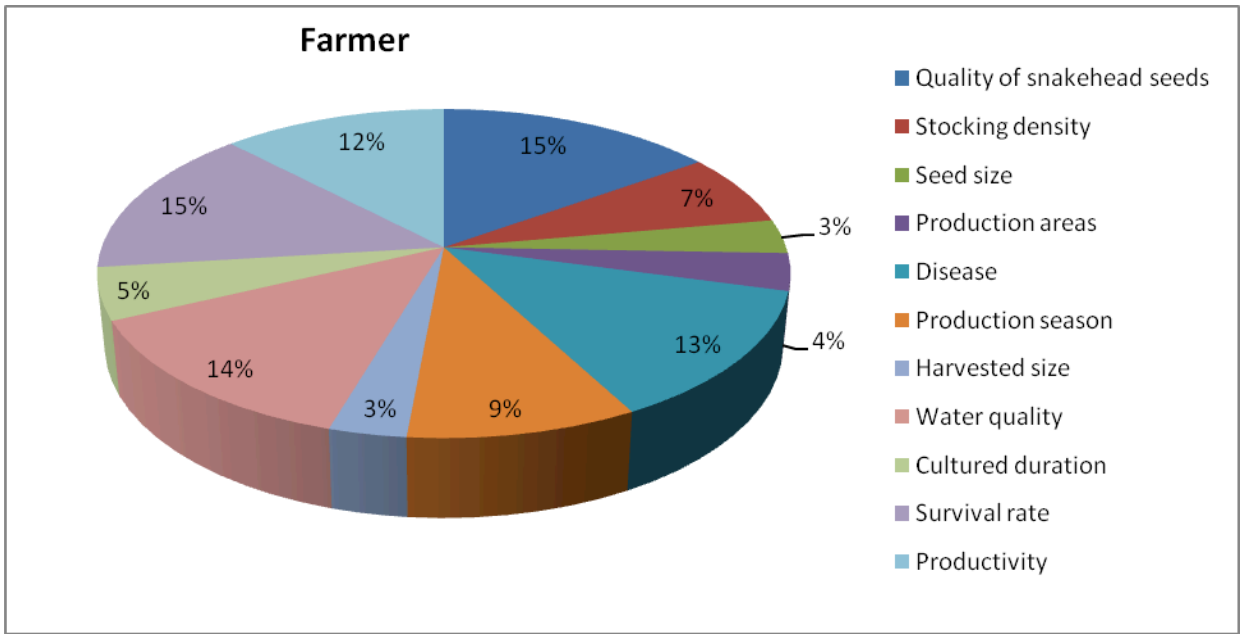

Figure 6. Main impact of climate change on farmer in Vietnam.

A vulnerability assessment for farmers identified drought, storms and higher water temperature factors having the strongest impact and causing the greatest vulnerability for snakehead culture (Figure 7). Drought, salinity, wind change, and flooding have a lower impact and vulnerability. Salt water intrusion impacts fish disease tolerance because snakehead is a fresh water species. It causes fish death and low survival rate. Storms and higher water temperature condition cause low production.

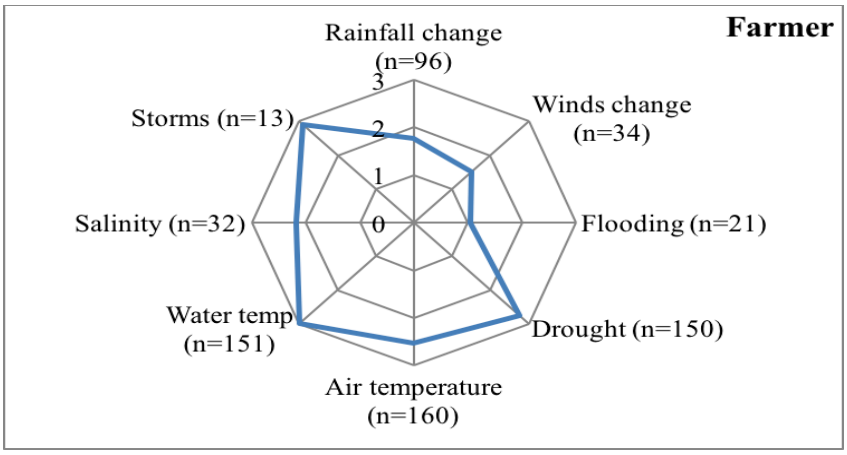

Figure 7. Vulnerability assessment matrix of farmer in Vietnam.

Traders reported that the main impacts of climate change on their business has been higher purchase price of fish, higher fish loss, and decrease in income (Figure 8). The responses were consistent across all five provinces studied. Traders reported that they expect the impacts of climate change in the next ten years will be higher snakehead purchase prices and lost markets.

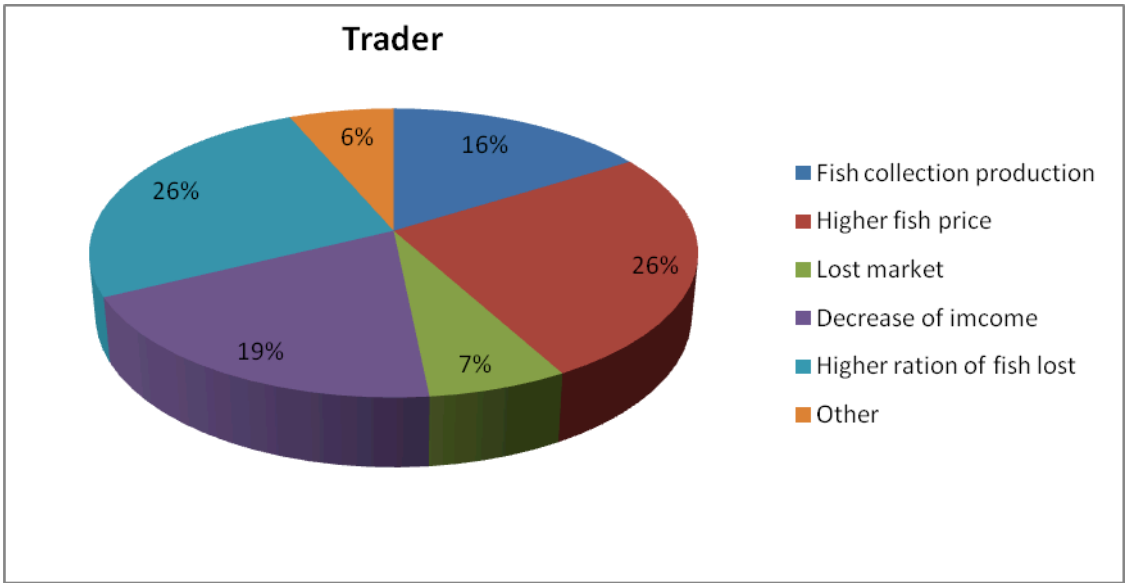

Figure 8. Main impact of climate change on trader in Vietnam.

A vulnerability assessment for traders shows that storms, higher water temperature, and salt water intrusion, drought and flooding factors have the strongest impacts and cause the greatest vulnerability (Figure 9). Wind change factors have a lower impact and vulnerability. Storms and salt water intrusion impact fish culture yield and low survival rates because snakehead is a fresh water species. Storms and higher water temperatures cause lower production. As a result, snakehead traders have less fish available to purchase.

