

## RESEARCH ARTICLE

## ASSESSMENT OF THE CURRENT SITUATION OF SALINITY INTRUSION IN TAN PHU DONG AND GO CONG DONG DISTRICTS, TIEN GIANG PROVINCE AND PROPOSAL OF SOLUTIONS

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## ABSTRACT

The research used statistical analysis methods, compared, and simulated the MIKE model, predicted the risk of salinity intrusion according to the scenarios RCP 4.5 and RCP 8.5 to assess the current situation of salinity intrusion and its impact on Go Cong Dong district and Tan Phu Dong district. After conducting the study "Assessing of the current situation of salinity intrusion in Tan Phu Dong and Go Cong Dong districts of Tien Giang province and proposing solutions", the researchers achieved the following results: the situation of salinity intrusion in both 2 districts became more complicated, salinity intrusion came early, high salinity encroached the fields. In 2020, salinity intrusion came 1 month early, the highest salinity level reached 25.4 g/l; Regarding the risk prediction of salinity intrusion: according to the scenarios of RCP 4.5 and RCP 8.5 through the periods of 2030, 2050, 2070, 2100, the salinity level in the studied area tends to increase gradually, the lowest salinity will be from 4 to 6 g/l, the salinity in the whole districts of Tan Phu Dong and Go Cong Dong will exceed 12 g/l in 2100. Regarding the assessment of the impacts of salinity intrusion to the main local industries including agriculture - forestry - fishery, the fields of land, water, and ecosystem resources, the agriculture and water resources sectors are most severely affected.

## KEYWORDS

climate change, MIKE model, salinity intrusion, solutions, Tien Giang

## 1. INTRODUCTION

In recent years, the situation of saltwater intrusion in Tien Giang has become increasingly complicated, salt water continued to penetrate major rivers, affecting production and people's daily life on a large scale. In the period from 2012 to 2019, saline intrusion caused about 6,300 hectares of high-yield rice to be lost, with a total loss of 140.5 billion VND. The heaviest was the 2015-2016 Winter-Spring crop, which caused a loss of 3,700 hectares, estimated at over VND 81.6 billion (Department of Natural Resources and Environment of Tien Giang Province, 2012). Saltwater intrusion 2019-2020 was complicated, the salinity line 4g/l goes deeper into the field and was higher than the extreme salinity in 2016. According to aggregated results from the Department of Agriculture and Rural Development/Economic Division of districts, towns, cities, and communes, as of June 26<sup>th</sup>, 2020, the total area of fruit trees damaged by salinity in the dry season of the year 2020 in the province was 5,343 ha (Western districts- 5,195 ha, Eastern districts-148 ha) (Ba et al., 2016). The damage rate (from 30 - 70%) was 1,434 ha, the rate of damage over 70% (dead) was 3,909 ha (Department of Natural Resources and Environment of Tien Giang Province, 2020).

Tan Phu Dong and Go Cong Dong districts are typical areas, most severely affected by saltwater intrusion. Every year, the district is affected by saltwater intrusion from 1 month to 3 months. Particularly in Tan Phu Dong and Go Cong Dong districts, each year there are from 3 to 6 months of salinity intrusion (Ba et al., 2016). The situation of saltwater intrusion into the system of rivers and canals in the past 10 years has complicatedly changed in both time and salinity level, causing serious damage to the life and production of local people. In the first months of 2020, the saltwater intrusion took place early with high salinity level. On February 18<sup>th</sup>, 2020,

the Department of Agriculture and Rural Development of Tien Giang province conducted salinity level and examined rice production of farmers in Go Cong Dong district (Ministry of Natural Resources and Environment, 2016). At the time of the survey, water level on the canals was very low, the lowest salinity level was 3 g/l and the highest salinity one was 3.7 g/l at Long Ung sluice, while the salinity level at Xuan Hoa sluice was 3.5 g/l (Tien and Sinh, 2016).

