Food and Agriculture Organization of the United Nations

CESRA
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CENTER OF EXCELLENCE FOR SOIL RESEARCH IN ASIA

Final Report

Improving information and developing a repository of sustainable soil management practices in Asia

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EXECUTIVE SUMMARY

1. The purpose of the project “Improving information and developing a repository of sustainable soil management practices in Asia is to support the development of a repository of Asia-specific sustainable soil management practices that are critical for member countries and stakeholders to use in developing programs to accelerate actions in halting soil salinization. This final report consists of a main body, and the Executive Summary.

2. The main body of the final report. The main body of the report provides a series of sustainable soil management best practices in Thailand as case studies to accelerate actions in halting soil salinization and saline soil management that are critical for Asian countries. It also incorporates the recommendations of local and national institutes/organizations which reviewed the process of the studies; the recommendations receiving from a national study conducted by experts and senior government officials.

3. The technical studies and data collection include: 15 best practices of sustainable soil management to accelerate actions in halting soil salinization and/or saline soil management.

1) Seaweed Development Fisheries Groups;
2) Eco-friendly system of seaweed culture;
3) Ked Forest Park, prototype of community forest management in the brackish water ecosystem at Khung Bang Krachao (Bang Krachao river bend);
4) Fish farming for saline soil management in KhonKaen Province, Thailand;
5) Manila tamarind planting in combination with integrated farming for saline soil management in Nakhon Ratchasima Province, Thailand;
6) Green manure: an amazing crop for soil amendment and saline soil reduction of the Northeast of Thailand (I-san);
7) Extension of using the green manure plant (sunn. hemp) in saline soils
8) Managing areas with saline soil by practicing eco-agriculture in Maha Sarakham Province, Thailand;

9) Integrated agriculture-based land use in areas with saline soil;

10) Khanap Nak community way: Restoring deserted shrimp farms with nipa palm forestry plantation;

11) Community Enterprise: Nipa Palm Sugar Processing Group, packages of Chantarangsee plantation;

12) Managing areas with saline soil for planting exported Hom Mali rice at Thung Kula Ronghai;

13) Technology of planting halophytes (Dixie grass) for restoring highly saline soil

14) Extending planting the halophytic grass (Dixie grass) in the areas of severely saline soil

15) The soil doctor network build sustainability in areas with saline soil and integrated farming system

4. The national workshop was held in April 2022 aiming at discussion among experts and senior from government officials and educational institutions. The national workshop endorsed the list of best practices to accelerate actions in halting soil salinization and/or saline soil management at the national level. The endorsement included that the key target groups would be smallholders of various categories and the rural enterprise should be included.

5. Executive Summary. The executive Summary consists of a summary of the information in the main body of the report.

BACKGROUND

INTRODUCTION

Land degradation is one of the biggest threats to food security and agriculture in Asia and the Pacific. Approximately 25% of all land in the region is degraded, with 13% classified as seriously degraded, leading to soil erosion and fertility losses, increased flash floods and landslides that particularly affect the poor and marginalized minorities. Asia is home to 37.2% of the global arable land and also the largest area of land under degradation.

The Regional Assessment of Soil Change in Asia, as part of the Status of World' Soil Resources (FAO, 2015) highlights the following main threats to soil in the region 1) Erosion; 2) Soil organic carbon change; 3) Soil salinization and sodification and 4) Nitrogen imbalance. These threats are driven by compounded impacts of population growth, industrialization, urbanization, unsustainable agriculture and climate change.

In 2019, the Fifth Asian Soil Partnership (ASP) Plenary Meeting held in New Delhi, India recommended and endorsed the establishment of the Center of Excellence for Soil Research in Asia (CESRA). The major mission of CESRA is to support ASP countries in achieving sustainable soil management with coordinated actions on soil protection, management and restoration in the regions and mitigate the negative impacts on food production and food security as well as sustaining provision of ecosystem services and climate change adaptation. CESRA is also expected to promote the exchange of knowledge, data, and experience in the region through, among others, the promotion and implementation of the Southeast Asia Laboratory Network (SEALNET) with data harmonization and standardization and facilitate technical cooperation.

The CESRA Secretariat was established in the Land Development Department (LDD), Thailand. The CESRA will serve as the regional hub for advancing targeted soil research based on regional priorities to feed decision making. FAO Thailand has developed a TCP project to support the development of an operational strategy and work plan for CESRA and strengthening technical capacity for soil testing laboratories with harmonization of soil data and information and the establishment of the National Thai Soil Laboratory Network.

A Global Soil Map is available through the Global Soil Partnership (GSP) in 2021. However, the Global Map of Salt Affected Soils lacks data and information of sustainable soil management for

a large part of the Asia-Pacific region. On the other hand, with the UN Decade of Ecosystem Restoration, launched in June 2021, countries are increasingly looking at tools to assess restoration opportunities to make a business case for investing in land, soil and broader ecosystem restoration. Furthermore, sustainable land and soil management is a priority for agri-food systems transformation as highlighted in the Global Food Security Summit.

With this regard, Food and Agriculture Organization Regional Office for Asia and the Pacific (FAORAP) in collaboration with Land Development Department (LDD) and CESRA developed project 'Improving information and developing a repository of sustainable soil management practices in Asia'. This project will support the development of a repository of Asia-specific sustainable soil management practices for halting soil salinization and saline soil management that are critical for member countries and stakeholders to use in developing programmes/projects and mobilizing resources for the implementation.

OBJECTIVES

1) To collect data and information of best practices on salt affected soil management in Thailand
2) To support the development of a repository of Asia-specific sustainable soil management practices for halting soil salinization and saline soil management that are critical for member countries and stakeholders under CESRA

DURATION OF THE PROJECT

January 2022 – February 2023

MAIN RESPONSIBLE AGENCY

1) Land Development Department (LDD)
2) Center of Excellence for Soil Research in Asia (CESRA)

SALT AFFECTED SOILS IN THAILAND

Salt-affected soils can be saline or sodic soils, saline soils are soils that contain soluble salts expressed as electrical conductivity of the saturation soil extract, higher than 2 dS/m at 25 degree Celsius and sodic soils with Sodium Adsorption Ratio higher than 13. Salinity causes problems on soil and crop to farmers in remediation and management practices. In 2015 and 2018, LDD

reported that more than 0.6 million hectares or 1.31% of the total area in Thailand is salt affected soils, comprising of the inland and the coastal salt-affected soils. The inland salt-affected soils in Thailand are formed through geochemical process and distributed in the northeastern part of the country while coastal salt-affected soils originated from seawater scattered along the coastal lines. The salt-affected soils are classified as slightly, moderately, severely salt-affected soils and potential salt source area and the management practices are in line with this classification.

The wide spread inland salt-affected soils in the Northeast of Thailand caused by both natural and anthropogenic salination processes. Management of inland salt-affected soil depends upon the degree of salinity and the prevalent local salination processes. In general, salt-affected soils in the northeast are high in sodium and chloride content, sandy and low in fertility. For the slightly to moderately salt affected soils, the areas are generally used for rice cultivation or other cash crops. Salt affected soil improvement practices mostly applied in these areas involve the use of appropriate technology packages, including the selection of salt-tolerant crop species and the use of organic amendments such as compost, organic matter, and green manure.

Numerous studies showed that application of organic amendments such as green manure, farmyard manure or compost to increase soil fertility and improve soil physical properties. The use of organic amendments in combination with reshaping the paddy field was another effective method that LDD promotes to farmers to increase rice yield in salt affected land. Furthermore, land leveling with planting salt tolerant trees on the ridge was successfully remediated the moderately salt affected soils.

Prevention and reclamation practices are used in strongly saline soils. In the Northeastern where strongly salt-affected soils occur, biological control as reforestation which include screening of suitable salt-tolerant varieties of plants with a deep rooting system and high consumptive use of water are recommended to prevent spread of soil salinization. These plants have been grown in saline areas to reduce amount of excess water that flows to water table, this saline which is lower from the groundwater table will not up to soil surface. For salt-tolerant trees, *Acacia ampliceps, Casuarina glauca and Melaleuca acaciodes,* grew successfully well in the severely salt-affected soils. While some native species namely *Azadirachta indica, Cassia siamea, Tamarindus indica* and *Pithecellobium dulce* could also tolerate at high salinity level.

The coastal salt-affected soils are found scattered along the coast of the Southern and Eastern regions. These areas are subject to tidal influences and brackish or sea water intrusion. These soils are very young heavy clay or silty clay with little profile development. They are very saline and most of them are flooded during spring tides only. Factors limiting plant growth include not only salinity but also potential acidity and degree of ripening of the soil. Therefore, sea barrier gate has been recommended to prevent an encroachment of sea water and then the salts from root zone will be leached by rain or water which has lower salt concentration.

Management of coastal salt-affected soils needs to cope with the specific characteristics of the soil, crop and water regimes. Rice cultivation is common in these areas. Beside rice cultivation, economic salt tolerant crops such as tomato, cabbage, sweetpotato, corns, cantaloupe and taro were suggested with organic amendments and chemical fertilizer application. Moreover appropriate irrigation with mulching and use of farmyard manure plus chemical fertilizer gave higher crop yield. In addition the removal of soluble and exchangeable sodium from the root zone was necessary. Dikes were constructed to prevent high tides from inundating the lands, with flood gates to regulate brine and fresh water flows. Farmers have also used indigenous technologies to reclaim their lands.

The last few decades, the rapid increase in numbers of shrimp ponds and salt flat displacing mangrove forests and agricultural lands. Although inappropriate land use gives farmers high profit, these land use activities has caused serious soil deterioration and environmental problems in salt affected soils. It would lead to a long term economic value, investment cost increasing, soil problems and water management. Several government agencies and related agencies have therefore set high priority in the research on the impacts of shrimp farming on coastal ecosystems particularly nutrients and sediment discharged from shrimp ponds on soil and water quality as well as performance of adjacent economic crops.

SELECTION CRITERIA OF TECHNOLOGIES AND APPROACHES FOR SUSTAINABLE SOIL MANAGEMENT PRACTICES

The following criteria have been agreed by National Consultancies during LDD regional meetings to inventory and select technologies for documentation using FAO-WOCAT tools for salt affected

soils in Thailand. Selection criteria of technologies and approaches for documentation questionnaire for technologies and questionnaire for approaches are as follow:

1) Relevance: The selected technologies should be able to address land degradations that are prevalent in the area or region,
2) Robust: The selected technologies should be able to withstand the test of time and proven to be applicable in a wide variety of conditions,
3) Replicability and Transferability: The selected technologies should be replicable and transferable to a wide variety of land users in similar conditions,
4) Effectiveness: The technologies should be effective in preventing, reducing, recovering from or adapting to land degradation problems facing land users in the area or region,
5) Efficiency: The technologies should be cost effective in addressing specific land degradation problems in the region. Nevertheless, priority should be given to technologies or approaches that generate favorable social returns with emphasis given to technologies or approaches that incentivize stakeholders or public-private partnerships in achieving long-term sustainability outcome.
6) Livelihood: The selected technologies should be applicable to livelihood activities that are prevalent in the area or region and can potentially contribute to household food security and sustainable livelihood enhancement,
7) Empowerment: The selected technologies and/or approaches can potentially contribute to empowering local community and enhancing social equality in favor of the disadvantaged, i.e., the poor, the aged, and women and girls, etc.,
8) No Negative Externality: The selected technologies should be free from creating negative externalities or off-site impacts be it environmental, social or economic, and
9) Sustainability: The selected technologies should be sustainable in all three main aspects: social, economic and environmental.

SUSTAINABLE SOIL MANAGEMENT BEST PRACTICES FOR ACCELERATING ACTIONS IN HALTING SOIL SALINIZATION AND SALINE SOIL MANAGEMENT

1. SEAWEED DEVELOPMENT FISHERIES GROUPS

1. General Information and description of best practice/technology

Introduction

The trend of consuming healthy food, a main value of the Thai society at the present age is considered to be an important factor which helps people see the importance of seaweed resources. This has brought about demand of products and raw products including business of seaweed cultivation. Seaweed especially for sea grapes is a seaweed with popularity for cultivation due to its good taste and being healthy food with high nutritional values rich in several vitamins. Therefore, there are a large number of people who are interested in cultivating and processing the seaweed for health food of this kind. Establishing a group of farmers for seaweed farming is grouping of farmers in the area of Laem Pak Bia sub-district and Bang Kaew sub-district, Ban Laem district and Hat Chao Samran sub-district, Muang district, Phetchaburi province and the area of sub-districts nearby due to the fact that most people make a living from conducting sea salt farming and coastal fisheries. Therefore, this is done to create a new occupation or a supplementary occupation bringing about incomes to families. Moreover, this is to promote seaweed to be well known, to expand markets and to propagate knowledge to farmers as well as for those who are interested in making a living from seaweed.

Initially, there were 26 applicants applying to be members of the group. There is an operation committee consisting of 9 people. The establishment of the Phetchaburi seaweed development fishery group is located at 118, Moo 1, Laem Phak Bia sub-district, Ban Laem district, Phetchaburi province.

Operating facility House No. 18, Moo 1, Laem Phak Bia sub-district, Ban Laem district, Phetchaburi province.

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Geographical location

Latitude 100.2865. Longitude 13.0464

Operation Start Date

The operation starts in 2022

2. Approach, aims, and enabling environment

Objectives of the approach

1. To create a new occupation or part-time self-employment bringing about incomes to families and to make use of areas with saline soil sustainably

2. To promote seaweed to be well known for market expansion

3. To build networks and propagate knowledge to farmers and exchange experiences

4. To build guarantee and equitable rights in accessing business of aquaculture for the type of algae cultivation

5. To access aid of goverment agencies and private agencies

Methods to be implemented

1. Training for propagating techniques and methods of cultivating and processing sea grapes

2. Assembling for establishing a group

3. Establishing as a group of farmers who cultivate sea grapes in order to obtain products enough to meet demand of the market and to have bargaining power

4. To build the network of those who cultivate sea grapes in the district of Ban -Laem

Procedures of operation

1. Department of Fisheries has extended research works by organizing the project of course training of cultivating and processing sea grapes in order to propagate knowledge, techniques and methods of cultivating and processing sea grapes.

2. Take the group member for a tour study to see sea grapes culture at Phetchaburi Coastal Aquaculture Research and Development Center and the Model Sea Farm Royal Development Project, Phetchaburi province

3. Gather the farmer group together to establish a group to exchange knowledge regarding techniques and methods of cultivating and processing sea grapes

4. Hold a meeting together for planning, determining directions, goals and appointing an operation committee to determine duties and responsibilities

5. Allow members to consider objectives and regulations of the group regarding details according to the document proposed by members

3. Participation and roles of stakeholders involved

1. The stakeholders involving in this approach and the roles

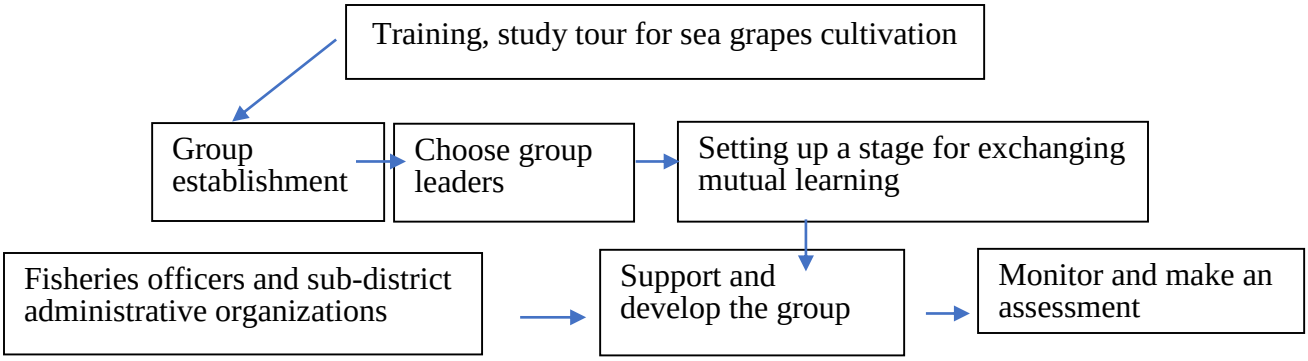
Stakeholders or organizations involving with this approach	**Identify stakeholders**	**Explain roles of stakeholders or organizations**
Local land users or local community	Group members accounting for 26 people	Taking actions together to make the group become strong and have bargaining power
SLM experts or agriculture consultants	Officers of Phetchaburi Coastal Aquaculture Research and Development Center	Give advice and knowledge in managing the group continuously

Researchers	Professor from Ratchapat Phetchaburi University	Conduct research regarding utilization of culled algae
Local government	Laem Phak Bia Sub-district Administrative Organization, Ban Laem district, Phetchaburi province	Participation and collaboration in establishing the group

2. Involvement of local land users or local communities in phases of the approach

Phase of the approach	**Involvement of local land users or local communities**	**Identify those involved and explain activities**
Initiative or motivation	Mobilize forces by oneself	Government agencies, group members propagating knowledge and making a study tour in order to adjust it in their own areas
Planning	Interaction and Mobilize forces by oneself	Officers from the model farm project and Laem Phak Bia Administrative Organization participate in helping plan group establishment.
Implementation	Interaction and Mobilize forces by oneself	The member group mutually helps draft group regulations and goods standards.
Monitoring or assessment	Mobilize forces by oneself	Monitor and check together with officers in order to bring about standards.

Diagram showing work procedures



Decision-making for selecting SLM technology : Land users are the ones who are the main decision makers supported by SLM experts

Decision-making is based on SLM knowledge assessment which has been well recorded (using data in making decisions) and from government agencies.

4. Technical specifications, implementation activities, inputs, and costs

1. Training has been set up for land users or other stakeholders whereby there are forms of training, namely

- Go to see the actual place / farmers vs. farmers
- Organize courses
- Use areas for demonstration

The training topic: Operational practice on sea grapes culture

2. Consulting services: Land users access consulting services available at the government agency which is Phetchaburi Coastal Aquaculture Research and Development Center.

3. Strengthening institutes (organizational development)

- Phak Bia Sub-district Administrative Organization gives aid and support in terms of the meeting venue and facilitates coordination.
- Phetchaburi Coastal Aquaculture Research and Development Centre gives aid in training, increasing knowledge and regulations of establishing the group.

4. Monitoring and assessment are part of the approach to bring about standards of the group.

5. Research: Professors from Ratchapat Petchaburi University conduct research on utilization of culled seaweed

4.1 Income and expenditure on technology

1. Initial costs and expenses in using the technology

Inputs	Unit	Quantity	Expenses per unit (USD)	All expenses per inputs (USD)	% of expenses incurred by land users
Labor					
Labor for planting in the area if 0.3 ha	Labor	3	8.82	26.46	100
Equipment					
Water pump of 0.5 horse power	Pump	1	73.5	73.5	100
Wheelbarrow	Item	1	176.5	176.5	100
Oxygen concentrator	Machine	1	147	147	100
Super Charge air compressor	Machine	1	117.6	117.6	100
Skimmer	Machine	5	14.7	73.5	100
500 liter plastic bucket	Bucket	5	58.8	294	100
Second-hand 120 hp. diesel sea water pump	Machine	1	441	441	100
8 inch water sucker	Machine	1	294	294	100
Water salinity meter	Machine	1	8.82	8.82	100
8 inch PVC tube with the length of 3 meters	Piece	3	29.4	88.2	100
Spin and dry machine	Machine	1	29.4	29.4	100
Yield storage basket	Item	5	17.7	88.5	100
Plant materials					
The variety used in the area of 2 rai	Kilogram	1,000	1.47	1,470	100
Service wage in building the nursery					
Materials and equipment in building the nursery including labor costs	Square meters	30	147	4,410	100
Digging the culture pond	Rai	2	588.2	1.176.4	100
Total expeneses of establishing the technology (US dollars)				**8,914.8**	

Calculation of costs and expenses

Expenses are calculated to technology-based areas (Unit of size and area: 2 rai)

The currency used to calculate expenses with the unit as Baht

Exchange rate (to US. dollars) 1 US. dollars = 34.0 Baht (year 2023)

Average wage in hiring labor per day is 300 Baht

Most important factors having effects on expenses

1. Labor cost
2. Electricity cost
3. Fuel cost

2. Maintenance costs

Inputs	Unit	Quantity	Expenses per unit (USD)	All expenses per inputs (USD)	% of expenses incurred by land users
Labor					
Management during culture	Force	1	29.4 USD/month	352.8	100
Yield management and management after harvesting	Force	1	29.4 USD/month	352.8	100
Others					
Electricity cost	USD	12	47	564	100
Diesel costs	USD	12	47	564	100
All expenses of technological maintenance (US dollars)				**1,833.6**	

Incomes from selling products and net income

- In an area of 0.3 ha, yields can be harvested for 1,200 kilograms (already selected to remain 600 kilograms) and in 1 year, harvesting can be conducted for 10 times. Therefore, all yields will be obtained accounting for 600*10 = 6,000 kgs/ha/year

- The wholesale price in front of the farm is 3.53 USD per kilo. The total income accounts for 6,000*3.53 = 21,180 USD.

- The sorting out cost is 0.58 USD per kilo. Therefore, the selection cost accounts for 1,200*10*0.58 = 6,960 USD.

- The net income/rai/year accounts for 21,180 – 6,960 = 14,220 USD

5. Conclusion

Impact analysis and summary

1. Impact of the approach

The approach	Given answers
makes land users implement SLM technology and maintain conditions or not	moderately
improves cooperation and operation of SLM effectively or not	highly
mobilizes forces or improves financial sources access for SLM operation or not	highly
improves knowledge and abilities of land users in conducting SLM or not	highly
builds or makes the institute become strong or brings about firm cooperation among stakeholders	moderately
promotes the youth or offspring of land users to participate in SLM or not	moderately
improves market access or not	highly
leads to sustainable land use or energy sources or not	highly
leads to employment opportunities and incomes or not	highly

2. Main motivation of land users to implement SLM

-Profits (ability) ratio of expenses to increasing benefits

- Decreasing land degradation
- Environmental conscious
- Increasing SLM knowledge and skills

3. Sustainability of approach activities

Land users can make things practiced based on this approach sustainable whereby there are government agencies from Phetchaburi Coastal Aquaculture Research and development Center as advisors

4. Strengths

Utilization in the area with saline soil with the context changed from conducting only salt farming previously has caused more problems of saline soil. It is hard to fix the problem. This requires very high investment. Using this approach has brought about adjustment of land use which is suitable with the plant (seaweed) and saltiness is not much used. Moreover, this also brings about more increasing good ecosystems. There is no sewage discharged from the system. Therefore, the environment has gradually become better up to the present time. Market (inputs procurement, selling products) and prices due to being close to the main communication route

5. Weaknesses/risks

When there is more production, there is always problems of competition for market shares, falling prices and labors. In some periods, there is shortage of labors. There are problems of expensive oil prices. Therefore, establishing a group is the approach to solve the mentioned problem in order to have bargaining powers to purchase items and equipment with lower prices. Moreover, goods standards can be upgraded.

Activities pictures

Fig.1 Salt farming had faced a low salt price Problem.

Fig.2 Maximum pond area is 0.32 hectare. Pond depth is 1.50 meters. Slope distance is 1.80 meters. Width is 2.50 meters.

Fig.3 Pump seawater into the pond, water level is 1.5 meters.

Fig.4 Seaweed culture at bottom of the pond Plant spacing is 50x50 cm.

Fig.5 Cleaning with Skimmer for exchanging air in water and making a small air bubble (Photographer : Kulvadee Sutthawat)

Fig.6 Seaweed sorting for distribution

VDO LINK : https://www.youtube.com/watch?v=l1G9d2Zcej0

2. ECO-FRIENDLY SYSTEM OF SEA GRAPES CULTURE

1. General Information and description of best practice/technology

Introduction

The Eco-friendly sea grapes culture system together with local wisdom is the guideline in the area of coastal saline soil for sustainable land use.

Sea grapes are considered to be a unicellular plant in the sea with importance to the environment. They are also part of food chain with the ecosystem to keep the natural balance of the ocean. They are important to human beings' living in terms of nutrition, supplementary food for health as well as necessity for young aquatic animals. They may function as shelters or food sources for them including prevention and removal of waste water possibly occurring in the sea water and water resources. Sea grapes live together with bacteria whereby bacteria help decompose organic compounds to be in the form of inorganic compounds and sea grapes use these compounds. For the other part, sea grapes can be used for industry and cosmetics. The extract from sea grapes is used in the pharmaceutical industry to prevent and treat diseases.

Previously, the area of this technology was *Avicennia sp.* Later, the area was changed to be the area of salt farming. In 1984, they transformed land use into Brine shrimp culture. Then once again, they faced economic, coupled with problems of environmental impact. Therefore, farmers changed utilization to sea grapes culture in 2016.

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Geographical location

Latitude 100.07979 Longitude 13.03804

Operation Start Date

The operation started in 2016

2. Approach, aims, and enabling environment

Main purpose of best practice / technology

1. To have eco-friendly sea grapes culture systems
2. To prevent and remove waste water likely to occur in the sea water and water resources
3. To utilize coastal lands (coastal saline soil) sustainably

Technical specifications, implementation activities

1. Area selection: Growing sea grapes in the pond system requires management in terms of growing factors to be suitable for growth of sea grapes. Regarding location of the farm, it has to be far away from the community zone and industrial factories to avoid problems of discarded water from communities and pollution sources. In this aspect, it is risky for consumption. Sea grape is a green seaweed that can tolerant a narrow range of salinity.

Therefore, farm location must be near the coast or the water must have salinity at the level of sea water such as coastal plains or areas at the mouth of the river connected to the sea. The reason for this is the fact that water salinity can be controlled at the suitable level and it should be far away from flooding of fresh water in the rainy season. The characteristic of soil should be clay or sandy clay so that it can store water. Water used to grow sea grapes should have salinity of 27-33 parts per thousand. The sea water along the shoreline is mostly used. Moreover, there should be convenient communication.

2. Pond preparation refers to conditioning the pond floor such as the pH value, cleanliness of the pond bottom and within the pond so that sea grapes can be cultivated resulting in highest yields per pond area.

3. Management during cultivation

3.1 During cultivation, there should be water drainage about 30% by pumping water into the pond at least 1 time per week so that the sea grapes will receive nutrients, growth stimulus. This helps circulate the water. The sea grapes can absorb nutrients better. Moreover, installation of water inlets and outlets with close and open water gate according to natural water levels can be done or the principle of tidal condition observation can be used together with the lunar calendar (local wisdom: waxing moon and waning moon).

3.2 Frequency of pumping water in depends on the age of cultivation and density of the sea grapes in order to increase natural nutrients, circulate water and keep the water level in the cultivation pond.

3.3 Shrimps and horse crabs are released into the pond to get rid of pests of the sea grapes and for the purpose of being supplementary incomes.