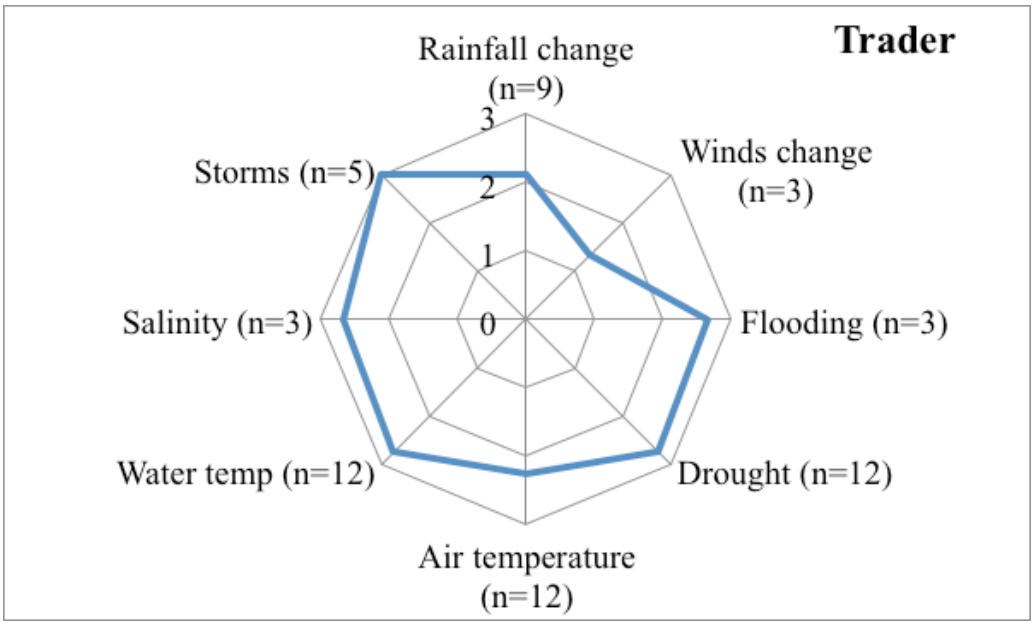

Figure 9. Vulnerability assessment matrix of trader in Vietnam.

Processors reported that the main impacts of climate change on their business have been lower quantity of fish available (processing products) and increasing price of raw fish (Figure 10). The responses were consistent across all five provinces studied. Processors reported that they expect the impacts of climate change in the next ten years will be increased price of raw fish and lower quantity of fish available.

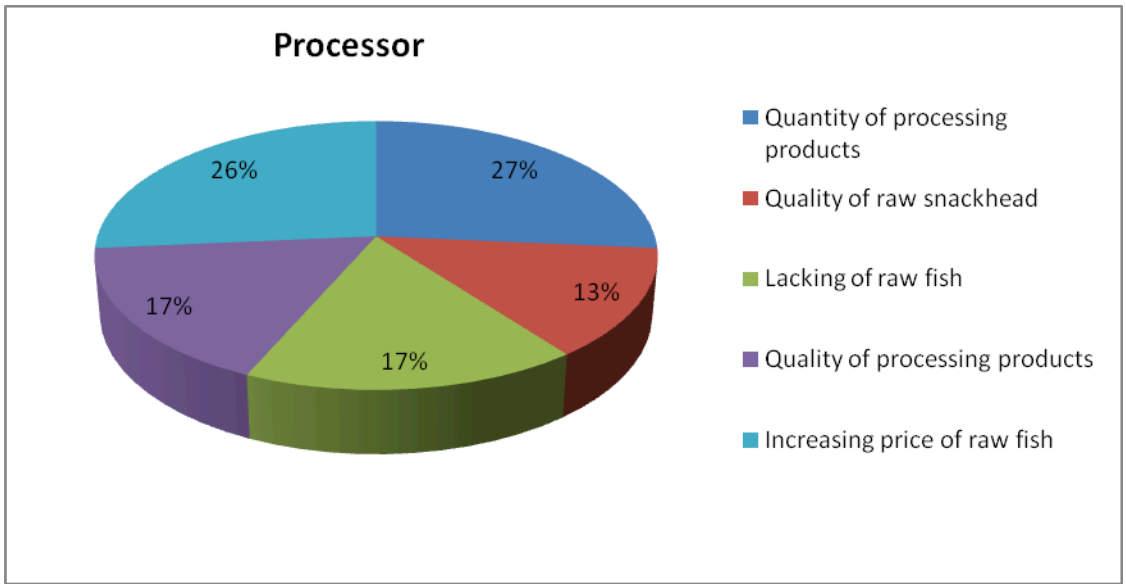

Figure 10. Main impact of climate change on processor in Vietnam.

A vulnerability assessment for processors shows that change in rainfall, increase in water and air temperatures, and storm factors have the strongest impact and cause the greatest vulnerability (Figure 11). Wind change, flooding, and salinity have a lower impact and vulnerability. Heavy rainfall and storms cause difficulty in processing and transporting fish.

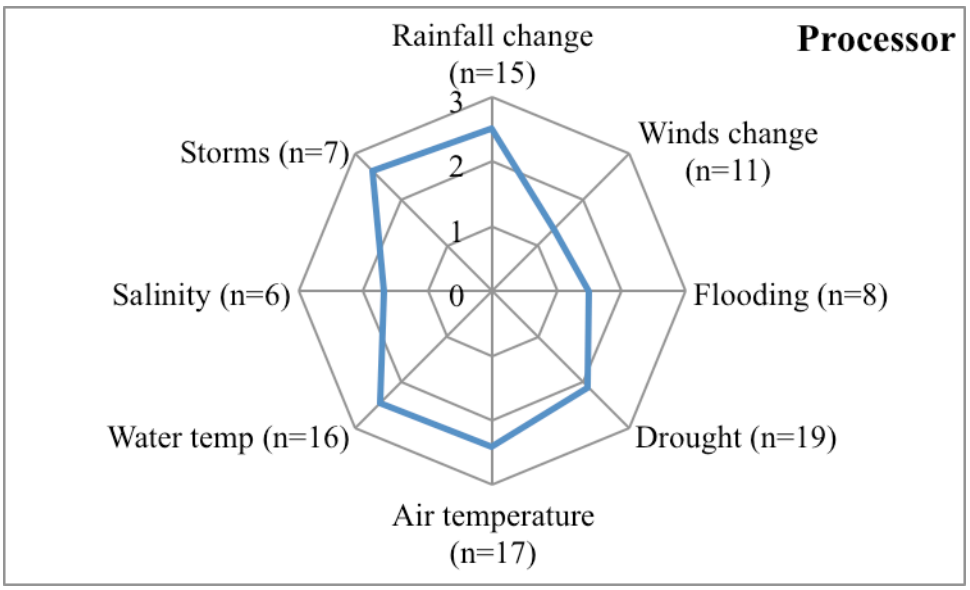

Figure 11. Vulnerability assessment matrix of processor in Vietnam.

The seed producers were asked how they plan to adapt to the impacts of climate change (Figure 12). The adaptation measures included changing the scale of seed production, temporarily stopping seed production, and selecting better brood stock.

