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ASSESSING THE IMPACT OF CLIMATE CHANGE AND SEA LEVEL RISE ON SHRIMP FARMING IN CAN GIO DISTRICT, HO CHI MINH CITY

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ABSTRACT

Can Gio is only coastal district of the Ho Chi Minh City. It plays a vitally important role in contributing aquatic food in general and shrimp in particular to residents of the city. However, the shrimp farming in there has been significantly fluctuated by climate change and sea level rise impacts in recent years. By approaching community, and using several sectors into applied statistic method, the article quantitated the change of shrimp farming in the study area in times of climate change and sea level rise.

Keywords: shrimp farming, climate change, sea level rise, Can Gio District.

TÓM TẮT

Đánh giá tác động của biến đổi khí hậu và nước biển dâng đến nghề nuôi tôm huyện Cần Giờ, Thành phố Hồ Chí Minh

Cần Giờ là huyện duy nhất giáp biển của Thành phố Hồ Chí Minh, nó đóng vai trò quan trong trong việc cung cấp sản phẩm thủy sản nói chung và tôm nói riêng cho người tiêu dùng ở thành phố này. Tuy nhiên, trong những năm gần đây, sự phát triển của nghề nuôi tôm ở huyện đã có những biến động nhất định trước tác động của biến đổi khí hậu và nước biển dâng. Bằng việc áp dụng một số công thức trong thống kê toán học và cách tiếp cận cộng đồng tại lãnh thổ nghiên cứu, bài báo đã đánh giá định lượng tác động của biến đổi khí hậu và nước biển dâng đến nghề nuôi tôm.

Từ khóa: nghề nuôi tôm, biến đổi khí hậu, nước biển dâng, huyện Cần Giờ.

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1. Introduction

Can Gio, the only coastal district of Ho Chi Minh City with mangrove forests covering over 50 percents of its total area which is home to the Can Gio Mangrove Forest - a biosphere reserve listed by UNESCO, is favourable for aquaculture and maritime economy. Shrimp farming and aquaculture more broadly, have diversified livelihood opportunities for the coastal poverty, which attracts over 70% of the district's workforce [1] (IUCN, 2013).