When saltwater intrusion occurs, it will lead to a shortage of water for production and daily life, specifically: In Phu Thanh commune, Tan Phu Dong district with high salinity concentration, the amount of stored water is not enough for people to use (Department of Water Resources Management, 2016). Currently, there are still over 3,300 households accounting for 27.34% of the households that have not yet benefited from the rural water supply program. In the dry season, they still need to buy fresh water to use with an expensive price (Dat et al., 2012). Life there is difficult. In Go Cong Dong district, there are still many residential clusters that do not have running water to use, especially in the dry season, people use from rainwater stored in pots and ponds and from canals (Dung et al., 2018). Water in those stored objects and water resources in the "Go Cong Sweetening Project" was contaminated, unsanitary and easily affected health and caused disease outbreaks for rural people.

The situation of saltwater intrusion is becoming more and more serious and complicated, which affects the daily life and production of local people of Tien Giang province in general and Go Cong Dong and Tan Phu Dong districts particularly (Hong, 2019). However, research on salinity situation in these two districts has not been well studied and still has limitations. Therefore, the research about "Assessing of the current situation of salinity intrusion in Tan Phu Dong and Go Cong Dong districts of Tien

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Giang province and proposing solutions" is necessary (Loi and Hung, 2016). This study will contribute to create a basis for the management activities, assess the situation and propose measures for people to adapt and minimize the damage to a low level while help to improve the lives of the people here and increase economic value in general.

## 2. MATERIALS AND METHODS

### 2.1 Materials

MIKE 11 model: MIKE11- HD and MIKE 11- AD modules: Set up river networks and cross-sections for rivers and tributaries. River network in the studied area includes 85 rivers, tributaries and 2077 sections (Man and Thao, 2012). The average emission scenario RCP 4.5 and the high emission scenario RCP 8.5 over the periods 2030, 2050, 2070 and 2100. The survey of people's opinions in Tan Phu Dong and Go Cong Dong districts. The situation of salinity intrusion in Tan Phu Dong and Go Cong Dong districts (Hoang, 2011).

### 2.2 Methods

Methods of inheritance and synthesis of documents: Collecting documents and reporting on salinity intrusion in Tan Phu Dong and Go Cong Dong; MIKE model. Methods of field investigation: examining fields, taking photos of dikes and sluices preventing salinity intrusion in Tan Phu Dong and Go Cong Dong districts; community consultation (Department of Natural Resources and Environment of Go Cong Dong District, 2019). Statistical methods and data processing: Recording statistical results of public consultation through survey forms, software EXCEL, SPSS, etc... Modeling method: using the MIKE model and setting up the MIKE 11-HD and MIKE11-AD modules, calibrating and verifying the model to describe the salt propagation process in 2 districts of Go Cong Dong and Tan Phu Dong, simulating the salinity situation under climate change scenario.

## 3. RESULTS AND DISCUSSION

### 3.1 Factors Affecting Saltwater Intrusion in Go Cong Dong and Tan Phu Dong Districts.

#### 3.1.1 Rainfall

The trend of annual rainfall in Go Cong in the period 1979 - 2017 tended to increase at a rate of about 9.9 mm/year. Annual rainfall mainly fluctuated around the average annual rainfall (about 1,422 mm), the largest annual rainfall was 2,062 mm (2017), the lowest annual rainfall was 471 mm (1981) (Phung et al., 2013). In Go Cong, the monthly rainfall in the rainy season ranged from 66.5 to 258.5mm, and the dry season was only from 2 to 39.3mm. The highest monthly rainfall occurred in October (258.5 mm), the lowest one was February (rainfall was only about 2 mm). During the period 1979 - 2017, almost every year there was no rain in February except the years: 1997, 1999, 2001, 2008, 2009, 2012, 2017 (Global Environment Fund of Vietnam, 1992).

