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Salt farmer's adaptation strategy facing climate change (case study in Pati Regency)

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Abstract. Climates change impact on salt productions in Pati Regency. The salt farmer usually only shifts to aquaculture in the rainy season. Thus, while the climate becomes unpredictable, they adapted to extreme weather conditions. However, changes in weather such as dryer summers, rain in summer, more extended summer season, longer rainy season, and high tides. It made the salt production decrease. Salt farmer have their adaptation strategies during climate change. This research aims to analyze reasons for adaptation strategies regarding climate change. The research conducted in Pati Regency from 2011 to 2016. Pati Regency is the 3rd most significant salt production area in Indonesia. We interviewed the respondents, as well as confirmed the data to other farmers, extension officers, and agency officers in the district. The data used in this paper are the salt farmer perception is regarding climate change and their adaptation strategies. We also used content analysis to strengthen our data based on literature and other founding. We found that Salt farmers use their strategy to fasten production, such as using canvas, black stone, LDPE (Low-Density Poly Ethylene), and HDPE (High-Density Poly Ethylene). LDPE and HDPE were introduced by Ministry Marine Affairs and Fisheries (MMAF) in 2013 and turned out to be very helpful for the farmers. The technology introduced by MMAF increased production by 14% and price by 144% than before while working loads become lighter, especially in the harvesting process. Several adaptation strategies have implemented in other Regencies, such as MMAF technology. However, it still needs continuous persuasion because not all farmers wanted to apply it.

1. Introduction

Climate change is a change in climate elements felt after 50-100 years because humans produce greenhouse gas emissions in every activity [1]. El-Nino and La-Nina are global phenomena of warming Sea Surface Temperature (SST) as a result of ocean interactions with the atmosphere. The difference El-Nino will reduce rainfall, while La Nina will increase rainfall [2]. Diposaptono *et al.* [1] mention the changes in drought and rainy season, while El-Nino was giving a contribution to it. Diposaptono *et al.* [1] state that climate change is including rising in air temperatures, ice melting, changes in rainfall, and rising sea levels. Two contributing factors are the natural change of the climate in 4.5 billion years ago and human activity that contributes to charcoal and CO_2, thereby increasing the greenhouse effect.

Moreover, Monsoon activity is also dominating weather and climate in Indonesia. There are Asian Wet Monsoon that is dominating in October until March and also Australian Dry Monsoon, which dominating from April to September [3, 4]. The two-argument has a similar trend that in October until April, the wind makes the rainy season. In general, climate change is a form of change in climate caused by rising CO_2 intensity in the air. The resulting impacts from climate change are temperature change, storm intensity, sea-level rise, increase flood, severe rain condition, and weather condition becomes unpredictable [5-13].

Climate changes commonly observed in the marine and fisheries sector include high waves, strong winds, strong currents, sea-level rise to sedimentation, or new land growth. Even climate change can lead to temperature changes that generate coral bleaching as well as threaten fishery species [14]. Salt ponds, which located on the seashore, are exposed to several climate change phenomena. The phenomena are high waves, strong wind, sea level rise to sedimentation, and new land growth. It has an impact on salt production that has implications for income and expenditure for repairs. The problem is not many farmers are aware of the changing in climate conditions. The change in the season made the production decreases. Maesey [11] states that in 2020, there was an increase in temperature of 0.41 degrees, where the temperature change will affect the phenomena that occur at this time. For this reason, salt farmers must have their adaptation strategies.

Climates faced by 58,007 salt farmers in 43 regencies are a dry season and wet season. The salt farmer usually only shifts to aquaculture in the rainy season. Thus, while the climate becomes unpredictable, they adapted to extreme weather conditions. However, changes in weather are dryer summers, rain in summer, long summer season, more extended rainy season, and high tides. The problem is only several farmers aware of climate-changing conditions. The changes in seasons made the production decreases. Salt Farmer have their adaptation strategies during climate change. This research aim is to analyze why they did the adaptation strategies regarding climate change.

2. Material and methods

The research was conducted from 2011 to 2016 in Pati Regency. Data collected from the salt farmer as the respondents in Pati Regency, as well as confirm the data to the other farmers and extension officers, and agency officials in the district. The data included the salt farmer perception regarding climate change and their adaptation strategies regarding changing the climate. We are also using content analysis to strengthen our data based on literature and other findings. The data was collected using survey methods for primary data and literature studies. The data will be explained using the description analysis [15–17].