4. Yield harvesting

4.1 It takes about 3 months to grow sea grapes until they can give yields. The yields can be harvested every 2 weeks continuously for 2 years. However, harvesting cannot be conducted during June to September due to the rainy season.

4.2 In the area of 1 rai, yields of 1,200 kilograms can be harvested.

5. Management after harvesting

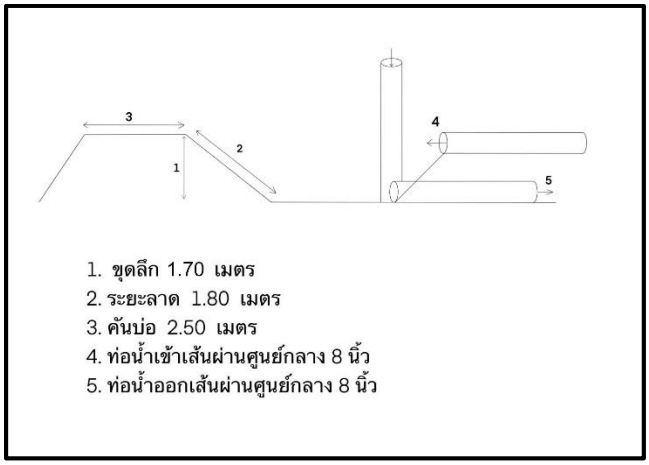
5.1 Put the sea grapes in a 500 litre storage tank. Fill it with water pumped from the pond to store the sea grapes for a night.

5.2 Sort out, clean by using the machine "skimmer" to circulate air in the water and produce very fine air bubbles. The objective of doing this is to remove dirt contaminating the sea grapes. The machine is turned on all the time not more than 3 days. during this time, the water has to be drained every day.

5.3 The process of yield packaging: After cleaning the sea grapes, shake off water from the sea grapes by using the spin and dry machine modified from the spinning bin of a washing machine for 30 seconds. Then, pack them in foam crates supported with water absorbent pads.

5.4 The age of sea grapes lasts 7 days. The sea grapes must be kept in room temperature.

Technical drawing plan of the technology



1. Dig 1.70 meter deep
2. Distance of the slope accounting for 1.80 meter
3. Ridge of the pond accounting for 2.50 meters wide
4. Water inlet with a diameter of 8 inches
5. Water outlet with a diameter of 8 inches

Location chosen to build a nursery

1. A place near the shoreline so that a large amount of sea water can be used for cultivation and water drainage.

2. A source where sea water has salinity not lower than 25 ppt. throughout the year because sea grapes can grow well in the sea water with salinity between 25-35 parts in 1000 (ppt.). The place where the farm is located at should be habitats close to the open sea. It should not be situated at the canal with brackish water carried a long way from the open sea making the water have low salinity in the rainy season. This is due to the fact that expenses are required and it takes time in adjusting salinity. If this is so, costs of cultivation increase.

3. Communication is convenient: There is readiness in terms of public utility systems such as electricity, tap water etc. This is important for equipment, instruments using electricity in sea grapes cultivation. For the water system, fresh water is used in the farm to wash equipment or to reduce the salinity level of the sea water.

4. The place should be far away from industrial factories or sources of agricultural farming using chemicals or being pollution sources. In fact, sea grapes can tolerate chemicals or pollution only very little. Sea grapes can be accumulated with some chemicals. This can affect consumers. Therefore, the farm location should be far away from the mentioned place.

5. The place should be the source where good sea grape species can be found easily.

6. The size of the pond should not exceed 2 rai whereby the dimension is as follows: dig 1.70 meter deep; distance of slope is 1.80 meters; Ridge of the pond accounting for 2.50 meters wide.

7. Dry the pone in the sun for at least 15 days. Spread lime for adjusting the pond bottom with the rate of 15 kg./rai.

8. Pump sea water to flood the soil surface at the pond bottom for the height of 50 centimeters in order to balance the pH soil reaction for 2 days. Then, discard the water.

9. Pump sea water into the pond for about a half of the pond, making it convenient for transplanting sea grapes on the soil surface at the pond bottom for the spacing of 50x50 centimeters. When transplantation is finished, fill up the pond with water.

Note If the pond is old, it should be dried, spread with lime for adjusting soil pH in the pond bottom. Drying the pond so that the pond bottom is exposed to sunlight and oxygen helps organic matters piling up in the pond decompose better. This helps improve the growth rate of sea grapes.

3. Environment

The mentioned area, the Annual Mean Rainfall is 987.40 mm., which is at the semi-dry level. The area is flat and 1 meter from the mean seal level. The soil depth is more than 120 centimeters. The soil texture on the top is fine clay. The soil texture at the bottom is clay. The level of organic matters is high (>3%). The ground water cannot be used. The water at the soil surface is at the level which is more than enough. Regarding the water quality (not treated yet), the water can be used for agriculture only. The soil is coastal saline soil.

3.1 Impact in the on-site from using the technology

1. Economic and social impact

Aspect	Impact	Before	After
1. Variety of products	**Very positive**	The area was used for salt farming and raising Brine shrimps. Small quantities of yields were obtained, which did not cover the expense.	Sea grapes culture and introducing shrimps and crabs in the culture system have brought about diversities.
2. Area for production	**Positive**	A little	When farmers receive knowledge transfer, the area of production has been expanded more.
3. Farm incomes	**Most increase**	Loss from raising Brine shrimps	Receive average profit of 480,000 per rai
4. Variety of income-producing sources	**Positive a little**	One-way income of raising Brine shrimps	Incomes obtained from sea grapes, shrimps and horse crabs

2. Social and cultural impact

Aspect	Impact	Before	After
1. Food security and self-reliance	**Positive**	One-way income of raising Brine shrimps	One-way income of raising Brine shrimps
2. Institute of the community	**Positive**	-	Unity of people in the community has been brought about more whereby people mutually exchange knowledge and experiences.
3. SLM or knowledge of land degradation management	**Positive**	The knowledge has not been propagated yet.	The technology has been accepted and the knowledge starts to be propagated more widely.

3. Ecological impact

Aspect	Impact	Before	After
1. Water quality	**Very positive**	Having problems of waste water	The problem of waste water has been reduced greatly.
2. Salinity level in the Soil salinity	**Very positive**	Salinity level more than 700 ppt	The salinity level of 28-32 ppt is suitable for sea grape culture.
3. Variety of animals	**Positive**	None	Introducing aquatic animals into the culture, namely Lutjanus, shrimps and horse crabs

3.2 Off-site impact from using the technology

Aspect	Impact	Before	After
1.The resilience/ability of filtration (by soil, plants, wetlands)	**Positive**	Due to being the area of salt farming, the soil is very saline. There are no plants growing at all.	The area of mangrove forests has been adjusted better. Swamp forests appear more. A variety of plants starts to appear.
2. Pollution occurs at the seaside.	**Positive**	Waste is released from the system.	Seaweed culture helps get rid of waste, making sea water become cleaner.

4. Acceptance of the technology and application

There is acceptance among farmers. They implement the technology through sea grapes culture. This is done by circulating water and treating natural water to keep balance of the ecosystem to be suitable for living of aquatic animals. This condition lasts throughout sea grapes cultivation without draining the water going through cultivation and organic matters into the environment or this culture is so-called Zero Waste Farm. Apart from obtaining products which are sea grapes, by-products resulting from releasing shrimps and horse crabs can be utilized and increase values.

Activities pictures

Fig. 1-2 Eco-friendly sea grapes culture system groups meeting, Petchaburi province

3. KED FOREST PARK, PROTOTYPE OF COMMUNITY FOREST MANAGEMENT IN THE BRACKISH WATER ECOSYSTEM AT KHUNG BANG KRACHAO (BANG KRACHAO RIVER BEND)

1. General Information and description of best practice/technology

Information

The story started with a small group of people in the area of Khung Bang Krachao. These people wanted to conserve and develop resources and the environment of Phra Pradaeng District in Samut Prakan Province since 2007 in the name of the group "Urban Community Forest Park, Suan Pa Ked Nom Klao (Ked Nom Klao Forest Park)" or so-called briefly as " Suan Pa Ked (Ked Forest Park)". It is the state property land in the project area of Garden amid the Metropolis. It is located at Moo 2, Songkanong sub-dristict, Phra Pradaeng District of Samut Prakan Province with the area of 16 rai. Mr. Prempree Tairat, the community leader of Moo 2, gathered community people in the area to conduct activities on the basis of natural resources and environment conservation so that they will remain in the original condition as much as possible. Changing area conditions should be avoided especially for building permanent objects or permanent buildings. A lot of things are done. For example, garden beds are cleaned. Weeds are removed. Planting and maintenance are conducted for indigenous plants, edible plants, medicinal plants. This also includes collecting seeds of indigenous plants for seedling propagation. Then, these seedlings are transferred to be planted in the forest park of urban communities.

Operating facility Suan Pa Ked Nom Klao, Moo 2, Soi Petch Hueng 16, Song Kanong sub-district (Soi Wat Pa Ked), Phra Pradaeng District of Samut Prakan Province 10130

Land user Mrs. Prempree Trirat

Compiler Mr. Pramote Yamclee

Reviewer Dr.Bunjirtluk Jintaridth

Geographical location

Latitude 100.558004 Longitude 13.6675744

Operation Start Date

The operation started in 2007

Main purpose of this best practice is to conserve and propagate indigenous plant varieties, to have green areas available in the form of urban community forests for environmental restoration, to prevent and treat soil and water pollution and to take advantage of land use in the brackish water ecosystem at the area of Khung Bang Krachao sustainably.

Moreover, he has also persuaded people from outside the area (outsider) to help plant other trees additionally. Products from the grown plants are cooked for food given to tourists in the form of "indigenous vegetables, and local food". Apart from cooperation in terms of being responsible for taking care of conserving soil and water resources and increasing green areas to Khung Bang Krachao (Bang Krachao river bend), people in this community can also transfer experiences and knowledge in local development to students, groups of people and organizations interested in coming for a study tour to extend and develop their own communities further. Therefore, Ked Forest Park is considered to be a prototype of developing green-area communities truly.

Currently, Suan Pa Ked (Ked Forest Park) is the network of public sector cooperating with Nakhon Khuean Khan Green Area and Eco-management Center under the supervision of the Royal Initiative and Special Project Bureau, The Royal Forest Department in the form of green area conservation network. This is promoting the public to participate in managing Khung Bang Krachao green areas to be in line with the concept of the Royal Initiatives of Her Royal Highness Princess Maha Chakri Sirindhorn. Conducting the mentioned activities brings about cooperation between agencies of the government sector, the private sector and educational institutes continuously in the form of activities of Corporate Social Responsibility (CSR). The approach of managing green areas sustainably must be based on conservation and development through participation in several sectors. Most importantly, it is the matter of participation of communities in the area because ultimately, the trees which everyone helps plant will benefit communities in the area directly. Therefore, Suan Pa Ked is the group of strong communities coming in to have roles and participate in taking care of green areas in Khung Bang Krachao continuously and sustainably for over 10 years. As a result, this area can absorb carbon dioxide for the annual average of 6,000 tonnes and produce oxygen for 6 million tonnes per day until it has been named as **"The Best Urban Oasis of Asia" by the Time Asia magazine, Best of Asia 2006 Edition.**

Therefore, this place has become learning resources in terms of eco-friendly development and is an important ozone source near the center of the metropolis.

***Remarks:** Khung means Bend of watercourse

2. Classification of the best practice / technology

Due to the fact that the area of this technology was previously the ecosystem of brackish-water forests or the convergence area of seawater (saline water) and fresh water. Salinity of the brackish water is between 0.5 – 30 ppt (part per thousand) or of the amount of salt sodium between 0.05 – 3 %. In recent years, there have been changes at Khung Bang Krachao (Bang Krachao river bend). What can be seen obviously is the fact that the area has been waterlogged by sea water longer than before. Previously, waterlogging lasted only 3-4 months, but currently, it lasts more than 6 months. When there is a longer period of waterlogging of the seawater, fruit trees which farmers plant in the garden bed gradually stand and die such as the Nam Dock Mai mango, Syzygium, Garcinia, including many kind of aquatic animals such as Freshwater fish which cannot live in saline water and dies in succession. When fish dies, mosquito larva are not eaten. As a result, the quantity of mosquito larva increases. The garden bed is transformed into accommodation. Watercourses are filled, resulting in no circulation of water resources and waste water. There is more waste in the area. Also due to more expansion of the community, green areas in the part of the private property about 90% have been changed rapidly in terms of social and economic conditions.

3. Technical specifications, implementation activities

1. Suan Pa Ked Nom Klao (Ked Nom Klao Forest Park) is considered to be one of the target areas of conserving green areas of the Garden amid Metropolis project according to Royal Initiative of His Majesty King Bhumibol Adulyadej (King Rama 9) who wanted to conserve the nature at the area of Khung Bang Krachao for all 6 sub-districts, namely Tambon Bang Nampueng, Tambon Bangkohbua, Tambon Song Kanong, Tambon Bang Krachao, Tambon Bangkasob and Tambon Bang Yo of Phra Pradaeng District of Samut Prakan Province or so-called pork stomach. The objective is to build and support it to be an eco-tourism destinations in the form of urban community forests and to function as lungs for Bangkokians.

2. Later, Her Royal highness Princess Maha Chakri Sirindhorn came to continue the project and had a royal idea regarding guidelines of utilizing the original area in the community to conserve plant varieties and way of life of villagers in the area of Suan Pa Ked Nom Klao (Ked Nom Klao Forest Park) to focus on simplicity like in the past. The objective is also to control construction to be in line with and not to destroy the environment so that this will be a prototype of development for people in the nearby district. In fact, people of Song Kanong sub-district have held on to this as guidelines for practice continuously to the present time.

3. Khung Bang Krachao areas consist of wetlands with the area accounting for about 11,818 rai characterized by an island surrounded by the Chaophraya river before the river flows into the Gulf of Thailand. Therefore, the area is influenced by rising sea water at the end of the year. Saline water floods the area until it becomes brackish water. Therefore, there is a structure of the ecosystem of brackish water plants. This can be noticed from Nypa palm which is ubiquitous along the line of the riverbank. Nypa palm growing as large Nypa palm forest groups is found at some parts of the island. It holds the eroded soil at the riverbank well. The plant society in the ecosystem of brackish water forests is the society of salt-tolerant plants. Besides the family of mangroves, there are also local plant varieties found mainly in brackish-water forests, namely:

(1) perennial plants such as *Sonneratia caseolaris*, *Aegiceras corniculatum*, ***Xylocarpus granatum*** **Koenig**, ***Barringtonia acutangula*** **(L.) Gaertn.,** *Intsia bijuga, Bruguiera sexangula, Pometia Pinnata Forst, Dolichandrone spathacea, Thespesia populnea, Hibiscus tiliaceus. L., Cerbera odollam, Nypa palm,* Nypa fruticans

(2) shrubs such as *Glochidion Littorale Blume*

(3) undergrowth such as *Acanthus ebracteatus* Vahl, *Acrostichum aureum* L., *Derris trifoliate* Lour., *Parthenocissus quinquefolia* (L.) Planch.

(4) Climbers such as *Stenochlaena palusris,* Melanthera biflora (L.) Wild, ***Flagellaria indica*** **L.**

and (5) living things found in the water are algae and plant plankton. Therefore, there are high biodiversity and characteristics consisting of environmental factors as follows:

1) Rising and falling of sea water in the ecosystem of brackish water forests occur in the area where the sea water does not flood so often by being influenced from waves and currents.

2) The ecosystem of brackish water forests is next to the seashore towards the inland. This is different from the ecosystem of mangrove forests which is connected with the seashore of the mouth of the river or the gulf.

3) Brackish water forests consist of hard clay while soil in mangrove forests is newly germinating clay with softness and depth.

4. Regarding restoration of the ecosystem in the area of brackish water forests, there is tree planting for 3 levels according to advice of The Royal Forest Department as follows:

1) Main plants refer to local plants in the area, namely plants in mangrove forests which are tolerant to being brackish and salinity of natural water resources for more than 6 months per year. The plants grown are *Cerbera odollam, Indian laurel, Bruguiera sexangul, Intsia bijuga, Thespesia populnea*, cork tree and Copper pod.

2) Secondary plants refer to edible plants for fruit trees and plants with edible leaves. These plants are tolerant to brackish conditions and salinity such as tamarind, neem, Cassod tree, Great morinda, Luna nut, *Ardisia polycephala*

3) Medicinal plants thriving well under shade of big trees such as *Piper Samentosum, Solanum incanum, Pandanus leaf, Cordyline fruticosa*, Sea holly

5. There is management of agroforestry forest park (Urban Forestry) through soil improvement, water management, fresh water reservation, saline water solutions in the dry season, weed removal, fertilizer application, tillage, planting for repairing and maintaining trees in the cultivation plot continuously. Raw materials in the area of urban forestry are processed to be products to build incomes whereby the community in the area is promoted to participate in caring for green areas because it is close to and uses trees in the cultivation plot directly. Therefore, this is consistent with the approach of the Royal Initiative of Her Royal highness Princess Maha Chakri Sirindhorn given for being used as main guidelines which will bring about sustainable green-area management.

4. Financing and external material support

Incomes and expenses in using the technology

1. Initial costs and expenses in using the technology

Inputs	Unit	Quantity	Expenses per unit (USD)	All expenses per inputs (USD)	% of expenses incurred by land users
Labor					
Deepen the garden ditch in the area of 2.56 ha	Bed	50	17.6	880	100
Equipment					
Water pump	Machine	2	147	294	100
Compost	Tonne	30	29.4	882	100
15-15-15 chemical fertilizer	Sack	20	29.4	588	100
Lime	Tonne	10	88.2	882	100
500 liter plastic bucked	BucKed	5	58.8	294	100
Water salinity meter	Machine	2	29.4	58.8	100
8 inch PVC with the length of 3 meters	Piece	3	29.4	88.2	100
Plant material					
Plant varieties including planting labor costs in the area of 2.56 ha	Tree	10,000	0.15	1,500	100
Service wage in building the nursery					
Materials used in building the nursery including labor costs	Square meters	20	29.4	588	100
Total expenses of establishing the technology (US dollars)				**6,055**	

Calculation of costs and expenses

Expenses are calculated to technology-based areas (Unit of size and area: 2.56 ha)

The currency used to calculate expenses with the unit as USD

Exchange rate (to US. dollars) 1 US. dollars = 34.0 Baht (year 2023)

Average wage in hiring labor per day is 8.82 USD

Most important factors having effects on expenses

1. Labor cost
2. Agricultural materials costs
3. Construction materials costs

2. Expenses for maintenance

Inputs	Unit	Quantity	Expenses per unit (USD)	All expenses per inputs (USD)	% of expenses incurred by land users
Management during planting and maintenance	Force	1	29.4 USD/month	352.8	100
Others					
Electricity costs	USD	12	14.7	176.4	100
Total expenses of establishing the technology (US dollars)				**529.20**	

3. Incomes from selling products and net incomes

Before using the technology No incomes

After using the technology Having net incomes from selling products related to the forest park and organizing tourism activities within the community, including OTOP goods about 2,941 USD annually

4. Summary of expenses and net incomes

Total income	8,823.5	USD
Total expenses in starting and maintenance	6,558.8	USD
Total net income	**2,264.7**	USD

5. Environment

The mentioned area has the annual mean rainfall in a period of 30 years accounting for 1,543.20 millimeters. The topographic area is flood plain with gentry slope (< 1 %). The elevation is 50-60 centimeters higher than the mean sea level. The soil is Samutprakarn soil series (Sm), soil series group 3. The parent material of soil is derived from marine sediments mixing with alluvial sediments. The soil depth is medium level. The top soil is clay texture. The subsoil is greenish gray clay. Soil reaction is moderately acidic to moderately alkaline (pH 6.6-8.0). The limitation factor of land-use is saline soil and be flooded by sea water. Farmers are normally used for fish farming, shrimps or left deserted. Ground water cannot be utilized. Water for farming is enough. Regarding the water quality (not treated yet), the water can be used for agriculture only.

5.1 Impact in the on-site from using the technology

1. Economic and social impact

Aspect	Impact	Before	After
1. Biodiversity	**Very positive**	The area was used for planting fruit. Small quantities of yields were obtained, which did not cover the expense.	Planting trees in the ecosystem of brackish-water forests and aquatic animal culture have brought about a variety of plant varieties and animal species.
2. Area for production	**Positive**	Very little	When the community is transferred with knowledge and public-benefit activities are organized, expansion of reforestation areas increases more.

Aspect	Impact	Before	After
3. Expenses of agricultural factors of production	**The impact can be ignored.**	Very little	Training has been organized. There is more learning from conducting study tour resulting in circulation of expenses.
4. Incomes from the forest park	**Increased**	Few incomes	Receive average profit of 10,000 Baht annually
5. A variety of income-producing sources	**A little positive**	One-way income of agricultural plants products	Having incomes from organizing tourism activities and OTOP product distribution

2. Social and cultural impact

Aspect	Impact	Before	After
1. Food security and being able to rely on oneself	**Positive**	One-way income of agricultural plants products	Having incomes from organizing tourism activities and OTOP product distribution
2. Institutes of the community	**Positive**	-	Unity of people in the community has been brought about more whereby people mutually exchange knowledge and experiences.

Aspect	Impact	Before	After
3. SLM or knowledge of land degradation management	**Positive**	The knowledge has not been propagated yet.	Bringing about the acceptance of the technology, having knowledge propagation and expansion of forestation areas more

3. Ecological impact

Aspect	Impact	Before	After
1. Water quality	**Positive**	Having problems of saline water, waste water	Problems of saline water and waste water reduce.
2. Soil salinity	**Positive**	Salinity level more than 30 ppt	Salinity level of 2-20 ppt which is suitable for forestation in brackish water
3. Biodiversity	**Positive**	None	There has been planting of local trees, salinity-tolerance trees and animal husbandry

5.2. Off-site impact from using the technology

Aspect	Impact	Before	After
1.The resilience/ ability of filtration (by soil, plants, wetlands)	**Positive**	Due to being the area of brackish water, the soil is very strongly saline. Sea water can reach the	The area of brackish water forests has improved. Tress of the mangrove family

Aspect	Impact	Before	After
		area and is waterlogged for a long time, resulting in damaging agricultural plants damaging.	increase. Plants start to have more diversities.
2. Pollution occurs to rivers and canals.	**Positive**	Waste is released from the system.	Brackish water forests help hold soil surface, reduce sediments, filter waste and absorb waste, making water resources become cleaner.

6. Acceptance of the technology and application

Nom Klao Ked forest park is an urban community forest initiated by the group of people who focus on the environment. People get together and work together from every sector of both government sectors and private sectors. People in the community cooperate with one another and support the project of green-area conservation. They do this by mutually driving the community to enter ecological learing resources. Moreover, people in the community cooperate in conservation and development by dredging canals so that they will become clearer and cleaner. They also help the water system circulate and treat natural water quality better. As a result, there are no more Aedes mosquitoes. They plant trees together according to the community way for more than 100 varieties. In addition to this, there are many kinds of birds living there for over 30 species. Therefore, this makes the community accept the technology and implement it to keep balance of the ecosystem and the environment to be suitable for living. By-products can be utilized and used to add values. Therefore, this place here is considered to be learning resources beyond the textbook where people can come to get in touch with natural way of life.

Activities Pictures

Fig.1 Samutprakarn Soil Series (Sm) found in the area

Fig.2 Closure dam blocking saline water with water inlet and outlet

Fig.3 Making compost from scraps in the forest park

Fig.4 Nypa palm forest growing in the brackish water ecosystem

Fig.5 Water sampling for salinity analysis

Fig.6 Soil sampling for salinity analysis

Fig.7 Building learning on local plant cultivation

Fig.8 Activities of using products from the forest park

Fig.9 Using questionnaires to distill knowledge learnt

Fig.10 Asking information from community leaders

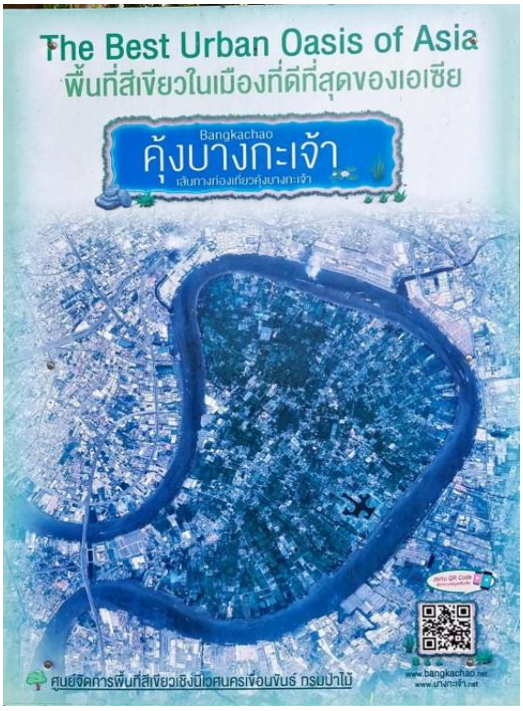


Fig.11 Bang Krachao, the green area in the best urban oasis of Asia

Fig.12 The operation team distills knowledge learned

VDO LINK :
https://drive.google.com/file/d/1mmn8l8q6WAESIxWumTNzWw_64gNlTnhA/view?usp=sharing

4. FISH FARMING FOR SALINE SOIL MANAGEMENT IN KHON KAEN PROVINCE, THAILAND

1. General Information and description of best practice/technology

Information

Saline soil management technology for the best utilization and efficiency through fish farming by Mr. Sompong Chaisong was applied at 171, Village No. 9, Ban Nong Nang Khwan Mueang Pia Subdistrict, Ban Phai District, Khon Kaen Province. The goal of this method is to do productively farming in saline soil. Previously, the land was mostly utilized for rice farming, but the yield was of poor quality in terms of flavor and texture, as well as quantity. It generated income of only 735.20 USD/ha in a year which they have *adequate income*. Nowadays, farmers earned 1,177-1,471 USD/ha after altering and adapting technology to tilapia and snapper farming, which was well worth the investment and required significantly less labor than rice production. In 2013, Mr. Sompong Chaisong who was selected to be the chairman of the Ban Nong Nang Khwan Fish Farmers Network Group. The Objectives are to reduce, prevent and restore the soil degradation in saline soil area and to improve farming incomes. in saline soil to be more diverse and sustainable agriculture.

