FOCUS Vietnam

Farmer Options for Crops Under Saline conditions

Australian Centre for International Agricultural Research

Australian Aid

TECHNICAL FACTSHEETS

Table of contents

Digital copies of these factsheets can be found on the project website FOCUS project | Mekong River Delta https://www.focusprojectmrd.com/ or follow the QR code.

Đại Học Cần Thơ

Charles Sturt University

SelectCarbon

Griffith University

une University of New England

Murdoch University

QUT

IAS

Alternative crops

Crop selection
Alternative crops must suit the dry season conditions to be profitable, and crops have different features that make them tolerant to different environmental stresses.

Water efficient
Certain crops use water more effectively to produce yield. They require less irrigation water and are good to grow in areas where water shortages occur during the dry season.

Salinity tolerant
In areas affected by saline intrusion, choosing alternative crops that can tolerate salt concentrations above 4 g/L will ensure they can grow during the dry season.


Maise tolerates moderate salinity but requires frequent irrigation.

Variety selection
Alternative crops have different varieties that will suit the dry season conditions better than other varieties. Generally, varieties that are shorter tend to grow better in saline and water limited conditions.


Cowpea tolerates salinity and captures nitrogen from the atmosphere and puts it in the soil.

Short duration
Plants that grow quicker have an increased chance of being harvested before peaks in salinity and water shortages.


Redbeet has a quick growing duration.


Quinoa can tolerate salinity and drought.

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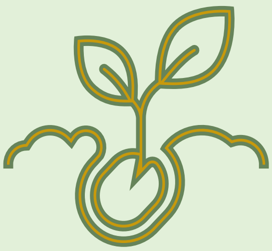
Time of sowing in the dry season

Sowing
The timing of sowing is crucial for avoiding abiotic stresses on plants, such as temperature extremes, drought, and salinity. Sowing at the right time ensures that plants grow during optimal environmental conditions, such as adequate moisture and favorable temperatures.

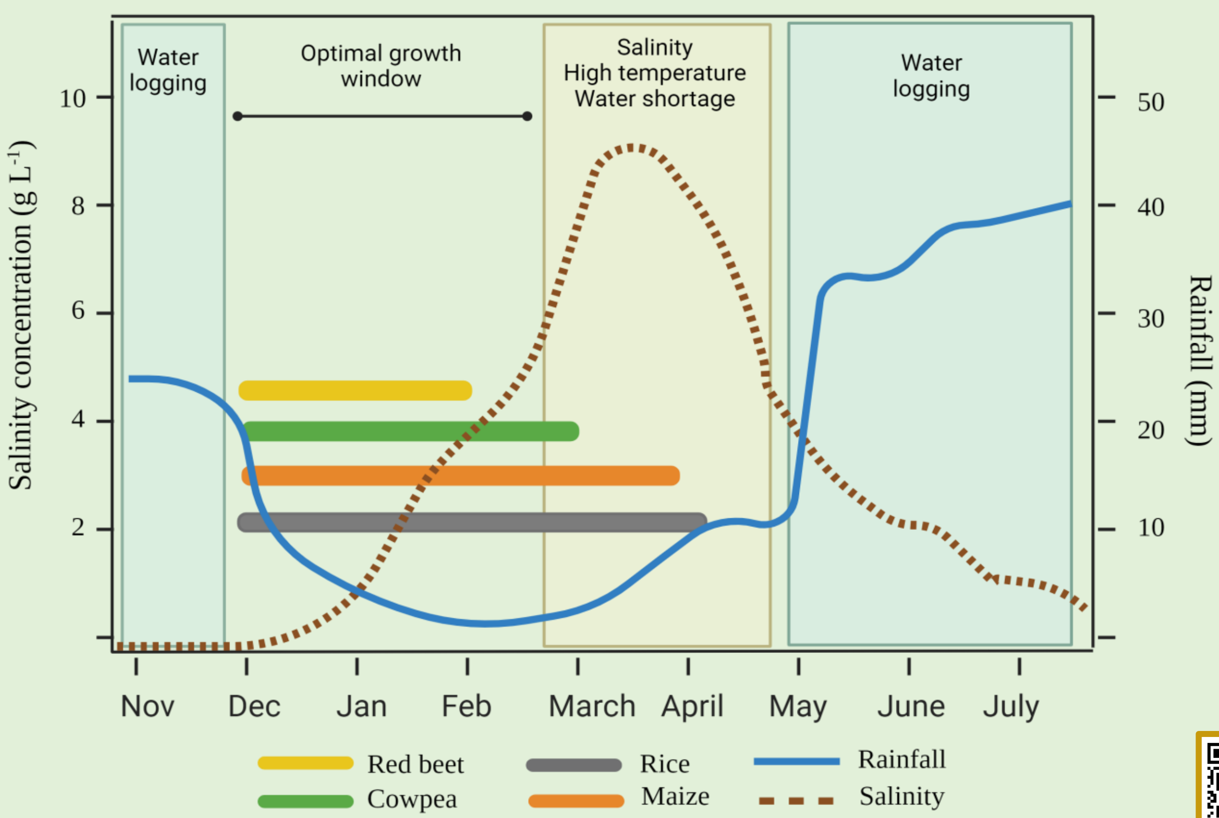
Planting too early could mean crops are waterlogged, or too late in the season can expose crops to heat stress, soil salinity, or inadequate rainfall, which can hinder germination, growth, and yield.