3. Results and discussion

3.1. Climate phenomenon salt pond

The climate phenomenon is closely related to the temperature differences above sea surface in the Pacific Ocean. This change then led to phenomena such as La-Nina and El-Nino. From 1982 until 2016, El-Nino and La-Nina phenomena existed in the Indian Ocean [18]. It shown from graphs underneath. Both El-Nino and La-Nina will influence the length of the wet and dry season (Figure 1).

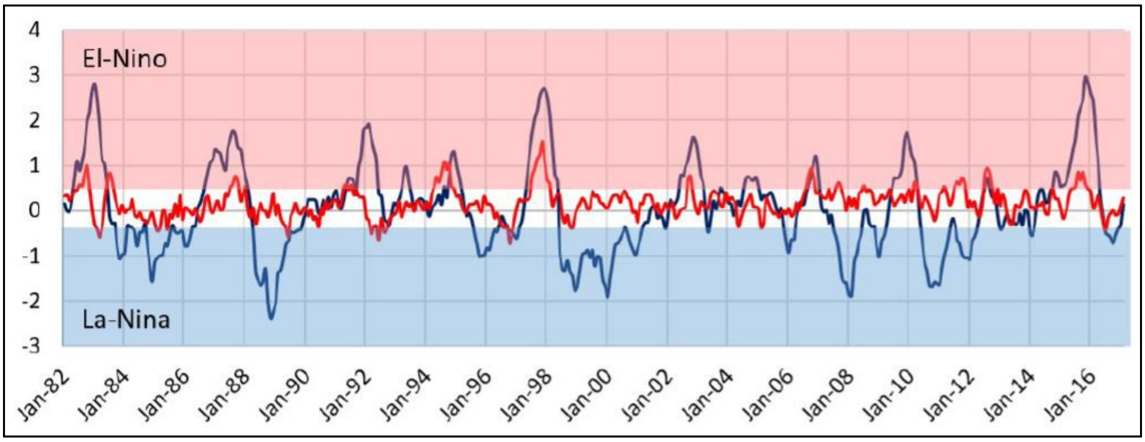

Figure 1. El-Nino and La-Nina in Indian Ocean [18]

If we examine further, several years have high rainfall trends. Those years were 1983, 1998, 2002, 2007, 2010, and 2016. High rainfall made salt farmers unable to produce at all because there was no sunlight, and salt, if exposed to water, would become water again. On the other hand, in 1985, 1989, 1999, 2000, 2008, 2009, 2011, 2012, and 2017 were the years that had a high dry season (Figure 2). In those years, salt production will rise in Indonesia, and in the market, there is an abundant supply of salt.

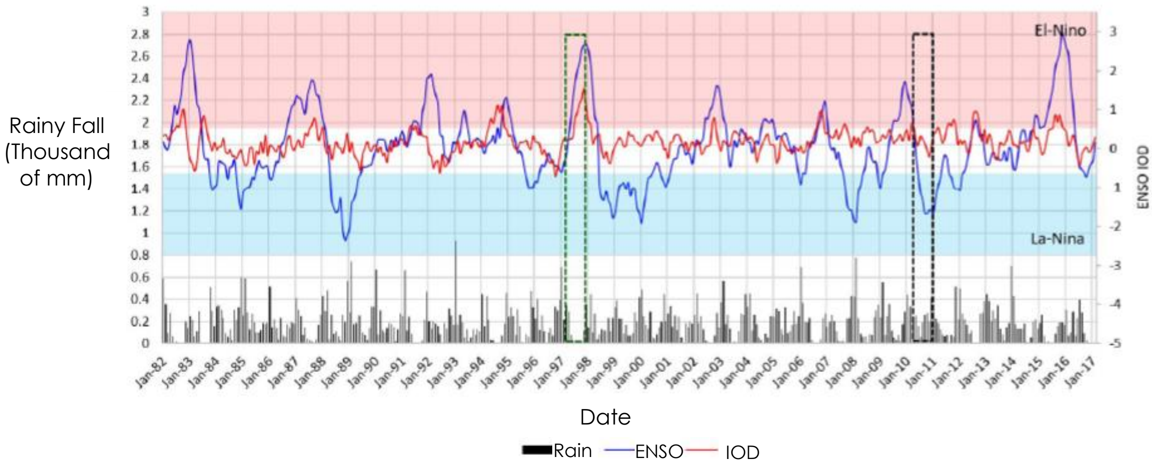

Figure 2. Overlay of La-Nina, El-Nino and rainfall in Indonesia [18]

If we overlay rainfall data with salt production time starting from 2010, it shows that in 1998, 2010 and 2016 are the years that have quite high rainfall. On the other hand, in 2012 and 2017 are the years that have a longer dry season within following the time of salt production in Indonesia (Figure 3).