#### 3.1.2 Sunshine and Evaporation Mode

The average number of sunshine hours per year ranges from 2,586 hours to 2,650 hours. The number of sunshine hours in the dry season is much higher than that in the rainy season (from 7.3 hours/day to 9.9 hours/day in the dry season and from 5.5 hours/day to 7.3 hours/day in the rainy season) (Sam, 2004). The average annual evaporation is 1,183 mm, the average is 3.3 mm/day. The dry season has high water evaporation, from 3.0 mm/day to 4.5 mm/day. The amount of water evaporation in the rainy season is lower, from 2.4 mm/day to 2.9 mm/day.

#### 3.1.3 Wind Mode

The southwest monsoon brings a lot of water vapor, blows in the rainy season. The wind direction is southwest, with a frequency of 60-70%, the average speed is 2.4 m/s. Northeast monsoon brings dry air, blows in the dry season (Tien Giang Province, 2020). The prevailing wind direction is the Northeast with a frequency of 50 - 60%, followed by the East with a frequency of 20 - 30%, the average wind speed is 3.8m/s. From November to April, the northeast monsoon prevails, blows in the same direction as the estuaries, increases tidal effects and saltwater intrusion along rivers and canals into fields, and at the same time damages sea dikes.

#### 3.1.4 Upstream Water Source

The Mekong River flows through six countries, providing food for more than 65 million people downstream through farming and fishing. A significant drop in rainfall between May and October 2019, especially in the lower reaches of the river, caused a persistent drought. In 2019 and 2020, the water level of the Mekong River continuously decreased, especially in the Mekong Delta; the water level dropped to the lowest level

in the past 100 years (Department of Agriculture and Rural Development of Tien Giang province 2019). Less water flew into the delta with the rise of sea level led to serious saltwater intrusion. Due to population growth and economic development in the Mekong region, water consumption on the secondary tributaries of the river increased rapidly. On the other hand, there was a drop in water levels due to many upstream dams. China, Laos, and Cambodia have built hydropower plants on the Mekong and its tributaries over the past 20 years to meet growing energy needs.

#### 3.1.5 The Influence of Tides

On the coast, sea waves have maximum height (average 1.25 m and maximum 3m) from October to February every year when there is influence of the northeast wind. In addition, the tidal in the East of Go Cong Sea area is directly influenced by the tides of the East Sea. The system of rivers and canals is affected by irregular semi-diurnal tides, the estuary region has very strong tidal activity, tidal amplitude is from 3.5 to 3.6 m, the tidal transmission speed is 30 km/h (is 1.5 times as much as the Hau River and 3 times as much as the Red River ). On the Tien River, in My Thuan, the tidal range is the largest from 121 to 190 cm, in the two largest halves (September - October) the smallest tidal range is from 100 to 130 cm and in two months of the dry season (April - May). The largest tidal amplitude is 190 – 195 cm. Tide peak (max) at My Thuan: 196 cm, low tide (min): -134 cm.

#### 3.1.6 The Rise of Sea Level

Sea level rise will expand the salinity intrusion, narrow the freshwater area. In the period from 2009 to 2017, the maximum water level at the stations had an unstable fluctuation. Specifically, the maximum water level at My Tho station tended to increase at a rate of about 0.78 cm/year. The highest water level was 181cm in 2017. The water level got maximum at Vam Kanh station; the maximum water level tended to increase at a rate of about 0.43 cm/year. The highest water level was 169 cm (in 2012) and the lowest was 160 cm (2010).

### 3.2 The Situation of Salinity Intrusion in Go Cong Dong And Tan Phu Dong Districts

#### 3.2.1 Trend of Saltwater Intrusion

The average annual salinity concentration at Hoa Binh station tends to increase slightly around 0.0361 g/l/year. The average salinity concentration in the period from 2009 to 2017 ranged from 2.1 to 5.7 g/l. The average salinity concentration at Vam Kanh station tended to increase slightly at about 0.2047 g/l/year. The average salinity was highest in 2007 (13.1 g/l) and lowest in 2012 (7.8 g/l). The saltwater intrusion in 2019 - 2020 appeared early, lasted from the end of February to the middle of March 2020, the salinity level and its depth was higher than the same period in 2020 and developed more complicatedly until the end of May 2020.

