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Adaptation and coping ability of rice farmers regarding the saltwater intrusion along the upper area of sathing Phra Peninsula of Thailand

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Abstract

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The upper area of Sathing Phra peninsula of Thailand has been affected every year by saltwater intrusion at > 1.5 grams/liter from Songkhla Lake, during April – June. Over 50% of the rice field area has been ruined by the intrusions. Recently, practices of the farmers to adapt to and cope with the saltwater intrusions into rice fields were assessed to be medium level effective. However, there were two adaptations rated at high levels. Those were "monitoring news on saltwater intrusions" and "supplementary careers instead of doing only rice farming". The farmers' guidelines to cope with the saltwater intrusions into rice fields were:1) alternating rice farming system, 2) adjusting the government support policies, 3) changing rice varieties, 4) growing other crops in the rice fields after rice farming season, 5) raising animals along with rice farming, 6) creating supplementary incomes, and 7) grouping farmers. The guidelines that most farmers agreed to practice were: 1) growing rice varieties that met household consumption, 2) growing high-value rice varieties, and 3) growing some saltwater tolerant plants after the rice-farming season. Coping with the problem of saltwater intrusions was rated at a high level. The study found that growing rice varieties that met household consumption along with the promoted rice varieties was preferred by the farmers. The second highest ranked was growing rice according to policies for the management of rice economic zone and mixed farms. These are guidelines that could be managed at the household level to maintain independent farming in the affected areas.

Keywords: adaptation; coping ability; rice farmer; saltwater intrusion

Introduction

In many places of the world, saltwater intrusions are natural disasters that mostly impact agricultural productivity. According to Mike (2003), saltwater intrusions will affect 380 million hectares, or roughly one-third of the world's agricultural land. Complex saline intrusion is currently affecting many coastal areas in Bangladesh, Orissa, Vietnam, and the Philippines (Mike, 2003, cited in Nhung et al., 2019). In the dry season along peninsular Thailand, the problem of saltwater intrusion occurs because the agricultural sector needs water more than the surface runoff can provide. Recently, subsurface flow, tidal influence, and natural-water-resource shallows have made the water quality no longer proper for agriculture (Abdullah, 2017; Carretero et al., 2013; Dogan & Fares, 2008). Farmers need to adapt their practices to cope with these problems, and the ability to adapt will be prepared to be ready for the recurring situation that may be dangerous (IPCC, 2001; IPCC 2007). Preparations may also include training for responses to the disturbances and mitigation efforts after such events (Gallopin, 2006). Coping ability plays an important role in addressing the impacts of saltwater intrusion. It is a process by which people seek to confront the consequences of saltwater intrusion and enhance their resilience (Adger, 2006; Smit & Wandel, 2006)

The upper area of Sathing Phra is 5-12 km wide and 70 km long, with its western side close to the Songkhla Lake and the eastern side close to the Gulf of Thailand. These expose the farming areas to influences of salinity in the sea, particularly in the dry season when saltwater intrudes into the farming areas. The upper area of Sathing Phra is its major rice farming area, with 23,600.4 ha of rice fields. Sub-districts that have been affected the most by saltwater intrusions are Ranot, Ban Mai, Takria, and Bankhao. These four sub-districts are plane-curved basins directly by the Songkhla Lake, and all the four sub-districts are major sources of rice in the upper area of Sathing Phra peninsula with a total field area of 19 510.6 ha (Ranot District Agricultural Extension Office, 2021) contributing 74% of the total rice fields in upper Sathing Phra peninsula, where 80% of the rice fields are irrigated. The saltwater intrusions have increased in severity for 20 years, due to the shallow Songkhla Lake being impacted by fishing activities and dumping of household waste/trash into it.

Although farmers have encountered the problem of saltwater intrusions into the rice fields for over 20 years, they have still kept on farming rice. Rice farming is a career that has been passed down from generation to generation, which makes the farmers dedicated and committed to it, insisting on continuing rice farming without change to some other career. Farmers are slowly learning to adapt and try to cope with this problem. This study aimed to 1) examine the adaptations to the problem of saltwater intrusions, 2) prepare guidelines to cope with the problem of saltwater intrusions in the rice fields, and 3) examine the ability to cope with the problem of saltwater intrusions. The results of this study are expected to be beneficial to farmers in other areas that have similar problems, possibly with selective adjustments for suitability, and support continued rice farming careers.