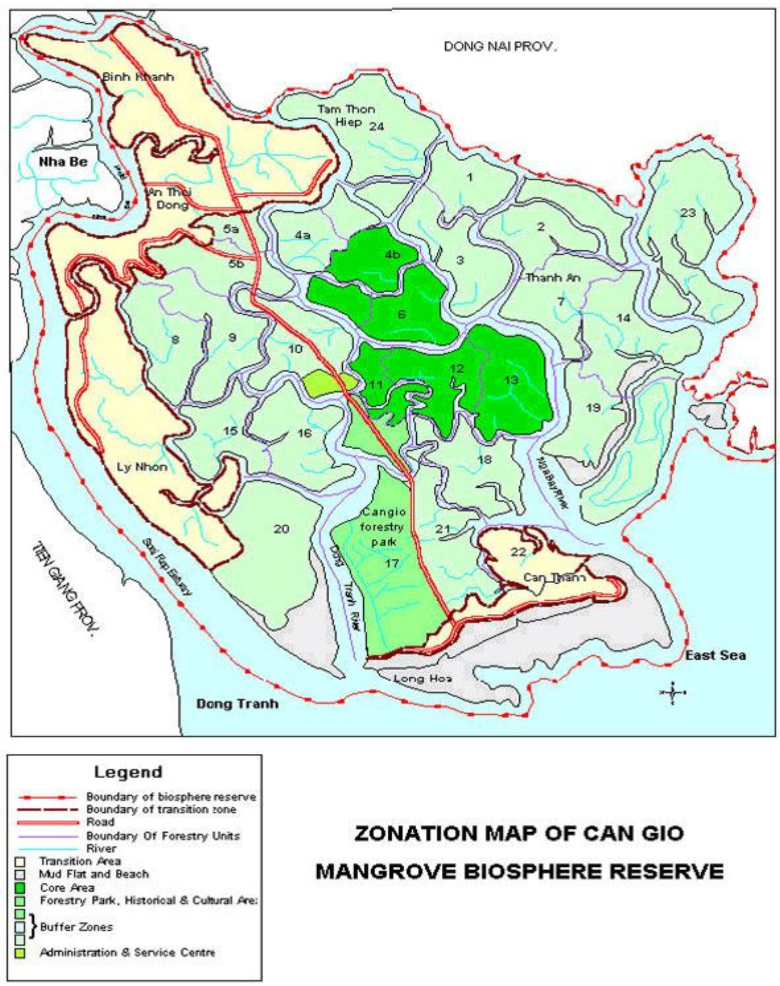

Fig 1. *Map of the study area [2]*

Over the last decades, the development of shrimp farming in the study area was developed by two main types of shrimp, including prawn and white-leg shrimp. It plays crucial role in the aqua-economy of HCMC, which has been determined that is the economic centre of Viet Nam, contributes to export earnings, food production, livelihood opportunities, and poverty alleviation.

However, this area is one of the most vulnerable areas to climate change and sea level rise in the Mekong lower basin [3] (ADB, 2010). Climate change and its impacts under the form of sea level rise, increasing temperature, disaster, and so on have certainly or uncertainly influenced on growing of shrimp farming in the district. Therefore, the identification of damaging consequences on shrimp farming, adaptation strategies must be developed to cope with the challenges. This paper accesses the temporal variations of shrimp husbandry in times of climate change.

2. Data and methods

2.1. Data

The statistics for doing research includes: average monthly temperature, monthly precipitation from 1978 to 2015 at Tan Son Nhat meteorological stations, and the data related to shrimp production was provided by Economic Division of Can Gio District.

2.2. Methods

- Arithmetic mean:

$$\bar{X} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (1)$$

- Standard deviation

$$Var = \sqrt{\frac{\sum_{i=1}^{n} (x_t - \bar{x})^2}{n}} \quad (2)$$

In that, $\bar{X}$: arithmetic mean of x values; n is the length of x values series.

- Moving average for 5 years

$$x_t = \frac{1}{10}(x_{t-1} + 2x_{t_0} + 3x_t + 4x_{t+1}) \quad (3)$$

- Solving general trend equation for the fit: least-squares regression

Assuming that this is actually how the data (x_1; y_1), …, (x_n; y_n) we observe are generated, then it turns out that we can find the line for which the probability of the data is highest by solving the following optimization problem:

$$S = \sum_{i=1}^{n} \left[f(t_i) - P(t_i) \right]^2 \rightarrow \min \quad (4)$$

We are going to fit a line y = at + b which show the change in weather. Here, x is called the independent variable or predictor variable, and y is called the dependent variable or response variable. Therefore, $f(t_i) = y_i$; $P(t_i) = at_i + b$

Take the place of (6). We get:

$$S = \sum_{i=1}^{n} (y_i - at_i - b)^2 \qquad (5)$$

S → min while $\frac{\partial S}{\partial a} = 0$; $\frac{\partial S}{\partial b} = 0$

We are going to fit a standard system equation below:

$$\begin{cases} a\sum_{i=1}^{n} t_i^2 + b\sum_{i=1}^{n} t_i = \sum_{i=1}^{n} y_i t_i \\ a\sum_{i=1}^{n} t_i + nb = \sum_{i=1}^{n} y_i \end{cases} \qquad (6)$$

Because t is temporal values, we can separate it in such a way that Σt = 0.

$$\begin{cases} a\sum_{i=1}^{n} t_i^2 = \sum_{i=1}^{n} y_i t_i \\ nb = \sum_{i=1}^{n} y_i \end{cases} \qquad (7)$$

Sloved (7)

$$b = \frac{\sum_{i=1}^{n} y_i}{n} \qquad (8)$$

$$a = \frac{\sum_{i=1}^{n} y_i t_i}{\sum_{i=1}^{n} t_i^2} \qquad (9)$$

- Coefficient of correlation:

$$r_{xt} = \frac{\sum_{t=1}^{n} (x_t - \overline{x})(t - \overline{t})}{\sqrt{\sum_{t=1}^{n} (x_t - \overline{x})^2 \sum_{t=1}^{n} (t - \overline{t})^2}} \qquad (10)$$