#### 3.2.2 Impact of Salinity Intrusion at Go Cong Dong District

##### 3.2.2.1 Cultivation

In winter-spring rice crop 2019-2020, Go Cong Dong district sowed 10,151 hectares, was lower 174 hectares compared to the same period last year, yield reached 4.6 tons/ha (2.37 tons/ha lower than the same period of the previous year) and the output was 43,062 tons (28,917 tons lower than the same period of the previous year). The whole district had 6,058.83 hectares of agricultural production area (rice, crops, fruit trees) which was damaged due to drought and saltwater intrusion, the total loss was estimated at 201 billion VND. Regarding vegetable production, in general, by the end of June 2020, the whole district had sown 12,000 hectares of rice, 8,502 hectares less than the same period last year; harvested with an output of 43,062 tons (28,917 tons lower than the same period of the previous year).

##### 3.2.2.2 Aquaculture

The total production of fishery products in the first 6 months of the year reached 39,220 tons, 2,625 tons lower than the same period in the previous year. The harvested output of clams as of the end of June 2020 was about 8,005 tons (3,000 tons lower than the same period in the previous year); because of high salinity, the clams died causing heavy damage and the clam farmers suffered heavy losses.

##### 3.2.2.3 Lack of Domestic Water

By the end of 2019, tap water could only supply 31,160/37,158 households, reaching 83.8% of the households in the district. In addition,

Go Cong Dong is a coastal district and is located at the end of the source of the "Sweetening Project", so in the dry season, strong winds (northeast monsoon) pushed saltwater into the mainland, saline water from the East Sea penetrated deeper. Therefore, the water level in the field was exhausted and heavily polluted. Since then, it has led to a shortage of fresh water, which seriously affected daily life and production in the district.

### 3.2.3 Impact of Salinity Intrusion at Tan Phu Dong District

#### 3.2.3.1 Cultivation

In the autumn-winter crop of 2015, Tan Phu Dong district sowed late while the salinity came early and penetrated deep into the upstream of the Tien River, this killed nearly 1,000 hectares of rice, accounting for 66.49% of the district's cultivated area. During the salinity drought in 2019-2020, people sowed 1200 hectares of lemongrass, but only obtained 650 hectares. The cause of the decrease in lemongrass area was due to lack of water along with the appearance of mealybugs on the roots and aphids on the leaves.

#### 3.2.3.2 Aquaculture

Due to the complicated situation of salinity intrusion in 2020, the high salinity level exceeded the allowable level, reduced the resistance of shrimp causing a high risk of shrimp being infected. In addition, due to the influence of saltwater intrusion, fish farmers also faced many difficulties when the salinity was high, the heat was intense, and the environment was unstable, which slowed down fish growth and consumed a large amount of food. Particularly, the shrimp-rice production model also decreased from 560 ha (in 2015) to 200 ha (in 2020).

#### 3.2.3.3 Lack of Domestic Water

Here, there are currently 12,074 households, but only 9,117 households have tap water, reaching 75.5%. Nearly 3,000 households have not yet registered to install water meters, there are about 1,500 households in remote areas without freshwater pipelines. If there are no support measures, in the dry season, domestic water is really a problem for local people.

### 3.3 Effects of Salinity Intrusion on The Livelihoods of People in The Studied Area

#### 3.3.1 The Situation of Agricultural Production

*Cultivation sector:* in Go Cong district, rice and crops are the main crops with 43/108 households growing rice and 56/108 households growing crops, followed by fruit trees with 16/108 households growing dragon fruits. As for Tan Phu Dong district, there are 28/52 surveyed households growing fruit trees, in which coconut and soursop account for the majority, 25/52 households grow lemongrass – this kind is being developed in the district. Crops and rice accounted for a lower proportion with 11/52 households growing crops and 6/52 households growing rice.

