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TECHNICAL-ECONOMIC EFFICIENCIES OF SNAKEHEAD SEED PRODUCTION UNDER IMPACTS OF CLIMATE CHANGE IN THE MEKONG DELTA, VIETNAM

Nguyen Thi Kim Quyen[1]† --- Truong Hoang Minh[2] --- Tran Ngoc Hai[3] --- Tran Thi Thanh Hien[4] --- Tran Dac Dinh[5]
[1,2,3,4,5]*College of Aquaculture and Fisheries, Cantho University, Vietnam*

ABSTRACT

This study was carried out from February to December 2014 by interviewing 75 farmers who operate snakehead seed production in An Giang, Dong Thap and Hau Giang provinces, Vietnam. The results showed that the total area for production was 629.01±756.77 m^2, whereas the volume for nursing was 582.10±119.81 m^3 for pond system and 1,019.56±736.66 m^3 for combining pond – hapa system). Each hatchery used 44.26±22.63 pairs of broodstock/breeding cycle and produced whole year. The quantity of seed per cycle of pond system was a half of that figure of other system while seed productivity per m^3 was much lower. Snakehead seed was mainly sold to seed traders in the Delta (82.3%). With average production cost of 47.81±16.23 thousand Vietnam dong (VND)/m^3, each farm in pond system could reach the total net profit of 49.83±18.74 thousand VND/m^3, equivalent to 328 million VND/year. These corresponding numbers of pond – hapa system were 106.98±86.25; 196.12±87.45 thousand VND/m^3, equal to 1.75 billion VND/year. Factors of climate change affecting snakehead seed production involved rainfall change, droughts, water and air temperature increase, salinity intrusion which caused diseases easier (36%), affected seed production in general (31%), bad water quality (10%), ... To reduce the impacts of climate change to production, the farmer in snakehead seed production often changed selling market, suspended production of seeds, used better brookstocks by choosing them more carefully and a number of other measures.

Keywords: Climate change, Efficiencies, Seed production, Snakehead, Technical-Economic.

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Contribution/ Originality

This study is one of very few studies, which have investigated the impact of climate change on snakehead seed production. The paper's primary contribution is finding that which and how climate phenomenon has effected on seed production as well as suggesting some adaptive methods for them.

1. INTRODUCTION

Snakehead production has developed rapidly in the recent years, total production increased from 5,300 ton to 40,000 tons during a 2002-2009 period [1]. Some provinces dominate in snakehead culture by volume and value, consisting of An Giang, Dong Thap, Hau Giang, Vinh Long, Tra Vinh (belong to the Mekong River Delta (MRD), Vietnam) [2]. Snakehead is a species that can reach high productivity in farming practice. This species also is an easy species that can culture with different systems, including earthen pond, cage, ditch and field culture systems [3].

† Corresponding author

Because of dramatically development of snakehead culture, a high demand of seeds has appeared in the MRD. Previously, snakehead farmers mainly collected natural seeds; and Cambodia was a crucial source of seeds [4]. Currently, many hatcheries and nurseries of snakehead are operated to supply for the culture. However, they are facing not only difficulties in production but also climate changes. Especially, salinization, high fluctuation in temperature between day and night, earlier flood season have created low growth rate, easier disease and low survival rate in fish [5]. Therefore, climate change has been one of the greatest challenges for the humankind, which has affected seriously to the production, livelihoods and environment all over the world [6]. Up to now, however, a few researches related to impacts of climate change on snakehead seed production have been done. Hence, evaluation of efficiency and impacts of climate changes on snakehead seed production is necessary to conduct in this study.

2. METHODOLOGY

Researched period: this study was carried out from February to December 2014. Three provinces where represents for snakehead culture in the MRD were selected for survey, including An Giang, Dong Thap and Hau Giang (Figure 1).