The **optimal planting** and growth window is narrow and out of your control. The only thing you can do as a farmer is select the crop that is most likely to be successful and fit within this window.

For example, selecting rice in 2023/24 because of high prices yet the growth of the crop was longer than the window and resulted in economic failure.



The growing duration of alternative crops shows the optimal dry season growth window to avoid waterlogging, salinity, temperature and water shortages.



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Chameleons- water saving

Chameleon soil moisture sensors help farmers decide when and how much to irrigate. The sensors indicate soil moisture status (water potential) with three coloured lights: Blue as wet soil (0 to -22 kPa), green as moist (-22 to -50 kPa), and red as dry (less than - 50 kPa).
When the light is red it is time to irrigate. Blue indicates no need for irrigation.

Wet → Dry

Soil condition	Free drainage	Plant available water		Water held by soil too tight for plants
Chameleon colour	Blue	Green	Red	
Water potential	0 kPa	-22kPa	-50 kPa	-1500 kPa

Irrigation schedules
Chameleons can help create irrigation schedules based on real measurements. This helps with management practice change and efficient water use.

There are two types of Chameleons

← Wi-Fi reader   Card reader →

The Wi-Fi reader takes frequent readings and sends them to an online portal for real time monitoring.

Chameleons and mulch
Using a Chameleon with mulch can reduce irrigation water applied by 70%. The mulch helps keep the soil moist and reduces evaporation and decreases salinity damage.

The card reader is cheaper but does not store data. It needs to be manually read.

Chameleons can

- Save water without yield compromise
- 25% saving in labour using a Chameleon
- 25% saving in fuel consumption through reduced pumping time

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Mulch and biochar management

Rice straw mulch and biochar makes use of rice straw residues to improve crop productivity and soil fertility.

Rice straw mulch -
acts as a protective barrier on the soil surface that can reduce evaporation, regulate soil temperature, and prevent weed growth, which all helps conserve soil moisture.

Biochar -
is a form of charcoal produced from heating organic material like rice husk. Biochar can improve soil structure and increase soil moisture holding capacity and contribute to soil fertility.

Effect on plants and soil
Applying mulch of 7 t/ha increased the yield of alternative crops by up to 114% and reduced the topsoil salinity by 13%.