Fish farming is a close system for Mr. Sompong Chaisong. Water will not be released from the fish pond to the outside, but it will be circulated around the farm. He would pump outside water into the ponds around 2-3 times a year once the water in the fish pond drained and decreased, but rainwater provided the majority of the water. Make a large and high embankment around the fish farming area to prevent saline water from outside seeping into the fish pond and spreading soil salinity. This technology has no serious impact on the environment or the local communities. Plants along the pond's edge include salt-tolerant perennials like coconut and tamarind, which are consumed in the home and to simply prevent soil erosion by holding the dirt on the embankment. Furthermore, it aids in keeping the soil surface moist at all times. It also prevents salt from moving from the bottom layers to the soil surface. Farmers who took part in the program and put the technology to work were pleased because they were able to produce high-quality agricultural products while still earning a steady income. Soil deterioration is also controlled by this

technology. The water in the area used to be 9-10 ppt salinity, but it is now 3-4 ppt, resulting in a decrease in soil salinity.

Operating facility 171 Village No. 9, Mueang Pia Subdistrict, Ban Phai District, Khon Kaen Province

Land user	Mr. Sompong Chaisong	
Compiler	Ms. Apasiree Meeklang	Land Development Department
Partner	Mrs. Pranee Sihaphan	Expert on land development system Office of land development district 5
	Mr. Mai Promsri	Agricultural Research officer Office of land development district 5
	Mr. Hassadin Laungphimai	Agricultural Research officer Office of land development district 5
	Ms. Thanyalak Nonthasri	Agricultural Research officer Office of land development district 5
	Ms. Methinee Phayomhom	Agricultural research officer Volunteer soil doctor research and development and network management service group
Reviewer	Dr.Bunjirtluk Jintaridth Dr.Prapa Taranet	

Geographical location

Latitude 102.683006 Longitude 16.095718

Operation Start Date

The operation started in 2002

2. Classification of the best practice/technology

Main purpose of best practice / technology

1. To have eco-friendly Sea grapes culture systems
2. To prevent and remove waste water likely to occur in the sea water and water resources
3. To utilize coastal lands (coastal saline soil) sustainably

The area used for fish farming is semi-arid. It receives 1,001-1,500 millimeters of rain on average. The annual rainfall averages 1241.6 milliliters (data from the Meteorological Station: Meteorological Department). The terrain is flat. Plateau height is 101-500 meters, soil depth is 81-120 cm. The topsoil is loamy and silty texture. The subsoil is coarse texture (sandy) and some may be fine/heavy texture (clay). The soil organic matter level is low (1%). Although the surface water is good in general, the water quality (untreated) is only suitable for agriculture. As a result of the salinity in the water, it is a limited issue for farming. Only a few types of crops can be produced as a result, and yields are poor.

3. Technical specifications, implementation activities, inputs, and costs

3.1 Implementation activities

1. The method was applied by building a fish pond that was divided into two parts: 1) a nursery pond with a size of 0.16 ha and 2) a pond for growing fish with a size of 0.16 ha or more per pond. The largest one is 0.56 ha.

2. The excavated soil was used as a pit with a 6 meter wide.

3. Adjust the acidity and alkalinity (pH) of the soil and water in the pond with manure and lime to reduce the salinity level.

4. With 40,000-50,000 fishes, non-sexual tilapia offspring were purchased. For roughly 1-2 months, they will be raised in nursery ponds.

5. Tilapia will be counted and placed into the pond when they reach around 2 inches in length, with 2,000-3,000 fishes per pond.

6. Asexual tilapia begin to give birth after three months, resulting in a dense population. The three-inch snapper was introduced into ponds to help remove tilapia juvenile fish. This method will lower the cost of tilapia and snapper food.

7. In a year, there are two rounds of fish production. Tilapia (primary income) sells for 1.77 USD per kilogram, while Snapper sells for 5.30-5.90 USD per kilogram (extra income).

3.2 Revenues and expenses in using the technology

1. Initial costs and expenses of using the technology

Input	Unit	Quantity	Expenses per unit (USD)	All Expenses per input (USD)	Percent (%) of expenses incurred by land users
Labor					
Fish pond digging and equipment	pond	22	1,029.40	22,647.20	100.0
Equipment					
set up such as water pumps, fishing nets	pond	22	441.18	9,705.88	100.0
Other					
herbivorous fish food and carnivorous fish food (given during the last 2 months before fishing) 1 pond 40 sacks of feed per production cycle.	sack	880	10.29	9,058.82	100.0
Manure (0.16 ha, put 100 kg) in an area of 6,72 ha (6.25 rai = 1 ha)	kilogram	4,200	0.06	252	100.0
Lime (0.16 ha put 100 kg) in the area of 6.72 ha (6.25 rai= 1 ha)	kilogram	4,200	0.05	210	100.0
Total expenses of establishing the technology				**41,856.47**	

Calculation of cost and expenses

Cost calculations and overhead costs are calculated per technology area. (Unit of size and area: 6.72 ha, conversion from 1 hectare: 1 ha = 6.25 rai).

The currency used to calculate costs with the unit as Baht

Exchange rate (to US dollars) 1 US. Dollars = 34.00 baht.

Average daily wage is 8.82 USD. Activities include digging fish ponds (period/frequency: beginning of production season) and purchasing established equipment such as Pumps, fishing nets (period/frequency: beginning of production season)

Most important factor having effects on expenses

Costs of fish feed have increased as a result of dense tilapia populations. To get rid of the juvenile tilapia, bring snapper to raise in the pond.

2. Maintenance costs

Input	Unit	Quantity	Expenses per unit (USD)	All Expenses per input (USD)	Percent (%) of expenses incurred by land users
Other					
Herbivorous fish food and carnivorous fish food (given during the last 2 months before fishing) 1 pond 40 sacks of feed per production cycle	sack	880	10.29	9,058.82	100.0
Manure (0.16 ha, put 100 kg) in an area of 6.72 ha (6.25 rai= 1 ha)	kilogram	4,200	0.06	252	100.0
Lime (0.16 ha put 100 kg) in the area of 6.72 ha (6.25 rai= 1 ha)	kilogram	4,200	0.05	210	100.0
Total expenses of maintaining the technological condition				**9,503.53**	

Maintenance activities

Feed the fish, check the water condition of the pond and fish in the pond (period/frequency: 2 times a day).

3.3 Revenue from sales of fish product

Before using technology**,** only 117.65 USD per year can be earned from rice farming.

After using technology**,** earning 147.06 USD each pond/production cycle from fish farming (there are 22 ponds). So the entire income is around 64,705.88 USD

3.4 Spending and net income

Total earnings	64,705.88	USD
The total cost of setup and maintenance	51,360.00	USD
A total net income was generated	**13,345.88**	USD

4. Environment

4.1 Impact in the on-site from using the technology

1.Economic and Social

Aspect	Impact	Before	After
1. Crop production	The greatest increase	Rice production with low yields but high capital costs.	Farming for tilapia and snapper with high yields and good prices, worth the investment.
2. Land management	Much easier	The efficiency of land utilization is estimated to be around 20%.	Approximately 80% of the land is used more efficiently.
3. Farm income	The greatest increase	Profit from the sale of 117.65 USD rice every production cycle.	Earn income from fish farming 1,470.59 USD per production cycle.
4. Workload	Increase	During the rice production stage, there are numerous activities and tasks to complete.	It does not require much attention and can be fed fish in its natural state twice a day.

2. Social and Cultural impact

Aspect	Impact	Before	After
1. Food security and self-reliance	A significant improvement	The return is low, making the investment unprofitable, resulting in debt.	The return on investment is worthwhile, and farmers can become self-sufficient.

2. Land use / Water use right	Improvement	Use the land to grow rice only.	The area is used for fish farming and salt tolerant perennial planting.
3. Knowledge on land degradation management	A significant improvement	Knowledge about land deterioration is limited.	Gaining knowledge through training and hands-on experience.

3. Ecology impact

Aspect	Impact	Before	After
1. Soil protection	increase	There is no chance for grass or weeds to grow.	Grass or weeds start to emerge. Weeds growing along the pond's embankment edge contributed to an increase in soil cover.

4.2. Off-site impact from using the technology

Aspect	Impact	Before	After
1. Greenhouse gas's impact	reduction	Preparing the plot by burning rice fields	It is possible to reduce carbon dioxide emissions from burning by switching to tamarind cultivation. Contribute to the reduction of greenhouse gas emissions.

5. Conclusion

5.1 The adoption of the Technology

Without any material or budget incentives, about 1-10 percent of farmers adopted and applied the technology in the initial phase. This is due to the fact that initial stage modification requires a significant initial investment. Because a nursery pond for baby fish and also many fish ponds must be dug, however when adjusted the price of tilapia and snapper production is relatively high, and the quality satisfies market demand. Furthermore, the quantity of labor required in fish ponds was less than that required in rice cultivation, and the yield from fish ponds was greater than that of rice fields. Farmers in the nearby areas became interested in learning about saline land fisheries from model farmers as a result of this.

5.2 Strengths/ advantages/ opportunities in the land user's view

1. Possibility of generating additional revenue.
2. In the area, there is a farmer who is a successful model for using technology.

5.3 Strengths: The opinion of compilers

1. Local farmers can successfully farm in saline and deteriorated lands. It helps in the reduction of migration from degraded land areas.

2. Farmers can turn a crisis into an opportunity by taking advantage of the limitations of having deteriorated soil to gain money by farming snapper and tilapia. As a result, greater income is generated because snapper can only be raised in very high salinity water and may be sold at a high price due to its high quality in terms of taste, which matches market demand.

3. Farmers will be able to rely on themselves if their quality of life improves. By measuring the green of phytoplankton in the pond water, the soil becomes more productive and the degree of salinity decreases. It is fish feed produced by balancing the acidity and alkalinity (pH) of the soil by adding manure and lime to the pond.

5.4 Weaknesses/ disadvantages/ risks in the land user's view

The salinity of the water in the pond has reduced, impacting snapper production in the area where the farmers in the network are requesting to drill an artesian well.

5.5 Weaknesses: The opinion of compilers

Farmers used to operate on their own, which resulted in low yields. Following that, more group meetings and gatherings were held to share information and discover solutions to various issues.

Activities Pictures


Figure 1-2 A field visit to interview and inquire about the details of the successful modification and use of technology in saline soil management by adopted of tilapia and snapper farming at "Pongcharoen farm" owned by Mr. Sompong Chaisong, Mueang Pia Sub-district, Ban Phai District, Khon Kaen Province.


Figure 3-4 Adaptation of the land through the use of saline soil approaches and the conversion of rice fields to fish ponds.

Figure 5-6 Embarkation for salt-tolerant plantations, primarily coconut and tamarind, for domestic consumption. It also helps in the restoration of soil moisture and erosion.

5. MANILA TAMARIND PLANTING IN COMBINATION WITH INREGREATED FARMING FOR SALINE SOIL MANAGEMENT IN NAKHON RATCHASIMA PROVINCE, THAILAND

1. General Information and description of best practice/technology

Information

Nakhon Ratchasima Province has a total saline soil area of 480,958 ha which is approximately the most saline soil area in the northeastern part of Thailand. More than 50% of the area of 11,196 ha has salt stains on the soil surface. The purpose of this technology, Manila tamarind planting in combination with integrated farming for saline soil management in Nakhon Ratchasima Province, Thailand, was to reduce the level of salinity in the soil and to improve saline soil areas to be able to grow a variety of plants and also to enhance sustainable integrated farming for farmers who live in saline soil areas for higher productivity, income, and a better quality of life. In terms of land use adaptation, Manila Tamarind was used in conjunction with integrated farming (tilapia and cow farming) in areas such as water restoration, maintenance, harvest, and transportation.

Mr. Niphon Plianklang is a volunteer soil doctor in Makha Sub-district, Non Thai District, Nakhon Ratchasima Province. He was a role model farmer who pioneered the application of this method in his area, which was formerly utilized for rice production but is now used to cultivate Manila tamarind using integrated farming. The land of the Manila tamarind plantation has been rehabilitated at this time. Previously, the salinity of the soil in this area had a negative impact on rice harvests. However, after implementing this technology, Manila Tamarind may thrive in saline soil environments. The taste, as well as the size and color, were excellent, and the market demand was met. Aside from tamarind production, there was also a section set aside for tilapia and cow rearing. As a result, there are goods that may be gathered and sold throughout the year as a source of revenue.

The objectives was to assess the soil salinity in order to prevent the salinity spread and reduce salt level and to be a future potential agricultural sustainability.

Operating facility No. 117, Village No. 3, Ban Maklua, Makha Subdistrict, Non Thai District, Nakhon Ratchasima Province.

Land user	Mr. Sompong Chaisong	
Compiler	Ms. Apasiree Meeklang	Land Development Department
Partner	Ms. Saowanee Prachansri	Expert on Land Development System Office of Land Development District 3
	Mrs. Nipaporn Sribundit	Agricultural Research officer Office of Land Development District 3
	Mrs. Phitchanan Raksasub	Agricultural Research officer Nakhon Ratchasima Land Development Station
	Ms. Methinee Payomhom	Agricultural Research officer Research and Development on Volunteer Soil Doctor and Network Management Group
Reviewer	Dr.Bunjirtluk Jintaridth	

Geographical location

Latitude 102.11202 Longitude 15.24495

Operation Start Date

The operation started in 2017

2. Classification of the best practice/technology

Activities and details

1. Manila tamarind cultivation. Prepare for Manila Tamarind planting by digging a trench on the land with a width of 4 meters and a depth of 2 meters. The ditch was used for water restoration and tilapia which is a fish that can grow well in saline soil areas because it can generate income while Manila Tamarind is not yet ready to harvest. The excavated soil was raised to the plot at 1.00 meters height and 6.00 meters width for planting Phetch Non Thai Manila Tamarind. The distance recommendation for the Manila Tamarind plantation was 8-10 meters, but there were 350 Manila Tamarind seedlings were planted in an area of 0.44 ha with a distance of 5 meters

each. The reason was for grafting every other plants. One seedling was sold for 0.74 USD. Beginning in March, add 1 sack of manure per plant (manure obtained from cow dung on the farm). After 8 months, apply bio-extract to nourish the tree after reproductive stage. During this period, *Bactrocera dorsalis* (Hendel), a major pest Manila Tamarind, will attack and destroy the pods. This caused the bent pods and lowered the price of the products. Applying fumigation and insect traps by burning straws to produce smoke to disturb them. When they fly up above, they will be eaten by birds. After 2 weeks, the sheath bark will be thickened and safe from pests. In the first year, products from Manila Tamarind weighed 1,500 kilograms total, and the average selling price was 2.35 USD per kilogram. It gave farmers an annual income of 3,529.41 USD. In the second year, after the harvesting period, pruning will be done by grafting the branches and cutting them for propagation. It takes about a month for grafting to form strong roots within the rootstock. Rootstock could be sold at 1.76 USD each, but if applied in a pot for 15 days, the price will be sold at 1.03 USD per pot. Presently, main income comes from the sale of Manila Tamarind propagation. Once, he sold 50,000 pots at a cost of 0.15 USD per pot. This brought his income from only selling Manila Tamarind seedlings up to 51,470.59 USD in that year.

2. Tilapia farming in Manila tamarind orchards. In brackish waters, tilapia can live. Phytoplankton and moths, which were created by manure and hay placed in the garden grooves, fed the fish in the ponds. They come from the farm's cow waste. The Nakhon Ratchasima Provincial Fisheries Office sold 0.03 USD per baby tilapia, and 15,000 transgender tilapia were released. Before they can sell, they need 5 months. The selling price per kilogram was 1.77 USD. After costs were deducted, the total profit per fish was 0.59 USD. Due to a lack of water, tilapia fish farming can only be done once a year, despite the fact that the income from fish farming is 8,823.53 USD per year. The fish had a lower disease-causing potential. In comparison to saline water, germs and parasites were reduced. This resulted in high-quality fish in terms of texture, flavor, and odor, which is why they fulfill market demand.

3. Cattle farm. There are two mother cows being raised on the farm. They are used for breeding and producing calves for sale. The price for a male calf is 735.29 USD and for a female calf is 1,471-2,941 USD. One cow produces 200 sacks of manure every 6 months. Therefore, two cows will produce 800 sacks of manure in a year, which is enough to use in the area of Manila Tamarind and fish farming in the orchards. Moreover, the excess amount

of manure can be sold at 1.18 USD per sack. It is a sustainable and self-reliant integrated farming system. There is a turnover of agricultural waste materials in the plots to be used in cattle farms, such as grass in tamarind plots used in feeding cattle. The cultivation of napia grass to be used as food for cows in order to reduce the production cost and the use of waste for soil improvement and as a foliar supplement to increase plant growth and productivity. In addition, manure can also be applied to the bottom of the fish pond or mixed alternately with a pile of straw to feed the fish in the pond as well.

Mr. Niphon Plianklang, of 117 Village No. 3, Ban Maklua, Makha Subdistrict, Non Thai District, Nakhon Ratchasima Province, has used this technology in his farming. A role model farmer who has successfully combined Manila tamarind with integrated agriculture to manage saline soil. This area used to have a salinity level of 10 ppt, which was quite high. The salinity of the soil was lowered after applying this approach. Until now, the soil in the area and the garden waterway had a salinity of 3.7-4.0 ppt, which is a moderate degree of salt. You can cultivate a wider range of crops

3. Technical specifications, implementation activities, inputs, and costs

3.1 Income and expenditure on technology

1. Initial costs and expenses of using technology

Input	Unit	Quantity	Expenses per unit (USD)	All Expenses per input (USD)	Percent (%) of expenses incurred by land users
labor					
Raising the garden groove, planting Manila Tamarind, laying the water system (17 people, 20 days)	force	340	8.82	3,000	100.0
Equipment Fertilizers and disinfectants/inhibits the growth of organisms (biocides)					

pump	machine	2	147.06	294.12	100.0
manure	sack	350	1.18	411.77	100.0
Chemical fertilizer formula 15-15-15	sack	3	20.59	61.77	100.0
Plant materials and construction materials					
Manila Tamarind Tree	Tree	350	0.74	257.35	100.0
land rent	rai	15	147.06	2,205.88	100.0
house of animals	house	2	176.47	35.29	100.0
other					
The value of the transgender tilapia larvae	tilapia	15,000	0.03	441.18	100.0
fish feed	kilogram	50	8.24	411.77	100.0
Total expenses of establishing the technology				**7,142.65**	

Calculation of costs and expenses

The cost is calculated per area in which the technology is used. (Area and unit size: 2.4 ha.: 6.25 rai = 1 ha).

The currency used to calculate costs with the unit as Baht

Exchange rate (to US dollars) 1 US. Dollars = 34.0 baht.

The average wage for hiring workers per day is 8.82 USD.

Most important factor having effects on expenses

Feed prices for fish are increasing.

- In the past (year 2017), it was at the price of 8.24 USD per sack.
- Currently, the price is 10.09 USD per sack.

As a result, the current cost of living has increased per year.

2. Maintenance costs

Input	Unit	Quantity	Expenses per unit (USD)	All Expenses per input (USD)	Percent (%) of expenses incurred by land users
Other					
Manila Tamarind Pruning and Propagation	branch	50,000	0.15	7,352.94	100.0
Equipment Fertilizers and disinfectants/inhibits the growth of organisms (biocides)					
Chemical fertilizer formula 15-15-15	sack	3.0	20.59	61.77	100.0
equipment, plant materials, etc.					
Fuel (mowing and pumping) 1 time per week, 2 liters each time, cost 60 baht (1 year = 52 weeks)	time	52	1.77	91.77	100.0
Material for grafting for propagation	set	50,000	0.15	7,352.94	100.0
Tilapia	Tilapia	15,000	0.03	441.18	100.0
Tilapia food cost	sack	50	10.29	514.71	100.0
Total expenses of maintaining the technological condition				**15,815.29**	

3.2 Revenue from sales of produce and net income

Before using technology, most of the income came from rice cultivation, but the yield is very low due to saline soil and water shortages. In an area of 0.16 ha, rice yields 80 kilograms (2.4 ha yields 1,200 kilograms), sold at 0.15-0.18 USD/kg, including income from rice cultivation, about 176.47 USD/year.

After using technology**,** they now have a more diverse agricultural production revenue, such as Manila Tamarind, which produces 1,500 kg, thanks to the use of technology. Sell it for 3,529.41 USD, or 2.35 USD per kilogram. The Manila Tamarind tree is utilized to sell the most seedlings, 1,470 USD, for a total of 51,470.59 USD, at 1.03 USD per tree. Depending on the breed, the female calf is sold for 735.29 USD, and the female is sold for 1,470.59-2,941.18 USD. 15,000

tilapia for a total of 8,823.53 USD at a profit of 0.59 USD each. Other farm products, including as manure and lime, brought in a total of 66,029.41 USD.

3.3 Spending and net income

Total earnings: 66,029.41 USD.

The total cost of setup and maintenance is 22,952.06 USD.

A total net income of 43,071.47 USD was generated.

4. Environment

The area is semi-arid, with an average rainfall of 1,001 to 1,500 millimeters. The annual rainfall averaged 1,070.5 milliliters in 2021. (Data from the Meteorological Station: Meteorological Department). The terrain is gentle. The elevation of the plateau ranges from 101 to 500 meters. The depth of the soil is greater than 20 cm. Fine-grained clay is the texture of the topsoil. Loam and silty clay texture is in the subsoil. Organic matter levels are moderate (1-3 percent). It is impossible to utilize groundwater. The water quality is unpurified, yet the surface water is moderate. Because of the salinity of the water, it can only be used for agriculture. As a result, it is a significant issue in agriculture. Only a few types of crops can be produced as a result, and yields are poor.

4.1 Impact in the on-site from using the technology

1. Economic and social impact

Aspect	Impact	Before	After
1. Crop production	The greatest increase	Because the soil is very saline, 0.16 ha of crop yields 80 kg (2.4 ha = 1,200 kg), resulting in less rice production; not worth the investment.	Yield of Manila tamarind is 1,500 kg per production cycle, or 15,000 tilapia.
2. Cultivation excellence	The greatest increase	Less rice yield whole grain rice.	When changing plant types to suit the soil

Aspect	Impact	Before	After
			conditions, it results in better quality yields, good flavor yields, and large pods.
3. Production of animal feed	A significant increase	The soil was so salty that there was not even any grass or weeds growing.	The salinity of the soil was reduced, causing grass and weeds to grow, allowing farmers to mow the grass to feed the cows on their farms.
5. Product variety	The greatest increase	only rice cultivation	More farm products were obtained, including Manila tamarind fruit, tamarind seedlings, manure, calf, tilapia, and animal feed.
6. Cost of agricultural inputs	A significant reduction	-	Because of integrated farming, he can reduce the cost of manure by up to 257.35 USD (the cost of manure put in the Manila tamarind plot is 350 sacks) and thereby reduce production costs significantly. Both in terms of the cost of manure pet food and the cost of food for raising fish in the garden grove.

Aspect	Impact	Before	After
7. Income	The greatest increase	He makes money by selling rice; the typical price of rice is 0.15-0.18 USD per kilogram, and he can produce 1,200 kg of rice in a 2.4 ha area, earning 176.47 USD.	This technology brings in more money for farmers. Manila trees, manure, calves, and tilapia for sale. 1. Revenue from the sale of 1,500 kg of Manila Tamarind pods every production cycle The price per kilogram is 2.35 USD, or 3,529.41 USD total. 2. Income from the sale of Manila Tamarind trees for 1.03 USD each, which used to sell up to 50,000 trees per year, resulting in an annual income of up to 51,470.59USD. 3. Increased revenue from the sale of calves Male calves cost 735.29 USD each, while female calves cost 1,470.59 to 2,941.18 USD each. 4. Annual profit from tilapia sales is 8,823.53 USD

2. Social and cultural impact

Aspect	Impact	Before	After
1. Food security and self-reliance	The greatest improvement	The price of 1,200 kilograms of rice is 0.15 USD per kilogram.	Produce 1,500 kg of Manila Tamarind at 2.35 USD per kilogram and 15,000 tilapia fish for domestic consumption.
2. Community institution	Maximum strengthening	-	Promoting community unity and sharing your thoughts in order to tackle the problem of saline agricultural land management
3. Knowledge about SLM (Land Degradation Management)	A significant improvement	There is still a scarcity of information.	As a result of the increased adoption of technology, knowledge began to circulate more widely.
4. The social and economic position of disadvantaged groups	Greatly enhance	They are still unsure how to transition from monoculture to integrated farming.	They received knowledge transfer from the learning center that they may apply in their local area, as well as seeking counsel and guidance from model farmers.

3. Ecology impact

Aspect	Impact	Before	After
1. Soil protection	Greatly enhance	There will be no more grass or weeds.	Grass or weeds start to emerge.
2. Salinity	The most lowered	A salinity of more than ten parts per thousand (ppt) is present.	The salinity was decreased to 3.7-4.0 ppt till other crops could be grown.

4.2 Off-site impact from using the technology

Aspect	Impact	Before	After
1. The availability of water	A significant increase	-	They can deliver usable water from saline land sources. Because the Manila Tamarind is a salt tolerant plant, and tilapia can thrive in brackish, salty water.
2. Fields of neighbors have been harmed as a result of the destruction.	A significant reduction	Pesticides are applied in massive quantities and inappropriate way.	Pesticides should be used less often. To limit the use of insecticides, concentrate on employing bug traps.
3. Greenhouse gas's impact	Reduction	Preparing the plot by burning rice fields	It is possible to reduce carbon dioxide emissions from burning by switching to tamarind cultivation. Contribute to the reduction of greenhouse gas emissions.

5. Conclusion

5.1 The adoption of the Technology

Approximately 1–10% of farmers have accepted and applied the technology without any material or financial incentives because the initial adjustments require a relatively high investment. There are local farmers who participated in the project and applied the technology in their own areas. By changing the area and type of crop grown from rice to a salt-tolerant crop, tamarind, in conjunction with fish and livestock farming, but adjustments must be carried out gradually and systematically planned.

5.2 Strengths/ advantages/ opportunities in the land user's view

1. Deteriorating soil conditions are more fertile.
2. improved earnings and productivity
3. Capable of pursuing a profession in agriculture in places with saline soil.

5.3 Strengths: The opinion of compilers

1. Farmers on saline terrain can adapt to sustainable farming. On the farm, diverse materials are rotated in order to lower input costs.

2. If certain farm goods are harmed, such as Manila Tamarinds that have been exposed to rain, they cannot be sold as food but can be used as cow feed. However, it has little impact on overall earnings. Because other farm goods, such as selling manure Manila Tamarind plants and tilapia, provide revenue.

5.4 Weaknesses/ disadvantages/ risks in the land user's view

Use the initial investment to acclimate the area and digging wells is quite high effect some farmers don't have the courage or don't have enough capital to start making changes.

5.5 Weakness: The opinion of compilers

The Manila Tamarind has a limited shelf life. If harvested during the rainy season, fungal is easy to grow. Farmers must be cautious as harvest season approaches. And keeping an eye on weather forecasts to determine when to harvest with the least amount of rain.

Activities Pictures

Figure 1 Land transformation from paddy fields to raising trenches for Manila Tamarind planting and digging ponds for raising tilapia and storing water for agriculture.