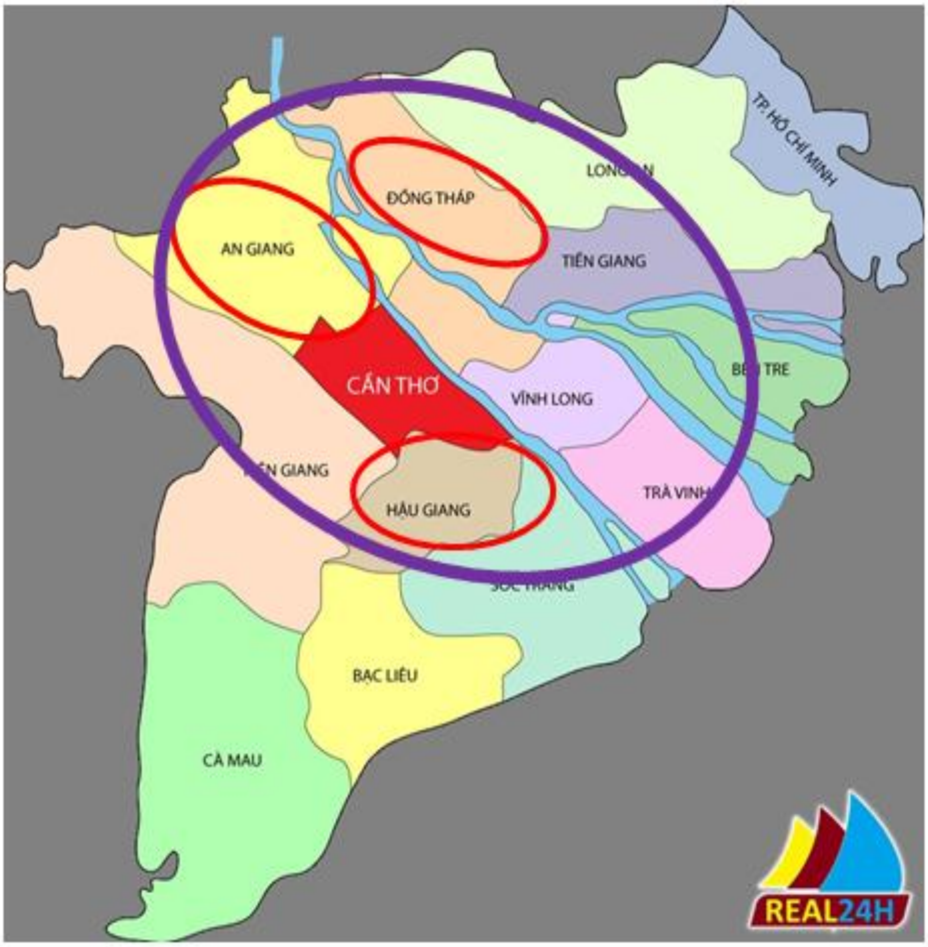

Figure-1. Map of the Mekong River Delta shows the study sites
(**Source:** Real24h [7])

2.1. Some Terminology on Climate Change

- Weather is atmospheric conditions at a current time that is determined by a combination of factors: temperature, pressure, humidity, wind speed, rain, ... [8].

- Climate is usually is defined as a timely average of weather [8].

- Ability to vulnerability due to impact of climate changes is a level that a system (nature, society, economy) could be vulnerable because of climate change or unable to adapt with negative impact of climate change [8].

- Response to climate change is human activities in order to adapt and mitigate climate change [8].

- Adaptability to climate change is the adjustment of natural or human system to the circumstances or environment changed, aimed to reduce ability to vulnerability due to current or potential fluctuation and changes of climate as well as taking advantages opportunities that they bring to Ministry of Natural Resources and Environment [8].

- Impact assessment of Climate change is a research that identity effects of climate change on environment and socio-economic activities of the local provinces. Apart from negative effects, it also resulted in positive effects. Impact assessment of climate change also includes reorganization and evaluation adaptation solutions to climate change [9].

2.2. Data Collecting Method

- Secondary data: was synthesized from related scientific reports and articles, annual statistical yearbooks from researched provinces, research result from previous studied and information from specialized organizations and Websites as well.