The maize plants are much higher in the 7 t/ha (b) than the 3.5 t/ha (a)

Mulch and biochar rates
The best yields come from the mulch rate of 7 t/ha. The optimum biochar rate is 5 t/ha and is spread on the soil surface/ incorporated into the soil.

Rice straw mulch on the field

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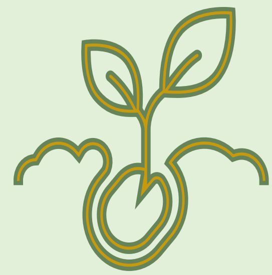
Soil microbiology

What are soil microbes?

Soil microbes are living organisms in the soil. There are approximately 10 billion in every gram of soil. They cannot be seen but are very important to soil function.

Soil microbes require water, air, food sources from plant material, warm temperatures, and a safe environment. Soils like acidic soils, saline soils, or soils with poor structure, are not ideal for microbial growth.

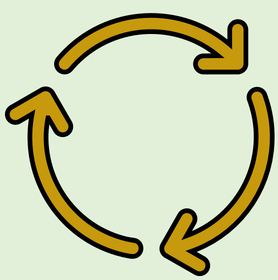


Straw mulch and biochar

Straw mulch and biochar makes the soil more suitable for microbes to live in. Microbes can help breakdown the mulch and biochar and provide additional nutrients to the plant.

Nematodes

Mulch and biochar applications increase the numbers of predatory nematodes. These nematodes control harmful rice root nematodes and decrease root disease to rice.



Microbial diversity and biomass

Increased microbial diversity and biomass will occur after straw mulch and biochar application. This means that a larger range of microbes live in the soil performing many different soil functions. Without mulch and biochar, a smaller range of microbes exist, limiting the types of processes that can happen.

Legumes and microbes

Legumes like cowpea can fix atmospheric nitrogen into plant available forms. Soil microbes like *Rhizobium* perform this whilst living in nodules on the plant roots. Pink nodules are healthy when you cut them open and mean the microbes are actively fixing nitrogen.

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Building soil organic matter

What is soil organic matter?
Soil organic matter is the organic fraction of soil. It is made up of materials in varying states of decay. Soil organic matter includes:

- Small pieces of plant material including roots, stems and leaves,
- Partially decomposed organic matter,
- Microbes, and
- Charcoal or biochar

How is it different to soil carbon?
Carbon is the measurable component of soil organic matter; being approximately 58% carbon by weight. The remainder includes nutrients such as nitrogen, phosphorus, potassium, sulfur and micronutrients, as well as oxygen and hydrogen.

Soil organic carbon is important

- Improves nutrient retention
- Maintains soil structure which improves water infiltration and plant available water
- Provides food source for microbes


A biochar furnace in the MRD

Carbon markets may be a key enabler of practice change to improve soil health. Well designed carbon farming projects could be an important source of farmer income.

Compost and biochar in a rice paddy

Ways to maintain and build soil carbon

- Add carbon rich materials (composts, biosolids)
- Grow a legume
- Use mulches
- Minimise tillage
- Manage plant nutrients

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Greenhouse gases

What are greenhouse gases
These are gases that trap heat in the Earth's atmosphere and include carbon dioxide, methane and nitrous oxide. Whilst greenhouse gases are naturally occurring, human activities such as burning fossil fuels, deforestation and some agricultural practices can increase the production of these gases.

Warming effects

Each gas has a different warming effect on the atmosphere.

- Carbon dioxide is the standard.
- Methane is 27 more times potent than carbon dioxide
- Nitrous oxide is 265 times more potent than carbon dioxide

Greenhouse gases can be measured by using chambers that are placed in the field to capture and measure the gases produced from growing rice or upland crops.

Storing carbon dioxide
Agricultural soils can be used to store carbon dioxide in the form of carbon. This has benefits for production with improved soil structure, water infiltration and storage, and increased food sources for soil microbes.

In flooded rice systems, methane is the major source of greenhouse gas, followed by nitrous oxide. This is because the soil microbes that produce these gases require anerobic conditions.