Figure 2 Phet Non Thai Manila Tamarind produced from the orchards of Niphon Plaeng Klang, Volunteer Soil Doctor of Makha Subdistrict, Non Thai District, Nakhon Ratchasima Province.

Figure 3-4 A field visit to interview and inquire about the details of the successful modification and use of technology in saline soil management at the Land Development Technology Transfer Center 2017 of Mr. Niphon Plianklang, a volunteer soil doctor at Makha Subdistrict, Makha District. Non Thai, Nakhon Ratchasima Province.

Figure 5 Phet Non Thai Manila Tamarind cultivar produced by Niphon Phenklang's tamarind plantation, which is currently considered the main product. Agriculture can produce and generate income for agriculture throughout the year.

Figure 6-7 Raising two broiler cows capable of artificial insemination and yielding calves which if a calf is a male, It can also be sold at 735.29 USD per cow, and if a female calf can be sold at up to 1,470.59-2,941.18 USD/head, it can also produce manure from cow dung, up to 23.53 USD per year, saving costs and reducing the cost of buying fertilizer to put in their own plots as well.

Figure 7-8 A ditch or ditch dug between the tamarind plots for raising transgender tilapia, releasing 15,000 birds per year, and because it is a saline area. The water in the raceway has a higher concentration of salt than usual, but tilapia has characteristics that can grow well in salty, brackish water. Raised tilapia is relatively easy to raise and less disease-causing because pathogens and parasites are less able to grow in salty water. Get good quality fish meat, a firm texture, and a sweet and delicious taste. No smell of mud on the fish. Therefore, it is the demand of the market and consumers.

6. GREEN MANURE: AN AMAZING CROP FOR SOIL AMENDMENT AND SALINE SOIL REDUCTION OF THE NORTHEST OF THAILAND (I-SAN)

1. General Information and description of best practice/technology

Information

In the past, besides using *Sesbania rostata* as a green manure for soil amendment in the area with saline soil, Land Development Department also promoted using *Crotalaria juncea* (sunn hemp) as a green manure plant with the objective to increase organic matter and improve soil. Moreover, planting and storing seeds can be done more easily than other green manure. This can also be planted and used as soil amendment together with various approaches, which has been accepted by farmers in every area. Due to problems of degraded soils used in cultivating industrial crops for a long time, the soils have been degraded chemically and physically with low fertility. Soil texture is characterized by being sandy clay loam. Flaky salt stain was found on the soil surface and the soil is saline with lack of water in the dry season. This also includes the fact that the area is outside the irrigation zone, making farmers unable to cultivate rice and obtain yields as needed. As a result, household incomes are low. Therefore, knowledge of using green manure plants has been implemented in the area with saline soils for growing rice together with using fermented bio-extracts from banana shoots and chemical fertilizers application according to advice.

Operating facility Moo 5, Ban Kok Phrom, Non Thai sub-district, Non Thai district, Nakhon Ratchasima province

Land user	Mr. Mana Siangsunthia	
Compiler	Ms. Wannaporn polsang	Land Development Department
Partners	Ms. Areerat Wangkaew	Land Development Department
	Ms. Pitchanun Raksasarp	Land Development Department
	Ms. Mana Siangsantia	Land Development Department
Reviewer	Dr. Bunjirtluk Jintaridth	
	Dr. Prapa Taranet	

Geographical location

Latitude 102.03417 Longitude 15.23985

Operation Start Date

The operation started in 2004.

2. Classification of the best practice/technology

The Northeast of Thailand covers the area of 17.12 million ha. This region has the most area of rice farming in the country. However, the ratio of yields per hectare is still low when compared with other regions. It must rely on rain water whereby the amount of rain distribution is not constant. Soil fertility is low. The organic matter in soil is decreased rapidly due to poor texture soil. Another 17% of the area consists of saline soils. A method of maintaining the fertility level of soil, this is to the increase of crop yield under the saline soil by increasing organic matter and plant nutrients in soil, especially nitrogen nutrition in soil. Due to the fact that nitrogen fertilizers currently costs so expensive, Land Development Department, Ministry of Agriculture and cooperatives, has the project of soil amendment with green manure plants (*Crotalaria juncea*) and the campaign project of plowing up and over to cover straw stubble and green manure plants for soil amendment to reduce global warming in every area of Thailand from the area of farmers growing rice. This area also has limitations from land use which are having saline soil with a slight salinity to moderate salinity, low organic matter and low fertility and pH values in soil with a slight acidity and alkalinity. In the area of Non Thai district, Nakhon Ratchasima province, it faces the problem of water shortage in the dry season. The area is also outside the irrigation zone. Farmerss and officers of Land Development Department have transferred knowledge regarding increasing organic matter in the areas with degraded soils whereby volunteer soil doctors and farmers in the area implement the technology including applying it together with soil and water conservation in cultivation areas.

Mr. Mana Siangsunthia, volunteer soil doctor of Non Thai district, Nakhon Ratchasima province, is a farmer who understands, reaches and is ready to learn problem solving in his own area made use for occupation by having cooperated with officers of Area 3 Land Development Office, Land Development Department since 1997 in receiving supports such as production factors, PD microorganisms, green manure plants, vetiver and water resources in the paddy field.

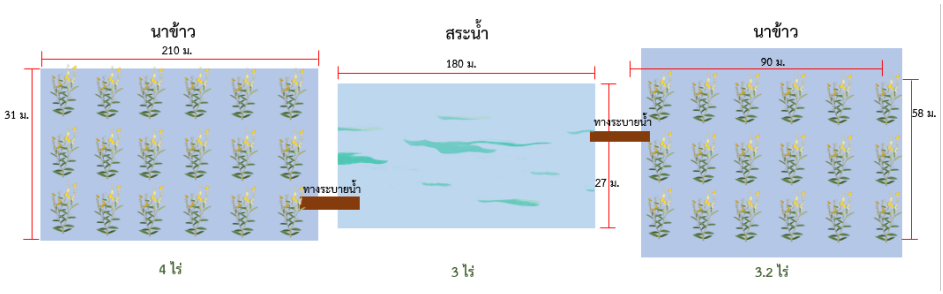
Moreover, guidelines obtained from learning are implemented to develop his own area where the Khaw Dawk mali 105 rice variety is grown accounting for 1.12 ha. Previously, any plants grown in the mentioned area could not produce any yields. Due to problems of degraded soils used in cultivating industrial crops for a long time, the soils have been degraded chemically and physically with low fertility. Soil texture is characterized by being sandy clay loam. Flaky salt stain was found on the soil surface and the soil is saline with lack of water in the dry season. As a result, a snag occurs. This also includes the fact that the area is outside the irrigation zone, making farmers unable to cultivate rice and obtain yields as needed. As a result, household incomes are low. Therefore, knowledge of using green manure plants has been implemented in the area with saline soils for growing rice together with using fermented bio-extracts from banana shoots and chemical fertilizers application according to advice. In 2004, average yields of 1,125-1,563 kg/ha were obtained. This had been practiced continuously until 2011. Rice yields increased to 2,500 kg/ha

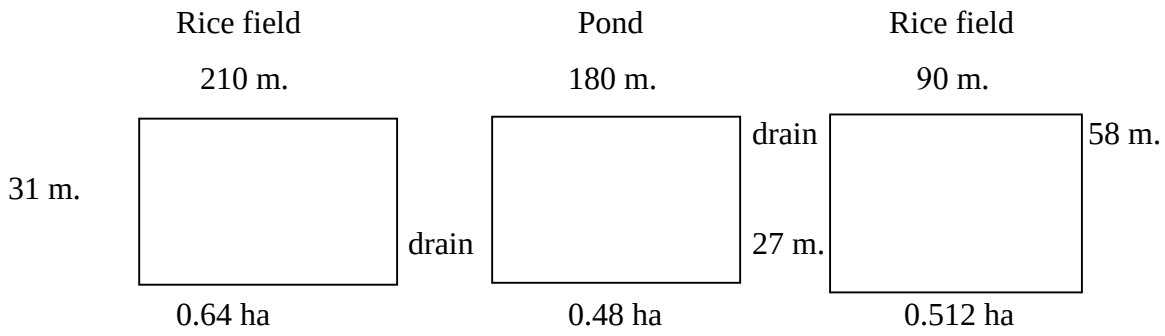
After having used *Crotalaria juncea* (Sunn hemp) for 16 years continuously, the soil has had better structures, becoming incoherent. Salinity of the soil has been reduced. This has brought about the origin of conducting farming based on natural agriculture restoring areas with saline soil without using chemical fertilizers from 2013 to the present time. Farmers also use the technique of observing weather conditions together with water management to be sufficient during having a dry spell due to climate variability. The green manure plant " Crotalaria juncea (Sunn hemp)" is used at the rate of 31.25 kg/ha for soil amendment for every 2 years together with selection of salt tolerance Kow Hom Thai rice varieties with outstanding characteristics of tolerating drought and pests well. As a result, yields of 3,125-3,750 kg/ha were obtained.

During the dry season after harvesting yields, in order to keep moisture in the soil, the method of plowing up and over to cover straw and stubble is used. They are not burned. The ground is covered with leaf debris. *Crotalaria juncea* (sunn hemp) is sowed during the harvesting season and it is allowed to fall naturally without plowing up an over during the flowering period. Fermented bio-extracts are used after harvesting. Soil and water conservation is focused in the cultivation area. During the rainy season, if rain water is at a high enough amount, it can be stored to be used in the dry season. Apart from this, farmers can also use the technique of washing off salt from the soil surface into water resources. There has been improvement of water quality with fermented bio-extracts at the rate of about 40 liters per cubic meters to be used for cultivation in the dry season.

3. Technical specifications, implementation activities, inputs, and costs

3.1 Technical plan of the technology





Methods of planting Crotalaria juncea (sunn hemp) to be used as a green manure plant in areas with saline soil are as follows:

1. The period of planting is during February to April whereby planting is conducted in between after harvesting rice yields so that Crotalaria juncea (Sunn hemp) can thrive and give out high biomass.

2. Plough and ferment rice stubble together with using PD 2 bio-extracts to create bacterial process in the soil accelerating decomposition taking about 2 weeks. Then, sunn hemp is sowed at the rate of 31.25 kg/ha in the soil with appropriate moisture throughout the plot in order to bring about regular germination.

3. Plowing up and over to cover sunn hemp stubble at the age of 120 days after collecting seeds of sunn hemp whereby the stem of sunn hemp is at the average of more than 1.2 meters resulting in obtaining more biomass. After that, during the period of preparing the area for planting rice, rice can be sowed in May or when there is enough amount of water.

4. When the seeds are kept to be used in the following season, the seed coat of sunn hemp is used as material incorporated with soil to make compost for soil amendment in growing vegetables.

3.2 Revenues and expenses in using the technology

1. Initial costs and expenses in using the technology

Inputs	Unit	Quantity	Expenses per unit (USD)	All expenses per inputs (USD)	% of expenses incurred by land users
Labor					
Plow to prepare plots	Time	1	14.71	14.71	
Sow rice	Time	1	17.65	17.65	
Pump water	Time	2	58.82	117.65	
Harvest yield	Time	1	183.82	183.82	
Plant materials					
Rice seeds	Kilogram	8	0.53	4.24	
Fertilizers and substances killing/ inhibiting growth of living things (Biocide)					
Weight	Liter	40	0.29	11.77	
Green manure	Kilogram	5	0.68	3.38	
Others					
Oil costs for farm truck	Time	1	58.82	58.82	
Total expenses of establishing the technology				**415.74**	

Calculation of costs and expenses

Expenses are calculated per areas using technology (Unit of size and area: 1.12 ha)

The currency used to calculate expenses with the unit as Baht

Exchange rate (to US. dollars) 1 US. Dollars = 34.0 Baht

Average wage in hiring labor per day is 8.82 USD

Most important factors having effects on expenses

1. Labor costs
2. Fuel costs

3.3 Incomes from selling products and net incomes

- In an area of 0.16 ha, yields can be harvested for 600 kilograms. Therefore, for the area of 1.12 ha, a total of products accounting for 4,200 kilograms/year will be obtained.

- The wholesale price of rice is 1.47 USD per kilogram Therefore, a quantity of rice accounting for 2,200 kilograms = 3,235.29 USD

(Stored for consumption in the household accounting for 700 kilograms)

- The selling price for seeds is 0.68 USD per kilograms. Therefore, the number of seeds accounting for 2,000 kilograms = 1,352.94 USD.

- Total incomes = 4,588.24 USD/year

- The net income/year accounts for 4,588.24 - 415.74 = 4,172.5 USD

4. Environment

4.1 Characteristics of the natural environment

The mentioned area has the average amount of rainwater between 1,001 - 1,500 milliliters. It is situated in the zone of semi-arid climate. The area is flat and 200 meter from the seal level. The soil depth is more than 120 centimeters. The soil texture on the top is sandy clay loam. The soil texture at the bottom is sandy clay. The level of organic matters is moderate (1-3%). The ground water cannot be used. The water at the soil surface is at a good level. The water can be used for agriculture only.

4.2 Characteristics of land users implementing the technology

Land users settle down and implement the technology as individuals/ households. They have incomes from outside the farm accounting for 10-50 % of all incomes. Regarding the wealth level, they have enough to get by. The land where the technology is implemented is small accounting for 4 ha. Land ownership is individual. They receive rights of land tenure.

Service access and infrastructures

Aspect	Access
Health	Good
Education	Medium
Technical aid	Medium
Employment (such as outside the agricultural sector)	Medium
Market	Good
Energy	Medium
Road and transportation	Good
Drinking water and sanitation	Good
Financial services	Medium

4.3 Impact in the on-site from using the technology

1. Economic and social impact

Aspect	Impact	Before	After
Production			
Crops production	**Moderately positive**	Being areas with saline soils with salt stain on the soil surface, yields per hectare	Soil properties become better, the quantity of products increases

Aspect	Impact	Before	After
Quantity of crop products	**Moderately positive**	The rice plant stands and dies. Yields per hectare are low.	The plants receive nutrients and the soil quality improves resulting in better product quality.
Land management	**Very positive**	Factors and soil amendment materials are used continuously every year.	Good soil properties make soil management for cultivation become easier.
Usefulness and water qualities			
Water availability for irrigation	**Very positive**	Rain water is used for conducting agricultural farming.	Water resources in the paddy field
Water qualities for irrigation	**Moderately positive**	Affected by salt water	Water qualities are improved by using fermented bio-extracts.
Incomes and expenses			
Expenses of factors of agricultural production	**Moderately reduced**	A large quantity of factors and soil amendment materials were used	Materials easily found in the area such as fermented extracts, green manure are used.
Farm incomes	**Greatly increased**	Low productivity	Received more quantities of rice products

2. Other social and cultural impact

Aspect	Impact	Before	After
Food security and being able to rely on oneself	**Positive**	Yields not enough for consumption in the household	Having the quantity of rice products for household consumption enough throughout the year accounting for 700 kg./year
Health situations	**Positive**	-	Conducting natural farming by avoiding fertilizer and chemical application
Institutes of the community	**Moderately positive**	Study how to solve problems by themselves	Building interaction of farmers groups in the area based on consulting and mutual problem solving
SLM or knowledge of land degradation management	**Positive**	There is no knowledge propagation.	Farmers in the adjacent plot accept the technology and implement methods of soil management in their own areas.

3. Ecological impact

Aspect	Impact	Before	After
Soil			
Moisture in the soil	**Moderately increased**	The soil is arid with flaky salt on the soil surface.	There has been accumulation of organic matter and mulch keeps moistures and reduces water evaporation in the soil.

Mulch	**Moderately increased**	-	Humus, straw, stubble cover soil surface.
Circulation and replenishment of nutrients	**Greatly increased**	-	Nutrients increase due to planting different crops such as sunn hemp and plowing up and over rice stubble.
Salinity	**Moderately decreased**	Moisture in the soil was low. The soil was characterized by having flaky salt appearing on the soil surface.	Salinity measured from the soil surface decreased. Organic matter and the number of microbes accumulating in the soil increased.
Organic matter in the soil/ lower than in the soil of C horizon	**Moderately increased**	-	Organic matter from plowing up and over to cover rice stubble, green manure plants
Biodiversity of plants and animals			
Biodiversity of plants	**Positive**	-	Plant varieties which can be planted and grow in the area more such as rice, sunn hemp

4.2 Off-site impact from using the technology

Aspect	Impact	Before	After
Water which can be utilized	**Moderately positive**	Small-scale water resources	Expansion of digging ponds resulting in more areas of water storage

Activities Pictures

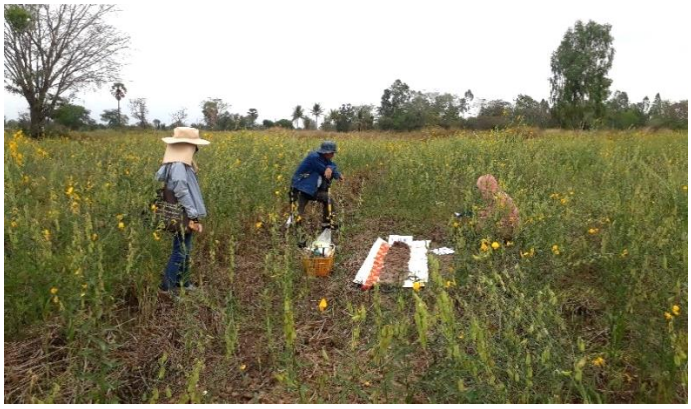


Fig.1 Soil survey in the area of Non Thai district

Fig.2 Cross sectional Pratai soil series (Pt-sclA)

Fig.3 Sunn hemp seed coat is used to make compost

Fig.4 Sow seeds of sunn hemp before the cultivation season

Fig.5 Plow up and over to cover sunn hemp

Fig.6 Harvest yields of salt tolerant Hom Mali rice

7. EXTENSION OF USING THE GREEN MANURE PLANT (SUNN. HEMP) IN SALINE SOILS

1. General Information and description of best practice/technology

Information

Due to the fact that chemical fertilizers are currently expensive, farmers cannot afford to buy them sufficiently to meet the demand of plants. There is also shortage of materials to make compost. Therefore, green manure crops are materials for saline soil amendment suitably to increase organic matter and nitrogen to soil. This is because they are cheap when compared with using other types of organic fertilizer. There are no residues in soil. This aspect is good to the environment. Green manure is-grown to be chopped and covered up into the soil in improving the soil in order to increase crop yields. This method can increase the available nitrogen for crops. This approach is pretty much focused on currently in the age of high costs. It is considered as an important method which makes people become aware of importance of reducing costs of production in improving soil qualities to increase plant yields. Moreover, this approach helps reduce soil salinity indirectly. In other words, soil properties are improved in terms of the fact that the soil becomes more friable. As a result, salt on the ground is washed off to the soil at the bottom more easily. There has been gathering of farmers in the area of Ban Kok Phrom, Non Thai sub-district, Non Thai district, Nakhon Ratchasima province and areas of sub-districts nearby because most farmers have an occupation of conducting rice farming mainly. Soil has low fertility due to problems regarding degradation of soils having been used for planting industrial crops for a long time. Therefore, this requires soil amendment in terms of physical, chemical and biological structures. Therefore, the outreach is to make farmers in the area know the benefits from plowing up and over to cover green manure plants, to demonstrate how to plough up and over to cover green manure plants correctly and suitably so that farmers can rely on themselves and can apply the knowledge in developing land in their own areas.

Initially, there were applicants applying to be members of the group accounting for 50 people. There is an operation committee consisting of 9 people. The establishment of the group replacing agricultural chemicals with organic substances. Strong Farmers Extension Group in the project of promoting organic substances use replacing agricultural chemicals.

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Land user Mr. Mana Siangsunthia

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	Ms. Nakanisorn Nakpalatho	Land Development Department
	Mr.Mana Siangsantia	Land Development Department
Reviewer	Dr.Bunjirtluk Jintaridth	
	Dr. Prapa Taranet	

Geographical location

Latitude 102.03417 Longitude 15.23985

Operation Start Date

The operation started in 2013.

Type of approach Natural agriculture, soil amendment with organic matter in the area with saline soil

2. Approach, aims, and enabling environment

Objectives of the approach

1. To build knowledge, understandings and farmers can access the technology of management and utilize areas with saline soil sustainably

2. To transfer knowledge regarding green manure plants (sunn hemp)-based saline soil management

3. To build networks and propagate knowledge to farmers and exchange experiences

Methods to be implemented

1. Training for transferring technical knowledge and demonstrating the use of green manure plants in areas with saline soil to increase rice yields

2. Establish a group, hold meetings for farmer groups and explain objectives

3. To scale up farmer groups using green manure plants in areas with saline soils in order to utilize areas with saline soils correctly and suitably according to academic principles and plan rice cultivation to keep up with climatic changes

4. To build networks regarding the use of green manure plants in areas with saline soils in Non Thai district and areas nearby

Procedures of operation

1. Land Development Department has extended the technology by organizing the project of training the course of soil amendment with green manure plants to increase organic matter and to transfer knowledge, techniques and to demonstrate use of green manure plants in areas with saline soil

2. To support factors of production and gather farmer groups to establish an association for exchanging knowledge and demonstrating use of green manure plants in areas with saline soil

3. Take group members for a study tour to see the way to increase rice products in areas with saline soil

3. Participation and roles of stakeholders involved

3.1 The stakeholders involving in this approach and the roles

Stakeholders or organizations involving with this approach	**Identify stakeholders**	**Explain roles of stakeholders or organizations**
Local land users or local community	Group members accounting for 50 people	Taking actions together to make the group and the network become strong in utilizing land correctly and suitably
SLM experts or agriculture consultants	Farmers and officers of Land Development Department	Give advice, knowledge and support factors of production in managing areas with saline soil continuously

Stakeholders or organizations involving with this approach	**Identify stakeholders**	**Explain roles of stakeholders or organizations**
Researchers	1. Farmers from Land Development Department 2. Students from Suranaree University of Technology	1.Monitor and assess saline soil management with organic matter together with water management in the area growing rice 2. Study and conduct research on prediction of soil salinity in the area for utilization from managing areas with saline soil in each period of the cultivation season
Local government	Non Thai Agriculture Marketing Organization Non Thai Informal Education	1. Participate and coordinate in establishing the group 2. Preparing the learning process of conducting agricultural farming through the method of natural agriculture

3.2Involvement of local land users or local communities in phases of the approach

Phase of the approach	Involvement of local land users or local communities	Identify those involved and explain activities
Initiative or motivation	Mobilize forces by themselves	Government agencies, group members transfer knowledge and take a study tour in order to implement learning and experiences in their own areas
Planning	Interaction and mobilize forces by themselves	Farmers and officers of Nakhon Ratchasima Land Development Station participate in planning to establish the group of using organic substances to replace agricultural chemicals.
Operation	Interaction and mobilize forces by themselves	The member group determines group rules and regulations together.
Monitoring or assessment	Interaction and mobilize forces by themselves	Monitor and check together with Farmers and officers of Land Development Department

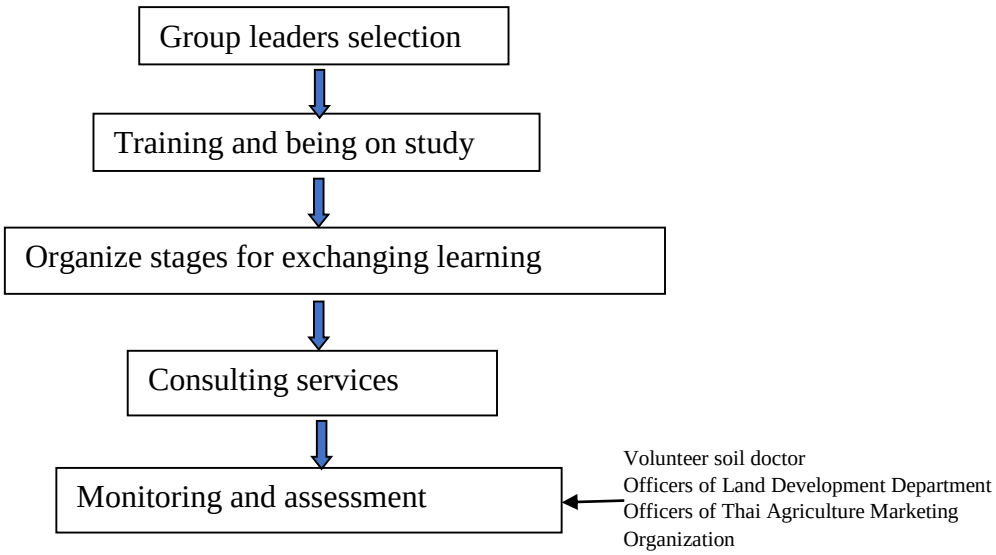

Diagram shows procedure of working

SLM technology Land users are the ones who are the main decision makers supported by SLM experts.

Decision-making is based on SLM knowledge assessment which has been well recorded (using data in making decisions) and from government agencies.

4. Technical support, building capabilities and knowledge management

1. Training has been set up for land users or other stakeholders with forms of training, namely farmers, students and interested people

- Visit actual places / farmers vs. farmers
- Experts give knowledge regarding soil collection and easy soil examination for fertility assessment.
- Use areas to demonstrate plowing up and over to cover stubbles and green manure plants

The training topic: Soil amendment with organic matter

2. Consulting services: Land users access consulting services provided by volunteer soil doctors stationed at Non Thai district and the government agency "Nakhon Ratchasima Land Development Station".

3. Strengthening agricultural sectors (organizational development)

- Non Thai Agricultural Marketing Organization, Nakhon Ratchasima province gives help and support in terms of meeting venues, facilitating collaboration

- Nakhon Ratchasima Land Development Station organizes training and supports factors of production, increases knowledge and regulations of establishing the group.

4. Central agencies by Land Management Research and Development Division monitor, check and make assessment. This is part of the approach to bring about use of areas with saline soil sustainably.

5. Research: There are students from Suranaree University of Technology who conduct research regarding prediction of soil salinity in the area for utilization from managing areas of saline soil in each period of the cultivation season.

4.1 Impact analysis and summary

4.1.1. Impact of the approach

The approach	Given answers
makes land users implement SLM technology and maintain conditions or not	Moderately
improves cooperation and operation of SLM effectively or not	Highly
mobilizes forces or improves financial sources access for SLM operation or not	Moderately
improves knowledge and abilities of land users in conducting SLM or not	Highly
builds or makes the institute become strong or brings about firm cooperation among stakeholders or not	Moderately
promotes the youth or offspring of land users to participate in SLM or not	Moderately
improves market access or not	Highly
leads to sustainable land use or energy sources or not	Highly
leads to employment opportunities or not	Moderately

4.1.2 Main motivation of land users to implement SLM

- Costs of production per unit reduce and incomes increase
- Land degradation decreases
- Ecological and Environmental conscious
- SLM knowledge and skills increase

4.1.3 Sustainability of approach activities

Land users can make things practiced based on this approach sustainable whereby there are government agencies from Land Development Department giving advice continuously. Moreover, government and private agencies come to ask for advice to exchange learning and implement area-based achievement. They apply this approach together with soil and water conservation of other methods to change use of salt-tolerant plant varieties (rice) and halophytes. This approach makes farmers able to restore areas with saline soil by using costs which are not so high, but this takes long time. Natural agriculture has been conducted, which does not have to depend on chemical fertilizers. Incomes of farmers, the ecosystem and the environment in areas with saline soil have been improved. This is utilizing land sustainably, which is eco-friendly.