*Livestock sector:* The main livestock species in this local area include chickens, cows, pigs, and goats. *The field of aquaculture:* Tan Phu Dong and Go Cong Dong are two districts that are located near the sea, convenient for aquaculture development, and shrimp and fish are the two main types of aquatic products. In Tan Phu Dong district, there are 14 shrimp farming households, 4 brackish fish farming households (pomfret, tilapia, ...), besides, there are also some crab farming households. Like Tan Phu Dong district, Go Cong Dong district also has a high percentage of shrimp farming households with 18 households, there are 3 fish farming households and especially in the locality, clams are also raised a lot, mainly in Tan Thanh commune with 8 households raising clams.

#### 3.3.2 People's Awareness About Saltwater Intrusion

According to the survey, 100% of the people surveyed were aware of the symptoms of salinity intrusion. Domestic water was contaminated with salt and had a cloudy yellow color; Crops showed signs of wilting, burning due to saltwater in the field, as well as concentrated water was contaminated with salt, leading to lack of fresh water for irrigation, causing plants to wilt and burn, especially rice.

#### 3.3.3 The Situation of Using Water

When salinity intrusion occurred, water sources in Go Cong Dong and Tan Phu Dong districts were all contaminated with salt water from rivers, ponds, and lakes to concentrated tap water. According to the survey, 190 out of 190 households suffered from saltwater intrusion in both districts. To prevent saline water from penetrating deep into the fields, the management units operating the sluices to prevent saltwater intrusion closed those sluices, leading to the state of water in canals, ponds and lakes

gradually being depleted. Some ponds and lakes suffered from a drought condition that led to aridity and cracking. In addition, when the salinity was high, the centralized water plant cannot handle to reduce the salinity level in the water, so the tap water was also salty. Therefore, there were 157 households experiencing water shortage in the dry season and drought and salinity situation.

### 3.3.4 The Situation of Salinity Intrusion

Regarding the development of saltwater intrusion, 100% of the surveyed people chose the answer "more and more serious". In the last 10 years, saltwater intrusion has occurred in the surveyed area, but 2016 and 2019 are considered the two most severe salinity waves in history. In particular, the 2016 salinity drought caused the most serious damage to the production and daily life of local people due to the sudden salinity drought and limited response tasks. By the end of 2019 - 2020, the salinity came early, the salinity level was higher than in 2016, but due to timely forecasting and response, the damage caused by saline intrusion was reduced.

### 3.3.5 Measures to Cope with Saltwater Intrusion

Through the survey, there were 32 households in Go Cong Dong and 14 households in Tan Phu Dong that had fresh water and rainwater storages. In recent years, in addition to tap water, people have also chosen to use 25-liter-bottled water for drinking, thereby increasing the source of fresh water to meet living needs when drought and saltwater intrusion occurred. With the method of changing the crop structure, there were 11 households in Tan Phu Dong and 13 households in Go Cong Dong applied and this change was mainly from rice production to growing crops. Most notably, all surveyed households were interested and continuously updated about saltwater intrusion from the media as well as local agencies to monitor and be ready to respond.