- Primary data: was collected by interviewing directly 65 snakehead production hatcheries and nurseries in An Giang, Dong Thap and Hau Giang by prepared questionnaire which was piloted first, then edited before coming to mass survey. A random method was applied to pick out typical samples from the list that was provided by authorities. Acording to Tuan, et al. [10] the majority of snakehead seeds in An Giang province were bought in the province whereas 93.7% and 6.3% snakehead farmers in Tra Vinh province bought seeds from An Giang and Dong Thap. Moreover, based on annual reports and field work observation in Hau Giang province, snakehead farmers there purchased seeds in Hau Giang. There are two models of snakehead seed production, including pond an combining pond-hapa hatcheries and nurseries. Therefore samples were distributed as follow:

Table-1. Distribution of samples in the research provinces

Province	Pond	Combining pond-hapa	Number of samples
An Giang	20	13	33
Dong Thap	8	14	22
Hau Giang	4	6	10
Total	32	33	65

Source: survey data

2.3. Data Processing Method

Raw data after collected was refined and coded before entering to the computer. Using Excel and SPSS for Windows to input, check and refined data before processing and analyzing. Several processing methods were applied as below:

a. Descriptive statistics: using statistical indicators such as Mean, STD, Min, Max, percentage, frequency in order to describe current status of snakehead seed production.

b. Statistical Comparison (independent sample t-test): aimed to test the differences between tow means of the population.

c. Vulnerability index: according to Intergovernmental Panel on Climate Change [11] three components that contribute to the vulnerable capacity include “exposure”, “sensitivity” and “adaptive capacity”. This study, therefore, using these index to assess the impact of climate change to the snakehead seed production, especially farmers who are operating these industry.

3. RESULTS AND DISCUSSION

3.1. Owner's Profile

Generally, famers in seed production households was in laboring age and mainly taking advantage of family labors to reduce production cost (Table 2). The number of women participated in pond-hapa system were 41%, higher than that of pond system due to high capacity to join in of this system [12]. It means that hapas usually were put in the ponds nearby which are easy to take care. Whereas pond production system mainly use ponds as places for hatching of brookstocks with a numerous outdoor activities, which are only appropriate for female labors.

Number of production experience years was 8.56 years, and there was no statistically significant difference between two systems. Educational level of the farmers was relative low, with secondary school and lower level constituting more than 94.7% in pond system and 88.9% in combining pond-hapa system, respectively. No one reached the higher education or had the specialization in aquaculture and fisheries.

Table-2. Profile of farmers who operated snakehead seed production

Indicators	Pond (n=48)	Hapa in pond (n = 27)
Experience on snakehead seed production (years)	8.57±4.83^{a}	9.26±3,37^{6}
Number of family labors (people)	4.58±1.18^{a}	4.33±1.57^{a}
Average age of farmers (years old)	45.5±7.72^{a}	43.0±8.06^{a}
Ratio of female labors (%)	28.7	41
Education level (%)	100	100
- Primary school	50	37
- Secondary school	44.7	51.9
- High school	5.3	11.1

Source: Survey data

3.2. Technical Efficiency in Snakehead Seed Production

Both two seed production system applied no any hormones to the broodstocks in order to encourage hatching. Long and Hieu [13] inferred that natural breeding is more effective than artificial one. The differences were shown in nursing the fingerlings, while pond system takes advantages of tank-ponds that were used for breeding to nursing fingerlings, the other one picked up and put fingerlings into a separate hapa to nursing after broodstock spawning.

