



**Anticipated Short- and Long-term Impacts
of Saltwater Intrusion on Soil Health and
Agricultural Production in the Mekong Delta**

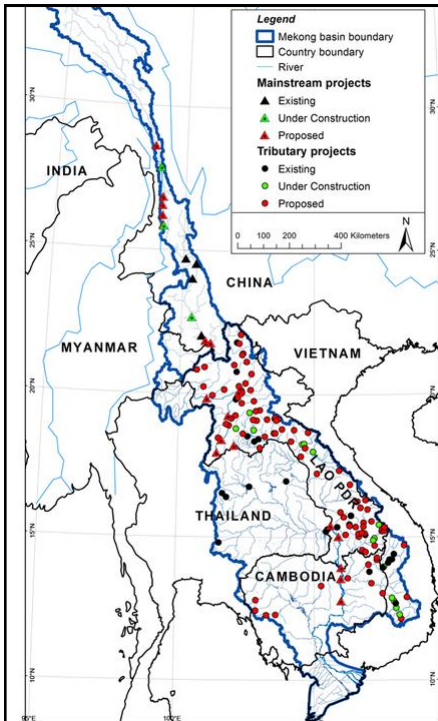
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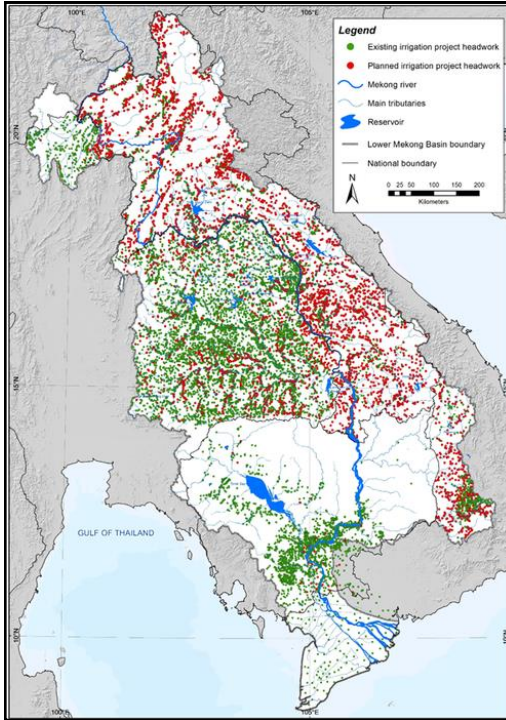
Content outline

- Salt water intrusion in the Mekong Delta
 - Facts and figures
- Short term impacts
 - Adverse impacts occur when the soils are left dried up before the onset of salt water
 - No impact when soils are continuously kept wet first with rainwater during the rainy season, then with salt water at the end of the rainy season.
- Long term impacts
 - Dry coastal soils were submerged in saltwater: subsoil contaminated with salt

Alternations of the Mekong River Course



New realities of the Mekong River Basin :
 Unruly Hydropower development
 (Mekong Flows,
<http://mekongriver.info/hydropower>)