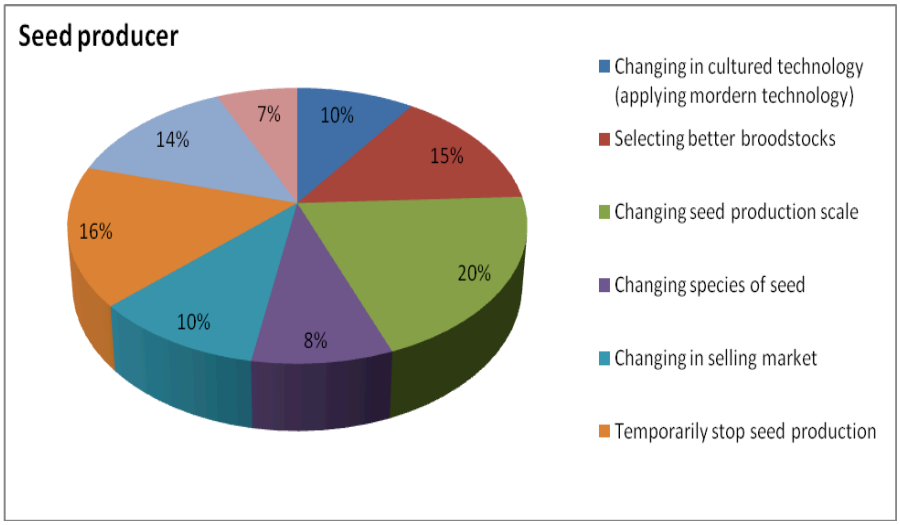

Figure 12. Adaptation strategy to the climate change of seed producer in Vietnam.

The farmers were asked how they plan to adapt to the impacts of climate change (Figure 13). The adaptation measures included changing to another culture method, stopping culture, applying more modern technology, and increasing inputs which will add to production costs.

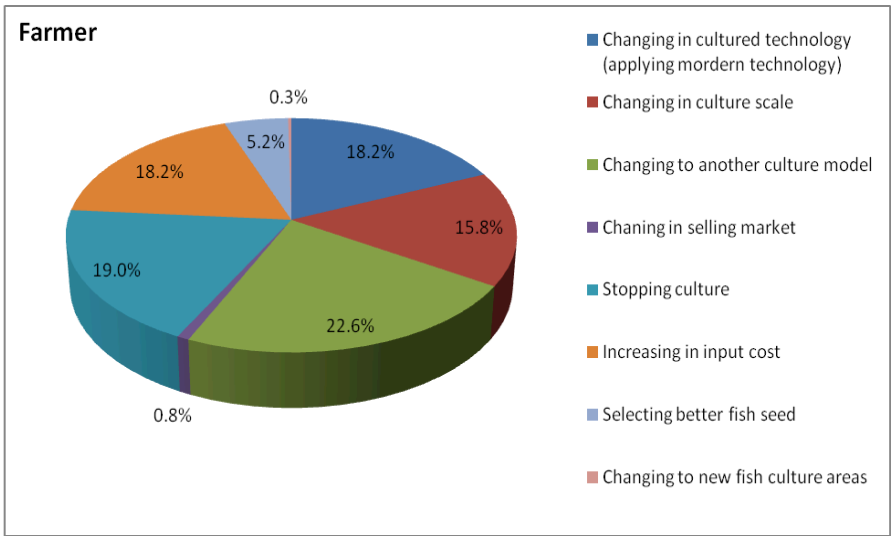

Figure 13. Adaptation strategy to the climate change of farmer in Vietnam.

The traders were asked how they plan to adapt to the impacts of climate change (Figure 14). The adaptation measures included choosing other fish species for their business, buying fish from other regions/areas, and increasing input which will add to production costs.

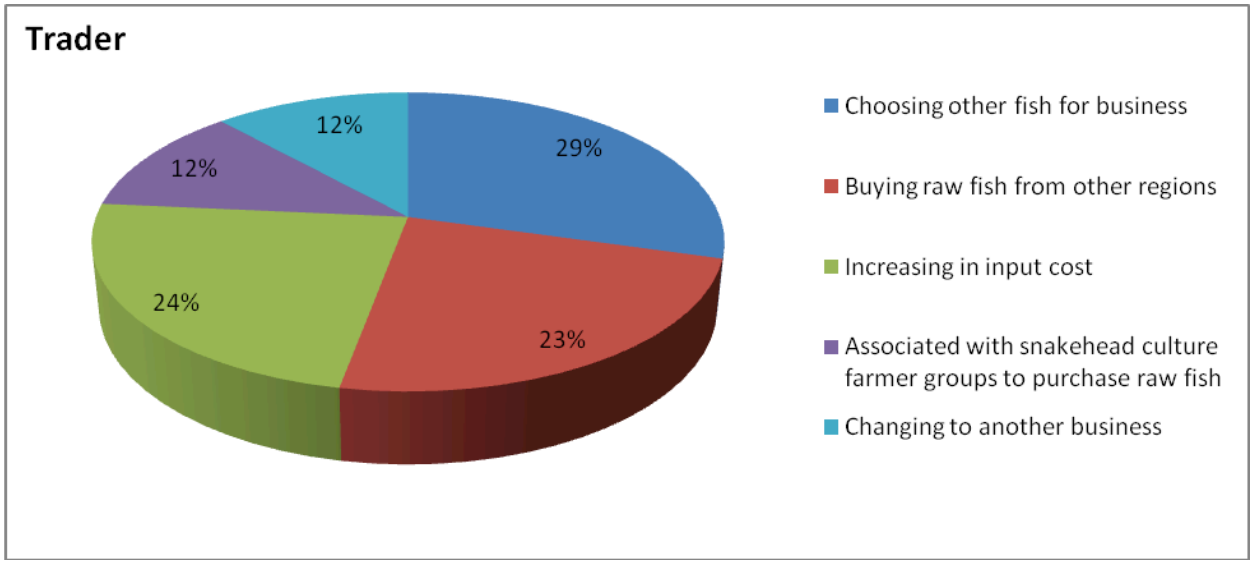

Figure 14. Adaptation strategy to the climate change of trader in Vietnam.

The processors were asked how they plan to adapt to the impacts of climate change (Figure 15). The adaptation measures included changing the scale of processing and temporarily stopping processing.