Materials and Methods

The methods used in this study were qualitative and quantitative. Qualitative data were collected from 20 key informants who were farmer leaders, farmer-group mainstays, farmer intellectuals, and farmer representatives. Preparing guidelines to cope with the problem of saltwater intrusions, the study arranged 2times focus-group discussions and 1time of Appreciation-Influence-Control (A-I-C). Quantitative data collection was carried out by using a semi-structured questionnaire. A list of farmers registered with the District Agricultural Extension Office was used to estimate with the Taro Yamane formula the necessary sample size of 357 farmers used in this study. However, in total 360 farmers participated in the data collection. Questions were developed from the results of qualitative research and coping guidelines, and were formulated as multiple-choice type questions. The analysis of opinion levels related to bringing the coping guidelines into practice, and the ability level of coping was surveyed with questions whose answers were level ratings. Two points would be given if the answer was "regularly practice/agree to follow the coping guidelines", 1 point would be given if the answer was "occasionally practice/uncertain to follow the coping guidelines", 0 points for "no practice/not agree to follow the coping guidelines". Interpreting the practice levels/bringing the coping guidelines into practice was classified into 3 levels. Those would be "practice to follow the coping guidelines at a high level/agree at a high level" (1.34-2.00), "practice to follow the coping guidelines at medium level/agree at the medium level" (0.67-1.33), and "practice to follow the coping guidelines at low level/agree at low level" (0.00-0.66). For the ability level of households to bring the coping guidelines into practice, the analysis was classified into 5 levels. Those would be the "highest level" (4.21-5.00), "high level" (3.41-4.20), "medium level" (2.61-3.40), "low level" (1.81-2.60), and "lowest level" (1.00-1.80).

Results and Discussion

Adaptation of farmers to the problem of saltwater intrusions in rice fields

The studied areas were located in the upper area of Sathing Phra peninsula composed of Ranot, Ban Mai, Takria, and Bankhao (Figure 1) connected with Songkhla Lake and the Gulf of Thailand. Mostly the area is rice fields and these have mostly been affected by saltwater intrusions. The problematic saltwater intrusions always occur in the dry season (April-June) every year, due to decreased amount of fresh water in the Songkhla Lake with increase of saltwater en-

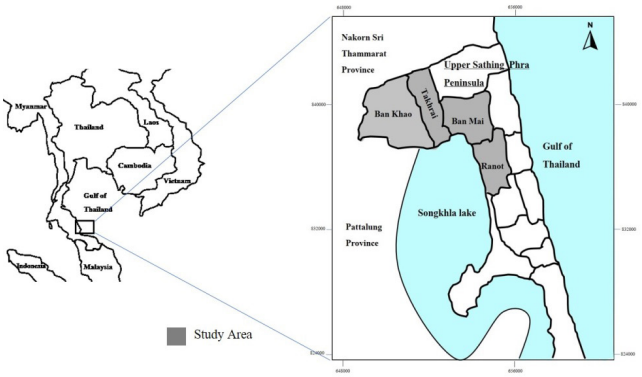

Fig. 1. The map of the upper area of Sathing Phra peninsula and the location of the studied district

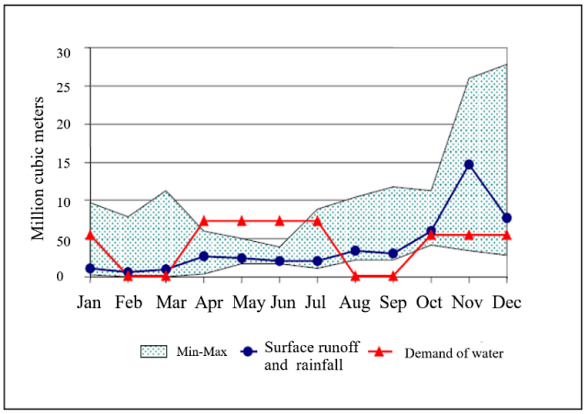

Fig. 2. Monthly averages of usable water and irrigation demand for water in the studied area

tering from the sea to the lower area of Songkhla Lake. This increases the salinity level of water close to the upper area of Sathing Phra peninsula to > 1.5 g/l. In this season, the usable surface runoff and rainfall are low in amount compared to the irrigation demand (Figure 2).