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Soil salinity training

Saline intrusion
Rising sea levels, land subsidence, drought and upstream damming are contributing to inland dry-season saline intrusion throughout the Mekong River Delta. Substantial rice crop losses are driving the need for soil management strategies and crops that can withstand saline environments and water shortages.

Where is the salinity?
Understanding the location and timing of saline intrusion will help select alternative crops and soil management practices such as raised beds and mulches. A monitoring program for farmers, DARD staff, and soil and agricultural science students was co-designed and implemented at the Provincial scale to diagnose on-farm salinisation.

Training

Training was designed in partnership with Can Tho University.

Farmers and DARD staff were trained in soil salinity principles and the importance of measuring soil salinity.

Soil salinity was measured (Electrical Conductivity (EC) 1:5 soil: water extraction) and gravimetric soil moisture measurement.

Training facts

- Training was delivered in Soc Trang, An Giang, Can Tho and Hau Giang.
- Over 200 people trained.
- 500 data points collected over 5 years.
- GIS team made a soil salinity map from the data points.

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Soil constraints training

Soil constraints can limit crop production and lead to substantial yield losses or irreversible land use change. Soil type, management practice, land use and climate change (including droughts and heat waves) can cause soil physical constraints such compaction, and chemical constraints such as acidity, salinity, nutrient deficiencies, and organic matter decline.

Diagnosing and addressing soil constraints can support crop production, improve overall farm profitability, as well having beneficial environmental outcomes.

Our approach

Stakeholder discussion groups identified a need for practical soil constraints training, delivered on-farm. Simple field-based methods helped participants identify soil constraints to plant growth. Our key target audience were Government staff who support and advise farmers.

Key learning outcomes

- Understand the impacts of soil constraints on plant growth and yield
- Identify and recognise soil constraints in the field
- Understand the aspects of soil health that management can influence.

Train-the-trainer

Local FOCUS team trained in soil constraints

Field training

Training groups of farmers, DARD & women's union members

Scaling out

Training e-Guide developed and available, training extension staff and farmers

Workshop findings

Soil constraints identified by workshop participants included:

- soil and water salinity
- low soil carbon content due to longterm cultivation with inorganic fertilizers
- rotated crop farming systems have better nutrient availabity than monocultivation.

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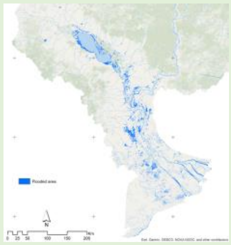
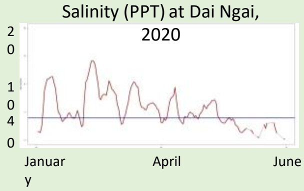
Annual risk of water salinity

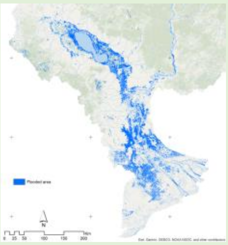
We have developed a tool to predict dry season salinity risk based on upstream flood extent from the previous year. This may help farmers and DARD with decision making for planting a third rice crop



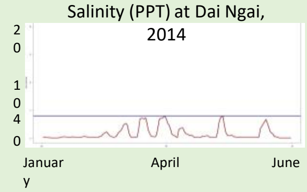
Salinity (PPT) at Dai Ngai, 2020



Larger upstream flooding in December, estimated by remote sensing, means more time with salinity below 4 PPT from January-June.