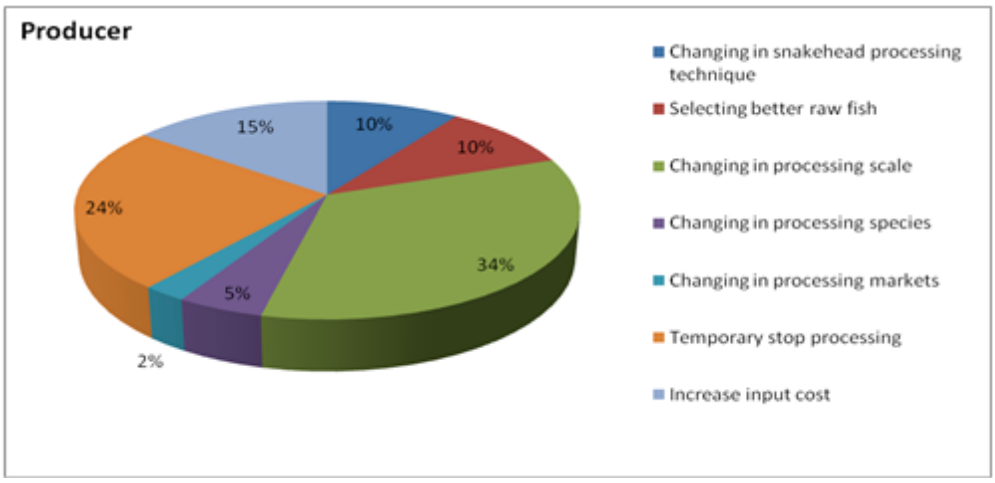

Figure 15. Adaptation strategy to the climate change of trader in Vietnam.

The vast majority of all respondents (seed producers 91%, farmers 93%, traders 92%, processors 95%) reported that other actors do not work together to deal with the impacts of climate change (Figure 16). The vast majority of respondents (seed producers 96%, farmers 88%, traders 92%, processors (90%) also reported that government has not assisted them in dealing with the impacts of climate change.

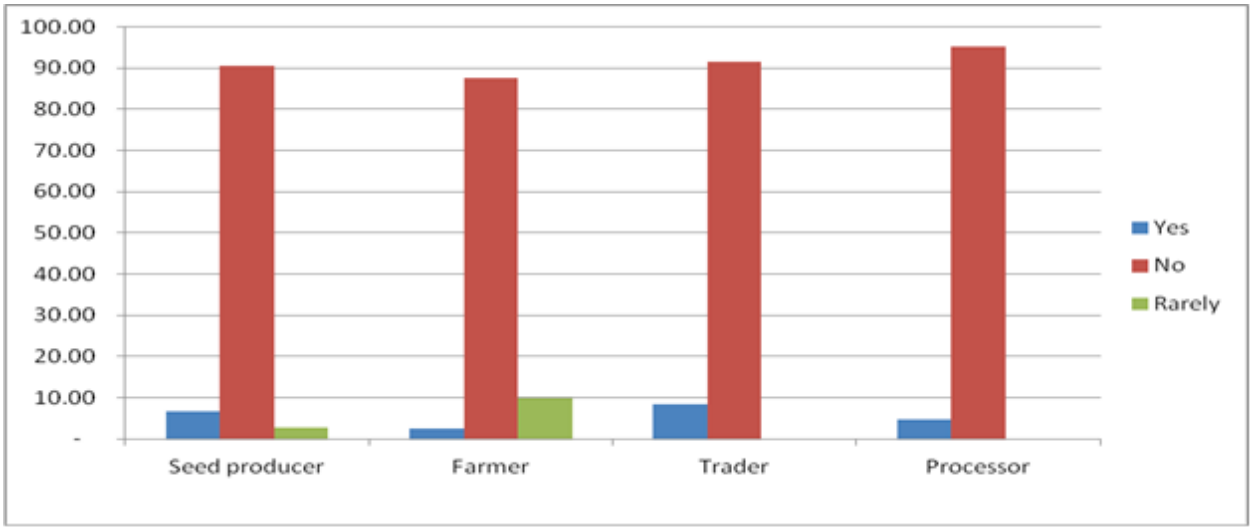

Figure 16. Snakehead culture actors working together to deal with the impacts of climate change in Vietnam.

Snakehead capture in Cambodia, One hundred percent (100%) of fishers, traders and processors interviewed in Cambodia reported that they were aware of climate change. The respondents reported that the main events that they consider as climate change in their area were changes in rainfall patterns, more severe storms, drought, and change in wind patterns. The climate change events of most concern to fishers were change in rainfall patterns, more severe storms and flooding; and to traders and processors were change in rainfall patterns and more severe storms (Figure 17). All of the respondents reported that they felt that the major changes to occur from climate change over the next ten years will be more severe storms and change in rainfall patterns.

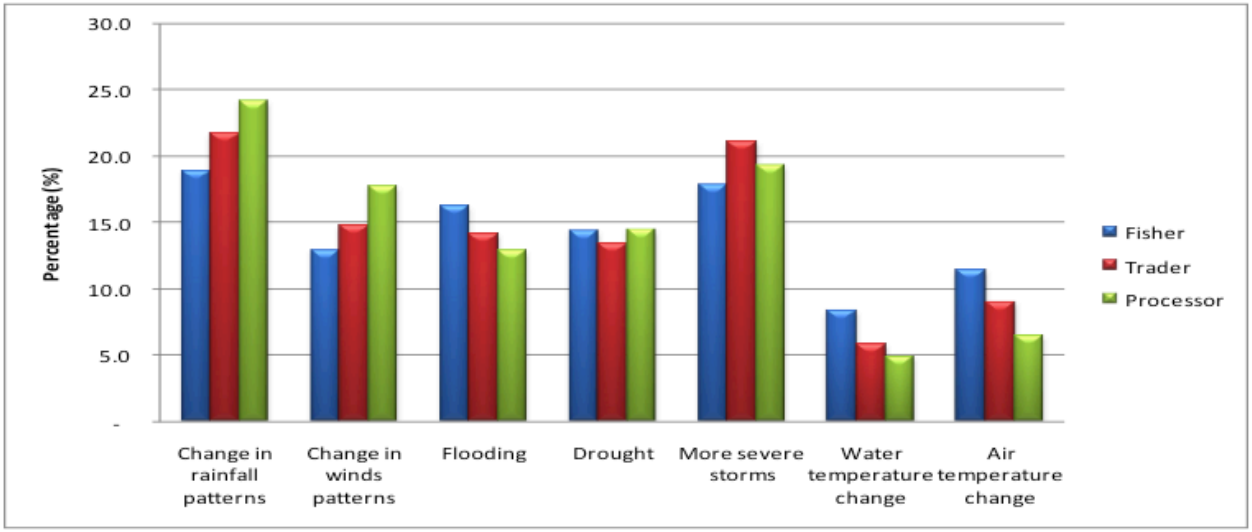

Figure 17. The percentage distribution of climate change events for actors in snakehead capture in Cambodia.

Fishers reported that the main impact of climate change on their business has been reduced fish catch/harvest/supply (Figure 18). More specific impact has been increased difficulty to go fishing due to the weather and climate. The responses were consistent across all provinces studied. Fishers reported that they expect the impacts of climate change in the next ten years will be a decrease in fish catch, increased difficulty to go fishing, and difficulty to earn income from fishing activity.