5. Conclusion

5.1 Strengths

1. Land users monitor climatic changes in predicting disasters to occur. This is used as data for planning cultivation. As a result, there will be no damage during yield harvesting.

2. Regarding knowledge in managing soil, water and plants for utilization in areas with saline soil, previously, rice farming could be conducted only and there was lack of knowledge of correct and suitable saline soil amendment until currently, costs of production can be reduced.

3. The fact that the wisdom obtained from learning and practices has been applied together with academic principles to restore areas with saline soil which are limitations and obstacles during the past ten years have been eliminated makes farmers utilize areas with saline soil sustainably.

5.2 Weakness

1. Before implementing the technology of planting sunn hemp as a green manure plant, the cultivation area is outside the irrigation zone. This has an effect on biomass of the sunn hemp.

2. The farmers who join the group are ready to learn and observe the surrounding environment, including keeping up with climatic changes all the time. At certain time, there is shortage of labor. There are problems of expensive oil. Therefore, establishing the group is the guideline to solve the mentioned problem.

Activities pictures

Fig. 1-2 Experts transfer knowledge regarding soil amendment with organic matter.

Fig. 3-4 Informal education regarding conducting cost-reducing rice farming and harvesting yields of salt-tolerant Hom Mali rice variety for reproduction of farmers of Saioar district, Non Thai district

8. MANAGING AREAS WITH SALINE SOIL BY PRATICING ECO-AGRICULTURE IN MAHA SARAKHAM PROVINCE, THAILAND

1. General Information and description of best practice/technology

Information

This eco-agriculture is located in the zone of Pratai soil series, area of Muang district, Maha Sarakham province. The area has soil with medium salinity. Traces of salt were found about 10-50% of the area. Most of the land is used for the paddy field based on rain water. Regarding the technological use of managing the area with saline soils by practicing eco-agriculture, the objective is to reduce the salinity level in the soil and develop the area with saline soil to be able to grow a variety of plants. This has made farmer living in the area with saline soils have better products, incomes and life qualities.

Mr. Jatuporn Thienma bought a farmland accounting for 8 rai and transformed the whole area into an area of integrated agriculture whereby the area was divided into a 0.24 ha paddy, a 0.16 ha pond, a 0.64 ha plantation of fruit trees and perennial plants, and a 0.24 ha elevated furrow-plantation of fruit trees. Water resources are managed by collecting rain water falling in the area. Moreover, the eco-agriculture system is managed to bring about circulation of matter and energy so that external dependence on factors of production is reduced as much as possible without using chemicals to get rid of pests and chemical fertilizers.

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Land user Mr. Jatuporn Thienma

Compiler Dr.Bunjirtluk Jintaridth

Reviewer Dr.Bunjirtluk Jintaridth
Dr. Prapa Taranet

Geographical location

Latitude 103.20421 Longitude 16.10494

Operation Start Date

The operation started in 2015

2. Classification of the best practice/technology

Activities and details of the operation

1. Building water resources

Building water resources by digging ponds with the depth of 3.50 meters to collect rain water falling within the area based on the calculation of soil surface runoff accounting for 30% of the annual amount of precipitation and building plantation furrows with the dimension of 3 meters wide and 2 meters deep to store water for water hyacinth (*Salvinia cucullate*) and frog spawn culture

2. Apply water to build vegetation

Applying the stored water to build vegetation at the plantation area resulting from filling soil by planting legumes, grass and farm plants. Then, allow these plants to cover the soil surface throughout the year. At the plantation furrow, planting water hyacinth and frog spawn.

3. Use vegetation to manage saline soil

Using the growing vegetation covering the soil surface at the plantation area resulting from filling soil to keep moisture in the soil continuously, improving the soil physical structure and increasing organic matter to the soil. At the furrow ridge, using water hyacinth and frog spawn to cover the soil surface to keep moisture in the soil. Improving the soil physical structure and increasing organic matter including plant nutrients to the soil.

4. Using the area to produce cash crops

Planting various cash crops like fruit trees by experimenting with planting various plants and selecting the variety which corresponds well with the area, namely pomelo, mangos, jackfruits, Manilkara Kauki, rose apples, guava. bananas, custard apples, tamarind. The fruit tree which is the main cash crop is pomelo and other kinds of fruits as supplementary plants. Moreover, the area between rows is used to plant farm plants such as corn, watermelon, pumpkin, including legumes etc.

3. Technical specifications, implementation activities, inputs, and costs

3.1 Technical plan of the technology

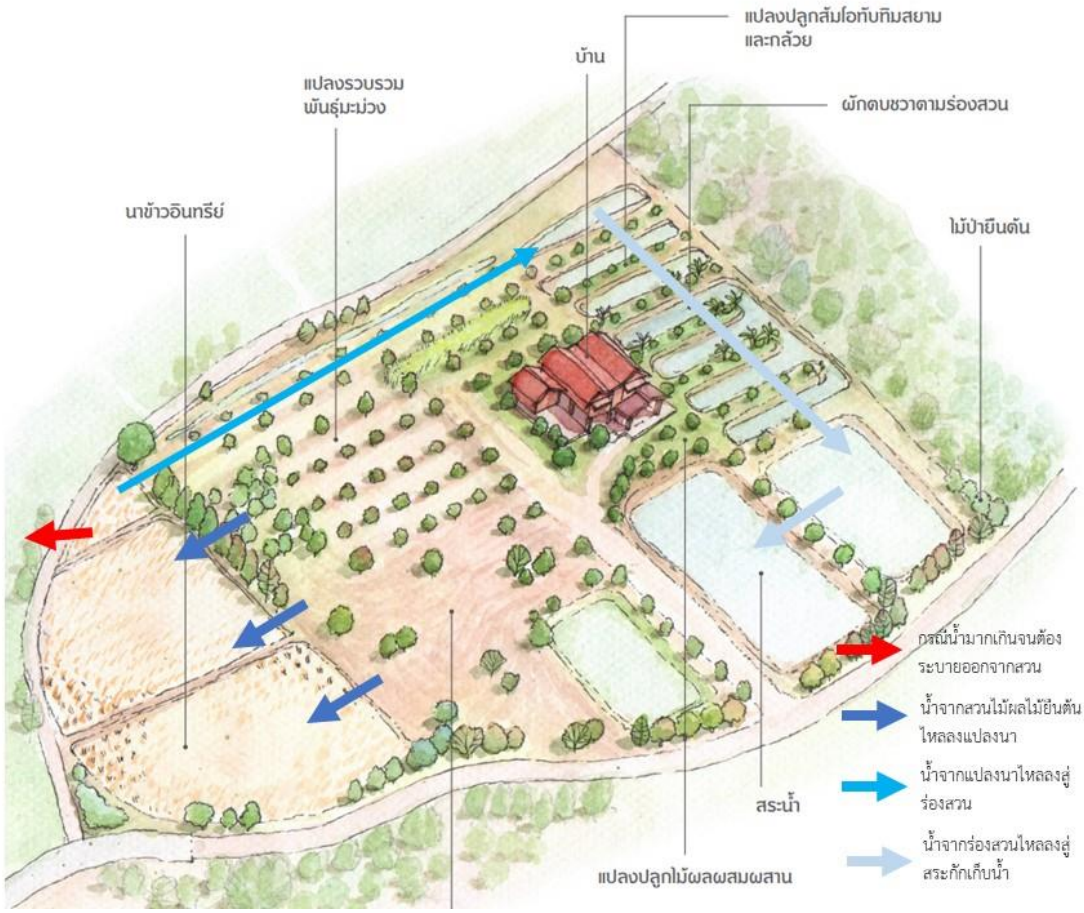

Fig. 1 shows circulation of water in the agricultural area

3.2 Revenues and expenses in using the technology

1. Initial costs and expenses in using the technology

Inputs	Unit	Quantity	Expenses per unit (USD)	All expenses per inputs (USD)	% of expenses incurred by land users
Labor					
Digging ponds	cubic meters	5,300	1.02	5,406	100
Digging plantation furrow	cubic meters	700	1.02	714	100
Equipment					
Water pump of 2 horse power	Pump	1	220.58	220.58	100
Sprinkler system	Zone	4	205.88	823.52	100
Total expenses of establishing the technology (US dollars)				**7,164.10**	

Calculation of costs and expenses

Expenses are calculated per areas using technology (Unit of size and area: 1.28 ha)

The currency used to calculate expenses with the unit as Baht

Exchange rate (to US. dollars) 1 US. dollars = 34.0 Baht

Average wage in hiring labor per day is 300 Baht

Most important factors having effects on expenses

1. Electricity costs
2. Manure costs

2. Maintenance costs

Inputs	Unit	Quantity	Expenses per unit (USD)	All expenses per inputs (USD)	% of expenses incurred by land users
Labor					
-	-	-	-	-	-
Others					
Electricity costs	Month	12	11.76	141.12	100
Manure costs	sack	360	1	360	100
Total expenses of establishing the technology (US dollars)				**501.12**	

3.3 Incomes from selling products and net incomes

Before using the technology There were no incomes from using the area due to the fact that the area was bought from farmers and the whole land was adjusted systematically to practice eco-agriculture.

After using the technology There are incomes from more various agricultural productions, namely pomelo products with the selling price of 2.94 USD per kilogram, jackfruits with the selling price of 100 Baht per kilogram, mangos with the selling price of 1.02 USD Baht per kilogram, bananas with the selling price of 0.73 USD per hand of bananas. Currently, there is an average monthly income of 117.6 USD. However, there is a small quantity of products obtained due to the fact that fruits do not give yields at their full potentials.

Estimating future incomes from pomelo which will be the main cash crop in 2027 or for the next five years is the pomelo tree accounting for 80 trees, each of which gives the yield for 60 fruits annually. The average fruit weight is 2 kilograms. This will give a total of yields accounting for 4,800 fruits annually. The selling price is 100 Baht per kilogram, accounting for the total income of 28,235.3 USD annually.

4. Environment

The mentioned area has the amount of rainwater accounting for 1,264 milliliters on average in 30 years. The area is characterized as being flat on the highland (compared with the surrounding area). The soil texture on the top is light brown clay loam. The soil at the bottom is the soil layer of salt accumulation. The soil texture is greyish brown clay. Traces of salt are found at the soil surface in the dry season.

4.1 Impact in the on-site from using the technology

1. Economic and social impact

Aspect	Impact	Before	After
1. Crops production	Increased at the most	-	Products of rice, pomelo, mangos, jackfruits, bananas, and vegetables
2. Product quality	Increased at the most	-	Planting variably and the products have good qualities and tastes.
3. There are more various income sources.	Increased at the most	-	Expenses are reduced from consumption of pomelo, mangos, jackfruits, bananas and vegetables Having incomes from selling fruits such as pomelo, mangos, jackfruits and bananas
4. Variety of products	Increased at the most	-	Products, namely pomelo, mangos, jackfruits, bananas. mango ice cream and dried bananas
5. Expenses of factors of agricultural production	Greatly reduced	-	Eco-agriculture is the farm management which is favorable for circulation of matter and energy. Therefore, it is not necessary to use external factors of production. There is only manure used at the beginning of planting fruit trees.

6. Incomes	Increased at the most	-	There is an average monthly income of 4,000 Baht. However, yields are not given at a full capacity.

2. Social and cultural impact

Aspect	Impact	Before	After
1. Food security and self-reliance	Improvement at the most	-	Pomelo products cost 2.94 USD per kg. Jackfruit products cost 2.94 USD per kg. Mango products cost 1.02 USD per kg. Banana products cost 0.73 USD per comb of banana.
2. Institute of the community	Improvement	-	Members in the community start to see guidelines of utilizing the area with saline soils. Previously, they believed that nothing could be done about it.
3. SLM or knowledge of land degradation management	Improvement at the most	-	The knowledge starts to be propagated more widely.

3. Ecological impact

Aspect	Impact	Before	After
1. Soil indumentum	Much improvement	-	Legumes, grass or weeds grow and cover the area.

2. Soil salinity level	Decreased at the most	Salinity level more than 6 dS/m	The salinity level has been reduced to be less than 3 dS/m until various kinds of plants can be grown.

4.2 Off-site impact of using the technology

Aspect	Impact	Before	After
1. Water which can be utilized.	Greatly increased	-	Water at the soil surface of areas with saline soil can be utilized. Water can be used to control soil salinity, including increasing organic matter to improve the saline soil structure until various plants can be grown.
2. Damages to neighboring cultivation areas	Greatly reduced	-	There is no use of pesticides and chemical fertilizers.
3. Impact of greenhouse gas	Reduced	-	There is no burning of organic materials at all. Helping reduce carbon dioxide release and reduce the amount of greenhouse gas emission

5. Acceptance of the technology and application

There is acceptance among farmers They implement the technology without receiving any material or financial motivations. This is due to the fact that initial adjustment requires high investment. There are off-site farmers who apply the technology in their own areas by land use changes and types of plants from rice to integrated plants. However, land use changes must be done gradually and there must also be systematic planning.

Activities Pictures

Fig 1 and 2 Establishing soil -surface water resources

Fig 3 and 4 Applying soil -surface water to build vegetation

Fig 6 and 7 Growing vegetation to manage saline soil

Fig 8 and 9 Land use changes in saline soil to increase products

9. INTEGRATED AGRICULTURE-BASED LAND USE IN AREAS WITH SALINE SOIL

1. General Information description of best practice/technology

Introduction

The problem of soil degradation in areas with saline soil originates from chemical and physical degradation and low fertility which are main limitations for land use, including shortage of water in the dry season and intermittent rain during cropping season. Farmers in the area of growing rice every year between May and October by implementing wisdom going through error- and trial farming including knowledge gained from performing duties as soil doctors stationed at Non Thai district, Nakhon Ratchasima which is done by growing vegetables for export supported by Marketing Organization for Farmers, Non Thai district, Nakhon Ratchasima province cooperating with private companies. Regarding soil amendment for planting vegetables in the Northeast, the method to increase and keep the fertility level throughout the harvesting season, including off-season production of chili spur pepper is to increase organic matter and plant nutrients, and to adjust pH values to be suitable. They can be planted in the irrigation zone throughout the year. However, the best time for planting them is in the period of January and February which is when chili peppers have good prices. For areas outside the irrigation zone, they should be planted in the rainy season. Chili peppers can thrive in every kind of soil, but the most suitable soil is sandy loam. They do not like waterlogged or wet areas because this condition can cause the root to become rotten and the plant to die easily. The form of planting chili peppers in Thailand is different according to soil characteristics. In any case, whatever methods are used, farmers place importance on procedures of cultivation preparation, watering as well as maintenance for diseases and insect prevention. This also includes vetiver as soil covering together with application organic fertilizers, fermented bio-extracts and useful microorganisms. Good soil management will make chili trees become strong and disease and insect resistant. This has been brought about challenges to overcome the nature with limitations in terms of soil, water and the environment whereby there is a motto lived by stating that "*There is nothing easy and nothing difficult either if we understand the nature before taking actions. Do not view money as denomination, but look at the value of products to occur at first.*"

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Geographical location

Latitude 102.03417 Longitude 15.23985

Operation Start Date

The operation started in 2022

2. Approach, aims, and enabling environment

The objectives of best practice / technology

1. To gain knowledge in integrated-agriculture land use in areas with saline soils for planting vegetables
2. To implement the technology in producing toxic-free plants to connect with quality chili peppers markets
3. To build local incomes sustainably

3. Classification of the best practice/technology

Activities and details of the operation

Mr. Mana Siangsunthia is a farmer who has implemented the knowledge obtained from being a soil doctor stationed at Non Thai district, Nakhon Ratchasima province to build opportunities for himself and farmers in the area. The problem of soil degradation in areas with saline soil originates from chemical and physical degradation and low fertility which are main limitations for land use, including shortage of water in the dry season and spell of rain in the cropping season. This has been brought an association of farmers ready to learn about increasing soil management potentials to increase plant yields and solve problems in their own occupation areas. The group is supported in terms of factor of production, namely LDD microbial activators

producing organic fertilizers and bio-fertilizers, vetiver of Songkhla 3 variety and dolomite. Moreover, the guideline obtained from learning, observance, trial and errors has been implemented and developed in the 0.04 ha planting vegetables. Previously, the mentioned area was characterized by soil with soil fertility deficiencies and giving low yields due to the problem of soil degradation. The soil texture was sandy clay loam consisting of saline soil a little bit. Moisture in the soil was very low in the dry season. Moreover, the area was outside the irrigation zone. Therefore, an idea came up with developing occupations for farmers in the community located at Moo 5, Ban Kok Phrom, Non Thai sub-district, Non Thai district to implement knowledge regarding integrated utilization of areas with saline soil in the organic agriculture system whereby agencies from Land Development Department provide knowledge in analyzing soil and improving soil prior to cultivation area preparation. The wisdom of farmers themselves is used together with the technology of Land Development Department, namely dolomite application for pH value adjustment and killing germs affecting growth of chili peppers together with applying manure to increase organic matter to the soil. Fermented bio-extracts have microbes which help stimulate the root system. Regarding moisture storage in the plot where chilies are planted, the drip irrigation technology system has been installed. The soil is covered with straw and vetiver is used to restore soil conditions. The objective is to do this as a prototype in building incomes for the community further.

After soil amendment, the soil has a better structure and has become friable and suitable for planting chili peppers by selecting the Amphawa Gold according to the demand of the market. Moreover, regarding intercropping, parsley is also inserted to be planted between plots, resulting in using water efficiently and worthily. Average yields of chili spur peppers account for 400 kilograms per 400 square meters throughout the age at 180 days. The harvesting price is 2.47 USD per kg and yields of parsley account for 108 kilograms per 400 m^2 (byproducts from watering chili pepper trees) based on harvesting yields for 1 generation per round of chili pepper production.

4. Technical specifications, implementation activities, inputs, and costs

4.1 Technical plan of the technology

Methods of managing the plot for planting vegetables in areas with degraded soil and soil with slightly amount of salinity as follows:

Cultivation plot preparation

1. Plough and blast soil, followed by plowing in regular furrows for the second time by using a 65 HP tractor and a small Kubota tractor to disintegrate soil to become smaller and finer

2. Elevate the furrow for the dimension of 30 centimeters high and 60 centimeters wide. The spacing between plots is 1 meter. Burn a pile of plant residues with the height of about 30 centimeters in the cultivation plot until it becomes charcoal with red spark to kill bacteria and disease-causing fungi. After that, follow by watering it to extinguish the blaze.

3. Spread dolomite thinly for soil amendment with the rate of 25 kilometers per rai. This is followed by using dung which is waste from pigs going through the process of gas fermentation at the rate of 100 kilograms per rai. Incorporate together and use the bio-extract with the rate of 2 spoons per 20-liter water to help improve the soil and stimulate the growth of plant roots.

4. Mix the cultivation soil with the ratio of 3 handfuls of soil: 1 handful of dung.

5. Dry the soil for 7-14 days. Before planting, place a cut banana stem with the length of 10 centimeters at the bottom of the hole to mix with the soil in the planting hole.

Planting and maintenance

1. Plant the chili pepper young plant of the Amphawa Gold variety at the age of 35 days together with sprinkling parsley around the planting plot. Cover it with rice straw and grow vetiver around the planting plot.

2. Watering in the morning and watering mixed with the Indian Laburnum pod fermented extract at the rate of 2 spoons per 20-liter water in the evening. Spray wood vinegar to prevent fungi once a week.

3. When the chili pepper buds, spray with the LDD 2 in the evening for every 5 days.

4. Put in place the drip system to be used in case of labor shortage of morning watering in order to keep moisture

5. In case of the anthracnose epidemic, destroy the chili pepper stricken with the disease. During the outbreak of aphis, spray with plain milk at the point of the outbreak. Leave it for 20 minutes and then wipe it off.

6. Withdraw old leaves of the chili peppers when they are at the age of 45-50 days in order to make the trunk expose to the sun. This helps chili peppers grow well and increase their yields.

Harvesting yields

1. When the chili pepper tree is at the age of 65 days, harvest the yield of the first generation and harvest yields the next time for every 5 days for the period of 6 months.

3.2 Revenues and expenses in using the technology

1. Initial costs and expenses in using the technology

Inputs	Unit	Quantity	Expenses per unit (USD)	All expenses per inputs (USD)	% of expenses incurred by land users
Labor					
Plough to prepare plots	Labor	1	8.08	8.08	
Soil preparation		1	4.41	4.41	
Cultivation, watering, plot maintenance	Labor	1	24.25	24.25	
Yield harvesting	Labor	1	137.64	137.64	

Plant materials					
Chili pepper tree	Tree	1200	0.029	34.8	
Parsley seeds	gram	600	0.01	6.0	
Rice straw	kilogram	180	0.10	18.0	
Fertilizers and substances killing/ inhibiting growth of living things (Biocide)					
Fermented bio-extracts	Liter	120	0.29	34.8	
Dolomite	kilogram	13.6	0.73	9.93	
Dung	bag	35	2.5	87.5	
Others					
Drip line	meter	4.6	1.76	8.06	
PVC tubes	meter	10	0.59	5.9	
1,000 liter bucket	bucket	1	67.65	67.65	
Total expenses of establishing the technology (US dollars)				**447.02**	

Calculation of costs and expenses

Expenses are calculated per areas using technology (Unit of size and area: 0.04 ha)

The currency used to calculate expenses with the unit as USD

Exchange rate (to US. dollars) 1 US. dollars = 34.0 Baht

Average wage in hiring labor per day is 8.82 USD

Most important factors having effects on expenses

1. Labor costs

3.3 Incomes from selling products and net incomes

In an area of 0.04 ha, chili pepper yields can be collected for 65 kilograms per round on average. The yields have already been collected for 6 rounds. The selling price is 2.47 USD per kilogram, obtaining a total of 963.52 USD.

Parsley yields have already been collected for 1 round accounting for 108 kilograms. The selling price is 4.41 USD per kilogram, obtaining a total of 963.52 USD, obtaining a total of 16,200 Baht.

Total incomes = 963.52+476.47 = 1,439.99 USD

Net income = 1,440-447.97 = 992.03 USD

4. Environment

4.1 Characteristics of the natural environment

The mentioned area has the average amount of rainwater between 1,001 - 1,500 milliliters. It is situated in the zone of semi-arid climate. The area is flat. The altitude level is 200 meters from the sea level. The soil is sandy clay loam. The level of organic matter is low. The ground water cannot be used. The water at the soil surface is at a good level. Regarding water quality, the water can be used for agriculture only.

4.2 Characteristics of land users implementing the technology

Land users settle down and implement the technology as individuals/ households. They have incomes from outside the farm accounting for 30-50% of all incomes. Regarding the wealth level, they have enough to get by. The land where the technology is implemented accounts for 0.32-0.81 ha. Land ownership is individual. They receive rights of land tenure.

Service access and infrastructures

Aspect	Access
Health	Good
Education	Medium
Technical aid	Good
Employment (such as outside the agricultural sector)	Good
Market	Good
Energy	Medium
Road and transportation	Good
Drinking water and sanitation	Good
Financial services	Medium

4.3 Impact in the on-site from using the technology

1. Economic and social impact

Aspect	Impact	Before	After
Production			
Crops production	**Very positive**	Being areas with degraded soil, filled soil with lack of fertility	Going through soil amendment making the soil have better properties
Quantity of crops	**Very positive**	Plants could not grow.	Plant thrive and give yields continuously.
Product diversities	**Very positive**	Plants cannot be planted.	Integrated cultivation, namely chili peppers, parsley and vetiver for soil amendment
Incomes and expenses			
Expenses of factors of agricultural production	**Moderately increased**	There was no cultivation.	Expenses for cultivation labor and soil amendment materials easily found in the area such as fermented nio-extracts, dolomite, leaf debris etc.
Farm incomes	**Highly increased**	There was no cultivation.	The quantity of products can be sold and exported.

2. Other social and cultural impacts

Aspect	Impact	Before	After
Health situations	**Positive**	-	Conducting natural farming by avoiding fertilizer and chemical application
Institutes of the community	**Moderately positive**	Studied how to solve problems by themselves	Building interaction of farmers groups in the area based on consulting and mutual problem solving
SLM or knowledge of land degradation management	**Positive**	There was no knowledge propagation.	Farmers in the area accept the technology and gather together to learn methods of soil management so that they can grow plants and implement them in their own areas.

3. Ecological impact

Aspect	Impact	Before	After
Soil			
Soil indumentum	**Moderately increased**	Being earthfill areas	There is soil amendment by using plant debris, rice straw and growing plants.
Nutrient circulation and supplementation	**Highly increased**	-	Nutrients increase from integrated cropping such as chili peppers, parsley, vetiver etc.

Soil stabilization	**Highly decreased**	Soil was compact and aggregated as hard clod of earth	Plowing and improving soil with organic matter and plant roots help reduce soil stabilization
Organic matter in the soil/ lower than in the soil of C horizon	**Moderately increased**	-	Organic matter from soil amendment such as manure and cropping systems
Biodiversity of plants and animals			
Biodiversity of plants	**Positive**	-	Plant varieties which are cultivated in the area grow more such as chili peppers, parsley, vetiver etc.

Activities Pictures

Fig.1 Sampling for analysis

Fig.2 Measure the soil salinity level

Fig.3 Simple soil analysis

Fig.4 Soil quality amendment with manure and dolomite

Fig.5 Cover the soil with rice straw and put in place the drip irrigation system

Fig.6 Experts of Land Development Department give advice and exchange learning about utilization of areas with saline soils

Fig.7 Harvesting parsley products (by products)

Fig.8 Chili pepper products prepared to send to markets conducting MOU together

10. KHANAP NAK COMMUNITY WAY: RESTORING DESERTED SHRIMP FARMS WITH NIPA PALM FOREST PLANTATION

1. General Information and description of best practice/technology

Introduction

It started in 2001 when Associate Professor Dr. Nopparat Bumrungrak, Professor of Faculty of Science, Songkhla Nakarin University, wanted to conduct research regarding utilization from nipa palm trees and was interested in restoring deserted shrimp farms to become land in use. Therefore, Mr. Kovit proposed areas at this location to be made as demonstration plots. Based on soil and water analysis, it was found that this area was suitable for planting nipa palm. The task started with the area of 3 rai to be transformed from deserted shrimp farms into nipa palm forests. There was extension of planting nipa palm trees more. After having planted for 7 years, yields from the nipa palm trees started to be collected.