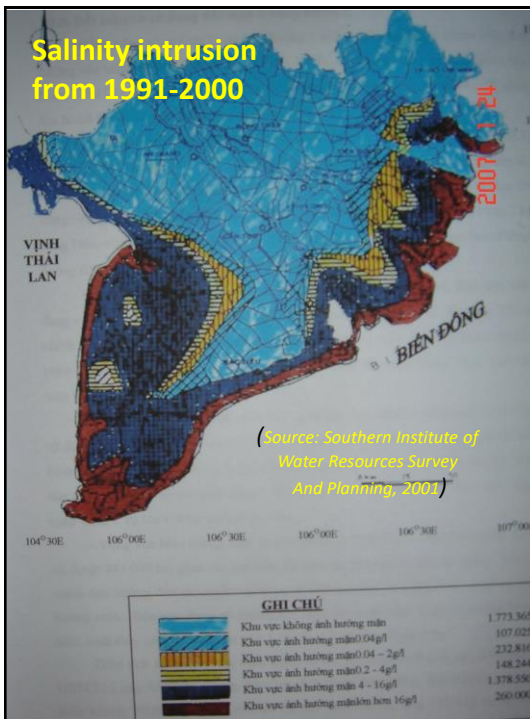


Irrigation projects in the Lower Mekong Basin

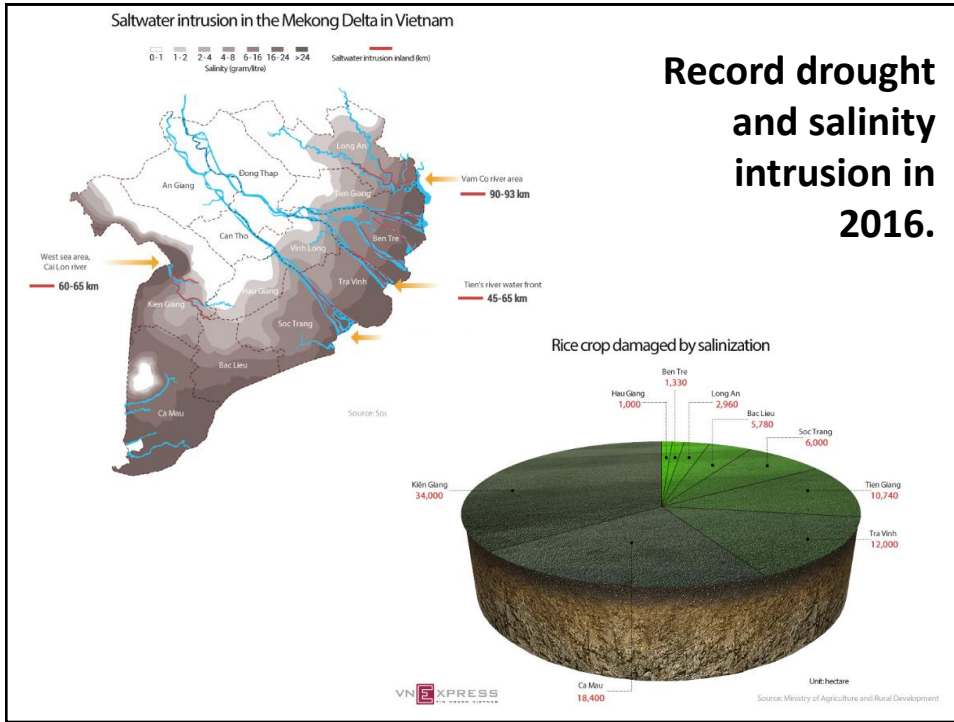
(Mekong Flows, <http://mekongriver.info/hydropower>)

Notice the green dots on the map of Northeast Thailand and Southeastern Cambodia. These are existing irrigation project headworks. With that, the Mekong water is being withdrawn to Thailand and Cambodia mainly, leaving little water to Vietnam.

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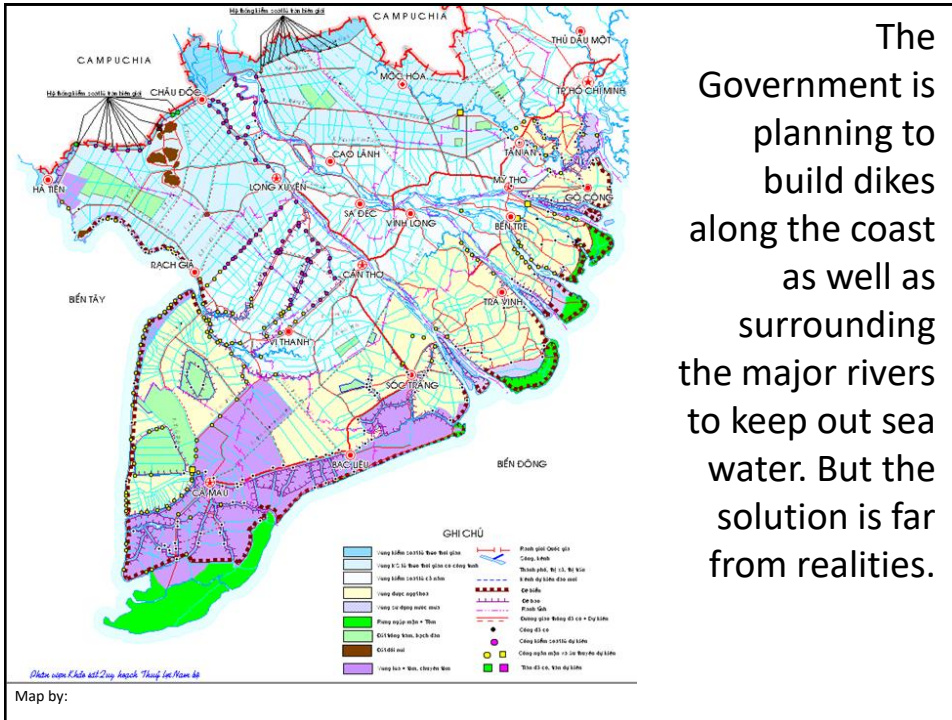


Salinity intrusion in the Mekong Delta is not new. For thousands of years through geologic times the rise followed by the recession of the sea levels have made up the fertile land that supports the lives of millions of Delta inhabitants. People learned by experiences how to co-exist with and take advantages of the saline water.