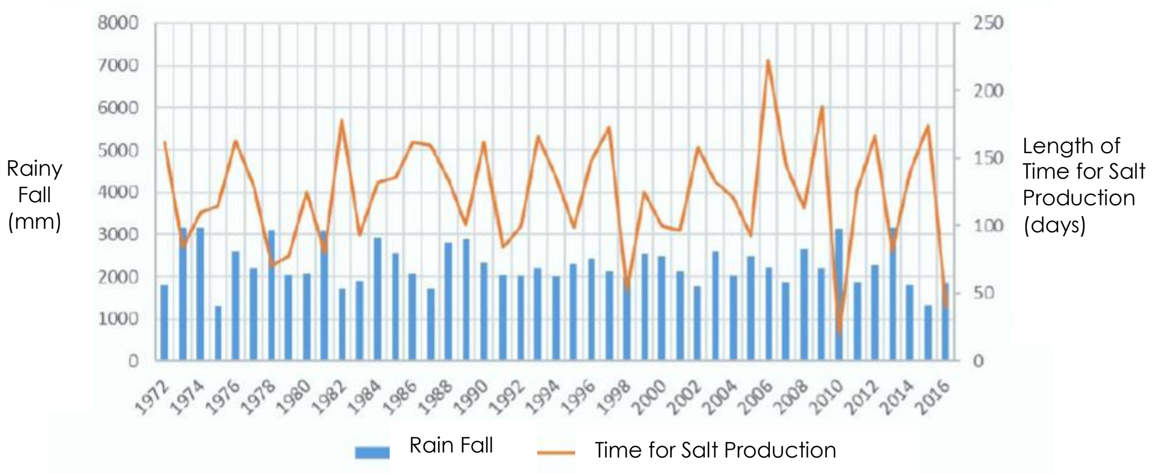

Figure 3. Comparison of rainfall with salt season time [18]

If we compare the production data with the rainfall data, we can see the data match with the time of production in Indonesia (Figure 4). The current salt production data can be trusted from 2011 to 2018 because MMAF records the salt production data at each salt production center. In 2010, there is an extreme weather condition that occurred in Pati, which caused the salt farmers zero production. Indonesia forced to import salt until the end of 2011. It also occurred in 2016.

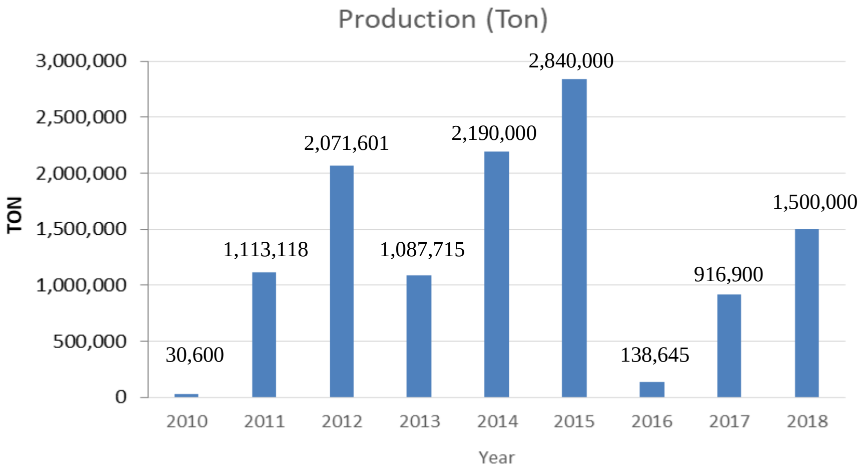

Figure 4. Salt Production in Indonesia [19]

3.2. Pati Regency

Pati Regency gets the third rank for the largest salt production centers, which has 10,193.116 hectares of salt pond area [20] and has 6,781 salt farmers. The salt produced in 2016 is 6,252 tons, which is the lowest production level from 2011 to 2018. In 2015, Pati Regency had the highest production level, with 381,704 tons of salt produced. This regency was variated production from the first, the second and also the third grades. However, The majority quality of salt stocks in the Pati Regency are the first, and the second grades. In production, the salt farmers still depending on the sunrise. Most of them expect that the sun will shine in the whole year, but in Indonesia, there are two seasons; they are the wet and dry season.