Since 1967 there have been irrigation systems in the area, and the study found that more natural water was used for agriculture. 100% of the farmers had adjusted the rice farming format from one crop per year to two crops per year (known as in-season rice farming and off-season rice farming). Recently, the freshwater level has been low in the Songkhla Lake. The causes of shallow water level include installed fishing tools and dumping of household waste/trash into the lake. Increased water use has reduced the amount of fresh water that enters into the Songkhla Lake. The salinity level of water in the Songkhla Lake has therefore increased, contributing to the problems with saltwater intrusions in rice fields, and this is affected by the topography of the plane-curved basin in the studied area that enables accumulation of salinity by the study area.

100% of the farmers have encountered saltwater intrusions in their rice fields. The average number of days that farmers had a problem was 77.2 days/year, with the damage being on average 377 703.8 baht/ha. The highest estimated damage cost was 1 875 000 baht/ha, and the least damage was 6250 baht/ha. The damaged area was about 50% of total household farming areas. This agrees well with the study of Miah et al. (2020), who found that rice farming areas in Southwest Bangladesh were ruined by saltwater intrusions for about 40% of the total household agricultural fields. The saltwater intrusions affected rice farming careers, rice farming fields, household finances, and mental status (Table 1).

Regarding scheduling of rice farming in the study area, it was found that the rice varieties grown were not those that the farmers usually consumed in their households, which would be RD 31, RD 41, and RD 47. The farmers would do the 1st rice farming (in-season rice farming) from October to November with harvesting ended in February. The 2nd rice farming (off-season rice farming) would be done in May and harvesting would end in August (Table 2).

From alternating rice farming systems to avoid flooding situations during the in-season rice farming, this affected farmers to encounter the occurrence of new risks. Those risks were water shortage and saltwater intrusion that increased the salinity level of water so it was no longer usable for rice farming. The saltwater intrusion is a general situation that occurs naturally and cannot be eliminated with some small effort. However, water is still the main factor for rice farming. Farmers have to properly cope with the situation to reduce the impacts of problems. Farmers followed the salinity level announcements from the pumping station supplying the irrigation system, before using that water. In addition, some farmers had applied skills and local wisdom to observe the salinity level and reduce risks from saltwater intrusion, as follows.

1) Observing the color of water. On observing primary physical characteristics of water its color may be associated with different salinity levels of the water. If the color was white, cloudy, or clear white, this meant that the salinity level of water was acceptable. If the color of the water was rather clear green, this meant that the salinity level of water was not proper for agriculture.

2) Tasting the water. This is more to the point than observing the color of water, because the color might not inform of obvious salinity levels. By tasting the water, farmers would be able to estimate the salinity and whether the water was usable or not for rice farming.

3) Observing evaporation. This was another local wisdom, that if there was some red stains floating on surface of the water, it meant that the salinity was quite high. If rice

Table 1. Impact of saltwater intrusions in rice farming fields (n = 360)

Negative impacts of saltwater intrusion	Mean	S.D.	Level of Impact
Rice farming career	3.77	0.48	High
Rice farming fields	3.75	0.51	High
Household finances	3.55	0.55	High
Mental status	3.48	0.64	High

Table 2. Seasonal aspects for rice farming in the study areas

Activities	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Note
Average monthly rainfall (millimeters, in 2010-2020)	137,2	22,0	22,8	19,6	36,4	37,6	9,7	12,2	56,7	173,3	456,9	429,7	
Salinity of water				❄	❄❄❄		❄❄						❄ low salinity of water ❄❄ medium salinity of water ❄❄❄ high salinity of water
Area seasons	←	delay in rainfall		→	dry season water shortage			beginning of rainfall			heavy rainfall flooding		
In-season rice field		harvesting	→						←	growing			↔ need water for rice farming
Prepare rice growing								Prepare rice seeds	prepare plots	release water	fill water		
Taking care and harvesting	♂ 2 Enrich ears of rice	harvest rice									♂ 1 enrich rice stems	Maintain water level	♂ fertilizing
Off-season rice field			←		sow			harvest	→				↔ need water for rice farming
Prepare to grow			prepare seeds	prepare plots	release water								
Taking care and harvesting						♂ 1	♂ 2	harvest					♂ fertilizing

was still young, it would dry quickly if this saline water was used for irrigation.