Table-3. Technical efficiency indicators of snakehead seed production

Indicators	Pond (n=48)	Hapa in pond (n = 27)
Total area (m^2)	1,177±1,304^{a}	1,635±1,862^{a}
Total area for seed production (m^2)	425.00±56.77^{a}	744.01±526.23^{b}
Total volume for nursing (m^3)	582.10±119.81^{a}	1,019.56±736.66^{b}
Number of ponds for hatching (pond)	36.00±21.50^{a}	61.10±44.00^{a}
Number of hapas for nursing (unit)	36.00±21.50^{a}	11.80±10.70^{b}
Number of broodstocks/cycle (pairs)	27.40±1.16^{a}	61.1±44.0^{b}
Number of production cycles/year (cycles)	11.30±1.17^{a}	8.74±1.87^{a}
Fertility (larvae/kg of female fish)	8,375.00±1,033,5^{a}	7,954.56±1,279.56^{b}
FCR	12.20±1.57^{a}	14.43±1.05^{b}
Total quantity of seed/cycle (1,000 individuals)	295.55±160.34^{a}	499.13±373.66^{b}
Nursing density (ind./m^3)	553.00±165.02^{a}	2,108.45±767.65^{b}
Survival rate (%)	56.21±2.55^{a}	61.93±5.31^{b}
Seed productivity (ind./m^3)	311.36±94.36^{a}	1,299.82±476.59^{b}

Source: Survey data

Generally, the total production area was relative large that was higher than that result of Chung [14]. The majority of farms used own land for production with the proportion of farmers who hired land for farming was 44% for pond system and 48% for combining pond-hapa system, respectively. The breeding area of the latter was much higher than that of the former (744.01 m^2 in comparison to 425.00 m^2), and depended much to the personal conditions of each household. Most farms excavated small pond with the average area of 9 – 15 m^2 to leave a pair of broodstock. Each farm, which belongs to pond system, operated 36 ponds for breeding with 1 pair of broodstock per pond, lower than that figure in combining pond – hapa system (61.10 ponds). In general, there were insignificant differences between two systems in terms of breeding pond structure (Table 3).

In nursing activities, the area in pond system was twofold larger than that of the other one. In contrast, nursing volume of combining pond – hapa system was much higher than that figure of pond system because the farm owners in pond system mainly conducted breeding and nursing activities at the same place. Almost farmers selected natural process of seed production without any hormone application on broodstocks. After breeding 2 to 3 days, fries were picked out and reared in hapa in the system of combining pond - hapa, while in system of pond, broodstocks were picked out of the pond and the fries were kept for rearing in the ponds.

There were 2 production crops, including main crop (in rainy season – from April to October of Lunar calendar) and secondary crop (the rest months of Lunar calendar). Following Long and Hieu [13] rainy season facilitated high fertility of snakehead thanks to it's favorable conditions. There were about 8 – 12 cycles per year, with the number of pair of broodstocks in combining pond – hapa being double of pond system. Feed used for broodstocks was trash fish that was evaluated as a good source to rear parent fish. Total feed quantity accounted for 5 – 10% of the body weight with the fluctuated price from 7 – 9,000 VND/kg. Artemia and trash fish were two main sources of feed for nursing fingerlings. FCR in combining pond – hapa system was slightly higher than that of pond system due to the higher use of trash fish in this system.

The total fingerlings produced per cycle was relative high, of which, the figure of combining pond – hapa system was nearly double that of other system. The study result shows that nursing density was significant different between two systems, and lower that the result of Chung and Sinh [1]. Nursing density had influenced sharply to the survival rate and productivity of further fingerlings [12] which were characterized by 56.21% and 311.36 individuals/m^3 for the pond system and 61.93% and 1,299.82 individuals/m^3 for the pond – hapa system, respectively (Table 3).