Based on the average monthly rainfall data 1971-2000 from Indonesia Meteorological, Climatological, and Geophysical Agency (BMKG), the salt harvesting period was from May to October (Figure 5). The salt farmer must start the production preparation in April so that the harvest did not start too late. With the climate change phenomenon, rainfall sometimes shifts faster when exposed to El Nino. On the contrary, the rainy season shifts slower or unable to harvest at all if it exposed to La Nina.

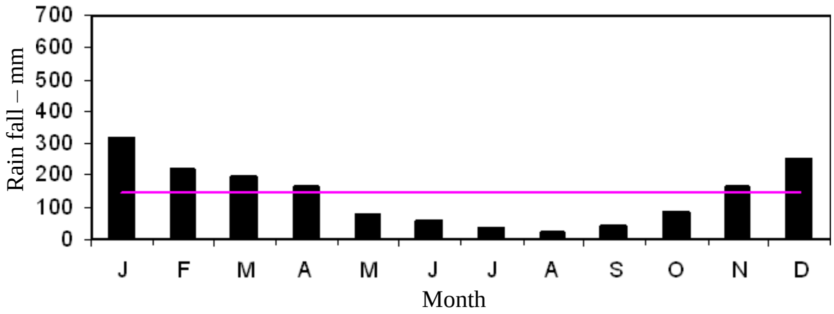

Figure 5. Profile of Average Monthly Rainfall (1971-2000) in Pati Regency [21]

Data from Figure 5 showed that the dry season in Pati Regency ranges from May to October, while the rainy season ranges from November to April. Salt farmers in Pati Regency can produce between May to October. However, the salt can only produce within four months plus one month of land preparation. Thus, the total length of salt production in the Pati Regency is five months.

3.3. Climate and salt farmers adaptation strategies

There are several types of climates faced by Pati's salt farmers. The standard climates are the dry season and the rainy season. Nevertheless, between both seasons occur anomaly or commonly referred to as climate change.

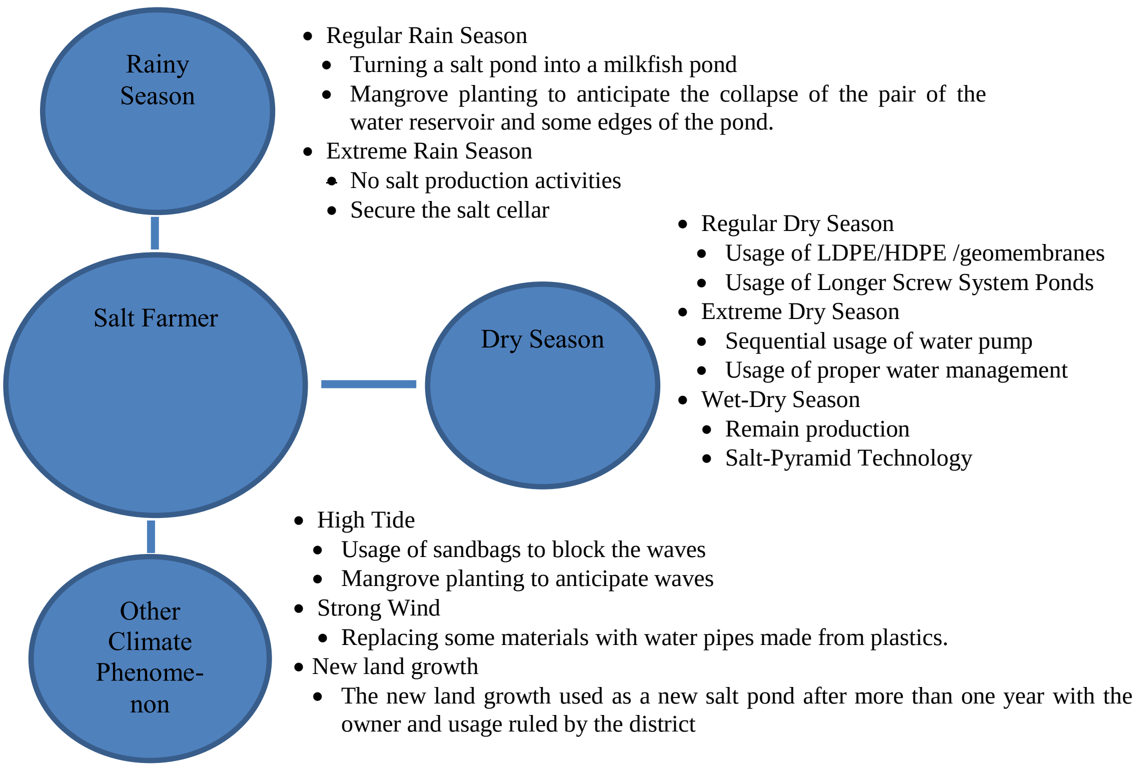

Figure 6. Adaptation strategy for salt fish fishermen in facing climate change in Pati Regency