4) Observing crystals. Observing salt crystals left on the ground after the water has evaporated is not a guideline for observing the water before using it, but this would show the severity of the saltwater problem affecting rice fields and accumulation of salinity in the soil. Farmers have to figure out how to reduce the salinity of soil before the next rice crop is planted (Figure 3).

Fig 3. Characteristic salt crystals in a salt contaminated rice field

Adaptation of farmers to the problem of saltwater intrusions

The study found that the farmer households had adapted to cope with saltwater intrusions overall at a medium level. Considering sub-items in the survey, it was found that farmers rated at high levels "following information related to saltwater intrusion" and "changing career/creating supplementary incomes" (Table 3). The most used information channels related to saltwater intrusions were the local announcements of Royal Irrigation Department (48.3%), exchanges among the farmers themselves (37.5%), and agricultural extension staff (17.1%) which confirms the study of Bagbohouna et al. (2018), which stated that most farmers of Gambia had coped with the problem of saltwater intrusions in rice fields in the dry season by following weather forecasts provided by the government sector. This current study found that checking for available information was a priority that the farmers did regularly, and compared to other practices this one was the most important for rice farming. Farmers would mainly follow the salinity value announced in front of the pumping station of the irrigation system. As an inferior practice, farmers changed careers and found supplementary incomes other than from rice farming. Most farmers would change from rice farming to growing some other crops that could tolerate salinity in the rice fields after the rice farming season, such as Duangmanee bird pepper, coconut, etc.

Guidelines of farmers to cope with the problem of saltwater intrusions in rice fields

Building guidelines for farmers to cope with the problem of saltwater intrusions in rice fields

From discussion related to guidelines to cope with the impact that occurred in the areas, it was found that the possible guidelines to cope with the problem of saltwater intrusions were alternating rice farming system, adjusting the government support policies, changing rice varieties, growing other crops in the rice fields after rice farming season, raising animals along with rice farming, creating supplementary income, and grouping farmers as follows.

1) Alternating rice farming system was a guideline that farmers could apply in their rice fields to cope with the problem of saltwater intrusions as follows.

1.1) Change from rice farming system from in-season rice farming and off-season rice farming in the cycle of 1 year, to do only in-season rice farming or off-season rice farming, in order to reduce the use of water or to adjust the cycle of production to match the growing season with ample water for rice farming.

1.2) Doing a mixed farm or organic farm which would give direction to managing how to utilize areas to grow different crops that would help reduce the risk from growing only a single crop. This also helped reduce use of chemicals in rice fields, such that might accumulate in the soil.

1.3) Changing rice fields by growing some other crops.

2) Adjusting the government-support policies to reduce risks caused by several factors as follows.

2.1) Growing rice following the policies of Zoning for economic management, utilizing areas suitable in soil type and typography.

2.2) Doing rice farming under the project "one rai one hundred thousand baht" (1 rai = 0.16 ha.) utilizes 1 rai to grow a different crop or to grow crops along with raising animals in proper proportions.

2.3) The farmers would receive support/assistance from the government to practice agriculture that meets the target set by the government.

3) Changing rice varieties to properly match the areas with objective to let rice be able to resist plant diseases and tolerate salinity, as follows.

3.1) Growing rice varieties that households consume would reduce the risk of relying on outside food.