### 3.4 Forecasting the Risk of Saline Intrusion In Tan Phu Dong And Go Cong Dong Districts Under The Influence of Climate Change

#### 3.4.1 The forecast of salinity intrusion according to the RCP 4.5 scenario

The salinity of Go Cong Dong district tends to increase gradually over the years, the lowest salinity is about 4-6 g/l and by 2100 the whole district has salinity > 12 g/l. In particular, under the RCP 8.5 scenario, by 2070, the salinity in the district will exceed 12 g/l. The communes of Tan Thanh, Tan Dien, and Tang Hoa are vulnerable areas due to salinity from 2030 all these communes have salinity of about > 12 g/l. The area of land contaminated with high salinity is increasing gradually. In 2030, the main land area will have salinity level of about 6 – 10 g/l. In 2050 and 2070, the area of saline soil will be about 10 - 12 g/l, accounting for the majority, from 245.40 km<sup>2</sup> in 2050 to 367.38 km<sup>2</sup>. By 2100, the salinity level of the two districts will be around 10 – 12 g/l and higher than 12 g/l; the soil area with salinity higher than 12 will accounts mainly for an area of 423.02 km<sup>2</sup>, accounting for 75.53% total natural land area.

#### 3.4.2 The Forecast of Salinity Intrusion According to The RCP 8.5 Scenario

Similar to Go Cong Dong district, the salinity in Tan Phu Dong district also tends to increase gradually over the years. The lowest salinity will be about 4-6 g/l by 2030, from 2050 the salinity will gradually increase, the lowest salinity will be around 8-10. By 2100, the whole area of Tan Phu Dong district will have high salinity level, the salinity will be higher 12 g/l. Compared with the salinity intrusion situation in 2016, the lowest salinity in Go Cong Dong and Tan Phu Dong districts is from about 2.5 - 4 g/l, by 2030, the lowest salinity will be around 4-6 g/l. From the forecasted results, it can be seen that the salinity intrusion tends to increase gradually, the higher the sea level rises, the higher the salinity will increase and by 2100, the entire 2 districts will face difficulties and challenges when salinity intrusion occurs.

The area of salinity intrusion tends to increase gradually in terms of salinity level and expand its area. In 2030, the salinity level will be around 10 - 12 g/l, the salinity area with higher than 12 g/l will be the least. However, over time, the saline area with higher 12 g/l tends to expand. By 2100, the entire natural land area of the two districts will be intruded with the highest salinity concentration (higher than 12 g/l).

### 3.5 Assessment of The Effects of Salinity Intrusion at Tan Phu Dong And Go Cong Dong Districts

#### 3.5.1 Agriculture, Forestry, and Fishery Industry

*Agriculture:* In recent years, salinity intrusion came early, high salinity level has made many fields be under shortage of water for irrigation, so



many rice farming households only got 50-70% of the output and more seriously, many rice fields were completely killed, people fell into a state of loss, damage to hundreds of millions of VND. Therefore, with the forecast results of salinity intrusion, the salinity level will be higher in the future, on a large scale, so the rice production industry is at risk of being more seriously affected.

**Fisheries:** Some freshwater aquaculture areas have decreased due to sea level rise, saltwater penetrating into the continent. The habitat and breeding areas of the coastal ecosystem will experience great changes due to changes in mangrove forest. The inshore fishery will therefore have corresponding changes (decrease). The decrease in the supply of photosynthetic products and nutrients for benthic organisms is related to a decrease in the ability of seaweed ecosystems to fix organic matter under conditions of increasing temperature, alkalinity, and salinity changes. Habitat quality for many types of marine life has deteriorated.

**Forestry:** When the sea level rises, the salinity level in mangrove forest can exceed 25%, causing many changes in the mangrove forest ecosystem, leading to the risk of losing a lot of species. Drastically change the mangrove ecosystem.

### 3.5.2 Water Resources Sector

According to the RCP 4.5 and RCP 8.5 scenarios, the salinity in the studied area is about 4-6 g/l and by 2100 it will exceed 12 g/l. With such a high salinity concentration, the local water source has been salinized. Therefore, this water source cannot be used for activities such as drinking, irrigation, but can only be used in livestock when the salinity is from about 2 - 10 g/l; if the salinity is higher than 10 g/l, water is used mining and industrial activities only. Thus, the water quality in Go Cong Dong and Tan Phu Dong districts does not meet the standards for domestic water supply according to QCVN 08-MT: 2015/BTNMT, causing water shortage in daily life and production, seriously affecting the lives of local people. The process of saltwater intrusion penetrating the field will lead to the risk of salinization of groundwater. Changes in evaporation, temperature and precipitation will change the amount of water replenishing aquifers and change the water level in aquifers. Besides, the extraction of groundwater for different uses also affects the groundwater levels. When there is drought, saltwater intrusion, and no rain, surface water will be degraded, depleted and there is a shortage of water for people's needs.