3.3.1. Adaptation to the rainy season

3.3.1.1. Adaptation to the regular rainy season

Salt that stroke by rain will dissolve it back into the water. This problem causes salt farmers to have to adapt the salt ponds to turn into milkfish aquaculture. Milkfish can live in salt ponds because they can live in brackish water or water with high salinity (15-30 ppm) [22, 23]. The obstacle faced by the salt farmers in milkfish culture due to a longer growing season, which takes six months. It causing the salt farmers often not get a good result compared with their efforts. This problem makes some farmers not to cultivate salt pond and choose them to take over other jobs for a living.

The saltwater dike or barrier made of soil, and they exposed to water. It is prone to landslides. Farmers were trying to plant mangroves around the water reservoirs and some edges of the ponds. It uses to anticipation it from collapse. The mangrove forest increase fish habitat, protect the trench wall and became catching area for tiger prawns.

3.3.1.2. Adaptation in the longer rainy season

During the longer rain, the people cannot make any production. They replaced by milkfish culture in ponds. They secure the salt cellar from its exposure to the rain so that it is safe from melting back into the water. In the rainy season, especially in the long rainy season, the salt price rises almost theree times than the previous price, especially if the industry does not have more salt stock. In 2015, the price of salt in the dry season was Rp. 200-250 per kg, in the rainy season, it reaches Rp. 500 per kg [24-26]. In 2016 and 2017, when the salt stock was running low, the price of salt could reach a minimum of Rp. 4,000-16,000 per kg [27, 28].

3.3.2. Adaptation to the dry season

3.3.2.1. Adaptation to the regular dry season

MMAF has tried to change production patterns to improve the quality and quantity of production from 2011 to 2018. Several of the technologies that have been delivered by the MMAF consist of screw-filter systems, LDPE/HDPE/geomembranes, and land integration. The purpose of applying this technology is energy efficiency and quality improvement. The dry season is the most awaited season by salt farmers. The production will decline if salt farmers do not respond well to the season.

Mr. Sanusi from Cirebon Regency found the screw pond system [29, 30]. This technology was disseminated to the salt farmer by MMAF in 2013. The screw system is also introducing the land division. The land divided for seawater storage, threaded, old water reservoirs, and harvesting places (salt tables). The advantage of this system is that there is a seawater reservoir. The seawater reservoir contains material for making salt and an old seawater reservoir that waits for five days or more to harvest. The availability of water will be enough for the production process in the pond.

LDPE/HDPE/geomembranes used as a base on the part of the land for salt harvesting. This membrane used to coat the soil so that the salt harvested does not mix with the soil when it dredged. This membrane also turns out to save the sun's heat so that it can accelerate the production process faster than three days. Even during the transition season, farmers can harvest the first time thanks to this membrane.

At present, salt ponds have an average size of 0.5 hectares to 2 hectares. The small size of ponds currently causes ineffective and inefficient production. For this reason, MMAF introduces a corporate farming system that unites several salt ponds so that a vast expanse obtained. This unification aims to enlarge the water reservoir and increase the number of threads so that the salt farmers easier to work. Besides that, the time needed is faster. It did not get much response from the community so that the pond land integrated with sales.

Integrated pond land is the latest technology from MMAF that implements corporate farming and integrated with cooperatives as buyers of salt from the people at a price that has determined. Integrated pond land makes several demonstration plots in the community different from corporate farming, which is only a concept without application in the community.

The implementation of the integrated land had successfully shown that this technology easy to use and also connected to sales. The cooperative who act as salt sales gives a reasonable price. Thus, it is now the technology preferred by the community. So, the community began trying to try to unify the farmers' land. The technology that was introduced by MMAF increased in production by 14% and price by 144% than before, while working loads became lighter, especially in the harvesting process.