Table 3. Recent adaptations by farmers to cope with the problem of saltwater intrusions in rice fields (n = 360)

Adaptation to cope with the problem of saltwater intrusions in rice fields	Frequency of practice (percentage)			Mean	Level of Adaptation
	regular	occasional	no		
1. change rice farming time to match the time of having ample water	48.17	27.44	24.39	1.24	Moderate
2. change rice varieties that give higher yields	26.22	21.04	52.74	0.73	Moderate
3. change number/size of area for rice farming	33.54	13.11	53.35	0.80	Moderate
4. have reserved rice field in other areas	4.88	0.00	95.12	0.07	Low
5. change producing path	34.45	28.96	36.59	0.98	Moderate
6. change to doing mixed farms	42.99	18.90	38.11	1.05	Moderate
7. build water reservoir or draining system in rice fields	24.77	13.15	62.08	0.63	Low
8. change career/have supplementary incomes besides only from rice farming	57.80	23.85	18.35	1.39	High
9. improve water managing system of community and develop waterway system	32.11	30.58	37.31	0.95	Moderate
10. reserve rice in case if the rice yield was affected by saltwater intrusion	33.33	19.88	46.79	0.87	Moderate
11 participate in rice farming with contact farming insured by the government sector	27.22	42.20	30.58	0.97	Moderate
12. follow information related to saltwater intrusion for the planning of rice farming	66.67	24.46	8.87	1.58	High
13. have processing for adding the value of agricultural products	24.92	7.07	68.01	0.61	Low
1.4. approach supporting resources in the community if encountering impact	43.43	29.97	26.61	1.17	Moderate
15. approach supporting resources outside the community if encountering impact	31.19	32.11	36.70	0.94	Moderate
16. seek compensating incomes from other sources during the impact moment	42.51	36.70	20.80	1.22	Moderate
17. use knowledge body and skill to cope with saltwater intrusion	33.33	21.10	45.57	0.88	Moderate
Total	**35.74**	**22.97**	**41.29**	**0.95**	Moderate

3.2) Growing rice varieties that have high selling price was a direction that the farmers mainly selected for commercial production. Selecting to grow only rice varieties that served the need of the market to get the higher price per ha.

3.3) Growing rice varieties that could tolerate salinity was a direction to directly cope with saltwater intrusions and reduce risks caused by it.

3.4) Growing rice varieties promoted by the government. This means using rice varieties from the government which let farmers receive knowledge of production process and assistance from the government in both production and marketing.

4) Growing other crops in the rice fields after the rice farming season could use the rice fields beneficially after harvesting for growing short-lived crops as follows.

4.1) Growing Duangmanee bird pepper for seeking supplementary income from agriculture was found a lot in the study area. Also, Duangmanee bird pepper was in demand by the marketplace.

4.2) Growing long beans for supplementary income, to utilize the soil for added benefit, and to circulate nutrients in the soil and make it more fertile.

4.3) Growing forages for raising animals or selling in the market.

5) Raising animals along with rice farming was reducing risks by increasing other activities of agriculture besides growing crops, by raising animals such as beef cattle, chicken, ducks, and fish.

6) Creating more supplementary income by producing value-added products such as promoting tourism in the local areas, processing agricultural goods, doing agricultural-goods market of community, etc.

7) Grouping farmers was another direction that helped reduce the severity of saltwater intrusions, although the effects of grouping might be abstract. For example, farmers had the strength and willpower to fight problems that occurred in the area. The study found that grouping influenced farmers to better bargain the price when selling products and or to request assistance from the government sector.

Opinions of farmers related to guidelines to cope with saltwater intrusions in rice fields

In the results from discussions among farmer households for bringing aforementioned guidelines into practice, to cope

with the saltwater intrusions in rice fields, it was found that the overall response was at medium level. Considering sub-items in the coping guidelines, the farmers agreed and rated "growing rice varieties that are mostly consumed in households" at a high level because some currently practiced this. Farmers divided the rice fields into 2 parts. Part 1 would grow rice varieties for the commercial market, to meet the market demands. Part 2 would grow local rice varieties for household consumption which reduces the risks when there is damage from saltwater intrusion. Following in rank order were "growing rice varieties that could sell at a high price" because the farmers still needed high profit for each rice crop, "growing bird pepper in rice fields after rice-growing season", and "doing mixed farms" (Table 4).

It could be seen that the guidelines that the farmers agreed to bring into practice were still related to growing rice in the same rice fields. Farmers are still determined to continue a rice farming career. However, the farmers need to adapt to cope with the saltwater intrusions in rice fields. This agrees with the study of Haider &Hossain (2013), which found that farmers in the saltwater-intruded rice fields used their lands for crop production where the soil salinity was the lowest. Farmers tried to diversify their production on these agricultural lands. Also, Ligate et al. (2017) found that farmers in Bagamoyo District of Tanzania opted to grow other crops during the dry season to avoid the problem of saltwater intrusion in rice fields, with determination to further keep on at rice farming.