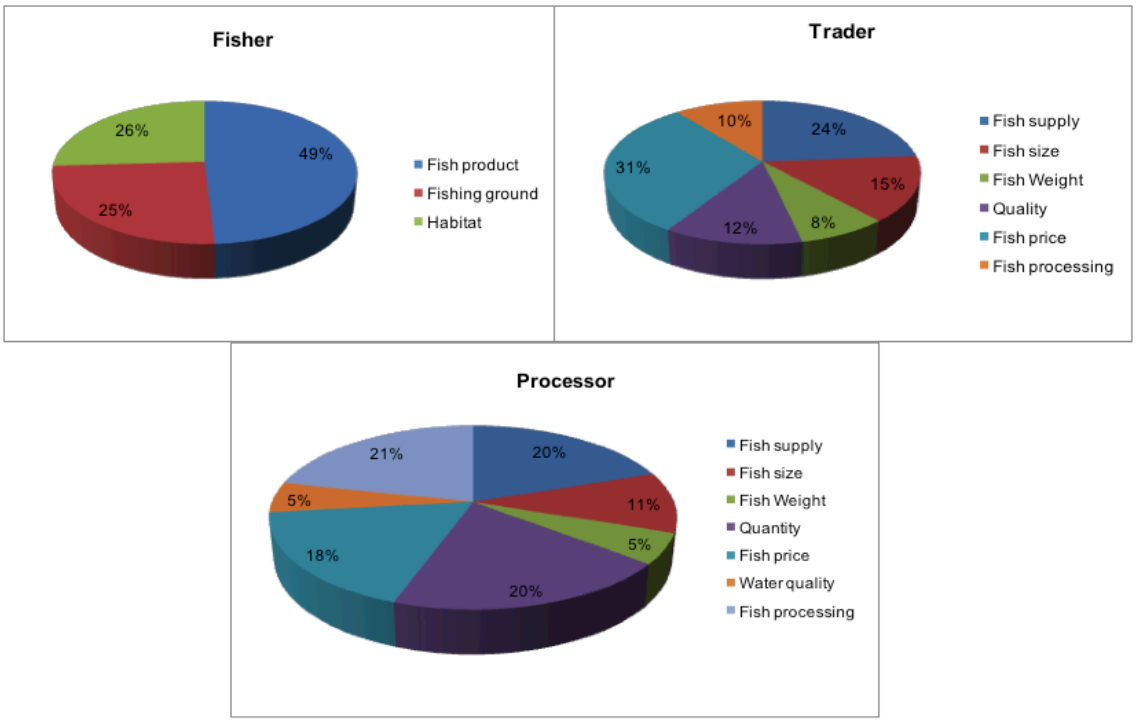

Figure 18. Main impacts of climate change on fisher, trader, and processor in Cambodia.

A vulnerability assessment of snakehead fishers identified storms as having the strongest impact and causing the greatest vulnerability. This was followed by drought, flooding, winds change, and rainfall change (Figure 19). Fishers feel more vulnerable as a result of storms as there is difficulty in going fishing and increased danger from fishing.

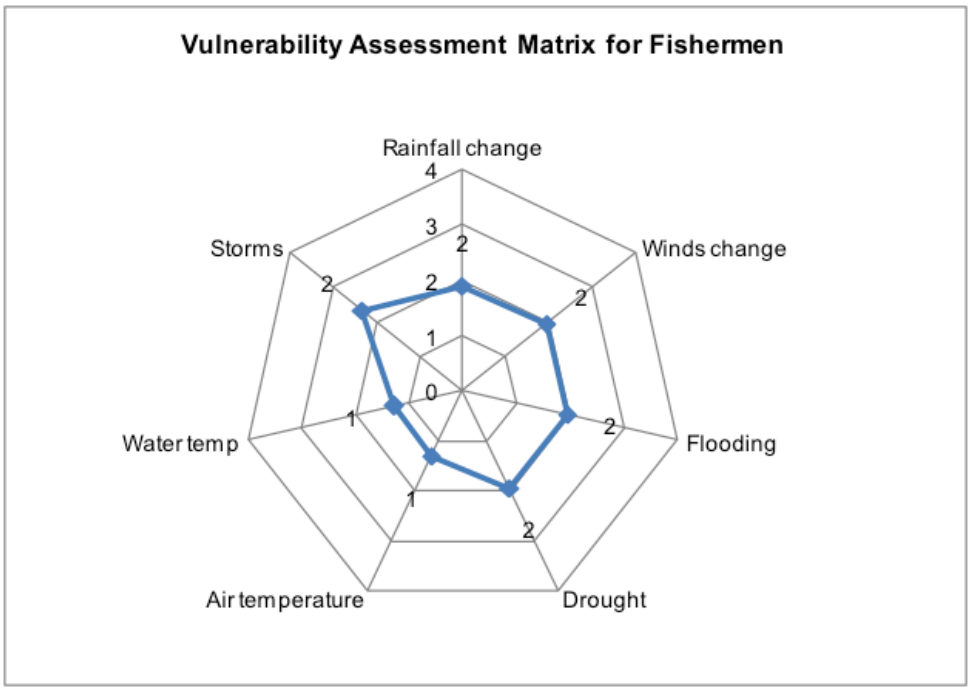

Figure 19. Vulnerability assessment matrix of fisher in Cambodia.

Traders reported that the main impacts of climate change on their business have been higher purchase price of fish and fish supply (Figure 18). More specific impacts have been a decrease in fish supply and do not have enough fish to sell. The responses were consistent across all provinces studied. Traders reported that they expect the impacts of climate change in the next ten years will be a decrease in the amount of fish available and the size of fish.

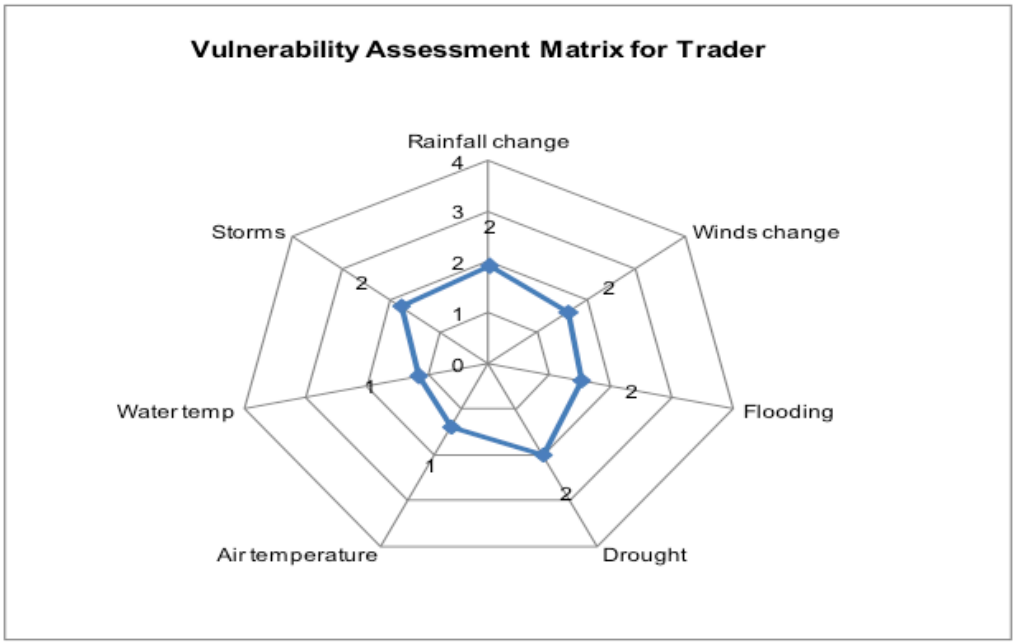

Figure 20. Vulnerability assessment matrix of trader in Cambodia.