### 3.5.3 Land Resources Sector

Tan Phu Dong and Go Cong Dong are vulnerable areas due to saltwater intrusion, with high salinity above 4 g/l, so when soil is under saline intrusion, it will become acidic (the process of salt intrusion and accumulation), which changes the physio-chemical properties of the soil and nutrients. Thereby it has a strong influence on plants, especially rice (such as withering leaves, dying plants), adversely affect the yield and quality of harvested agricultural products. The rise of sea level brings in salinity, so the salinization of the soil increases, the alum of the surface layer decreases due to the process of leaching alum into the deeper layer. When the water level on the canals and fields decreases, the drought begins, the process of salinization and especially alum rising to the surface is very strong. The process of salinization and acidification sometimes coexist, sometimes oppose each other to create soil that is both saline and alkaline.

### 3.5.4 Natural Ecosystems and Biodiversity

Saltwater intrusion causes the saline-brackish ecosystem to move deeper into the mainland and inland; many species of marine ecosystems and the saline-brackish ecosystems will gradually move into the inland, contributing to the increase of biodiversity for the region. Tan Phu Dong and Go Cong Dong have a relatively rich and diverse aquatic composition, with both saltwater and freshwater aquatic systems. Climate change increases saltwater intrusion, tides will be the factor that reduces the composition of freshwater aquatic systems and increases saltwater aquatic systems. The saltwater aquatic system will favorably develop and overwhelm the freshwater aquatic system. This will reduce the rich composition of the aquatic system in the area, seriously affect the development of fisheries, freshwater aquaculture, biodiversity, and ecology in the region.

## 3.6 Solutions to Cope with And Minimize Salinity Intrusion at Go Cong Dong and Tan Phu Dong Districts

### 3.6.1 Non-Structural Solutions

#### 3.6.1.1 Raising Public Awareness

It is necessary to improve expertise and management capacity of authorities at all levels and managers in encouraging people to change the

structure of crops and livestock to adapt to salinity intrusion, improve economic efficiency, and conform to the project "Planning on agriculture, forestry and fishery" of the district. It also needs to guide people on advanced and modern techniques in production. It is also important to raise people's awareness through training courses as well as change the structure of plants and animals to adapt to salinity intrusion to limit damage when it takes place and improve the economic efficiency of families and localities.

#### 3.6.1.2 Changing the Structure of Crops and Livestock

It is crucial to implement the transformation of crop structure according to the Project "Construction planning in Tien Giang province to 2030, with a vision to 2050", select the cultivars with tolerance to drought and salinity, change the season and planting schedule to suit saline intrusion and change appropriate farming methods (planting density, fertilization, weeding, plowing, pest control, crop rotation). Tan Phu Dong district focuses on developing soursop (specialized fruit growing area) and coconut tree (coconut growing area). In addition, according to the plan, the district will develop a concentrated livestock and poultry breeding area according to the model of an industrial farm that meets Viet GAP standards. As for Go Cong Dong district, it belongs to the area specializing in cultivating specialty fruit trees with acerola, watermelon and safe vegetable growing areas. In the field of livestock production, like Tan Phu Dong and Go Cong Dong districts, it is necessary to develop a concentrated livestock and poultry breeding area according to the model of industrial farms that meet Viet GAP standards.