Table 4. Opinions related to guidelines to cope with saltwater intrusions in rice fields and coping ability (n = 360)

Guidelines to cope with saltwater intrusions in rice fields	Agreed with guidelines (percentage)			Average	Opinion Level	Coping Ability		Coping Ability Level
	high	medium	low			Mean	S.D.	
1. Alternating rice farming system								
1) doing only in-season rice farming	25.96	27.24	46.79	0.79	Moderate	3.50	0.83	High
2) doing only off-season rice farming	4.81	20.51	74.68	0.30	Low	3.47	0.51	High
3) doing mixed farms	42.95	26.28	30.77	1.12	Moderate	4.23	0.90	Highest
4) doing organic farm	26.92	38.14	34.94	0.92	Moderate	4.06	0.10	High
5) changing to grow other crops	62.46	17.80	19.74	0.60	Low	4.22	0.04	High
2. Adjusting the government support policies								
1) growing rice following policies of Zoning for economic management	53.53	19.23	27.24	0.74	Moderate	4.24	0.73	Highest
2) doing rice farming under the project "one rai one hundred thousand baht"	30.45	25.00	44.55	0.86	Moderate	3.57	0.10	High
3) growing rice varieties promoted by the government	26.60	39.42	33.97	0.93	Moderate	3.57	0.09	High
3. Changing Rice varieties								
1) growing rice varieties that households consume	58.01	22.44	19.55	1.38	High	4.52	0.89	Highest
2) growing rice varieties that have a high selling price	51.60	24.36	24.04	1.28	Moderate	4.19	0.07	High
3) growing rice Varieties that can tolerate salinity	6.73	0.32	92.95	0.14	Low	3.25	0.50	Moderate
4) growing rice varieties promoted by the government	17.95	15.06	66.99	0.52	Low	3.91	0.70	High
4. Growing other crops in the rice fields after rice farming season								
1) growing Duangmanee bird pepper	50.00	16.99	33.01	1.22	Moderate	4.12	0.13	High
2) growing long bean	33.65	17.95	48.40	0.90	Moderate	4.17	0.90	High
3) growing forages	24.52	19.03	56.45	0.68	Moderate	4.19	0.08	High
5. Raising Animals along with rice farming								
1) raising beef cattle	19.17	12.78	68.05	0.51	Low	2.64	0.67	Moderate
2) raising chicken and duck	31.95	22.18	45.86	0.86	Moderate	3.34	0.88	Moderate
3) fish farming	31.58	11.65	56.77	0.75	Moderate	3.25	0.82	Moderate
6. Creating supplementary incomes								
1) promoting tourism in the local areas	14.66	8.65	76.69	0.38	Low	1.87	0.16	Low
2) processing agricultural goods	16.92	22.18	60.90	0.56	Low	1.65	0.15	Lowest
3) doing agricultural-goods market	16.92	18.80	64.29	0.53	Low	1.82	0.20	Low
7. Grouping farmers	34.59	28.20	37.22	0.97	Moderate	1.81	0.86	Low
Overall	30.99	20.65	48.36	0.77	Moderate	3.44	0.47	High

However, several guidelines that the farmers agreed with were rated at low levels and considered not proper to cope with the saltwater intrusions, as follows. 1) Growing rice varieties that could tolerate salinity because there was no study to support that such rice varieties could grow well in the saltwater areas. Although some rice varieties can tolerate salinity, these might be unpopular among consumers. However, Thi Huyen et al. (2019) and Nguyen Huu et al. (2019) suggested that farmers in Vietnam should solve the problem of saltwater intrusions in rice fields by growing rice varieties that could tolerate salinity.