A vulnerability assessment of snakehead traders identified drought and rainfall change as having the strongest impact and causing the greatest vulnerability (Figure 20). Traders felt that drought would reduce the fish supply and cause higher prices. Increased rainfall may cause difficulties for the trader to transport and sell fish.

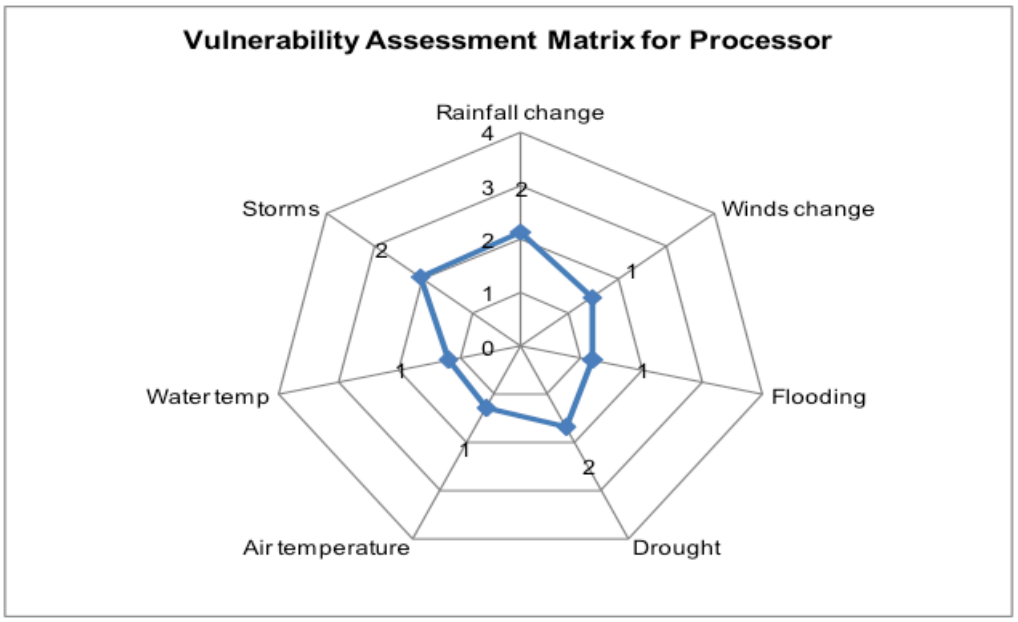

Figure 21. Vulnerability assessment matrix of processor in Cambodia

Processors reported that the main impacts of climate change on their business have been reduced fish processing, reduced fish supply, and higher purchase price for fish (Figure 18). More specific impact has been a lack of fish to process. The responses were consistent across all provinces studied. Processors reported that they expect the impacts of climate change in the next ten years will be a difficulty in processing, lack of big fish for processing, and a lack of fish for processing, especially to make *prahoc* (fish paste).

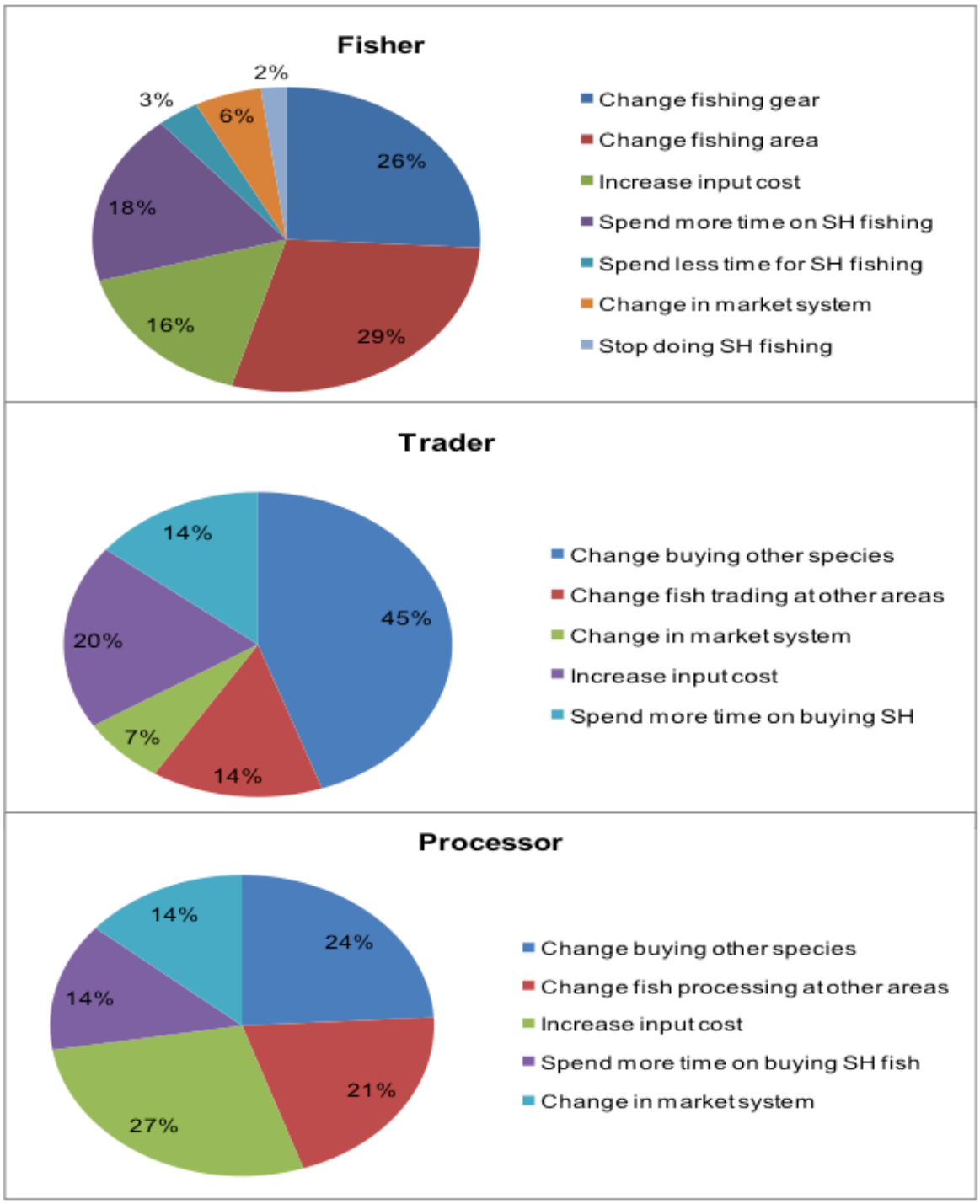

Figure 22. Adaptation strategy to deal with the climate change by fisher, trader, and processor in Cambodia.

A vulnerability assessment of snakehead processors identified changes in rainfall and storms as having the strongest impact and highest vulnerability (Figure 21). Processors felt that increased rainfall and storms would reduce the number of sunny days for processing fish products.