3.3. Economic Efficiency in Snakehead Seed Production

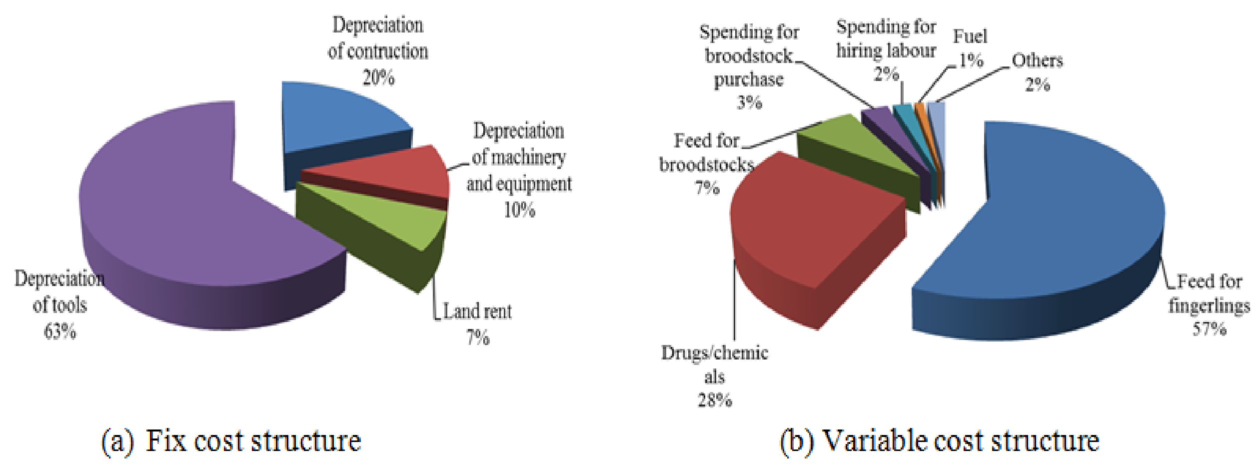

Figure-2. Structure of fix cost (a) and variable cost (b) of pond system of seed production

Source: Survey data

The research result shows that the total production cost per cycle was high with 47.81 thousand VND for pond system (Table 4). In which, the fix cost accounted for 5% of the total cost with key proportions being depreciation of tools (63%) and construction (20%) (Figure 2a). Variable cost shared more than 95% of the total cost, of which three types of cost were feed for fingerlings, drug/chemicals and feed for broodstocks (57%, 28% and 7%, respectively) (Figure 2b.). Similarly, the structure of cost illustrated the same pattern in pond – hapa production system with proportions of tool depreciation and construction depreciation being 48% and 40% of the total fix cost, respectively. Ratios of feed cost for fingerlings and drug/chemicals cost were 61% and 27%, respectively (Figure 3).

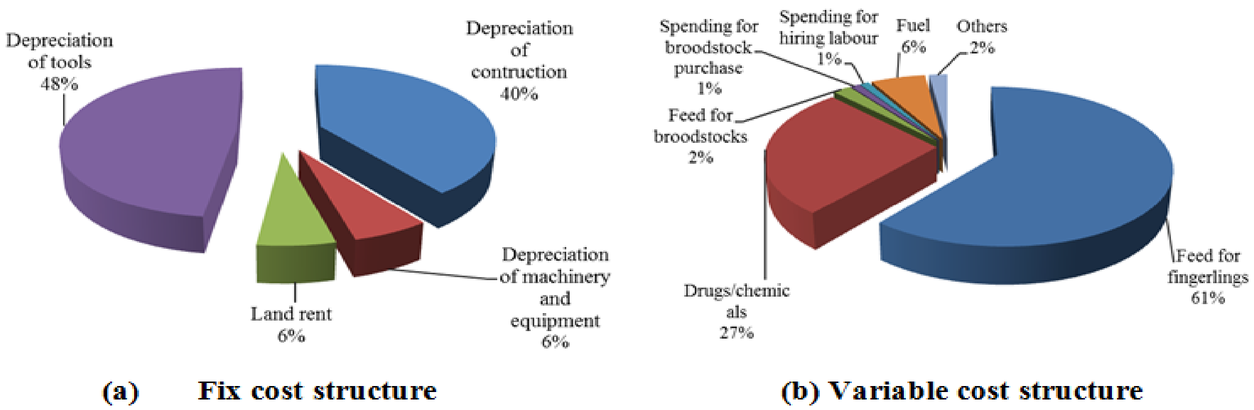

Figure-3. Structure of fix cost (a) and variable cost (b) in seed production of combining pond – hapa system

Source: Survey data

The fingerlings after nursing were usually sold to snakehead grow-out farms of the province. A small proportion of them was kept at the farm for commercial rearing. The revenue of seed production could reach high achievement, with the higher amount belonging to combining pond – hapa system. After deducting production cost, each farm could gain from 50 to nearly 200 thousand VND per m³ (Table 4). However, marginal ratio illustrates that the use of financial capital in pond system was more effective that of other system due to lower production cost in pond system [12].