Problem conditions of the area before taking actions

"Khanap Nak sub-district", Pak Phanang district, Nakhon Si Thammarat province is the area at the river mouth adjacent to the gulf of Thailand. There are natural water resources which villagers call "Hua Sai Canal" and "Na Kote Canal" which have been recently dug to connect with the seashore. This makes Khanap Nak sub-district have 3 kind of water resources in the same area, namely fresh water, salt water and brackish water. The traditional main occupations of the people of Khanap Nak sub-district are padding rice farming and upland crop farming. Since 1987, there has been a trend of raising sea shrimps in industrial ponds. As a result, areas used for conducting rice farming and nipa palm farming have been transformed into a large number of ponds raising sea shrimps. After farmers faced problems of failure in raising sea shrimps, water and waste from shrimp ponds were discharged into rivers and canals. Raising shrimps did not work out. Shrimp ponds were deserted. As a result, the problem of saline soil arises. Sea water intrudes into agricultural areas

Operating facility House No. 3, Moo 2, Khanap Nak sub-district", Pak Phanang district, Nakhon Si Thammarat province

Land user Mr. Kovit Chantarangsee

Geographical location

Latitude 100.236100 Longitude 8.212501

Operation Start Date

The operation started in 2001.

2. Approach, aims, and enabling environment

Objectives of the technology

1. To change land use from deserted shrimp farms to sustainable nipa palm plantations

2. To conserve natural resources and develop touring routes to be used as an instrument in conserving resources from the strong point of the Khanap Nak community which is way of life related to nipa palm plantations

3. To conserve way of life in doing nipa palm forestry plantations

Activities and details of operation

1. Crop variety selection: Replanting nipa pal trees starts with crop variety selection by planting the variety of nipa palm which gives much juice. The method of selection is generally based on observing from the original tree which gives out more juice than other trees in the same plantation or plantations nearby. When it is obtained, its fruits are cultured to be planted further.

2. Nipa palm breeding: The method is to bring the selected fruits which must be mellow to be erected in line in marshy ground. The arrangement is done by sticking the rear part into the soil in order to make the shoot grow upwards. Nipa palm breeding takes 2 months until the shoot grow out. When the shoot put forth fresh leaves of about 15 centimeters, it can be planted.

3. Soil preparation: Regarding soil preparation for nipa palms planting. In general, it is the matter of only clearing ~~other~~ weeds out of the cultivation area.

4. Preparing holes and planting: Planting nipa palms is conducted from February to March when water is dried out, which is suitable for preparing holes. Hoes are used to dig shallow holes to have enough width and depth to bury the young plant.

5. Method of planting: Regarding planting nipa palm trees, spacing between trees is 9 meters with planting by serration because when the nipa palm tree grows up to the age of 2-3 years,

there is tillering expanding to all directions. This must be tailored to remain 3 trees per clump. The number cannot be more than this due to competition for food resulting in decreasing yields.

6. Maintenance: Planting nipa palms does not require much care, fertilizer and pesticide application are not used to apply. This is because nipa palm trees do not have insects or diseases as enemies. Therefore, this agriculture uses very low costs. For general maintenance, trimming leaves and covering weed removal are only required. In general, maintenance is divided into 2 periods as follows:

6.1. Early stage of planting to the stage of giving yields: Regarding maintenance, make sure that there are no creeping plants, grass and other weeds covering the tree. If the young plant dies or is incomplete, planting for repairing can be done.

6.2 When the nipa palm tree is at the age of 7 years up, more maintenance must be done. This must be done by clearing surrounding weeds completely. If the surrounding area of the clump has soil pushed up to protrude, a hoe is used to dig to lower it down. If the soil is left pushed up to protrude, the nipa palm tree will grow incompletely.

7. Yields harvesting: Nipa palm trunk at the age of 7 can give yields continuously for 3-4 months.

Procedures to produce sugar from nipa palm trees

1. Selecting nipa palm trunks for slicing off palm juice by counting the age of nipa palm trunks starting from having the palm cluster to the age of 3 months

2. Beating nipa palm trunks or so-called by villager as "beating palm". The trunk is stricken for 50 times when each "beating palm" is performed. This is performed every other day for 6 days. Then, a brake is allowed for a month followed by a process called "Prae Tan" is performed. In other words, do this again every other day for 3 days accounting for 50 times each.

3. Slicing off nipa palm trunks to get palm juice should be performed at about 3.30-4.00 p.m. Put about 10 flakes of craib wood into a bamboo flask used to receive palm juice in order to prevent the palm juice to become sour. Leave everything until 6 a.m. of the following day. Then, slice off the trunk again. This procedure is called "wash the face of the palm". Once again, leave everything until 10 a.m. and put away the bamboo flask used to collect the juice for simmering further.

4. Simmering the juice

While the juice is being simmered, scoop "sludge of the juice" or white stain resulting from simmering. This part is scooped to be put in a jar to make vinegar for consumption further.

Simmering the juice in a pan takes about 3 hours to get liquid sugar about the size of viscous. After that, remove it from the stove to be drenched by using the palm-drenching stick to batter and press it in the pan with sugar. The reason of doing this is prevent the sugar from coagulating. Drenching the palm takes 30 minutes. Put the obtained sugar in buckets, which is the final step. Fresh sugar of 6 buckets is simmered to get a bucket of sugar.

Benefits of nipa palm trees

Parts of nipa palms to be utilized as follows:

1. Pond Jak (Leaf sheath) of nipa palm or is called locally as "Pong Jak" which is used as a buoy to hold on to during swimming. It can be used as a lot of toys such as ships, guns or swords. The part a little above Pond Jak can be cut to be used as a stick to beat spine of fish-fin for fishermen. For dry Pond Jak, it can be used as firewood in making nipa palm sugar.

2. Palm leaf: The back of the palm leaf can be used as a sheath to row a boat which is better than nylon sheath in terms of being tougher except for the disadvantage which is not being durable. The most benefit used mostly of palm leaves is making pieces of a tap thatching (bamboo silver to which nipa leaves are sewn to make thatch). Dry palm leaves can be used well as firewood.

3. Nipa palm crown: nipa palm leaflets are sewn to be hats used well as an umbrella for rain protection or sun protection. These hats are similar to ngob (a farmer' hat shaped like an inverted basin) of the central region but different in shapes. People in the southern region call this "Piew".

Old nipa palm leaves are sewn to make pieces of a tap thatching (bamboo silver to which nipa leaves are sewn to make thatch) or house partition.

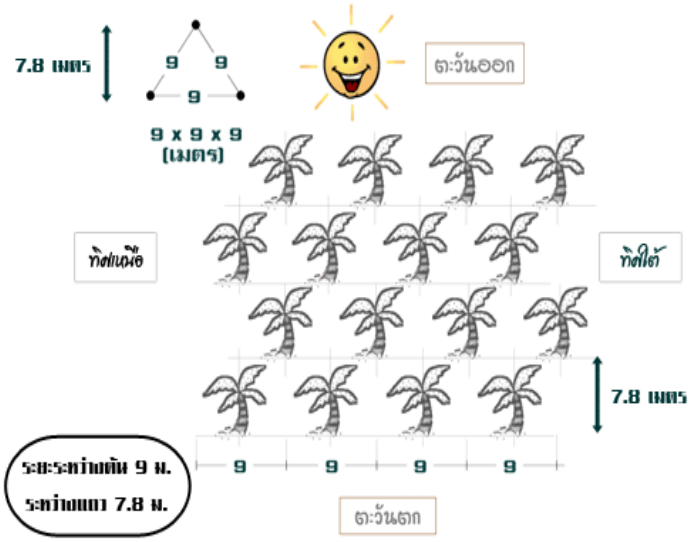
4. Nok Jak (inflorescence) is part of the flower stalk sprouting from the stem under the soil surface at the leaf base. When the white flower coat is peeled, it can be boiled and eaten with chili sauce or cooked as coconut milk curry.

5. Young nipa palm trunks can be made as brooms or insect-repelling whips.

6. Nipa palm fruits: Young nipa palm fruits can be cooked as curry for eating or if they are appropriately young, they can be eaten as fruits in syrup or candied as desserts or eaten with ice cream.

7. Juice of the nipa palm tree or nipa palm sugar and palmyra palm sugar have similar taste. The difference is that nipa palm sugar is a little bit salty. This is due to the fact nipa palm is a plant growing in brackish water and nipa palm sugar can be simmered to make nipa palm honey or can be fermented to make nipa palm vinegar. In fact, nipa palm sugar can be made as distilled liquor. Moreover, when nipa palm sugar is simmered, nipa palm honey is obtained and then palm sugar is obtained.

Technical plan of the technoloigy



SLM Categorization of the technology

Main objectives of the technology

1. To reduce, prevent, restore land degradation (soil, water, plant)
2. To conserve the ecosystem
3. Maintain or improve biodiversity

4. To build economic impact which is useful (Opportunities to increase incomes or employment)

Incomes from selling products and net incomes

The period in planting to harvesting nipa palm sugar from the first time takes about 6 years. Therefore, in this first period, farmers do not have incomes from nipa palm plantations and will start having incomes from the 6th year on. Regarding the period in producing nipa palm sugar, yields can be given for 4 months in a year.

- In an area of 1 rai, yields of nipa palm sugar can be harvested for 300 kilograms per rai per year.

- The selling price is 1.76 USD per kilogram. Therefore, the total income: 300*1.76 = 328 USD.

Besides making nipa palm sugar, farmers who grow nipa palms can create income from other products such as sewing nipa palm leaves for palm leaf thatch roofing, nipa palm vinegar, nipa palm leaves used to make cigarettes, making distilled liquor and making Nam Tan Tuoy (cup sugar).

Property characteristics of the natural environment

The mentioned area, the Annual Mean rainfall is 2,778.30 mm., which is at the moisture level.

The area is flat and 1 meter from the mean seal level. The soil is very deep with the depth more than 120 centimeters. The top soil texture is fine clay and the bottom soil texture is clay. The level of soil organic matter is high (>3%). The ground water cannot be utilized. The water at the soil surface is at the level which is more than enough. Regarding the water quality (not treated yet), the water can be used for agriculture only. The salinity value of soil is between 2-8 dS/m.

3. Environment

3.1 Impact in the on-site from using the technology

1. Economic and social impact

Aspect	Impact	Before	After
1. Plant production	**Positive**	Planting was conducted a little and natural nipa palm forests were encroached to conduct shrimp farming.	Areas have been increased more than 50% in the Khanap Nak district.
2. Diversities of products	**Very positive**	No diversities	Nipa palm sugar has been produced mainly and other products are also obtained, namely nipa palm vinegar, nipa palm honey, distilled liquor and wickerwork.
3. Areas for production	**Positive**	A little	When farmers receive knowledge transfer, the area of production has been expanded more.
4. Expenses of agricultural factors of production	**Greatly reduced**	Shrimp farming required high costs.	Low costs
5. Diversities of income-producing sources	**Positive**	One-way income of raising shrimps	Nipa palm sugar has been giving incomes mainly and other products are also obtained,

			namely nipa palm vinegar, nipa palm honey, distilled liquor and wickerwork.

2. Social and cultural impact

Aspect	Impact	Before	After
1. Food security and self-reliance	**Positive**	One-way income of raising brine shrimps	Nipa palm sugar has been giving incomes mainly and other products are also obtained, namely nipa palm vinegar, nipa palm honey, distilled liquor and wickerwork.
2. Recreational opportunities	**Very positive**	Not being tourist attractions	Being used as tourist attractions and social and cultural learning sources
3. Institute of the community	**Very positive**	Having little interaction	Unity of people in the community has been brought about more.
3. SLM or knowledge regarding land degradation management	**Positive**	The knowledge was not propagated yet.	The technology has been accepted and the knowledge starts to be propagated more widely.

3. Ecological impact

Aspect	Impact	Before	After
1. Water quality	**Very positive**	Having problems of waste water	The problem of waste water has been reduced greatly.
2. Mulch	**Very positive**	Being areas used for raising black tiger farm	Utilization has been changed to forestry plantations for more than 50% of the area.
3. Animal diversities	**Positive**	None	There has been an increase of young aquatic animals more.
4. Types of the variety giving benefits (predators, earthworms, insects doing pollination)	**Very positive**	A little	More increase
5. Carbon and greenhouse gas release	**Very positive**	-	There are more trees and there has been less release.

3.2 Off-site impact from using the technology

Aspect	Impact	Before	After
1. Occurrence of pollution in ground water or rivers	**Positive**	Waste were discharged from the system of shrimp culture greatly.	Due to the fact that utilization has been changed to planting nipa palms, problems of waste do not occur.

Acceptance of the technology and application

There is acceptance among farmers and they implement the technology. This accounts for 476 households. A total of areas used for planting account for 4,576 rai. The technology has been used for a long time whereby the form has been adjusted to be compatible with the current age.

Activities Pictures

Fig.1 Problems at first of areas used for shrimp farming. Currently, they become deserted shrimp farms.

Fig.2 Current conditions are complete nipa palm forests.

Fig.3 Preparing cultivation areas in the form of serration with planting spacing of 9 x 9 meters

Fig.4 Nipa palm seedlings with the size ready to be planted

Fig.5 Complete Nipa palm trees and they give yields

Fig.6 Products from Nipa palm sugar (Photographer : Kulvadee Sutthawat)

VDO LINK : https://www.youtube.com/watch?v=W_mgulCTyHI

11. COMMUNITY ENTERPRISE: NIPA PALM SUGAR PROCESSING GROUP, PACKAGES OF CHANATARANGSEE PLANTATION

1. General Information and description of best practice/technology

Introduction

Khanap Nak sub-district, Pak Phanang district, Nakhon Si Thammarat province is 24 kilometers away from the Pak Phanang district office. Currently, Khanap Nak sub-district has an area of about 24,250 rai. It has 10 villages. It was found that the Khanap Nak community is characterized by having an area of a plain. The area is adjacent to the gulf of Thailand on the east. It is connected to Pak Phanang river on the west whereby the Pak Phanang river has carried soil sediments to pile up at the mouth of the river for a long time. In 2015, the Khanap Nak community had the area of nipa palm forests or plantation from occupations regarding nipa palm forests as high as 4,578 rai accounting for 476 households. Comparing the quantity of areas of nipa palm forests, way of life related to and depending on nipa palm forests both in Nakhon Si Thammarat province revealed that Khanap Nak sub-district has the most area of nipa palm forests. Currently, nipa palm honey has been made in the Khanap Nak community more. The products obtained can be processed as a variety of products with good prices. This has increased incomes for households.

Currently, government agencies come in the area to help promote utilization of space in order to restore the natural ecosystem to be fertile by developing deserted shrimp ponds to plant nipa palm forests. Besides conserving important natural resources, there must be conservation of way of life in conducting nipa palm farming and the process of making nipa palm honey. The reason for this is that without conservation and passing on this to the next generation, values and importance may be lost.

The nipa palm forest area or nipa palm plantation in the Khanap Nak community has a large-scale area. In other words, it is the natural forest area with the most remaining fertility in Thailand. It should be conserved in terms of natural resources and way of life of the community related to nipa palm forests. Moreover, eco-tourism is a sustainable form of tourism which has a major role to the economy, conservation of the environment and natural resources as well as ~~well as~~ helps promote life qualities of the local people living in tourist attractions and adjacent areas.

Therefore, conservation of the nipa palm forest resource can be conducted based on eco-tourism as an instrument in management and leading to conservation.

The establishment started in 2017 with members accounting for 10 people.

Operating facility Moo 2, Khanap Nak sub-district, Pak Phanang district, Nakhon Si Thammarat province

Land user Mr. Kovit Chantarangsee
Mrs. Utsanee Chantarangsee
Mr. Pongsak Somsuk

Geographical location

Latitude 100.28654. Longitude 13.04643

Operation Start Date

The operation started in 2017

Type of approach Traditional/ indigenous

2. Approach, aims, and enabling environment

Objectives of the approach

1. To transfer knowledge regarding nipa palm forest farming to farmers in Khanap Nak sub-district and sub-districts nearby
2. For processing, namely palm sugar, palm juice, powdered nipa palm sugar and nipa palm vinegar and basket making from the elderly in the sub-district
3. To collect products and buy products from members. Members in the community enterprising: nipa palm sugar processing group, packages of Chantarangsee plantation determine the selling price of the product. The profits obtained from selling are shared with the members at the end of the year.
4. To buy items from people in the community nearby (select only people who produce according to the determined standard in order to keep the standard of products)
5. To receive budget support from government agencies
6. To conduct community touring activities

Methods to be implemented

1. To survey problems in the sub-district, prepare data of local community problems, households in trouble, solutions to be used to plan problem-solving

2. Holding meetings to prepare development plans of solving local community problems by analyzing problem conditions, sub-district data, prepare plans of problem-solving within the sub-district so that the community will have plans of social, economic, natural resources and environmental development to implement and build concrete success from driving the work

3. Solving problems of local development by leading the plan developing local communities to problem-solving through organizing stages presenting the development plan to related member agencies. The objective is to connect and support problem-solving in the area so that activities can be conducted to be in line with contexts, way of life and cultures in balance.

4. Integrate and connect member agencies: Connecting working, organizations in the group at the level of sub-districts, districts, provinces. There is mutual integration with member agencies.

5. Monitor and summarize performances. The community organization council manages the mechanism of monitoring problem-solving regarding troubles under solving problems by the community organization council and connecting and coordinating with related agencies for problem-solving

Conditions favorable for implementing the technology under this approach

- Cooperation or coordination of practitioners due to having corresponding needs
- Conceptual framework in taking legal actions (land tenure, rights of using land and water)

due to the fact that every farmer has his own land

- Policies: Due to being consistent with the policy to keep the environment
- Market (inputs procurement, selling products) and prices: Due to the fact that being the area in the Royal Initiative Project, Pak Phanang river basin, there are high marketing opportunities.

Conditions hindering the implementation of the technology under this approach

- Market (inputs procurement, selling products) and prices are obstacles: The Covid situation makes the price fall.

3. Participation and roles of stakeholders involved

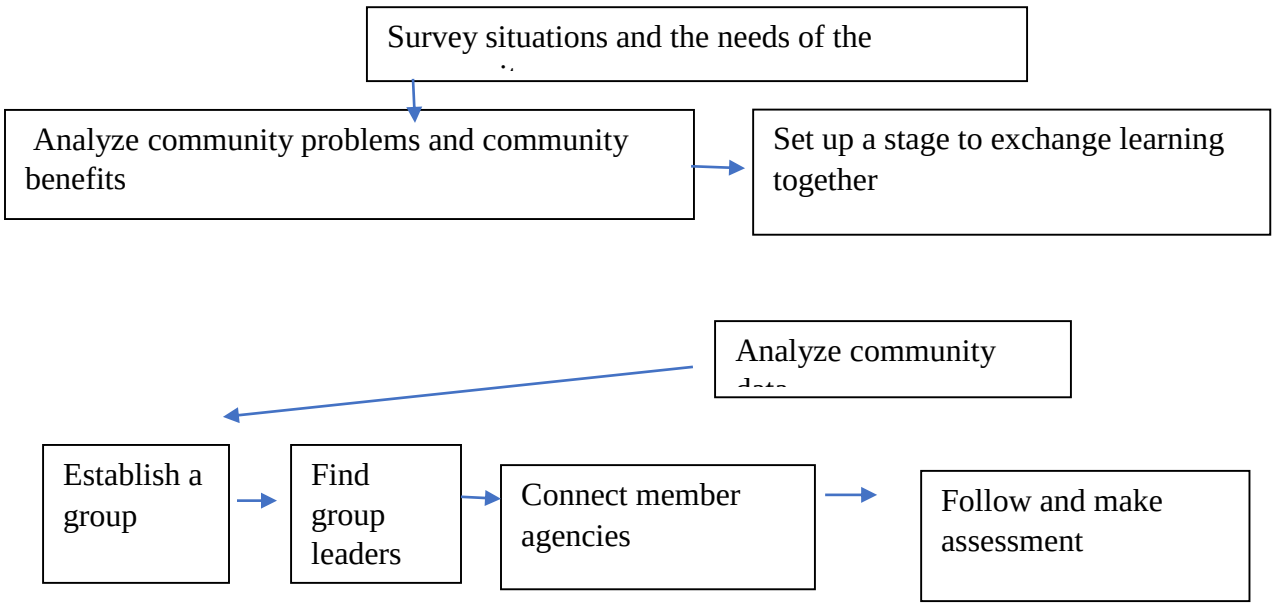
1. The stakeholders involving in this approach and the roles

Stakeholders or organizations involving with this approach	**Identify stakeholders**	**Explain roles of stakeholders or organizations**
Local land users or local community	Group members accounting for 10 people	Taking actions together to make the group become strong and have bargaining power
Researchers	Professor from Songkhla Nakarin University, Walailak university	Conduct research regarding following aspects: 1. Package development 2. The ecosystem and the environment 3. Tourism
Local government	Khanap Nak Sub-district Administrative Organization, Pak Phanang district, Nakhon Si Thammarat province	Participate and coordinate in establishing the group, procure markets and make public, support budget
The project of developing Pak Phanang river basin due to Royal Initiative	Officers of the project of developing Pak Phanang river basin due to Royal Initiative	Make public, procure markets

2. Involvement of local land users or local communities in phases of the approach

Phase of the approach	**Involvement of local land users or local communities**	**Identify those involved and explain activities**
Initiative or motivation	Mobilize forces by themselves	Government agencies, group members, universities transfer knowledge and take a study tour in order to implement learning and experiences in their own areas
Planning	Interaction and mobilize forces by themselves	Self operation
Operation	Interaction and mobilize forces by themselves	The member group determines group rules and regulations and goods standards together.
Monitoring or assessment	Interaction	Monitoring or assessment to bring about standards

Diagram shows procedures of working



Decision-making for selecting SLM technology Land users are the ones who are the main decision makers supported by SLM experts.

Decision-making is based on experiences.

4. Technical support, building capabilities and knowledge management

1. Training has been set up for land users or other stakeholders whereby there are forms of training, namely

- Go to see the actual place / farmers to farmers
- Use areas for demonstration

The training topic: Practicing making nipa palm and sugar nipa palm products

2. Consulting services: Land users access consulting services available providing plots of land users

3. Strengthening institutes (organizational development)

- Khanap Nak Sub-district Administrative Organization gives aid and support in terms of the meeting venue and facilitates coordination and budget.

4. Monitoring and assessment are part of the approach to bring about standards of the group.

5. Research: Professors from Songkhla Nakarin University conduct research on sociology, economics/marketing and ecology.

Impact analysis and summary

1. **Impact of the approach**

The approach	Given answers
helps land users implement SLM technology and maintain conditions or not	yes highly
mobilizes forces or improves financial sources access for SLM operation or not	yes moderately
builds or makes the institute become strong or brings about firm cooperation among stakeholders or not	yes highly
makes the underprivileged have social and economic power or not	yes moderately

promotes the youth or offspring of land users to participate in SLM or not	yes moderately
leads to food security or improves nutrition or not	yes moderately
improves market access or not	yes highly
leads to sustainable land use or energy sources or not	yes highly
leads to employment opportunities and incomes or not	yes highly

2. Main motivation of land users to implement SLM

- Land degradation decreases
- Risks of disasters decrease
- Joining the process, the project, the group, the network
- Ecological and Environmental conscious
- Aesthetic Improvement

3. Sustainability of approach activities

Land users can make things practiced based on this approach sustainable on the basis of having a strong group, cooperation honesty

4. Strong points / advantages of the approach

The community enterprise does not operate alone but cooperates with members giving support from several sectors such as: Khanap Nak Sub-district Administrative Organization which supports community tourism; Walailak University regarding research and developing the touring route leading to tourism and forest resources conservation from within the community and package development. Land Development Station supports factors of production in making compost. Display of products has been organized at Sufficiency Economy Center, Koh Tuad sub-district, Pak Phanang district, Nakhon Si Thammarat province. There are also activities of setting up booths distributing products at BOTA market at Walailak Botanic Park Walailak University. This is a channel for product distribution, including making public and releasing the products to be well-known among consumers as well as increasing sales volume to villagers in the community in another channel as well.

5. Weak points / disadvantages of the approach and solutions

The group still lack abilities in writing the project and business plans. It lacks abilities in finding markets. The group members do not know how to determine the marketing target group. Public relations have not been done much.

The approach to fix the problem is to place importance on leader development of the community enterprise group. There should be a policy in promoting finding markets and public relations to distribute goods especially for markets at the national level and exporting to foreign countries.

Activities picture

Fig.1 Meeting of the community enterprise group : The nipa palm sugar processing group, packages of Chantarangsee plantation

Fig.2 The group is observing the work on the study tour during the visit to see nipa palm sugar production.

Fig.3 describe beating nipa palm at the learning base

VDO LINK : https://www.youtube.com/watch?v=**2-**ioLr**6**EMVY

12. MANAGING AREAS WITH SALINE SOIL FOR PLANTING EXPORTED HOM MALI RICE AT THUNG KULA RONGHAI

1. General Information and description of best practice/technology

Information

Located in the southeast of the Korat Plateau, "Thung Kula Ronghai" is a large-scale plain. The terrain is characterized by being a large pan basin with gradient less than 2%. There are highlands around the edge of field which is gradually aslope to the middle region of the area. The area stretches crosswise along the Moon river with the maximum length measured by 150 kilometers and the maximum width measured by 50 kilometers. There are several main rivers, namely Lam Nam Siew, Lam Plub Pla and Lam Tao. The territory covers the areas of 51 sub-districts, 12 districts in 5 provinces, namely Roi Et, Surin, Si Sa Ket, Yasothon and Maha Sarakham accounting for 0.34 million ha. The area has physical, chemical and biological environments which are not suitable for doing paddy farming. As a result, products of rice and agricultural crops are very low. Therefore, Land Development Department entered the area to make a survey to classify the soil, make plans for land use and study how to solve the problems of soil, water and communication. The objectives for this are to develop the agricultural areas of Thung Kula Ronghai to be suitable with doing paddy farming and other agricultures of other aspects. It has been doing this since 1981 by initially establishing a pilot project in the area of 704 ha. This has been done by making a survey and designing the engineering infrastructure to be the water-controlling canal system in the paddy field or so-called "land remodeling" in order to mitigate flooding conditions. Water is drained from the area to reduce damages occurring to the rice tree. Moreover, water in the water drainage canal can also be used sufficiently in production. Ponds have been dug to store water to be used during the spell of rainy period. The soil and water conservation system has been constructed and maintained, and distribution of areas with saline soil has been reduced as follows:

1) The water-controlling system has been built to drain water at the soil surface and release salt together with the water harvesting system -water from rainwater and water from canals;

2) The communication system in the paddy field or roads in the paddy field have been built to be the economic route or roads connecting between communities with agricultural areas;

3) Water storing ponds or fish ponds each with the capacity of 400 cubic meters have been built to be reserved water sources for farmers;

4) Bridges or crosswalks of the water-distribution canal at each distance of 500 meters have been built;

5) Growing perennial plants has been promoted and conducted along the road in the paddy field throughout so that this can function as a windbreak to reduce problems of soil erosion due to whirlwind.