Salinity (PPT) at Dai Ngai, 2014

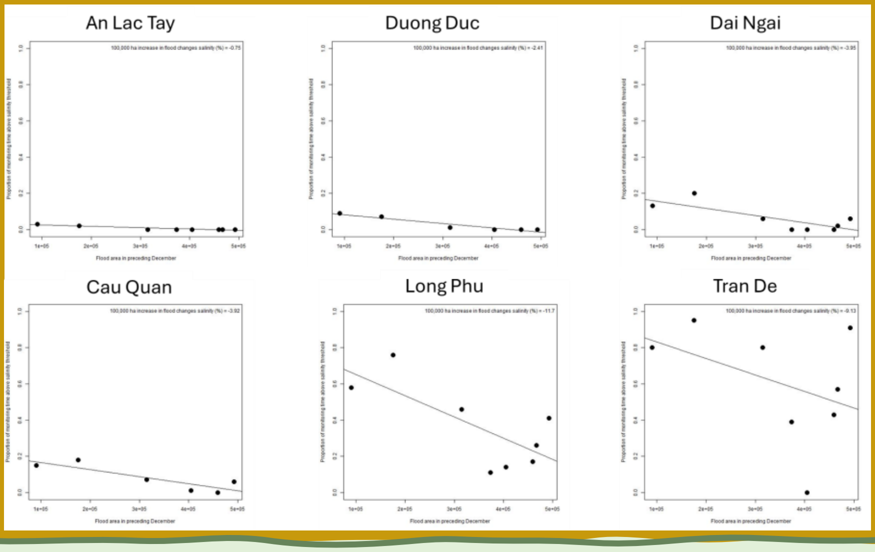


Salinity risk

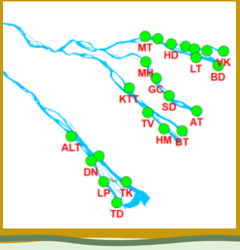
- In the model we have defined salinity risk as the number of days the minimum daily salinity is above 4 PPT between January and June each year, measured at DARD monitoring stations in the river. More days above 4PPT is a higher risk for farmers who have planted a third rice crop.

The model predicts annual salinity risk with 80-90% accuracy in the main rivers of the Mekong

This tool can assist farmers and DARD in salinity affected regions of the Mekong Delta with planning decisions for the dry season.



The relationship between flooding and salinity is stronger closer to the sea



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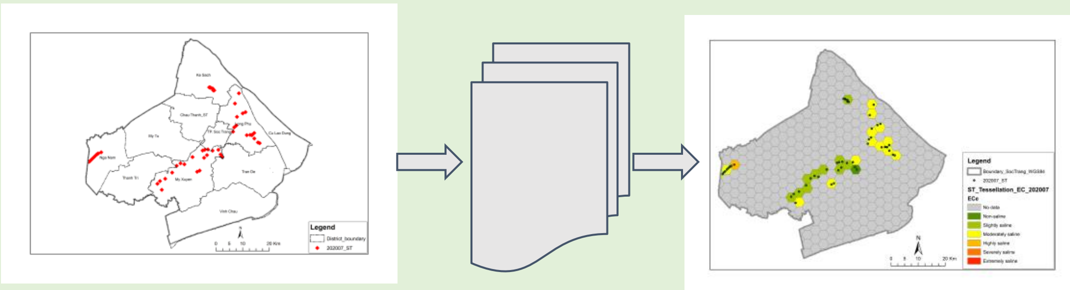
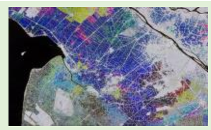
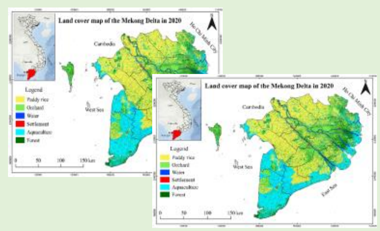
Soil salinity and land use change

- We used locally collected data to produce maps of soil salinity in the provinces during the dry season
- We also developed maps of land cover change across the entire Mekong Delta using remotely sensed data