The fishers were asked how they plan to adapt to the impacts of climate change (Figure 22). The adaptation measures included change fishing gear, change fishing area, and spend more time fishing. When asked about other adaptation strategies, 50% of the fishers reported conserving or replanting forests. The traders planned to buy other fish species and increase input costs (for example, purchasing

more fish or traveling to other areas to purchase fish) (Figure 22). When asked about other adaptation strategies, 62% of the traders reported conserving or replanting forests. The processors planned to increase input costs (for example, purchasing more fish or changing the type of processing that they do) and purchase other fish species (Figure 22). When asked about other adaptation strategies, 65% of the processors reported conserving or replanting forests.

While all respondents reported that other actors do not work together to deal with the impacts of climate change, more fishers (40%) reported working together than traders (22%) or processors (20%) (Figure 23).

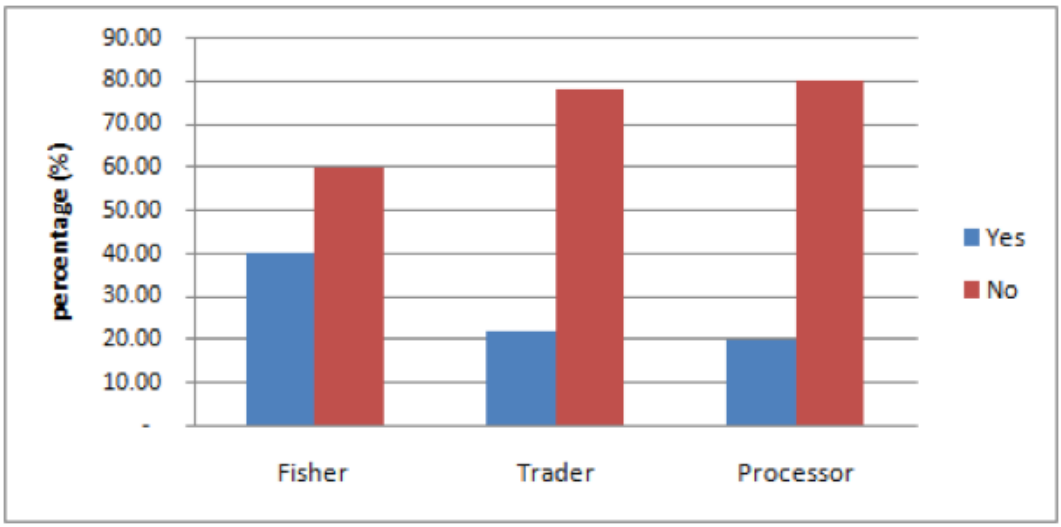

Figure 23. Snakehead capture actors working together to deal with the impacts of climate change in Cambodia.

Fishers reported that they felt that government assisted them in dealing with the impacts of climate change much more than traders or processors (Figure 24). The fishers reported that the government assisted them by providing basic needs (i.e., food) and by conserving forests. Those traders and processors who felt that government had assisted them reported that did so by conserving forests and providing basic needs to poor households (Figure 24).

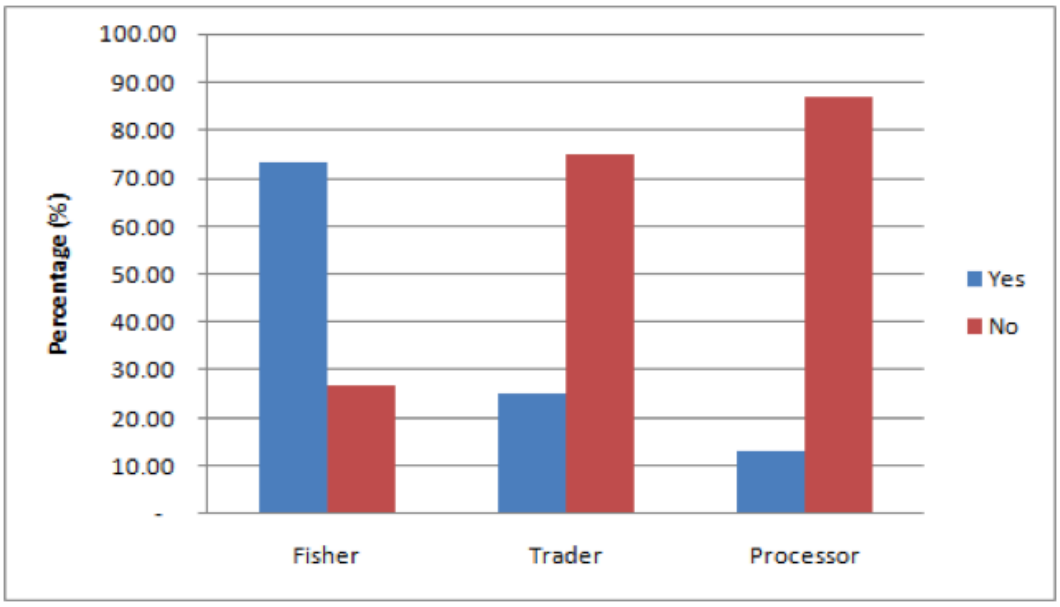

Figure 24. The government assisting actors with the impacts of climate change in Cambodia.

DISCUSSION

There was a high awareness of climate change among all of the actors in both snakehead capture and snakehead culture value chains in Cambodia and Vietnam. It was especially interesting to note that all of the actors in Cambodia reported awareness of climate change. Most of the actors in Cambodia and Vietnam reported concerns about changes in rainfall patterns, whether more drought or more rainfall. As would be expected, snakehead fishers in Cambodia are concerned about more severe storms as they must be out on the Tonle Sap Lake in boats. Snakehead farmers are concerned about increasing water and air temperature which will impact upon fish productivity. Traders and processors are concerned about more rainfall as it will impact upon their ability to transport the fish or process the fish.

Snakehead seed producers and farmers and snakehead fishers all reported the primary impact of climate change has been reduced production, whether as a result of disease or lower seed production or lower catch. Snakehead traders and processors in Cambodia and Vietnam report the impacts of climate change being higher purchase price for fish and less snakehead fish being available.

The vulnerability assessment identified a range of factors, as perceived by the snakehead value chain actors, to the effects of climate change on snakehead culture and capture. Snakehead seed producers and farmers in Vietnam were concerned about increases in water temperature on their production system. These farmers located in coastal provinces, as well as traders and processors in those areas, were concerned about increases in water salinity rates as a result of changes in rainfall and storms, which would impact upon snakehead production. In contrast, snakehead fishers in Cambodia were concerned about increases in storms which would impact their safety while fishing and their ability to go fishing. Traders and processors in Cambodia were concerned about changes in rainfall patterns and storms, bringing more rain, as well as drought; all of which would impact the availability of snakehead fish and their ability to transport fish.

Adaptation strategies were similar whether a snakehead farmer or fisher, that is, change the production system. Farmers in Vietnam plan to adjust their culture system or stop growing snakehead and culture another species. While fishers in Cambodia plan to change their fishing gear or target other fish species.

Similarly, snakehead traders and processors in Cambodia and Vietnam plan to make changes in their purchasing patterns by buying other species or in other areas, which may increase their operating costs.

Except for snakehead fishers in Cambodia, all of the other actors in the snakehead value chain tend to not work together to address the impacts of climate change. It is interesting to note that fishers, who have a reputation of being independent than farmers, work closer together. This may be a result of all of the work that has been done organizing fishers through community fisheries in the Tonle Sap Lake.