Table-4. Economic efficiency in snakehead seed production

Indicators	Pond	Pond - Hapa
Fix cost (1,000 VND/m³/cycle)	3.45±1.02ᵃ	5.51±2.54ᵇ
Variable cost (1,000 VND/m³/cycle)	44.45±15.62ᵃ	201.35±85.26ᵇ
Total cost (1,000 VND/m³/cycle)	47.81±16.23ᵃ	106.98±86.25ᵇ
Selling price (VND/fingerling)	237.00±16.21ᵃ	230.23±17.26ᵃ
Sources of selling product (%)	100	100
- Keeping for grow-out	7.89	17.6
- Selling in the province	78.9	74.6
- Selling out of province	13.2	8.8
Total revenue (1,000 VND/m³)	97.78±22.74ᵃ	404.55±133.69ᵇ
Net profit (1,000 VND/m³)	49.83±18.74ᵃ	196.12±87.45ᵇ
Margin rate	1.16±0.54ᵃ	1.09±0.52ᵃ

Source: Survey data

3.4. People Awareness about Impact of Climate Change on Snakehead Seed Production

Some climate change phenomenon were awared by farmers including changes in rain level, drought, water temperature, air temperature, flood level, wind and storm (Figure 4). Climate change is considered as a key origin that causes extreme weather phenomena and early coming rainy season [15]. Research result shows that the late rainy season and less precipitation occurred most popular which may influenced negatively on snakehead seed production. Moreover, drought phenomenon was stimulated that sunny was tougher and last longer. The temperature of water and air increased in sunny season, decreased in rainy season that could cause temperature stratification evident in the water body, affect the life processes of fish [9]. Following Fourier [16] the temperature of the earth could rise due to the changes of composition of the atmosphere. During converting heat process, the atmosphere absorbs more solar heat than reflecting it back to space. Hence, the majority of farmers thought that the temperature has been increasingly hot in the recent years. Flood, wind and storm were seen as the natural disasters, which damaged seriously on human and economic properties [17]. Climate change will increase the frequency of these climate phenomenon that might result more harm such as rising flooding in the coastal and riverside areas, rising risk of infrastructure devastation [9]. Recently, most farmers have aware that flooding season would come earlier and uncertainly, similar to the result from some researches on climate change of Jorn, et al. [5].