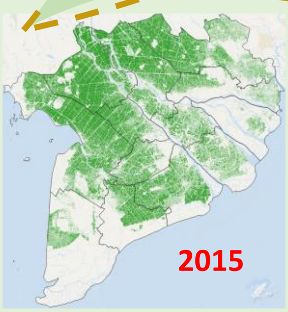


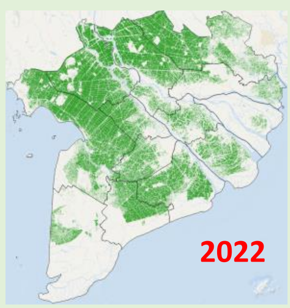


Land use/Land cover change using remote sensing

❖ Spatial and temporal variation in salinity levels is evident with high levels of salinity apparent in certain regions of Soc Trang

❖ Across the whole delta there has been substantial land use change over the monitoring period

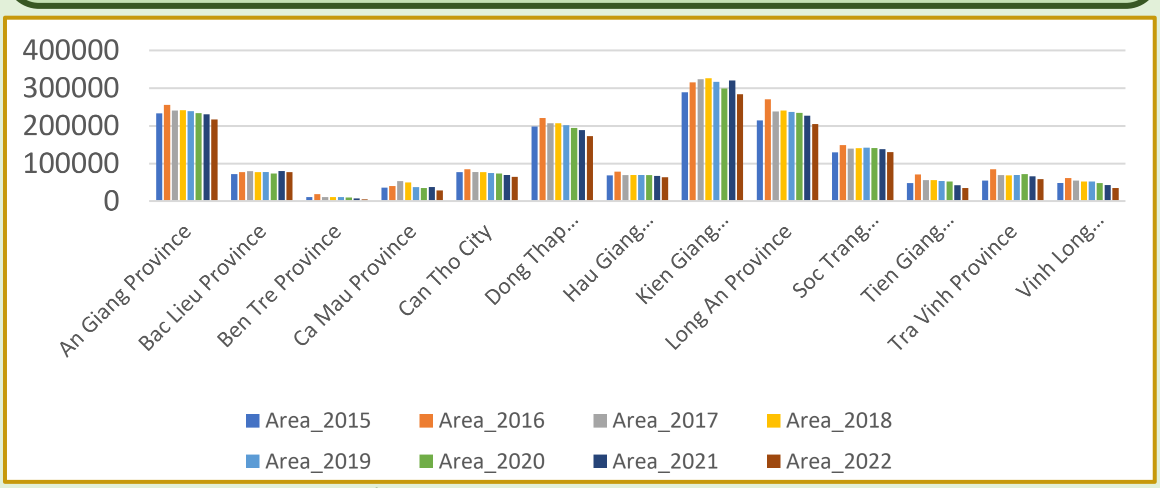




Remotely sensed areas of paddy rice in 2015 and 2022

With salinity and other drivers of interest, we now focus on remote sensing of paddy rice area

- Consistent declines in the area of paddy rice across the delta since 2015
- Some areas do not have a salinity problem yet still see declines (e.g. An Giang and Dong Thap provinces)
- Ongoing analyses to determine reduction in the number of crops not just the area, which we hypothesise may be related to saline intrusion among other factors



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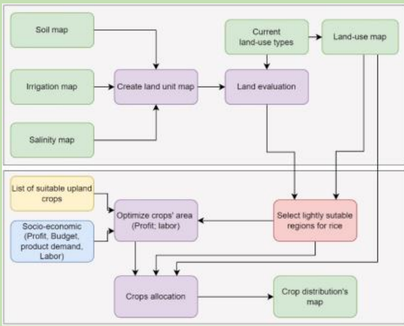
Upland crop areas optimization

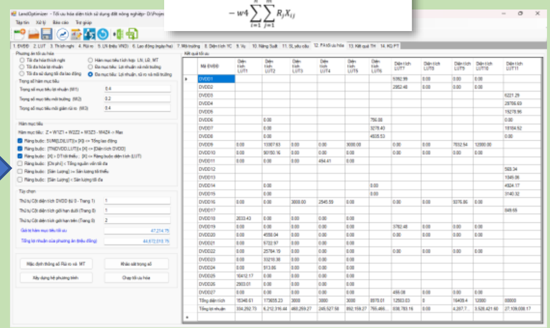
What we did:

- Making land evaluation for upland crops based on: soil map, salinity in the dry season, fresh water abilities.
- Using linear programing optimization for upland crop allocation.