Moreover, Land Development Department has established the program of increasing standard Hom Mali rice products for export in the area of Thung Kula Ronghai. The objective is to support rice varieties and methods suitable for increasing Hom Mali rice products to alleviate troubles of target farmers for 87,400 households consisting of 400,000 lives living in Thung Kula Ronghai. Other objectives are to develop the production infrastructure, to build the transport route system for convenience in maintenance and product harvesting including transportation to the market. After that, there has been expansion of the operation area continuously to the present time. The achievement of land remodeling for the Thung Kula Ronghai development project from 1983 to 2018 can be categorized according to individual provinces as follows: 1) Roi Et accounting for 78,203.2 ha; 2) Surin accounting for 57,542.4 ha; 3) Maha Sarakham accounting for 13,840 ha; 4) Yasothon accounting for 1,766.4 ha with a total area accounting for 151,352 ha.

2. Problem conditions of the area before taking actions

1) Soil problems: The soil lacks fertility. It is very sandy and part of it is saline soil.

2) Water problems: Water cannot be controlled. There is shortage of water at the beginning of the cultivation season and there is flooding at the end of the cultivation season. There is also drought in the dry season.

3) Rice variety problems: The rice varieties used are not suitable with soil characteristics resulting in low average yields per hectare.

4) Land tenure problems: There has been freehand land tenure without ownership in the land.

Operating facility House No. 19, Moo 2, Ban Kho, E-ngong sub-district, Chaturaphak Phiman district, Roi Et province.

Land user Mr. Somporn Hittaphon

Compiler Mr. Pramote Yamklee

Partner Dr.Bunjirtluk Jintaridth
Mr. Boonthom Kumphon
Ms. Nuanrat Yingcharoen
Mr. Apisith Buapai
Mrs. Pornpen Ploensiri

Reviewer Dr.Bunjirtluk Jintaridth
Dr. Prapa Taranet

Geographical location

Latitude 100.808868 Longitude 103.523083

Operation Start Date

The operation started in 2011

2. Approach, aims, and enabling environment

Objectives of the operation

1. To solve the problems by reducing the salinity level and preventing distribution of saline soils in agricultural areas

2 . To solve areas with saline soils to be used agriculturally with diversities and sustainability

Activities and details of the operation

1. Mr. Somporn Hitaphon has owned the land for farming accounting for 2.88 ha. The soil texture in farm is sandy clay. It is in soil classification Soil Series group 20, Kula Ronghai soil sries (Ki). The problems of saline soil are found mostly on the surface soil. Previously, rice farming had been conducted for a long time, resulting in rice yields for only 625-937.5 kg/ha. This is considered very low. Therefore, the technology of saline soil management has been used to replace the traditional method by conducting integrated farming. The rice variety of Dok Mali 105 is planted together with acacia or *Acacia ampliceps* on the levee. After the rice is harvested, vetiver grass, watermelon and corn are planted as plants after rice harvesting. Currently, the mentioned

areas have been stored. When the soil in the paddy field was examined again, it was found that soil salinity reduced. In the past, the water in this areas had the salinity of 4.0 ppt considered to be at a high level of salinity. After using the technology, the salinity of the water in the pond is at the level of 1.5 ppt considered to be a medium level of salinity. This condition has enabled various plants to be grown more. As a result, products of rice and other plant have increased so many that they can be harvested and sold to be incomes throughout the year. This farmer is considered to be the primary prototype farmer who is able to solve saline soil problems in Thung Kula Ronghai.

2. Regarding rice cultivation, soil amendment is enhanced with organic matter continuously in the area of 2.88 ha. Rice variety of Kao Dok Mali 105 is grown in the area of 2.08 ha for distribution. Sticky rice variety Gor. Kor. 6 is grown in the area of 0.8 ha for consumption. The procedure starts with plowing up and over rice stubble after doing rice farming. Dolomite is used at the rated of 625 kg/ha. Plowing and incorporating it for 7 days are conducted. Cultivation is conducted by sowing dry rice in the rainwater field in May. Chemical fertilizers are applied for the first time according to the advice from the soil analysis value after the rice germinates for 7-10 days. The formula 16-16-8 at the rate of 156.25 per ha. Top-dressing urea fertilizers are applied at the rate of 31.25-62.5 kg/ha during rice pregnancy for the second time. The amount of nitrogen (N) accounts for 39.38-53.75 kg/ha. The amount of phosphorus (P_2O_5) accounts for 31.25kg/ha. The amount of nitrogen (K_2O) accounts for 12.63 kg/ha. For protection, fermented bio-extracts are used to prevent the plant from pests and get rid of them. The water is left to be dry within 7 days before harvesting at the end of November. As a result, the rice builds and secret the aromatic substance called 2AP. Rice products account for 2500 kg/ha. The average selling price is 0.59 USD/kg, making farmers have the income of 3,529.41USD annually.

3. For planting crops after doing rice farming, the area is divided into planting corn and watermelon accounting for 0.32 ha. The products obtained are used as food in households and for distribution. There is circulation of reusing agricultural scrap remainders. For example, leaves of vetiver grass are cut to cover soil in order to keep moisture and prevent salt accumulation at the soil surface. Plots of vetiver grass propagation are made for 0.48 ha. Regarding planting vetiver grass, its shoots separating from the clump are cut to remain for 20 centimeters and the root is also cut to become short. After that, the cut root is soaked in water with the level of 5 centimeters for 5-7 days. The root will branch out again. Then, it is grown in the field with spacing of 50x50 centimeters. After planting it, watering must be done regularly. When it reaches the age of 1 month,

the 15-15-15 fertilizer is applied for 1 teaspoon per tree. When it reaches the age of 4-6 months, it is dug to be cultivated in plastic bags or it is prepared to be seedling with naked roots for being utilized further. For the area of 0.16 ha, 100,000 vetiver seedlings are obtained on average. This bring about the income of propagating vetiver grass accounting for 882.35 USD ~~30,000 baht~~ annually. This is due to the fact that the vetiver variety of Songkhla 3 can grow in the soil with a slight to medium salinity and it is in much demand of the market. Therefore, this is an important place of producing vetiver grass seedlings of Thung Kula Ronghai.

4. Regarding planting *Acacia ampliceps* on the levee, it is a salt-tolerant (high salinity) plant which can be propagated by seeds. This can be done by collecting seeds from the tree at the age of 2 years up. Flowers start to bloom in October and seeds are collected in succession from March to May because pods are not ripe together at the same time. Before planting the seeds, they are soaked in hot water with the temperature of 90 °C in order to destroy dormancy. Sandy loam and rice hull ash are mixed with compost or manure with the ration of 2: 2: 1 to be planting materials. Then, the young plants are transferred to a pierced plastic bag. After 7 days of germination, the height is about 5 centimeters. In the third month, the young plant is allowed to be fully exposed to light to increase strength. Then, the young plant at the age of not more than 3 months is transferred to be planted in the soil at the beginning of the rainy season from July to August. The planting distance of 2 meters along the levee is used. The size of a hole is 30x30x30 centimeters. Compost and manure incorporated with soil is put at the bottom of the hole. After the planting hole is covered up, rice hulls are used to cover it. Mr. Somporn can produce *Acacia ampliceps* seedlings to be sold in the amount of 1,176.47 USD per year. Planting *ampliceps* is an alternative which farmers in areas with saline soil can manage by themselves in order to restore degraded soil to have better qualities.

5. The achievement from using the technology in managing water perfectly with soil meeting the needs of rice and managing the integrated planting system is the environment which other areas do not have. Therefore, Thung Kula Ronghai is the source of producing top-grade hpm Mali rice suitable with the rice variety Kao Dok Mali 105 in building an aromatic substance called 2- Acetyl- 1- Pyrroline or 2AP which is the same substance found in pandanus leaves. This substance smells like jasmine. The ability to build this kind of substance is determined by genes in DNA. This substance originates when rice is in stress from drought, water shortage in some periods especially during the harvesting period in which rice builds and secretes this aromatic

substance at the most. Moreover, it was also found that the sandy paddy field with a little salinity has an effect on making rice build the aromatic substance. 2AP more. This kind of rice has good cooking qualities which are rising well with cooking of rice. In other words, the rice becomes fluffy rice (flagrant, long, white and soft). Therefore, Hom Mali rice of Tthung Kula Ronghai has high prices, demanded by consumer's markets domestically and it is also exported internationally. It was registered for geographical indication on 21 April 2006. The applicant requested for registration of 5 provinces situated in the area of Thung Kula Ronghai.

3. Technical specifications, implementation activities, inputs, and costs

3.1 Revenues and expenses in using the technology

1. Initial costs and expenses in using the technology

Inputs	Unit	Quantity	Expenses per unit (USD)	All expenses per inputs (USD)	Percent (%) of expenses incurred by land users
Labor					
Rice	hectare	13	367.63	4779.74	100.0
Equipment, fertilizers and substances killing/ inhibiting growth of living things (Biocide)					
Water pump	Machine	1	147.06	147.06	100.0
Manure	Sack	100	1.47	147.06	100.0
16-16-8 chemical fertilizer	Sack	2	44.12	88.34	100.0
Plant materials and construction materials					
Rice seed	Kilograms	100	0.74	58.82	100.0
Land rent	ha	13	36.75	477.94	100.0
Tractors + oil costs	Time	4	29.41	117.65	100.0
Others					
Expenses of vetiver grass propagation plots	ha	3	367.63	1102.94	100.0

Expenses of watermelon and corn planting plots	Kilograms	2	117.65	235.29	100.0
Total expenses of establishing the technology				**1,811.76**	

Calculation of costs and expenses

Expenses are calculated to technology-based areas (Unit of size and area: 2.4 ha)

(1 hectare = 1 ha = 6.25 rai)

The currency used to calculate expenses has the unit as Baht

Exchange rate (to US. dollars) 1 US. Dollars = 34.0 Baht

Average wage in hiring labor per day is 8.52 USD

Most important factors having effects on expenses

1. Costs of agricultural materials, increasing prices of chemical fertilizers
   - In the past (2017), each sack cost 29.41 USD.
   - Currently, each sack costs 47.06 USD

   As a result, the cost of expenses has increased 294.12 USD annually.
2. Labor costs account for 211.77 USD.
3. Rice seed costs account for 58.82 USD .

2.Maintenance costs

Inputs	Unit	Quantity	Expenses per unit (USD)	All expenses per inputs (USD)	% of expenses incurred by land users
Labor					
Weed removal/fertilizer application/rice harvesting/ rice threshing	ha	13	183.81	2389.69	100.0
Equipment, fertilizers and substances killing/ inhibiting growth of living things (Biocide)					
Price of 16-16-8 chemical fertilizers	Sack	3.0	44.12	132.35	100.0

Equipment, plant materials and others					
Fuels (tractors/ water pump) once a month, 10 liters per time (1 year = 2 months)	Time	12	11.77	141.18	100.0
Costs of materials used for planting seedlings of *Acacia ampliceps*	Bag	10,000	0.03	294.12	100.0
Water melon variety costs	Can	300	0.06	17.65	100.0
Corn variety costs	Kilograms	50	0.24	11.76	100.0
Total expenses of maintaining the technology				**979.41**	

3.2 Incomes from selling products and net incomes

Before using the technology Incomes came from doing rice farming only. However, obtained products were very low due to saline soil and water shortage. In the area of 0.16 ha, rice products accounting for 100 kilograms were obtained (2.88 ha resulted in products about 1,800 kilograms). The selling price was 0.15 USD /kilograms. The total income from rice cultivation accounted for 264.71USD /year.

After using the technology Incomes comes from more various agricultural production, namely

Rice products account for 2,500 kg/ha. The most production is 5 tonnes. The selling price is 294.12 USD / ton. This gives a total of 1,470.59 USD.

The vetiver seedling variety is produced at the most accounting for 200,000 trees. The selling price is 0.0044 USD per tree. This gives a total of 0.88 USD.

The Acacia ampliceps seedling variety is produced at the most accounting for 10,000 trees. The selling price is 0.12 USD per tree. This gives a total of 1.18 USD.

Other product from the farm are watermelon, corn etc.

The total income is 3,529.41 USD.

3.3 Summary of expenses and net income

The income accounts for a total of 3,529.41 USD.

Expenses in conception and maintenance account for a total of 2,791.18 USD.

The net income accounts for 738.24 USD.

4. Environment

4.1 Property characteristics of the natural environment

The terrain is quite flat and 130-160 meters higher than the average sea level. Regarding the climate, there are 3 seasons. The average lowest and highest temperature are 21°C and 35°C respectively. It does not rain regularly. The average amount of rainwater is between 1,000-1,400 millimeters. The soil has rather poor water drainage and is more than 20 centimeters deep. It is grayish brown and has spot with colors. The soil texture on the top is sandy clay loam. The soil texture at the bottom is silt clay loam. The soil is Thung Kula Ronghai soil series (Ki) influenced by salt in the category of Maha Sarakham rock. The ground water cannot be used. The water at the soil surface is at a medium level. However, due to the water quality, the water can be used for agriculture only. However, water salinity is an important problem in conducting farming. As a result, only certain plants can be planted and low yields are obtained.

4.2 Impact in the on-site from using the technology

1. Economic and social impact

Aspect	Impact	Before	After
1. Crop production	**Increased at the most**	Products of 100 kilograms were obtained from crop production for 0.16 ha (2.08 ha = 1,300 kilograms) because the soil was very saline resulting in low production of rice.	Rice products of 5,000 kilograms per round of production are obtained.
2. Cultivation qualities	**Increased at the most**	Only a small quantity of the rice product was	When the planting system is changed to be suitable with soil conditions,

Aspect	Impact	Before	After
		obtained. The rice did not cover the whole seed.	products with better qualities are obtained.
3. Fodder production	**Greatly increased**	Due to the fact that the soil is very saline, there were not even grass or weeds growing.	Soil salinity has been reduced. As a result, farmers can use areas to conduct farming more variously.
4. Products which are sources of income has more diversities.	**Increased at the most**	The monoculture farming conducted was growing rice.	The integrated farming system is operated, namely rice, vetiver grass, watermelon, corn and Acacia ampliceps.
5. Variety of products	**Increased at the most**	Rice was grown only.	There are more products obtained from the farm, namely rice, vetiver grass seedlings, Acacia ampliceps seedlings.
6. Expenses of agricultural factors of production	**Much reduced**	-	Costs of chemical fertilizers can be reduced for 88.24 USD (costs of chemical fertilizers applied in the paddy field for 2 sacks) because there is crop rotation, reducing costs of production much.
7. Incomes	**Increased at the most**	Incomes came from selling rice. The average price of rice was 0.15-0.18USD /	Farmers have more incomes from rice production, propagation of

Aspect	Impact	Before	After
		kg. In the area of 2.08 ha, rice was produced for 1,800 kgs bringing about the income of about 264.71 USD.	vetiver grass variety seedlings, Acacia ampliceps variety seedlings. 1. Having incomes from selling rice up to 5 tonnes with the price of 294.12 USD/ton. The income accounts for 1,470.59 USD. 2. Having incomes from selling vetiver grass variety seedlings for 0.0044 USD/tree. The sale volume is 200,000 trees/year bringing about the income up to 882.35 USD 3. Having more incomes from selling Acacia ampliceps variety seedlings for 0.12USD/tree. The most sales account for 10,000 trees bringing about the income up to 1,176 USD

2. Social and cultural impact

Aspect	Impact	Before	After
1. Food security and self-reliance	**Improved at the most**	Rice was produced for 1,800 kilograms. The selling price was 0.15 USD per kilo.	Rice is produced for 5,000 kilograms. The selling price is 0.29 USD per kilo. Vetiver grass seedlings and Acacia ampliceps seedlings are produced for sales to be supplementary incomes. Water melon and corn are grown to be consumed in households.
2. Community institutes	**Strengthened at the most**	-	Being a prototype plot for people in the community to come to see for study, exchanging knowledge and experiences, expressing opinions together and solving problems mutually regarding management of agricultural areas with saline soils
3. SLM or knowledge of land degradation management	**Improved**	There was not much propagation of knowledge.	The technology is accepted. There starts to be more propagation of knowledge and farmers start to follow the practice more.

Aspect	Impact	Before	After
4. Situations of the underprivileged	**Much improvement**	There was no knowledge of transforming monoculture farming into integrated farming.	Receiving knowledge transfer from the learning center and being able to implement the knowledge in one's own areas together with asking for advice from prototype farmers

3. Ecology impact

Aspect	Impact	Before	After
1. Things covering the soil	**Much improvement**	There was no grass or weeds growing.	Halophytes such as grass and salt-tolerant plants start to grow.
2. Level of soil salinity	**Reduced at the most**	The salinity level was more than 4 ppt.	The level of soil and water salinity is reduced to 1.5-2.0 ppt until other plants can be grown.

4.3 Off-site impact from using the technology

Aspect	Impact	Before	After
1. Usable water	**Greatly increased**	-	Water from areas with saline soil can be utilized because vetiver grass and Acacia ampliceps are salt-tolerant plants which can grow in salt water with medium salinity.

Aspect	Impact	Before	After
2. Damages done to neighbors ' cultivation areas	**Greatly reduced**	Pest-repelling substances were used in inappropriate amount.	Using pest-repelling substances has been reduced. Organic substances are focused on in order to reduce using chemicals.
3. Impact of greenhouse gas	**Reduced**	The area of paddy field was burned to prepare cultivation plots.	They turn to plant rotation crops after doing rice farming in order to help reduce carbon dioxide gas originating from burning rice stubbles and reduce greenhouse gas emission.

5. Acceptance of the technology and application

Farmers accept the principles by participating in the project of developing and preventing distribution of areas with saline soil based on integration. They apply the technology in their own areas. They adjust the farming system and change the cropping system by planting rice as the main plant, vetiver grass, corn, water melon as plant after doing rice farming and planting *Acacia ampliceps* as plants for use on the earthen dyke. There is saline soil management according to the principle. There are a lot of farmers who participate in the project due to the fact that changes at the beginning do not require high investment and they receive benefits from the project.

6. Conclusion

6.1 Strong points: Viewpoints of land users

1. Soil properties under the degradation factor have transformed into more fertility.
2. Having better products has brought about more incomes.
3. Being able to have agricultural occupations in areas with saline soil sustainably

6.2 Weak points: Viewpoints of land users

At the beginning of the project, making a survey for designing construction was required to adjust area conditions of conducting farming and water management. As a result, some farmers did not decide to start or they did not have enough land to start with adjustment.

6.3 Strong points: Viewpoints of the complier

1. Farmers can change the cropping system on areas with saline soils by themselves until there are more various kinds of products supported by the market. Occupations and sustainable incomes from conducting farming have been built.

2. If agricultural areas face problems such as flood, drought, damaged paddy fields, change can be done as follows: Changing to planting short-lived plants using a little water; or making plots to propagate halophytes or salt-tolerant perennial plants to be sold further

6.4 Weak points: Viewpoints of the complier

Making plots to propagate vetiver grass, halophytes or salt-tolerant perennial plants to be sold requires support from the market or demand on using a large quantity of products continuously because they are plants used in particular areas. Therefore, farmers must plan production to be in line with the market demand and the cropping season mainly.

Activities pictures

Fig.1 -2 Plough and incorporate rice stubble before sowing sunn hemp and sunn hemp plots during the flowering period

Fig.3-4 The plot of salt-tolerant Hom Mali rice variety for the period of 60 days and harvesting the Hom Mali rice to be used as a rice variety for reproduction

13. TECHNOLOGY OF PLANTING HALOPHYTES (DIXIE GRASS) FOR RESTORING HIGHLY SALINE SOIL

1. General Information and description of best practice/technology

Introduction

Dixie grass (*Sporobolus virginicus*) is a halophyte plant. The objective of growing is to increase suitable land use change for farmers and to prevent saline soil distribution. Dixie grass can be used as fodder. Land Development Department has been trying to propagate Dixie grass to cover the area severely affected by salt. Growing halophytic grasses (Dixie grass) aims to make farmers able to utilize land and to decrease distribution of areas with saline soil. Dixie grass can be used as a plant, fodder for cattle.

Land Development Department has brought the technology of planting halophytes for restoring areas with highly saline soil to be used in the area of Mr. Chalong Munkarn residing at the address: 6, Moo 8, Kud Jok sub-district, Bua Yai district, Nakhon Ratchasima province. The area is a plateau with the steep slope of 0-2%. The soil has an electrical conductivity of more than 16 dS/m. The area has soil with high salinity and a semi-arid-climate. The amount of rainfall accounts for 751-1,000 mm. per year. Most farmers grow crops based solely on rainwater. This is due to the fact that the area has a condition of highly saline soil, making farmers obtain low productivity. Halophytes are plants which grow and give good yields at the level of high salinity especially for Dixie grass (*Sporobolus virginicus*) with the ability to survive accounting for 100% in the salinity of 40 ppt (NaCl). Dixie grass has adapted itself to have smaller vascular bundles and has adjusted the osmotic pressure. There is salt excretion at the glands on the leaves. Planting halophytes is to utilize areas with saline soil and to grow cover crops. This helps control moisture at the soil surface and prevent salt accumulation at the soil surface. This also includes being fodder for farmers conducting livestock farming whereby there is excreted salt on the leaves of the grass which cows like to eat them. The grass has qualities similar to other fodder plants.

Operating facility Ban Don Pae, No. 5, Moo 8, Kud Jok sub-district, Bua Yai district, Nakhon Ratchasima province

Land user Mr. Chalong Munkarn

Compiler Miss Kamolthip Sasithorn Land Development Department
Mr. Pairaj Pongvichien, Land Development Department
Mrs. Jutarat Ratanapanya, Land Development Department
Mr. Vinai Chombud, Land Development Department

Reviewer Dr.Bunjirtluk Jintaridth
Dr. Prapa Taranet

Geographical location

Latitude 102.477 Longitude 15.556

Operation Start Date

The operation started in 1983 - 2012

2. Approach, aims, and enabling environment

Objectives of the technology

1. to prevent highly saline soil distribution
2. to utilize farmers' land to bring about most benefits
3. to use the grass as a cover crop and restore the ecosystem in areas with highly saline soil.

Activities and details of the operation

Planting halophytes has been supported from Land Development Department under the project of promoting integrated development of areas with saline soil in sub-watershed areas and activities of restoring areas with highly saline soil by growing salt resistant perennial plants and halophytes. The stakeholders are officers working together with soil doctors and community leaders in making public relations and coordinating the project work with farmers. Regional office of Land Development Department has supported Dixie grass varieties based on compost, chemical fertilizers to plant them on levees and the unused area with highly saline soil. Planting them on the levee with the width of 1.5 meters and the plant spacing of 20x20 centimeters. They are alternatively planted with *Acacia auricuriformis* with spacing between the trees of 2 meters. Dixie grass propagation can be done by cutting the grass tree with the length of 2-3 inches for the number of 3 nodes to be cultured in black bags. When the young plant is at the age of 1 month, it can be cultivated. Using this technology has brought about changes within 3 years. Numerous types of

plants come back to grow such as several types of wild grass. As a result, living things such as dragonflies, birds, rats etc. have come to live in this area. Farmers who grow Dixie grass on the levee can grow rice. Also, Dixie grass can be used as fodder for cows, resulting in increasing farmers' incomes due to having occupations in their own areas. Moreover, this also reduces migration to make a living in other areas. Farmers are satisfied with the technology in terms of the fact that it can restore the area with highly saline soil so that the area can be utilized more. It is the practice with small investment. Dixie grass can replace fodder and helps increase farmers' incomes from selling the young plant of Dixie grass to Land Development Department. Although growing Dixie grass is improving saline soil based on the period of time in restoring saline soil conditions which gives results not so fast as based on engineering management, investment is lower than using the engineering approach with high investment.

3. Technical specifications, implementation activities, inputs, and costs

3.1 Classifying types of technology to reduce distribution of highly saline soil

Areas with highly saline soil are the area with no farming conducted. The area is deserted. The area is chemically degraded in terms of salinization or alkalinization. As a result, farmers cannot utilize in desert the area. Therefore, Land Development Department must promote farmers to restore highly saline soil by using the technology of planting halophytes (Dixie grass) for restoring highly saline soil. This is the conservation method based on planting grass. The main purpose is reducing, preventing and restoring degradation of saline soil, conserving the soil and plant ecosystem as well as maintaining or improving biodiversity in areas with saline soil. The goal of preventing degradation of areas with saline soil is promoting and transferring degradation prevention and restoring areas with saline soil with using the technology of planting halophytes (Dixie grass) to restore highly saline soil for farmers. Advising regarding guidelines for sustainable land management is also included, which is growing Dixie grass to prevent saline soil distribution, to cover the ground to salt movement to the surface. After the area with highly saline soil has been improved with planting Dixie grass for 3-5 years, the environment of soil and plants is better and integrated land use occurs in the area. Plants and livestock are integrated by using Dixie grass as fodder for conducting livestock farming and reducing risks of occurrence of dry areas.

3.2 Technical drawing plan of the technology

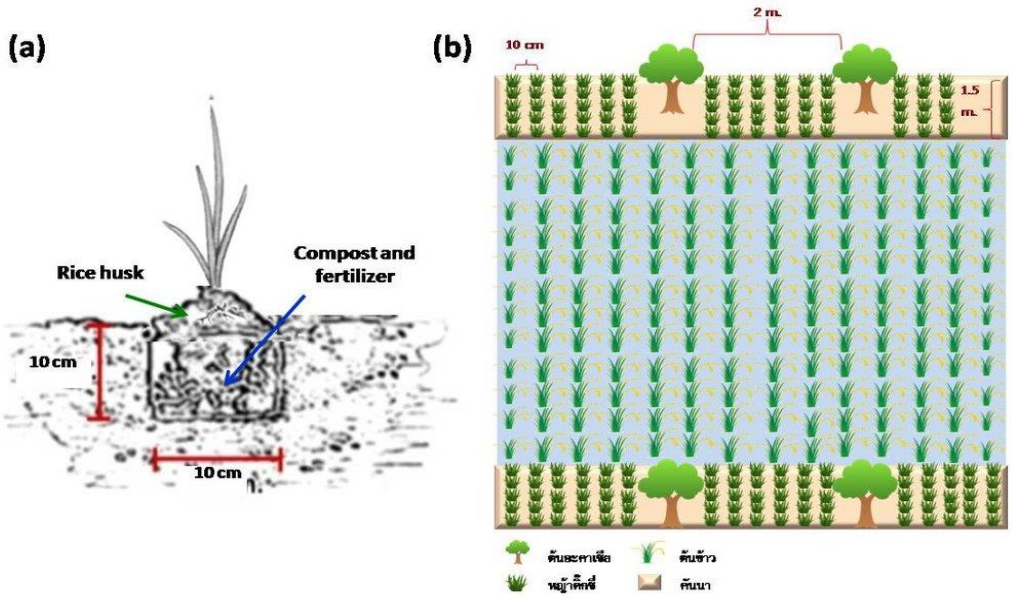


Fig 1 Dixie grass propagation and plating Dixie grass on the area with highly saline soil

(a) Propagating Dixie grass can be done by cutting the grass tree for the length of 2-3 inches with 3 nodes. Bring the piece to be cultivated in a black bag with mixture of soil and compost used as growing media. When the grass seedling is 1 month old, it can be cultivated. Prepare soil by digging a hole with the size of 10x10x10 cm^3. Put compost for 200 grams per hole and the 15-15-15 chemical fertilizer for 6.25 grams per hole. After that, cover it with paddy husk for 400 grams per hole and the planting spacing is 30x30 centimeters; (b) The picture shows growing Dixie grass in the area with highly saline soil between levees where Acacia Auricuriformis is planted to prevent saline soil distribution.