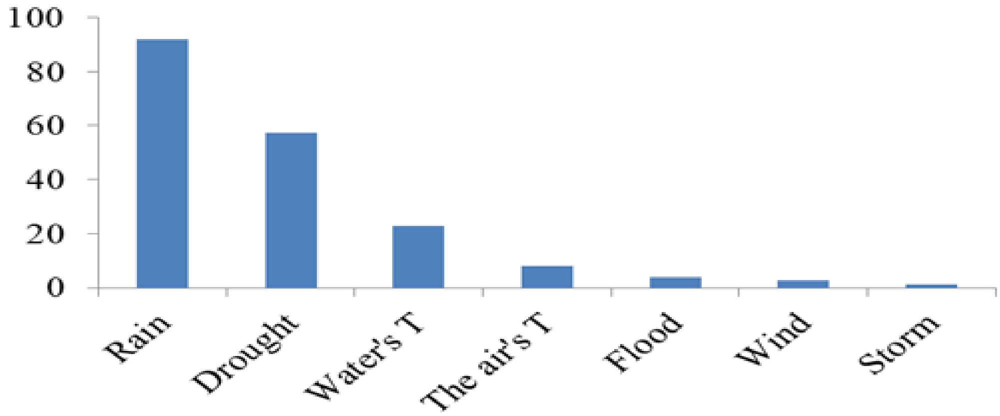

Figure-4. Some key climate change phenomena aware by famrers

Source: Survey data

The research result shows that climate change might affect much on snakehead production technique (Figure 5). The impacts of climate change on aquaculture included direct effects on fish growth, fecundity, survival rate and indirect effects on the vitality of ecosystems, pollution ratio and eutrophication in environment and pathogens [18]. More specifically, the ratio of disease outbreak would be higher (36% of the respondents). When the water temperature increase, fish have to move to deeper layer where concentrate pathogens and toxic gases [19]. Moreover, snakehead seed production in general could be influenced because of climate changes due to the continuously impacts from input to output that could not be measured exactly by the respondents (31% of the respondents). Additionally, lower quality of snakehead seed was a significant impact of climate change, which made up 13% of the total. It was closely followed by bad water quality because of water stratification, which created many toxins in the bottom and lack of oxygen at night time [19]. Considerably, climate change could affect to the hatching of egg as well as the quality of parent fish (Figure 5).

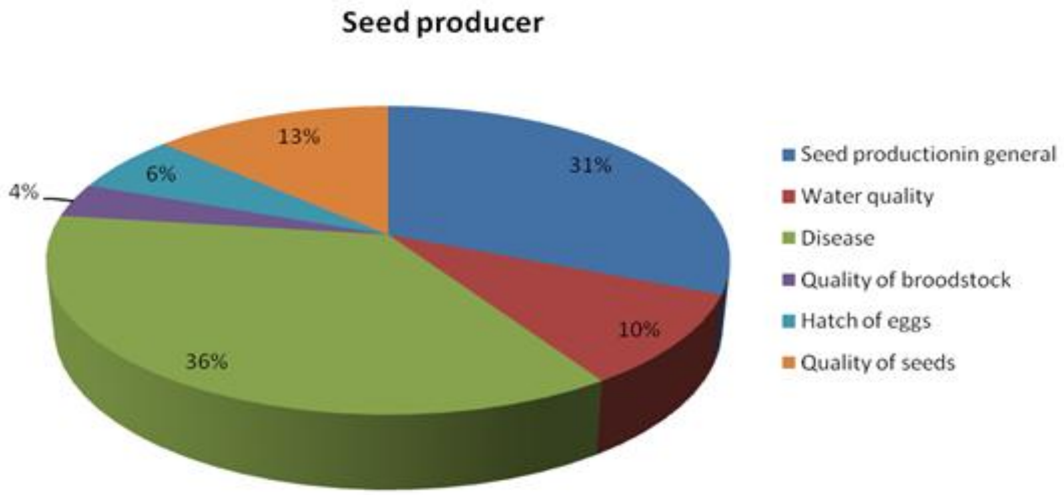

Figure-5. Impacts of climate change on snakehead seed production

Source: Survey data

Using the scale of 3 *(1 = low, 2 = medium, 3 = high)* to calculate the vulnerability of seed production farmers under different climate expressions, the result show that the increase in water temperature caused the maximum vulnerability of the community (Figure 6). Based on Huong and Trinh [20] primary cause that affected to fish aquaculture was high increase of water temperature. Air temperature, drought, flooding, wind change and rainfall change shared the same ratios of people vulnerability (medium rate) while community were at least vulnerable by storms (Figure 6).