Except for snakehead fishers in Cambodia, all of the other actors in the snakehead value chain reported that government did not help them address the impacts of climate change. Snakehead fishers in Cambodia reported that they felt that government assisted them in dealing with the impacts of climate change through the provision of basic needs (i.e. food) and by conserving forests.

CONCLUSIONS

Snakehead are a preferred fish species for food in both Cambodia and Vietnam, and are consumed in both fresh and processed forms in the Lower Mekong Basin. In Cambodia, snakehead capture fisheries remain of importance in the capture fisheries sector, while snakehead aquaculture is important in Vietnam.

Snakehead production, whether capture or culture, is highly vulnerable to climate and non-climate (specifically water development such as hydropower dam development) related drivers of change. This includes increased temperatures; changes in rainfall patterns; changes in the hydrological regime (water levels, duration of flooding, timing of flooding); changes in run-off or sediment load/movement; increased instances of extreme weather events (storms, floods and droughts); and saline water intrusion (Keskinen et al. 2010; Hoanh et al. 2010; Västilä et al. 2010; Lauri et al. 2012). These drivers of change will be felt throughout the snakehead fish value chain and will pose significant challenges for fisheries and aquaculture production; food security and the nutrition and health of people, especially poor households; household income; livelihoods; markets and trade; and gender issues in the LMB of Cambodia and Vietnam. However, a complete understanding of the impacts of and vulnerability caused by each individual driver and a combination of drivers is only just beginning. Adaptation is urgently needed to foster the resilience of the snakehead fisheries and aquaculture sectors.

It is important to note that while the focus of this study was on snakehead capture and culture, similar impacts, vulnerability and adaptation strategies may be felt by fishers and farmers who target other fish species. For example, those fishers who target snakehead fish in Cambodia also target other fish species and those snakehead farmers in Vietnam also culture other species such as catfish (*Pangasius*).

Several actions need to be taken to address the impacts and vulnerability from climate change on snakehead culture and capture in Cambodia and Vietnam:

1. Governments in both Cambodia and Vietnam need to become more active in working with the various actors in the snakehead value chain to assist them in adapting and preparing for the impacts of climate change on their business. Only Vietnam has a strategy to address the impacts of climate change on aquaculture. Cambodia will need to develop such a strategy. Neither government has provided a budget to work with the industry actors to help adapt to climate change. The provinces in both countries will play an active role in any adaptation program. Much more outreach will need to be provided to the aquaculture industry in both countries.
2. The actors in the snakehead value chain will need to begin working together or be better organized to be able to share information and develop appropriate adaptation strategies to address the impacts of climate change on their business. In Vietnam, there are aquaculture associations

and organizations, but there are no such organizations in Cambodia (due to the small size of the aquaculture industry). Aquaculture industry actors in Cambodia, working with or without government, will need to be encouraged to organize. This will allow sharing of information among actors and allow governments to have points of contact for assistance.

3. The Government of Cambodia should consider reviewing the ban on snakehead aquaculture in order to provide an alternative livelihood to households as an adaptation strategy. The government of Cambodia put a ban on snakehead farming in September 2004 by Announcement No. 4004. The reasons for this were the potential negative impacts on wild fish populations from wasteful snakehead seed collection and on other fish species diversity, particularly the small-sized or low value fish used feed for snakehead aquaculture, and also the potential negative effects on poor people from decreased availability of small-sized/low value fish (So et al. 2007). The ban was also meant to force people to investigate other alternatives for their aquaculture and hopefully to create positive ecological effects (PRIAC 2006). In order to remove this ban, the same announcement mentioned that successful technologies for domestication (breeding, weaning and rearing/grow-out) of snakehead using formulated diets should be developed and applicable in on-station and on-farm levels in Cambodia. The government will lift the ban only when research develops a sustainable process to raise farmed snakehead without doing harm to the wild fishery on which so many people depend. There is currently a snakehead formulated feed, developed by this project, which will address one of the reasons for the ban. Current work by Can Tho University and IFREDI is on domestication of indigenous snakehead in Cambodia.

4. The aquaculture research facilities in Cambodia and Vietnam need to develop a program to better understand and address the impacts of climate change on snakehead seed production and grow-out. Neither IFREDI nor Can Tho University have a research strategy and program to address the impacts of climate change. This strategy needs to be developed along with a financial strategy to support the research program. This financial strategy should incorporate funding from government, donors, and the private sector.

ACKNOWLEDGEMENTS

This research was funded by the AquaFish Innovation Lab under USAID CA/LWA No. EPP-A-00-06-00012-00 and by US and Host Country partners.

LITERATURE CITED

Adger, W.N., S. Agrawala, M.M.Q. Mirza, C. Conde, K. O'Brien, J. Pulhin, R. Pulwarty, B. Smit, and K. Takahashi. 2007. Assessment of adaptation practices, options, constraints and capacity. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II. Fourth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 717–743. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson, eds. Cambridge, UK: Cambridge University Press.

Allison, E.H., A. Perry, M-C Badjeck, W.N Adger, K. Brown, D. Conway, A.S. Halls, G.M. Pilling, J.D. Reynolds,N.L. Andrew, and N.K. Dulvy. 2009. Vulnerability of national economies to the impacts of climate change on fisheries. Fish and Fisheries 10(1): 173-196.

Glick, P., B.A. Stein, and N.A. Edelson (Eds.) (2011) Scanning the Conservation Horizon:
A Guide to Climate Change Vulnerability Assessment. National Wildlife Federation, Washington, D.C.

Hoanh, C. T., K. Jirayoot, G. Lacombe, and V. Srinetr. 2010. Impacts of climate change and development on Mekong flow regime, First assessment – 2009. MRC Technical Paper No. 29. Mekong River Commission, Vientiane, Lao PDR.

Kaplinsky, R. and M. Morris. 2001. A Handbook for Value Chain Research. International Development Research Center, Ottawa, Canada.

Keskinen, M., Chinvanno, S., Kummu, M., Nuorteva, P., Snidvongs, A., Varis O. and K. Vastila, .2010. Climate change and water resources in the Mekong River Basin: putting adaptation into the context. J. Water Climate Change 1(2): 103-117.

Lauri, H., H. de Moel, P.J. Ward, T.A. Räsänen, M. Keskinen, and M. Kummu. 2012. Future changes in Mekong River hydrology: impact of climate change and reservoir operation on discharge. Hydrol. Earth Syst. Sci. 16(12): 4603-4619.

Le Xuan Sinh, Hap Navy & R. S. Pomeroy .2014. Value chain of snakehead fish in the Lower Mekong Delta of Cambodia and Vietnam. Aquaculture Economics and Management 18(1): 76-96.

Smit, B., I. Burton, R.J.T. Klein, and R. Street. 1999. The science of adaptation: A framework for assessment. Mitigation and Adaptation Strategies for Global Change 4(3): 199–213.

Smit, B. and J. Wandel. 2006. Adaptation, adaptive capacity and vulnerability. Global Environmental Change. 16(3): 282–292.

Vastila, K., M. Kummu, A. Snidvongs, and S. Chinvanno. 2010. Modelling climate change impacts on the flood pulse in the Lower Mekong floodplains. Journal of Water and Climate Change 1(1): 67–86..