Activities for setting up are 1) Planting Dixie grass seedlings (period of time/frequency: May-July 2015), 2) soil preparation for cultivation (period of time/frequency: May-July 2015) and 3) using chemical fertilizers (period of time/frequency: May-July 2015).

3.5 Incomes and expenses in using the technology

1. Initial costs and expenses in using the technology

Inputs	Unit	Quantity	Expenses per unit (USD)	All expenses per input (USD)
Labor				
Labor for planting Dixie grass: 1 person/day for 300 USD per day and 1 rai requires labor for 4 persons, accounting for 1,200	ha	1	35.2	220
Plant material				
Dixie grass seedlings for 1,600 trees/ha, 0.5 USD/tree	Seedling	10,000	0.015	147
Fertilizers and substances killing/ inhibiting growth of living things (Biocide)				
Compost price: 0.10 USD/kg., 0.2 kg/hole	kg	320.0	0.10	32
Paddy husk price: 0.12 USD/kg., 0.4 kg/hole	kg	640.0	0.12	76.8
15-15-15 chemical fertilizer price: 0.59 USD/kg, 6.25 kg/hole	kg	10.0	0.59	5.9
All expenses of setting up technological (US dollars)				**481.7**

Calculation of costs and expenses

Expenses are calculated per the area of using the technology

the currency calculated for expenses: Baht

The exchange rate is 1 US dollar = 34.19 Baht

Average wage in hiring daily labor is 300 Baht.

The most important factor having an effect on expenses is the policy of the government on the minimum wage which is an important factor having an effect on the cost of the project.

2. Activities for maintenance There is no maintenance for these activities because Dixie grass can grow and propagate by itself.

3. Incomes and expenses of farmers can be compared from benefits from expenses: It was found that for short term returns, there are short term returns and long term returns in the positive trend greatly. Regarding benefits from expenses in maintenance, it was found that for short returns, there are short term returns and long term returns in the positive trend greatly.

4. Environment

Regarding changes of severity of the climate (disaster) such as disasters from drought, forest fire, fire on the land, flash flood and invasion of insects, worms, there are trends which are constant and decreasing. There is not much impact from consequences related to other climates such as extended period of cropping and reduced period of cropping.

4.1 Natural environment of the area around the area with highly saline soil

1. Regarding climate data from 1983 to 2012, the annual average amount of rain water accounts for 1,028 millimeters. The agricultural climate is semi-dry. The average temperature is 21-36 °C. Relative humidity is 75%. Source: Meteorological Station: Meteorological Department

2. The area is plain to plateau with the gradient of 0-2%. The altitude from the sea level is 101-500 meters.

3. The soil depth is about 81-120 centimeters. The top soil texture is coarse sand. The soil texture is 20 centimeters lower than the soil surface. The soil is silt loam and there is low amount of organic matter in the soil.

4. Ground water can be dug at the level less than 5 meters but there is a problem of water salinity.

5. There are low diversities of plants and animals.

4.2 Characteristics of land users applying the technology: Farmers have the main occupation which is doing farming and the secondary occupation is doing business. The main income outside the farm accounts for about 10-50% of the entire income. Livelihood is at the medium level. Most farmers are male and middle aged. They own areas for about 1.6 – 2.4 ha with their own ownership. They use labor within the family to conduct farming and receive a right of using the irrigated water.

4.3 Access to services and infrastructures Farmers receive public health services, education, knowledge promotion from the government, employment outside agricultural areas and building marketing opportunities at the medium level for support in terms of energy, transportation, utilities and sources of investment funds for loans at the low level.

4.4 Impact

4.4.1 Economic and social impact

Farmers have areas for producing quality plants, increased plants used for feeding livestock and for supporting utilities with good water such as quality drinking water, quality water for livestock and irrigated water with qualities for cultivation. The main income of farmers comes from products from their own plots. Some incomes come from other sources such as being employed and doing business etc.

4.4.2 Social and cultural impact

Farmers have good health and self-reliance food security. Social conditions of the community and culture have stability. Using areas with saline soil sustainably can be transferred. There is unity in the community. There is help for people in the community to reduce social inequality.

4.4.3 Ecological impact

Using the technology of planting Dixie grass to restore highly saline soil revealed that the ground has more plants which can grow to cover the ground. As a result, there are diversities of numerous types of plants and animals. Water has better qualities, decreasing soil salinity and increasing more fertility.

4.4.4 Impact outside the operation area

There are few changes in the environment of the outer area of the project: Pollution of usable water in the water source has been reduced. Seasonal flooding is normal, causing a few damages to the cultivation area and infrastructures of the community.

5. Conclusion

5.1 Strengths

Regarding opinions of the farmers using the technology, they view that Dixie grass is the plant which resists salt highly and after planting it, salinity is clearly reduced. The environment becomes better. As a result, other plants return to grow in the area. The area in not empty any more. Also, the owner of the area can grow and propagate Dixie grass for Land Development department.

The only grass halophyte is Dixie grass which can grow in areas with highly saline soil. After growing Dixie grass for 2-3 years, soil salinity has been reduced, resulting in the occurrence of biodiversity of animals and plants such as butterflies, birds, rats, worms and indigenous plants etc. It is better for farmers to use their own land for more extension than leaving the land become dry. Dixie grass can be used as fodder, increasing the land owner's incomes.

5.2 Weaknesses/risks

Farmers' opinions: Lack of knowledge of planting halophytes to reduce distribution of highly saline soil and there are no other alternatives to find better incomes than planting Dixie grass. Farmers from nearby areas always burn rice straw after harvesting, making the Dixie grass partly. Suggestions are that officers should meet farmers and transfer knowledge about reducing highly saline soil distribution to farmers. Public relations are necessary to stop burning rice straw.

Every researcher and officer must understand and be trained regarding mechanism of halophytes, importance of Dixie grass on the working plan of this project and monitoring results of the operation efficiently. Suggestions are that officers must be trained at levels such as receiving more training and knowledge about the project and placing importance on weak points and obstacles of achievement of the project more.

Activities Pictures

Fig. 1-2 Planting Dixie grass in the area with restoring highly saline soil

14. EXTENDING PLANTING THE HALOPHYTIC GRASS (DIXIE GRASS) IN THE AREAS OF SEVERELY SALINE SOIL

1. General Information and description of best practice/technology

Introduction

The government promotes planting Dixie grass to control areas with severely saline soil as well as restoring the ecosystem and preventing salt distribution under the cooperation of the land owner, farmers, soil doctors, local authorities and experts in fields.

Regarding extending planting Dixie grass in the areas of salt-affected soils, Land Development Department, Ministry of Agriculture and Cooperatives has a project in restoring areas with severely saline soil by planting salt tolerant perennials and halophytic grasses in the northeastern part of Thailand. The project started in 1996 and has been operated. The project supports planting the halophytic grass (Dixie grass) on deserted areas with severely saline soil. The main objective is to disseminate to farmers to use the land for maximum benefits and to prevent saline soil distribution by planting Dixie grass to cover the ground, and to restore the ecosystem of salt-affected soil. The first activity is to do public hearing from people in the community, to specify the area severely affected from salt and to prepare demonstration plots on farmers' areas as a learning center. Then, cooperating with administrative organizations was conducted. Before preparing the demonstration plot, officers hold a meeting with farmers for brainstorming regarding weakness, strength, opportunities and obstacles of planting Dixie grass on areas with severely saline soil. The demonstration plot consists of activities for 4 steps as follows: Step 1- Preparing Dixie grass seedlings, selecting areas, preparing soil, public hearing and preparing demonstration plots at Dan Chang sub-district, Bua Yai district, Nakhon Ratchasima province in the area of severely saline soil; Step 2- Coordinating with researchers and farmers who are the owner of the area for planning together the operation and monitoring and assessing results on the operation; Step 3- When farmers are selected, the officers demonstrate the method of planting and propagating Dixie grass as well as taking farmers for the study tour in the achieved area in Northeastern Thailand; and Step 4 - Regarding the extension, officers will take farmers participating in the project for 3 years to come to extend and propagate results of the work with achievement of Mr. Chalong Munkarn. Previously, the area was very salty that plants could not be

planted. After 3 years of operation, it was found that the deserted area where Dixie grass is planted, there are other kinds of plants growing to cover the ground more than before. Rice can be cultivated. This makes farmers have secure incomes and reduces migration and labor to big cities. this project has made local authorities, officers, researchers and experts from Land Development Department work together in these area. Although the plant method does not require high expenses and takes time longer than the engineering method with high investment and fast results, farmers can practice the method of growing Dixie grass by themselves in their own area. When strength points in extending the results are assessed, it was found that having soil doctors, local administration organizations and farmers can access the source of Dixie grass seedlings easily and there are no expenses. The technology helps improve the environment of severely saline soil in Northeastern Thailand. Land Development Department agriculturalists and the community helping spread knowledge about planting Dixie grass continuously. Also, there are demonstration plots. For weakness points in extending the results, public relations are not made thoroughly, Land Development Department should coordinate with local administration organizations to help regarding public relations. Some farmers do not believe that Dixie grass can withstand salinity at the severely salty level and after cultivation salinity will decrease. Therefore, Land Development department officers should transfer knowledge and take these farmers to see achieved examples.

Operating facility Ban Don Pae, No. 5, Moo 8, Kud Jok sub-district, Bua Yai district, Nakhon Ratchasima province

Land user Chalong Munkarn,

Compiler Miss Kamolthip Sasithorn Land Development Department
Mr. Pairaj Pongvichien, Land Development Department
Mrs. Jutarat Ratanapanya, Land Development Department
Mr. Vinai Chombud, Land Development Department

Geographical location

Latitude 102.477 Longitude 15.556

Operation Start Date

The operation started in 1983 - 2012

2. Approach, aims, and enabling environment

2.1 objective of the approach

The main goal or objective of the approach is to promote land users to bring about agricultural maximum benefits in order to prevent saline soil distribution in areas with severely saline soil by growing Dixie grass as a cover crop and to restore the soil ecosystem severely affected from salt.

2.2 Conditions favorable for implementing the technology under this approach are as follows:

1) Land owners have guidelines for practices following successful neighbors.

2) Financial and service sources are Bank for Agriculture and Agricultural Cooperatives.

3) Local Administration Organizations are the supportive agency.

4) Coordination of volunteer soil doctors and community leaders in the area with farmers in the area

5) The government has a policy of preventing soil degradation.

6) Supporting the knowledge regarding sustainable management of areas with saline soil for land users

7) Providing budget to support farmers to participate in the project continuously in areas with saline soil

2.3 Decision-making in selecting the technology of managing land with saline soil sustainably

Experts of managing areas with saline soil sustainably are main decision makers by using data of the environment of areas with saline soil. Using the technology of soil management is suitable with solutions. There are guidelines for practices easy to understand which farmers can actually follow in the area. The decision is based on assessing farmers' knowledge about soil management and interest of participation in the project etc.

3. Participation and roles of stakeholders involved

Identifying stakeholders	How do implementing Stakeholders or organizations involve with this approach?	Explaining roles of stakeholders or organizations
Local land users or local community	Farmers participating in the project take the technology to be available in the area.	Planting halophytic grasses (Dixie grass) in areas of saline soil
Sub-district administration organization / municipality	Facilitating technology implementation	Support the project for achievement such as making public relations
Land Development Department	Being the agency which supports the operation	Supporting knowledge, allocating the budget
Researchers / Experts of sustainable land management	Being workers	Giving advice, promoting and transferring the technology
Government (planner and decision makers)	Project sponsor	Capital, planner, decision maker

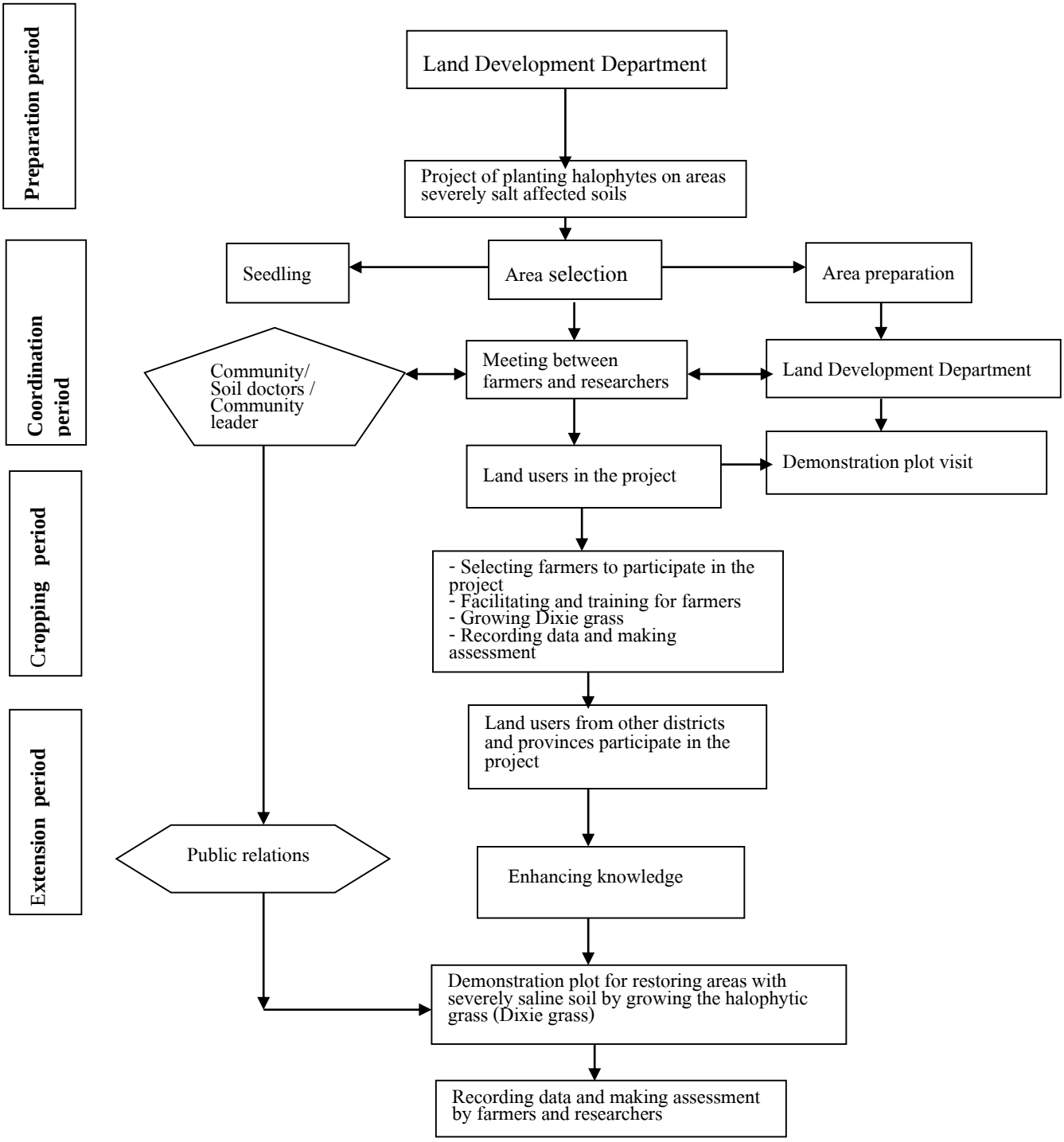


Fig. 1 The process with participation for 4 steps of developing the technology among organizations, volunteers, community in soil amendment, farmers and experts of sustainable land management and researchers

4. Technical support, building capabilities and knowledge management

The approach of extending results of planting the halophytic grass (Dixie grass) to control areas with severely saline soil: 1) Transferring the knowledge of restoring severely saline soil based on planting Dixie grass; 2) Building awareness of reducing saline soil distribution in the community area of one's own; 3) Participants of the restoring project must take the study trip to see the achieved sample plot; and 4) Officers give advice, monitor and assess results of the operation.

4.1. Procedures of the operation are as follows:

4.1.1 Prepare the budget of restoring severely saline soil under the topic "Preventing and restoring the land affected by salt with available technology and increasing incomes to farmers" using the technology of halophytes cultivation (Dixie grass) for restoring severely saline soil based on the reference from the group of researching and developing saline soil management conducting the research on the topic “Halophytes plantation and flow path along the landscape in Northeast Thailand” together with Dr. J.L. Gallagher from Delaware, University.

4.1.2 Recruitment announcement for farmers who possess areas with severely saline soil and intend to participate in the project

4.1.3 Officers explain details, steps of the operation and consequences which farmers will obtain

4.1.4 Officers transfer knowledge about Dixie grass cultivation for restoring areas with severely saline soil and visit the achieved place whereby farmers who are the owner of the plot and soil doctors pass on experiences, keys to success and open up a stage for exchanging opinions with one another. Experts of improving saline soil give advice and answer academic questions so that farmers will have more knowledge and understanding.

4.1.5 Officers must monitor and assess the project: Making a survey of the survival rate, monitoring growth of plants in the area with severely saline soil, supporting knowledge and solutions

4.2 Support in terms of finance and materials & equipment

Land Development Department has supported farmers who participate in the project for restoring severely saline soil by planting the halophytic grass (Dixie grass) in areas with severely saline soil of Northeastern Thailand: Support for finance / materials & equipment; Production factors not less than 2,000 US dollars are Dixie grass seedlings, expenses for planting preparation such as fertilizers, planting labor.

5. Conclusion

5.1 Impact of the operation approach:

5.1.1 Farmers who participate in the project obtain food security and family incomes.

5.1.2 Establishing the learning center for farmers to be a source of transferring technology and data of restoring severely saline soil based on growing the halophytic grass influences farmers' decision-making, acceptance and implementation in their own areas, which increases a little bit.

5.1.3 Most farmers tend to use the technology to maintain the environment of the area to become better and propagate this technology to farmers in nearby areas further.

5.1.4 Farmers participating in the project adjust the knowledge and apply the method of managing saline soil to have a form which is suitable with their own areas.

5.1.5 The area participated in the project has more diversities of plants and animals. As a result, farmers can grow rice and use the grass as fodder for cows.

5.2 Main motivation of land users to implement sustainable land management

5.2.1 Farmers have increased agricultural products after implementing the technology of planting Dixie grass for restoring saline soil.

5.2.2 Farmers can see problems of soil degradation occurring to areas and losses of plant production and incomes form the area.

5.2.3 Regarding areas with saline soil of farmers participating in the project, farmers have knowledge and positive attitudes towards growing Dixie grass more and more. They can utilize

the land sustainable. For example, there is better environment. Rice can be grown in the area. There is fodder for livestock. Also, farmers have increasing incomes.

5.3 Strength

Volunteer soil doctors, local administration organizations and local leaders are coordinators in the area. This makes farmers able to access the market and the source of Dixie grass seedlings easily. Growing Dixie grass in areas with saline soil and propagating Dixie grass seedlings can be done with no expenses.

The attitude of the complier: The techniques are supported and built to help improve the environment on severely saline soil in Northeastern Thailand. The techniques in growing Dixie grass are prepared by Land Development Department and community volunteers in improving soil and demonstration plots achieved as sample plots in the area.

5.4 Weakness/ disadvantages/risks

Public relations of the project are not made sufficiently especially for areas with severely saline soil. Suggestions are: Land Development Department must coordinate closely with local administration organizations to promote the project.

The attitude of the complier: Some farmers do not believe that Dixie grass can withstand salinity and reduce soil salinity after cultivation. Suggestions are: Officers should build knowledge from successful farmers by visiting farmers in the area often under the project "Growing Dixie grass to restore areas with severely saline soil"

Activities Pictures

Fig. 1-2 Experts, researchers and owners of the area discuss together regarding utilizing Dixie grass in areas with severely saline soil

Fig. 4-5 Areas with severely saline soil before being restored with Dixie grass

15. THE SOIL DOCTOR NETWORK BUILD SUSTAINABILITY IN AREAS WITH SALINE SOIL AND INTEGRATED FARMING SYSTEM

1. General Information and description of best practice/technology

Introduction

Most agricultural areas in Northeast Thailand rely on rain water and some areas are saline soil. The most cultivated plant is rice. Currently, there is climate variability. Rain distribution has changed. There has been labor shortage. The labor cost is high. Production factors cost and most farmers are old.

From the mentioned reason, adjusting the agricultural system from monoculture to integrated farming is another alternative for farmers because it is the method of helping farmers utilize their own cultivation areas most worthily. This method can build diversities of products and food security. Integrated farming is combining at least 2 types of agricultural farms in the same period of time. Balance and sustainability are built for agricultural areas.

Soil doctor network in the area of Ban Doo Noy, Non Daeng sub-district, Non Sila district, Khon Kaen province have transformed the area with rice cultivation conducted for only once a year into doing integrated farming through field level adjustment, adjusting levees for bigger sizes, digging ponds in the field together with drilling artesian wells and cropping for many types, namely rice, papayas, bananas and grasses for feeding animals on the levee, growing vegetables, cropping after rice harvesting, such as sunn hemp, sweet corn, sugar cane and raising cows etc.

Operating facility Ban Doo Noy, Moo 7, Non Daeng sub-district, Non Sila district, Khon Kaen province

Land user	Mr. Kasem Saihoe
	Mr. Prakob saengdao
	Mr. Chai Ushi
Compiler	Ms. Supranee Srithanboon
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Mrs. Tossaporn Phonruang

Editor Dr. Bunjertluk Jintaridth

Mr. Pramote Yanklee

Dr. prapa Tarnnate

Geographical location

Latitude 102.676958 Longitude 16.016233

Operation Start Date

The operation started in 2017

2. Classification of the best practice/technology

Objectives of the technology

1. To build the network of soil doctors who use the integrated farming technology in using areas with saline soil sustainably.

2. To propagate knowledge regarding building food diversities for households in areas with saline.

3. To access assistance in aspects from government sectors and private sectors

Methods of operation

1. Land Development Department officers holds a meeting for discussion with soil doctors and network farmers to provide the technological data of land development, determining activities operation plans to be conducted and forms of managing areas with saline soil

2. Land Development Department officers conducts focused group interviewing with the soil doctor network to drive actual implementation of integrated farming in areas with saline soil

3. Land Development Department officers operate mutually with farmers of the soil doctor network, collect data in the area such as soil, water, plant sample collection and details of agricultural activities to analyze and summarize data with the farmer network after implementing the integrated farming technology in the area with saline soil as well as summarizing problems and extension development

3. Participation and roles of stakeholders involved

Stakeholders	Roles of stakeholders	Obtained benefits
The group of farmers of the soil doctor network	It is the one implementing the approach of using the integrated farming technology in its own agricultural areas. There are 10 members participating in the network.	Being able to conduct integrated farming in the area efficiently. There is a variety of agricultural activities, helping build food security and incomes to families.
Land Development Department officers	They are the ones who transfer knowledge, support production factors such as Sunn hemp seeds etc., including giving advice regarding putting in use correctly, suitably and mutually studying changes occurring in areas with saline soil	Being able to transfer knowledge to other areas and, develop and extend the technology of managing areas with saline soil suitably with social landscape.
Farmers and the interested general public	Participating in the field study to exchange knowledge in the prototype soil doctor plot and in the plot of network farmers	Applying knowledge to develop their own agricultural areas due to the fact that production factors can be made locally with prices not so high
Government agencies and local agencies	Are the ones supporting in terms of knowledge of other related areas	Being able to propagate knowledge and the technology in managing areas with saline soil to people who are interested in using it or to adjust in other areas

4. Steps and activities of the operation

Steps of the operation	Activities	Supporting or being supported
1. Holding a meeting with network farmers	Giving technological data regarding to developing areas with saline soil and attending the meeting for discussion to determine the operation plan	Transferring knowledge to the network and the farmer group, giving related information in the area such as operated agricultural activities, information in terms of economy, society and the need of farmers
2. Planning the operation	Focused group interviewing, determining activities to be conducted and forms of managing areas with saline soil	Farmers receive support: Sunn hemp seeds and Land Development Department' products
3. Operation in the area	Actual implementation of the technology in areas with saline soil	Farmers receive training and transferring knowledge and practices
4. Monitoring and assessment	Collecting data in the area such as soil, water, plant sample collection and details of agricultural activities	Giving advice and attending focused group interviewing to collect and summarize data with the farmer network after implementing the technology in the area

5. Conclusion

1. Strong points: Viewpoints of land users

1. Having an opportunity to see managing the integrated farming area which has been achieved and being able to adjust it in their own areas

2. Having points of exchanging learning in the community, being able to access them easily

3. Having an opportunity to receive advice and exchange knowledge both from officers and the soil doctor network

4. Having an opportunity to receive support from government agencies and local agencies

2. Weakness: Viewpoints of land users

Requiring a period of time for at least 3 years until changes can be seen in areas of saline soil

3. Strength: Attitudes of compliers

1. Transferring the technology of the soil doctor network about self-reliance, family labor and factors in the farm. This helps reduce production costs.

2. Prototype soil doctors always provide knowledge data regarding production and give advice regarding suitable practices. This helps bring about security in occupation of the network group using integrated farming technology.

4.Weakness: Attitudes of compliers

Agricultural areas are still affected from water qualities for agriculture from artesian wells in terms of receiving brackish water during the dry season, Some farmers solve the problem by digging a pond in the field to pull water from the artesian well to be stored before using it in the agricultural plot.

Activities pictures

Fig. 1 Soil characteristics and salt stains found

Fig 2 Giving advice to the group

Fig. 3 Rice in the farmer's plot grown after plowing up and over Sunn hemp scraps

Fig. 4 Planting papaya, bananas and grasses for feeding animals on the ridge after being adjusted for a bigger size

Fig. 5-6 Growing Sunn hemp for storing seeds and sweet corn after harvesting rice

Fig. 7 The artesian well pumps water with solar cells which farmers operate by themselves

Fig. 8 The artesian well pumps water with solar cells together with the water distribution system supported by Department of Groundwater resources