3.3.2.2. Adaptation to the longer dry season
The dry season is the season that salt farmers have been waiting for the most, but if the dry season is too long, salt farmers also experience problems with their salt production. The most felt obstacle is drought. This turbidity occurs because seawater cannot rise to the location of irrigation. This drought anticipates using a water pump machine and also proper water management.

This drought can be anticipated by using machines to draw water so that it can water storage ponds. If the farmer does not use a water pump, water cannot store on the farm. However, if in one channel, all farmers to pull the seawater at the same time, then they will both not get seawater. It needs consideration and alternates between one farmer and another. Otherwise, there will be a conflict between those who need seawater. So that cooperation is needed between seawater users by making a water withdrawal schedule to the pond with mutual agreement.

However, salt farmers enter the water after their free time in the pond/not harvesting time. It means taking their rest time that usually done in the evening or evening. For this reason, several ponds use irrigation management services to get seawater. With this management, they do not need to spend time to entering the water so that production can continue. If farmers do not use water management, and today is not their time to get water, then they need more time to harvest salt.

3.3.2.3. Adaptation to the wet – dry season
During the wet-dry season, the community can still produce even though a little adaptation using a LDPE/HDPE/geomembrane. The ponds currently being developed with a pyramid model that will make salt farmers can produce in the rainy season but has not been able to cover the entire land, only partially.

3.3.3. Adaptation to other climate phenomenon
3.3.3.1. Adaptation to high tide
High waves located in the sea, but these waves certainly crash into the beach where the salt ponds located. High waves in the rainy season will destroy fishponds, while in the dry season, it will harm salt production. It happens to ponds located on the seafront. On the wall of a pond made of soil will be destroyed, and the contents of the pond washed away to sea. For that, we need adaptation to avoid these losses.

The first adaptation is the use of sandbags. Salt farmers first use sandbags to block the waves so that the edges of ponds made of soil do not drift away. It is not entirely successful because there are still sandbags that washed away so that they do not get optimal results. It raises the awareness that embankment ponds need to strengthen so as not to be destroyed and cause losses. The loss on ponds located on the seafront can reach 100%, while those located quite far will suffer lesser. On the other hand, there are also salt farmers who plant mangroves to anticipate landslides in dams in seawater reservoirs. It used on several ponds near the sea.

3.3.3.2. Adaptation to strong wind
The wind is one of the climate elements needed for salt production, but a strong wind is also dangerous for salt ponds equipment such as windmills. Wood-based windmills will break if thrown by the strong wind. It uses to pump water from the seawater reservoir to the screw part of the pond. If they do not use a windmill, then the farmer must spend money to buy gasoline for powering a generator.

Damage that occurs such as broken propellers or broken supporting poles of the wheel. The supporting pole can be made thicker by using more woods, but the wheel made of a broader and thinner board will be more vulnerable if it is against the strong wind. For this reason, several windmill makers have started to develop windmills made from dilated pipes. This pipe is more flexible so that it is stronger to withstand exposure to strong wind.

3.3.3.3. Adaptation to new land grow

Water waves from the sea and sediment from river water carried by the sea sometimes cause new land to arise. The community cannot predict the emergence of this land. Sometimes, it has suddenly reached hundreds of meters jutting into the sea. The arising land is waiting for about one year from the time it first appeared and then taken care of its use in the district. New land arising is considered belonging to the village and may be used by the community to produce using a production sharing system scheme as a replacement of rental fee. It does not disappear again. It does not cause conflict and can also be used to improve the welfare of the community and increase village income.

Several adaptation strategies have implemented in other Regencies, such as the MMAF technology, but still, need continuous persuasion because not all farmers wanted to apply it. Communal adaptation is almost similar in several Regencies. Thus, it does not need further persuasion.

4. Conclusion

Pati Regency is the third biggest salt production in Indonesia. The salt farmers have experience climate change observed between 2010 to 2018. Their adaptation strategies are: (1). Adaptation in the rainy season, they have to change salt ponds into milkfish ponds, and also planting mangroves. (2). In extreme rainy seasons, they must secure their salt stored in warehouses and near land. (3). In the dry season, they use screw-pond-system, LDPE/HDPE/geomembranes, integrated land technology. (4). The long dry season, they use water-pump machines and water irrigation management. (5). Anticipating high waves, they use sandbags and mangrove planting. (6). Anticipating strong wind, they use pipe materials for windmill materials. Several adaptation strategies have been implemented in other Regencies, by continuous persuasion with giving samples will make the salt farmer see how much they will get the profit by applying the technology.

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