- Testing hypotheses

The confidence of correlation coefficient r_{xt} was tested by H_o hypotheses

H_o: r = 0 (*)

Standard of testing for first time is r – 0 ≥ dα, r is recognized as a significant; r – 0 < 0, r is no significant, dα must ensure that H_o will be true if $P\{|r-0| \geq d\alpha\} = \varepsilon$

According to statistical probability theory, variable t has Student distribution with $t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$, so (*) is exchanged by (**)

$$(**) \quad \begin{cases} |t| \geq t\alpha \\ |t| < t\alpha \end{cases}$$

Giving the condition that H_o will be true, if $P\{|t| \geq t\alpha\} = \alpha$

By the mentioned method, the correlation coefficients with survey sampling will be good enough, if they are available by standard of α = 0.05 and 0.01, showed in Table 1

***Table 2.** Confidential standards of correlation coefficient*

n-2	10	20	30	40	50	60	70	80	90	100
α = 0.05	0.567	0.423	0.349	0.304	0.273	0.250	0.232	0.217	0.205	0.195
α = 0.01	0.708	0.537	0.449	0.393	0.362	0.325	0.302	0.283	0.267	0.254

3. Results and dicussion

3.1. Manifestations of changing climate and sea level rise in Can Gio District

3.1.1. Temperature and precipitation

The yearly mean temperature of study area was remarkably increasing by 0.8°C for 38 years, from 1978 to 2015 and it has upward trended during period and future, shown on the chart by the linear in company with general trend equation 0.0361x – 44.3682; they illustrated that the average temperature increased about 0.03°C per year and about 0.3°C per decade.

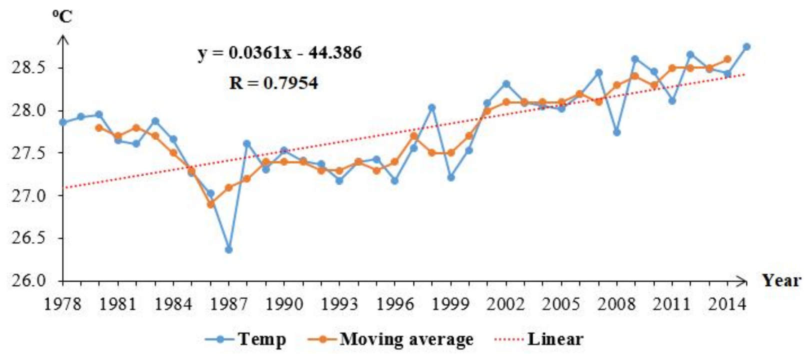

Figure 2. *The fluctuation of annual average temperature in Can Gio (Tan Son Nhat station) from 1978 to 2015*

There was a considerable increasing in the trend of precipitation for 38 years ago with linear equation y = 2.6991x + 1828.5 and the quite high; so it had a large reliability in forecast for the yearly rainfall per 5 years.

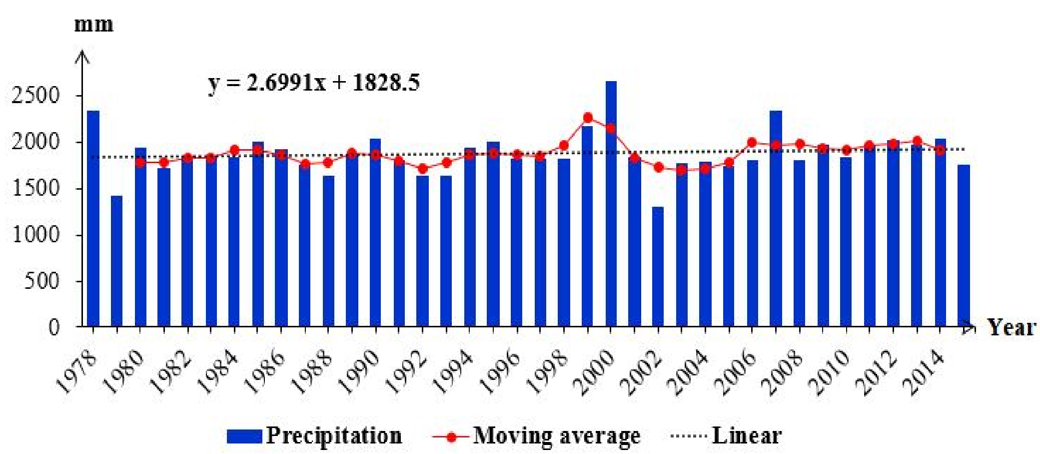

Figure 3. *The fluctuation of annual rainfall in the district (Tan Son Nhat station) from 1978 to 2015*