2) Growing only off-season rice varieties because most farmers in the areas had rice-farming careers, with main income from rice farming. Doing only off-season rice farming, the farmers would have less income. Also, growing off-season rice in the areas was carried on only during the time of the saltwater problem. 3) Guideline to promote tourism in the local areas because this was a new guideline and farmers did not have the skills – they might need grouping to learn more. Also, the areas had not been developed to be tourist attractions yet. 4) Raising beef cattle because the cost of beef cattle breeds is quite high and raising time is long. If the farmers needed to raise animals, they preferred to raise chickens or ducks rather than beef cattle. 5) Growing rice varieties promoted by the government because this guideline was a national policy in which some rice varieties were not proper for the area, and were unpopular among consumers. Also, the different growing times would make farmers adjust the growing cycle each year. Those promoted rice varieties had low disease immunity and had a slow growth rate as well. 6) Doing agricultural-goods market because most farmers had no marketing skills. 7) Processing agricultural goods because there was some difficulty and farmers needed to have knowledge and capital for production management. This was confirmed by the study of household practices to cope with saltwater intrusions, which found that farmer households processing agricultural goods was rated at a low level. Farmers preferred selling products in the paddy form to selling milled rice. This agrees with the study of Bagbohouna et al. (2018) which found that most farmers in Gambia rated poorly a change from crop production to animal rearing or to marketing of agricultural products. And finally, 8) Changing to grow some other crops because farmers still had the determination to keep at a rice farming career.

The ability of farmer households to cope with saltwater intrusions in rice field

The study found that guidelines to cope with the problem of saltwater intrusion in rice fields, such that the farmers could practice at the highest level, was "growing rice varieties that households liked to consume", followed in rank order by "growing rice varieties following policies of Zoning for economic management" and "doing mixed farms" (Table 4).

Considering Table 4, it was found that growing rice varieties that farmers like to consume in their rice fields was the guideline that the farmers agreed with and rated at a high level, and had coping ability rated at the highest level. For growing rice varieties that had high selling price, growing chili in rice fields after rice-farming season, and doing mixed farms, the study found that farmers agreed and rated these at high levels. Farmers still needed support from the project for "growing rice following policies of Zoning" for economic management by the government sector, and felt that farmers would have the ability to cope with the problem of saltwater intrusion in rice fields. However, considering promoting tourism in the local areas and doing agricultural-goods market, the study found that farmers rated this and associated coping ability at low levels. The reasons were that farmers thought they could not accomplish this by themselves. Farmers need cooperation and support from relevant units, to provide knowledge and support to tourist attraction sites or agricultural-goods market. The results agree with the study of Haider & Hossain (2013), which stated that the farmers' responses to salinity were not very encouraging. Farmers also emphasized the need for more active government participation in solving the salinity problem, such as support to infrastructure and agro-tourism. These were similar to the guidelines of grouping or being members of a farmer group, for which farmers rated coping ability at a low level. The reasons were that farmers had different available times and did not believe in grouping to help reduce the impacts of saltwater intrusions in the rice fields. For processing agricultural goods, the study found that farmers rated their ability at the lowest level among the coping guidelines, and felt that there was no relation to coping with the saltwater intrusions in rice fields. Although farmers had more income from agricultural products, they still lacked technology and knowledge for processing produce to value-added forms. This agrees with the study of Ligate et al. (2017), which found that work in agricultural processing (such as salt mines) as alternative livelihood activity served as the coping mechanism when the production of crops was low. Money obtained from the produce was used to buy food and seeds for the next seasons. Somehow, the approach had nothing to do with saltwater intrusion mitigation measures, and so the problem would continue to affect crop production.

Conclusion and Recommendation

For the adaptation of farmers' practices to cope with saltwater intrusions in rice fields, this study found that farmers had adaptation rated overall at a medium level. Also, some adaptations were rated at the two highest levels, namely "following information related to saltwater intrusion" and "alternating of supplementary careers instead of doing only rice farming". This study found that appropriate guidelines for farmers to cope with saltwater intrusions in rice fields were: 1) alternating rice farming system, 2) adjusting the government support policies, 3) changing rice varieties, 4) growing other crops in the rice fields after rice farming season, 5) raising animals along with rice farming, 6) creating supplementary income, and 7) grouping farmers. The most agreed to guidelines for bringing into practice were: 1) growing rice varieties that the farm households consume, 2) growing rice varieties that have high selling prices, and 3) growing other crops that could tolerate saltwater after the ending of the rice-growing season. Guidelines that the farmer households did not agree to bring into practice were: 1) growing rice varieties that could tolerate saltwater, 2) doing only off-season rice farming, and 3) promoting tourism in the local areas.