### 3.6.2 Construction Solutions

#### 3.6.2.1 Water Management and Regulation And Operation Of Irrigation Systems

It is important to review and evaluate the performance of the irrigation system, adjust the water storage capacity, regulate water in the dry season, expand the irrigation system, invest in completing the project of canals to supplement fresh water for key agricultural areas and water shortage areas in the eastern part of the province. It is necessary to complete "the Go Cong Sweetening project" with the goal of preventing salinity, leading freshwater, waterlogging, alum discharging, etc. to serve production and people's livelihood and economic development in the project area and focus on completing the network of water supply pipelines in the East and Go Cong booster pumping station. Currently, in Go Cong Dong and Tan Phu Dong districts, many large and small irrigation systems have been built, including dikes to prevent saline intrusion, and have met the requirements.

However, in recent years and as predicted from the scenarios RCP 4.5 and RCP 8.5, the situation of salinity intrusion has become more and more complicated, causing many difficulties for these irrigation systems. Therefore, it is necessary to strengthen the operation and ensure the security of water sources to meet the needs of daily life and local production. Upgrading and renovating sea dikes, estuary dikes and Go Cong River dikes to actively prevent saline intrusion, fresh water leading, waterlogging, alum discharging to serve production and people's livelihood and promote economic development of local people in the project area are important.

#### 3.6.2.2 Water Storage Solutions

Building concentrated water reservoirs: To increase water storage capacity and improve water use efficiency, Tien Giang Province has implemented "the Nguyen Tan Thanh Canal Reservoir Project" to form a water reservoir serving an area of nearly 80,000 hectares and to create a water supply for daily life of nearly 807,716 people in a part of Chau Thanh district My Tho city and the eastern districts of Tien Giang province. Particularly in Tan Phu Dong district, to solve the shortage of fresh water, the province is implementing the project to build the Cua Trung river reservoir to create a water reservoir (with a capacity of about 35 million m<sup>3</sup> of fresh water) serving 9,500 ha production and living land for 45,000 people in Tan Phu Dong district. In addition to deploying the construction of concentrated water reservoirs, local people can also implement the construction of household-scale water storage works by collecting water through a system of pipes and scourers from roof or from other roofs into the collection tank, storage jar, large capacity water tank.

## 4. CONCLUSIONS

Regarding the assessment of the current situation of saltwater intrusion in Tan Phu Dong and Go Cong Dong districts, the situation of saltwater intrusion in the two districts is increasingly complicated, with early salinity, high salinity encroaching further into the field. In 2020, salinity

came 1 month early, the highest salinity reached 25.4 g/l, seriously affecting the daily life and production of local people. Regarding the prediction of saltwater intrusion: According to the scenarios of RCP 4.5 and RCP 8.5, through the periods of 2030, 2050, 2070, 2100, the saltwater intrusion in the study area tends to increase gradually, the lowest salinity is from 4-6 g/l, by 2100, the salinity in the whole district of Tan Phu Dong and Go Cong Dong will exceed 12 g/l.

Regarding the assessment of the impacts of salinity intrusion: Based on the results of forecasting the saltwater intrusion according to the scenarios, the study has evaluated the impacts of the salinity intrusion on the main local industries including the following: Agriculture - forestry - fisheries and land, water, and ecosystem resources. Based on the results of public consultation, the agricultural sector and the water resource sector are the most severely affected. The study also gave preliminary solutions to respond to the effects of salinity intrusion for each industry and sectors in accordance with the natural, socio-economic conditions as well as the planning direction of Go Cong Dong and Tan Phu Dong. However, the measures are still preliminary and qualitative, so they need to be considered and analyzed in more detail when applied in practice.

## RECOMMENDATIONS

In addition to the obtained results, the research also has some recommendations as follows: it is important to study, select and create new plant varieties that are resistant to or adapted to salinity corresponding to salinity in the forecast scenario. Researching, evaluating the impacts, and proposing specific solutions of the salinity intrusion affecting on the exploitation and use of water, ensuring the water source for daily life and production of the people are important.

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