3.1.2. Sea level rise

There is a difference in from the trend of fluctuation in the data of average sea level which was observed at coastal gauging stations in Vietnam and the Vung Tau gauging station is chosen as a representative station for the South of Viet Nam in general and Can Gio District in particular.

The line graph shows the change in sea level for the past 31 years at Vung Tau gauging station. It is clear that tidal fluctuation range had quite large. The sea level fluctuated between 116 and 148 centimetres in high tide days, and -332 and -279 in the low tide days by comparison with national datum.

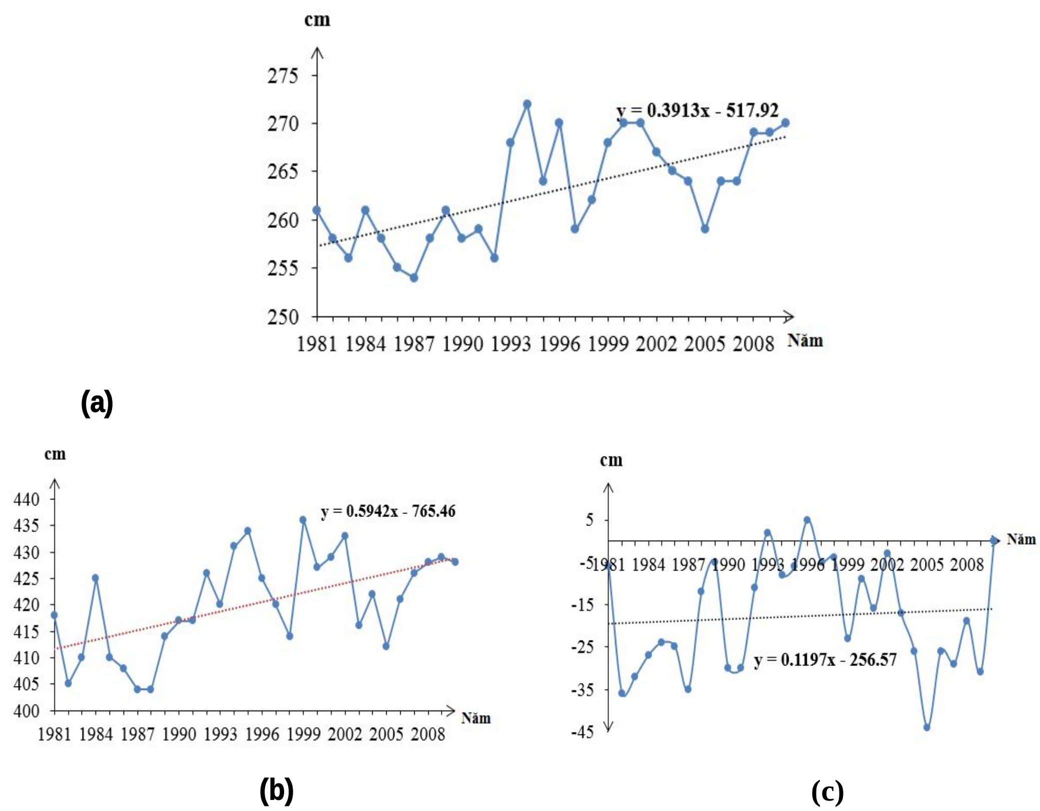

Figure 4. *Changes in average sea level (a), maximum sea level (b) and minimum sea level (c) at Vung Tau gauging station*

The line graph of sea level was upward over 0.3 centimetres per year and the maximum sea level rose slightly by over 0.5cm/year, while the minimum sea level increased gradually about 0.12cm per year. For the report 5th of IPCC in the fact projected that sea level rose 3.1cm ± 0.7cm during period of 1993 – 2003, it means that it rose 0.4cm, so it is identical with the observed datum in Eastern Sea. Hence, the observed water level in Vung Tau gauging station from 1981 to 2010 was trended upward.