How we did: Land evaluation and Mathematical model

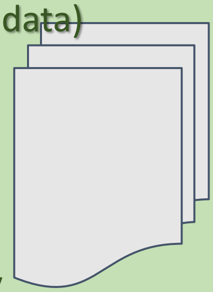


$$max: w1\sum_{i=1}^{n}\sum_{j=1}^{m}P_{ij}S_{ij}X_{ij} + w2\sum_{i=1}^{n}\sum_{j=1}^{m}E_jX_{ij} + w3\sum_{i=1}^{n}\sum_{j=1}^{m}L_jX_{ij} - w4\sum_{i=1}^{n}\sum_{j=1}^{m}R_jX_{ij}$$

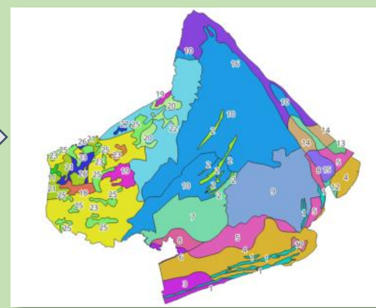


Input data (spatial data)

Soil Texture
Actual ASS depth
Potential ASS
Freshwater period
Salinity
Persistence Salinity



overlays



Land unit map

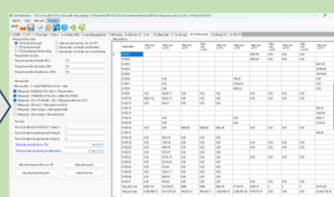
Application of Optimization model

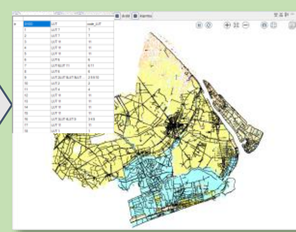
LUT	TEN_LUT	MOTA	nangsuat	dientichht	Loinhuan
LUT1	3 lua	3 lúa	18	64627.42	66.00
LUT2	2 lua	2 lúa	13	80816.26	36.09
LUT3	Lua-hau	Lúa - dưa hấu	23	2336.24	156.09
LUT4	lua-bap	Lúa - bắp	19		91.09
LUT5	lua-den	Lúa - củ dền	78		297.39
LUT6	lua tom	lúa - tôm	7	18494.89	84.22
LUT7	Duahau	Dưa hấu	11	16409.4	120.00
LUT8	Bap	Bắp	6		55.00
LUT9	Cuden	Củ dền	65		261.30
LUT10	CLN	cây ăn trái	15	10874.83	294.04
LUT11	Tôm	tôm	6	56842	384.39

LUT	min_area	max_area
LUT1	0	10000000
LUT2	0	10000000
LUT3	0	3000
LUT4	0	3000
LUT5	0	3000
LUT6	0	10000000
LUT7	0	16409.4
LUT8	0	16409.4
LUT9	0	16409.4
LUT10	0	12000
LUT11	0	80000

LUT	ruiro
LUT1	0.1
LUT2	0.05
LUT3	0.18
LUT4	0.18
LUT5	0.18
LUT6	0.15
LUT7	0.2
LUT8	0.2
LUT9	0.2
LUT10	0.25
LUT11	0.3

Input data sheet, scenarios





Land use maps

How to apply: Using our built model for supporting upland crops allocation.

- Defining land use scenarios:
  - Scenario 1: Land use list and land use area based on demand of MONRE
  - Scenario 2: Implement new upland crops (Corn, melon, beet or rice and upland crop rotation)
- Analyzing land change area and profits of defined scenarios

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