Regarding the ability of households to cope with saltwater intrusions in rice fields, it was found that farmer households had the most coping ability for "growing rice varieties that households consume". The next ranked items were "growing rice following policies of Zoning for economic management" and "doing mixed farms". These 3 guidelines could be followed at household level independently. The farmer households rated their coping ability low for "supplementary incomes" and "being members of farmer groups".

Suggestions based on this study are as follows.

- The relevant working units should use as communication channels online social media, to let the farmers promptly access up-to-date information on saltwater intrusions.
- Promoting or supporting rice varieties that the households consume along with the varieties for selling, to reduce risks from saltwater intrusions in rice fields and to improve food security at the household level.
- Promoting crops that can tolerate saltwater to let the farmers grow those in the fields after the end of rice-growing season.
- Increasing skills and abilities of farmers to produce value-added products from rice, in particular skills that are needed include marketing, processing of products, etc.

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References

Abdullah, A. D. (2017). Modeling Approaches to Understand Salinity Variations in a High Dynamic Tidal River: The Case of the Shatt al-Arab River. Dissertation Report.

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, *16(3)*, 268-281.

Bagbuhouna, M., Yaffa, S., Sogbedji, J. M., Bah, & Koglo, Y. S. (2018). Knowledge and adaptive responses of rice farmers to saline-water intrusion on swamp rice-growing fields in lower river region of the Gamba. *Journal of Environment and Earth Science, 8 (3),* 63-76.

Carretero, S., Rapaglia, J., Bokuniewicz, H. & Kruse, E. (2013). Impact of sea-level rise on saltwater intrusion length into the coastal aquifer, Partido de La Costa, Argentina. *Cont. Shelf. Res., 61*, 62-70.

Dogan, A. & Fares, A. (2008). Effects of land-use changes and groundwater pumping on saltwater intrusion in coastal watersheds. *Water Resources, 33,* 219-249.

Gallopin, C. G. (2006). Linkages between vulnerability, resilience, and adaptative capacity. *Global Environment Change, 16(75),* 301-329.

Haider, M. Z. & Hossain, M. Z. (2013). Impact of salinity on livelihood strategies of farmer. *Journal of Soil Sciences and Plant Nutrition, 13(2),* 417-431.

IPCC (2001). C*limate Change: the scientific basis. Contribution of Working Group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press,* Cambridge, UK.

IPCC (2007). Climate Change Impacts, Adaptation and Vulnerability Synthesis Report Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.*

Ligate, J. E., Kitila, M. M., Chen, C. & Wu, C. (2017). Impact of salt water intrusion on Maize (*Zea mays*) and Rice (*Oryza sativa*) production under climate change scenarios in Bagamoyo District-Tanzania. *Universal Journal of Agricultural Research, 5(2),* 148-158.

Miah, Y., Kamal, Z. U., Salam, A. & Islam, S. (2020). Impact of salinity intrusion on agriculture of Southwest Bangladesh – A review. *International of Agricultural Policy and Research, 8(2),* 40-47.

Nguyen, H. T., Sansanee, C., Doung, V. N. & Kulvadee, K. (2019). Impact of saline intrusion and adaptation options on rice- and fish-farming households in the Mekong Delta of Vietnam. *Kasetsart Journal of Social Sciences, 40*, 427-433.

Ranot District Agricultural Extension Office (2021). Database of Agricultural in Ranot District. http://ranot.songkhla.doae.go.th/main/?page_id=6765

Smit, B. & Wandel, J. (2006). Adaptation, adaptative capacity, and

vulnerability. *Global Environmental Change, 16(3),* 282-292.

Thi Huyen, T. D., TS, A. P. Z. & Klaus, M. (2019) Paddy in saline water: Analysis variety-specific effects of saline water intrusion on the technical efficiency of rice production in Vietnam. *Outlook on Agriculture, 48(3),* 237-245.

TranThi, N., PhuLe, V., VuVan, N. & HoQuoc, B. (2019) Salt intrusion adaptation measures for sustainable agricultural development under climate change effects: A case of Ca Mau Peninsula, Vietnam. *Climate Risk Management, 23*, 88-100.

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