3.2. The temporal variation of shrimp farming in the study area

Table 3. *The fluctuation of households, surface, and yield of shrimp farming in Can Gio District*

	2000	2005	2010	2015
Households	1,080	3,025	2,980	3,105
Area (ha)	2,733	5,264	6,047	5,046
Output (tons)	597	6,670	8,453	10,515

Source: Economic Division of Can Gio District

There was an overall increase among the households, area, and yield of shrimp development in the study area. The number of output increased considerably during period of study, while, there was a fluctuation between the figure for area and households. The number of them enormously developed by over two times from 2000 to 2005; however, the figure for households unexpectedly went down in 2010, while it went up for area. The period of 2010 – 2015, the value of households tailed off 2,980 before rose to 3,105, while the figure for area of shrimp farming surged at 6,047 and a final levelled off.

Table 4. *The change in types of shrimp farming during period of 2005 - 2015*

Year	Total area (ha)	Types of farming			
		Intensive	Semi-intensive	Square	Improved extensive
2005	5,264	799.2	722.0	1,459	2,283.8
2010	6,047	1,692.47	584.41	1,314.25	2,455.87
2015	5,046	2,137.38	902.98	1,070.04	938.60

Source: Economic Division of Can Gio District

There was a difference among types of shrimp raising from 2005 to 2015. It is clear that the intensive, and semi-intensive farming increased significantly because of their effect on economy of dwellers as well as advantages to approach modern technologies during producing period, while the square, and extensive improvement of farming were downward trend due to influence of climate change, salt, sea level rise, and so on.

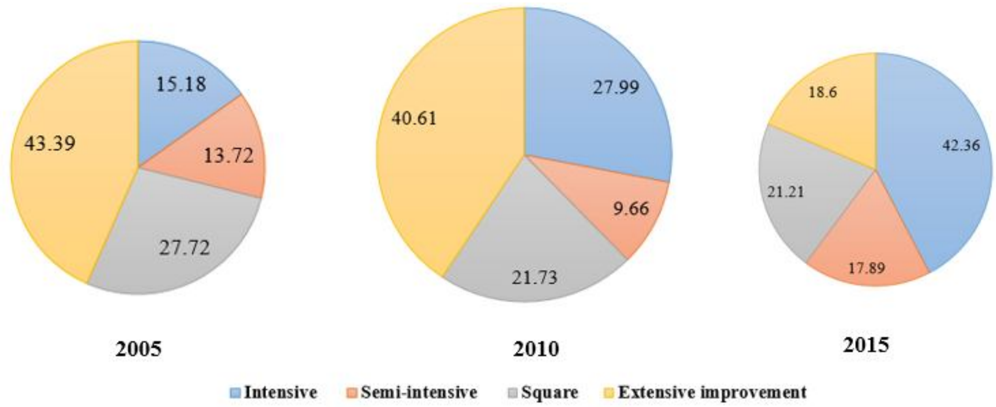

Figure 5. *The transformation in types of shrimp rearing in the study area from 2005 to 2015*

Source: Calculated from Economic Division of Can Gio District

Of which, the percentage of extensive class decreased remarkably by 24.79%, while the proportion for intensive farming developed from 15.18% to 42.36% during period of 2005 – 2015.

3.3. Assessing the effect of climate change and sea level rise on shrimp farming in the district

The temperature plays a vitally important role for developing of shrimp. The higher temperature, the more serious drought in dry season, the more died shrimp. In 2015, there were a myriad of tiger shrimps died and lost about 30% of area intensive and semi-intensive for white-leg shrimp by effect of drought and high temperature. Besides, sea level rise and precipitation directly effect on salt water intrusion and salt level. All of them have indirectly influenced on shrimp development. It was demonstrated from 2005 to 2015 by the regression analysis:

Production = - 107120 - 76 Sea level + 4455 Temperature + 1.18 Precipitation

Predictor	Coef	SE Coef	T	P	VIF
Constant	-107120	78296	-1.37	0.214	
Sea level	-76.3	230.0	-0.33	0.750	1.159
Temperature	4455	2979	1.50	0.178	1.226
Precipitation	1.179	5.007	0.24	0.821	1.122

S = 2585.65 R-Sq = 28.1% R-Sq (adj) = 0.0%

PRESS = 159261428 -Sq (pred) = 0.00

Area = - 1552 + 56.1 Sea level - 140 Temperature + 1.22 Precipitation

Predictor	Coef	SE Coef	T	P	VIF
Constant	-1552	15966	-1.10	0.925	
Sea level	56.08	46.90	1.20	0.271	1.159
Temperature	-140.5	607.5	-0.23	0.824	1.226
Precipitation	1.221	1.021	1.20	0.271	1.122

S = 527.273 R-Sq = 33.8% R-Sq (adj) = 5.5%

PRESS = 6320330 -Sq(pred) = 0.00

Households = - 8095 + 24.9 Sea level + 240 Temperature + 0.110 Precipitation

Predictor	Coef	SE Coef	T	P	VIF
Constant	-8096	7276	-1.11	0.303	
Sea level	24.86	21.37	1.16	0.283	1.159
Temperature	240.5	276.8	0.87	0.414	1.226
Precipitation	0.1105	0.4653	0.24	0.819	1.122

S = 240.284 R-Sq = 34.6% R-Sq (adj) = 6.5%

PRESS = 1421320 -Sq(pred) = 0.00

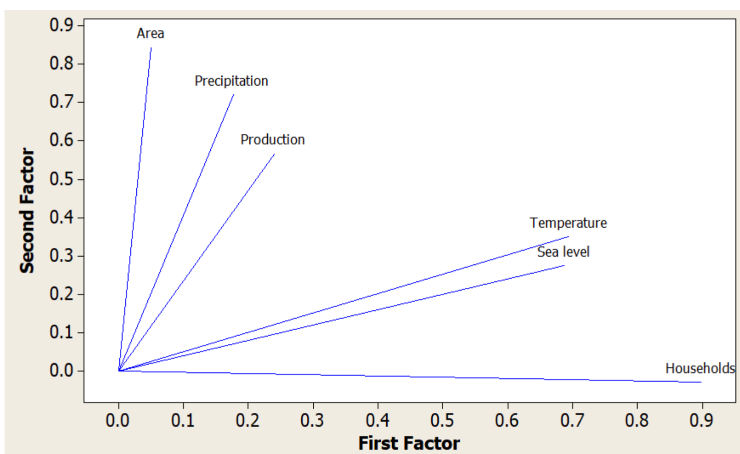

***Figure 6.** The impact factors of components*

The P-value of agents were over 0.1, therefore, H_o hypotheses kept as there were no or indirect implication among climatic and rising sea level on area, household, and production of shrimp in study area. However, there were a correlation between temperature, sea level rise and production, household of shrimp farming respectively.

By contrast, based on approaching to residents and interview, the co-authors can identify that climate change and sea level rise have dramatic consequence in shrimp farming in the study area. The effect of changing climate on shrimp culture has been characterized by different climatic variables. The pair-wise comparison regression equation that drought is the most significant climatic variable that affects shrimp farming, followed by sea level, and climatic conditions.

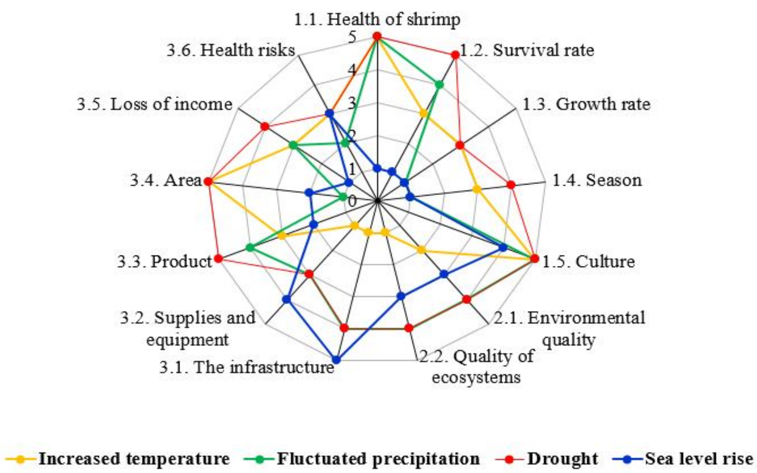

Figure 7. *The effect classifications of temperature, rainfall, drought, and raising sea level on shrimp farming in the study area*