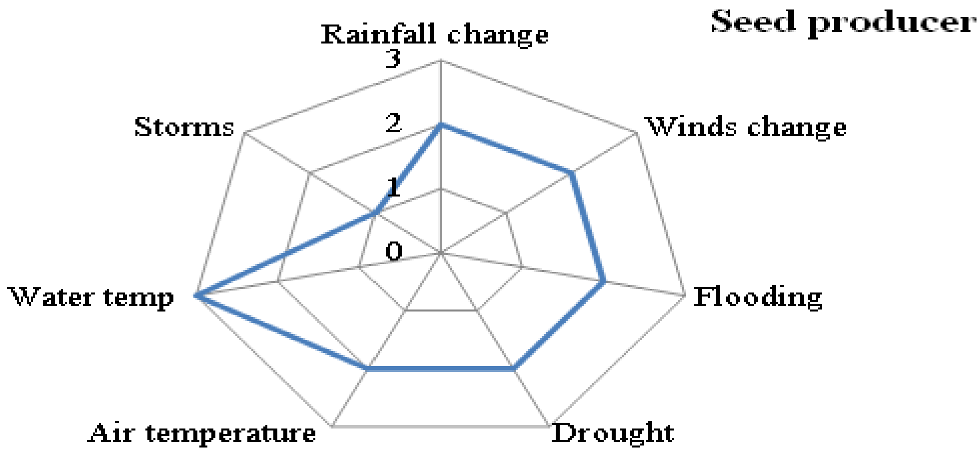

Figure-6. Spider diagram of vulnerable level of farmers due to climate change

Source: Survey data

In order to adapt with climate change, seed production farmers tend to narrow down their production scale that allow them to monitor farms more effectively (45% of respondents). When climate change impacted seriously on their production which could cause heavy losses or lack of capital for reproduction, the farmer could stop production temporarily. To deal with low broodstock quality, the farmers would try to choose better parent fish by finding out other source of broodstocks or paying more money for purchasing good quality one. This adaptive method together with culture pond and material improvement to adapt with climate change could increase the input cost which was selected by 30% of respondents. Other adaptive measures, including changing selling market, changing to produce other species or other business were chosen by 15 – 22% of respondents.

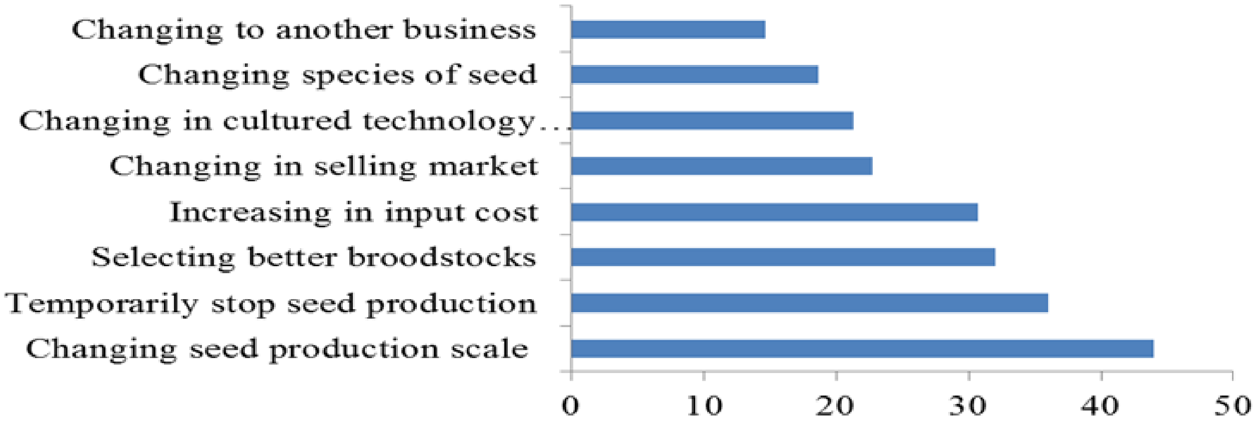

Figure-7. Adaptive methods to climate change of snakehead seed production farmers

Source: Survey data

4. CONCLUSION AND RECOMMENDATIONS

There were 2 production systems of snakehead seed: pond and combining pond – hapa which were both natural reproduction without using any hormone. Pond – hapa system used larger area, higher nursing density, higher survival rate and productivity than the other one. Net profit of pond – hapa system was also higher than pond; effectiveness of using capital in pond system, however, higher than that of pond – hapa system.

Some key climate change phenomenon that affected fish seed production were (1) rain, (2) drought, (3) temperature and (4) flood. They affected directly to the seed production in general, easier diseases and quality of seed. In which water temperature might create the highest level of vulnerability. Adaptation measures were (1) changing production scale, (2) Temporarily stop production and (3) Selecting better broodstocks.

Recommendations: (1) Should conduct more trainings on technique climate changes in seed production; (2) Building linkages; (3) Improving process of artificial breeding; (4) improving quality of broodstocks and seeds with capacity in tolerance with climate change; and (5) Financial support for seed production farmers to reduce effects of climate changes.

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