The consequences of changing temperature in summer and variation of rainfall in rainy season have damaged on the health of shrimp most. If the value of temperature decreases under 28°C or increases over 30°C, it can impact on developing shrimp, such as: they will grow faster or slower, and disease may outbreaks more easily.

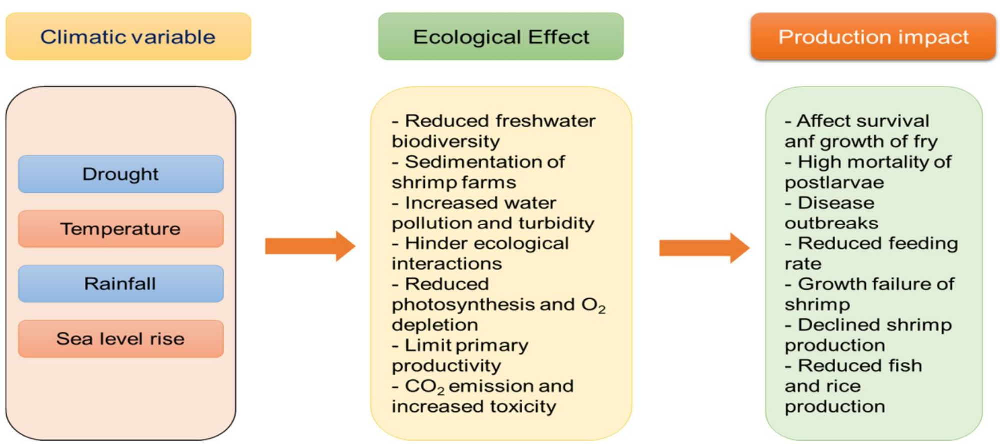

Figure 8. *Ecological effect and impacts on shrimp production by climatic fluctuation [4, compiled by co-authors]*

The area will be also indirectly affected by going up temperature which causes drought, water shortage. On the other hand, the infrastructure will be the most vulnerable due to rising sea level because it will make erosion happen on dykes, canals, and river inland.

The change in rainfall impresses on salt, water level mud, the amount of algae into plash and it will lead to death of shrimp gradually.

All identified climatic changes have severe influences on the ecosystem of shrimp farms. Shrimp is highly sensitive to ecological conditions and variations in ecosystem have profound impacts on their survival, growth, and production.

4. Conclusions and recommendation

4.1. Conclusions

Based on the results of the article, there are several conclusions below:

- Climate change has influenced clearly in the study area.
- The sea and tide level rise are developing considerably. It is the main reason that causes salinization.
- The growing of shrimp has been much fluctuated in recent decades.
- The authentic of shrimp farming in the Can Gio District area of coastal HCMC is vulnerable to climate change. The consequences of it on shrimp culture have been to different climatic variables, including drought, temperature, precipitation, and sea level rise. However, they have indirectly influenced on shrimp farming process. Besides, there is an overwhelming evidence that different fluctuation of climate have severe implications on the ecosystem of shrimp farms as well as shrimp production.

4.2. Recommendation

- The government and dwellers need to expand area of intensive and semi-intensive of farming because this types ought to adapt to climate change.
- The general planning for area of residents, industrial production areas, and aquaculture areas. All of them aim to control the pollution of rivers and canals and create a safe farming areas.
- Reinforcement of shrimp square in coastal areas within the possible limits, includes: An Thoi Dong and Ly Nhon commune.
- It is necessary to allocate appropriate aquaculture zones in 3 eco-zones for each kind of aquaculture. For examples, breeding tiger shrimp and white-led shrimp at brackish zones in Soi Rap River riparian and Long Tau River belong to Ly Nhon, An Thoi Dong, Tam Thon Hiep communes

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