Mekong river water level measured at Tan Chau from 1904 to 2015 (in meter). *(Figures in bold indicate high flood year)*

1904 Thin 4,50	1971	4,29	1991	4,64	2011	4,16	
1916 Thin ?	1972	4,17	1992	3,42	2012 Thin	3,50	
1928 Thin 3,89	1973	4,17	1993	3,46	2013	4,31	
1940 Thin 4,89	1974	3,65	1994	4,53	2014	3,96	
1952 Thin 4,70	1975	4,21	1995	4,30	2015	2,56	
1956	4,31	1976 Thin	3,64	1996	4,87	2016	3,10
1957	3,98	1977	3,42	1997	4,18		
1958	4,15	1978	3,94	1998	2,81	Notes:	the word "Thin"
1959	3,90	1979	3,94	1999	4,20	means "dragon year."	
1960	4,28	1980	4,45	2000 Thin 5,06	4,76	From the old days,	dragon years brought
1961	5,11	1981	4,52	2001	4,34	high floods in a cycle of	12 years. This trend no
1962	4,54	1982	4,24	2002	4,33	longer works after	1964. More irregular
1963	4,22	1983	4,02	2003	4,45	events, and starting	2010, year-of-less-
1964 Thin 4,46	1984	4,81	2004	4,45	2004	4,45	water often occurs.
1965	3,82	1985	4,18	2005	4,25		
1966	5,03	1986	4,02	2006	3,96		
1967	4,27	1987	3,55	2007	4,05		
1968	3,92	1988 Thin	3,14	2008	4,00		
1969	4,23	1989	3,48	2009	4,17		
1970	4,52	1990	4,18	2010	2,38		

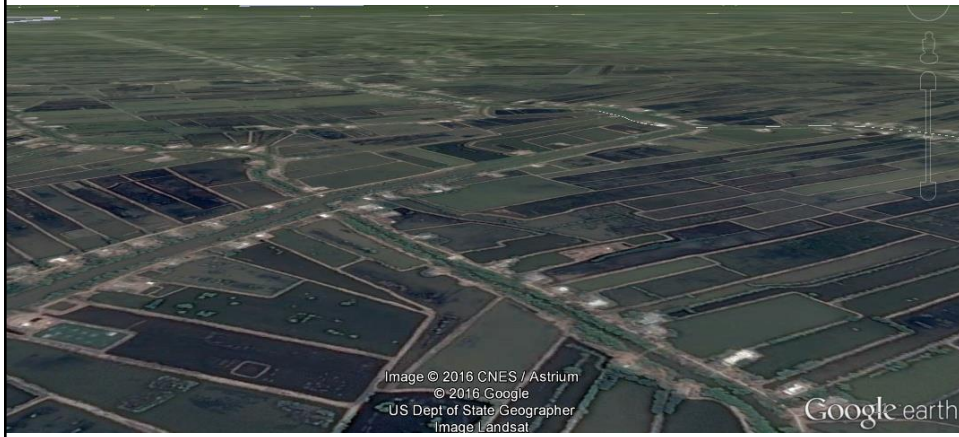


The Government is planning to build dikes along the coast as well as surrounding the major rivers to keep out sea water. But the solution is far from realities.

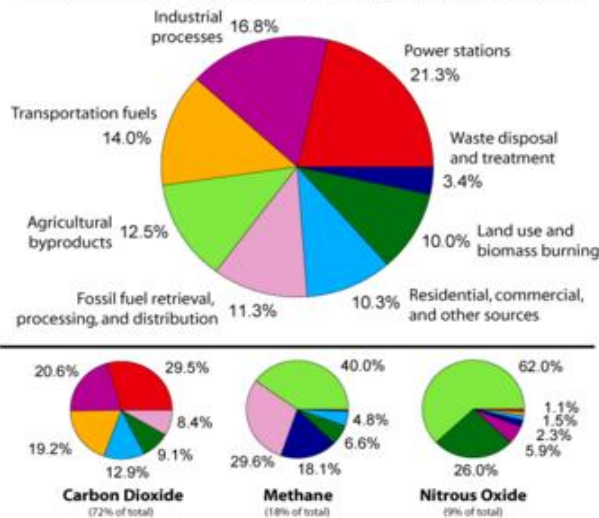


For centuries the forefathers of the Mekong Delta inhabitants found their sustainable ways to use fresh (rain) water to grow rice on saline affected coastal land. Each block of land were carefully consolidated, saltwater-free through the dry season, waiting for the next rainy season to grow rice again

MEKONG DELTA: Today, rainfed rice on shallow drainage system on potential acid sulphate soils along coastal region during the monsoon season. Note the ponding of fresh water collected during the rainy season for use during dry season (Ca Mau province).



Annual Greenhouse Gas Emissions by Sector



Source: WIKIPEDIA

As climate change has become a reality, the farming sector realizes that they are responsible for 25% of the emission of GHG.

The Mekong River System in Realities

1. Climate changes accompanied by El Nino and La Nina are here to stay and might become worse if mitigation efforts are not effective.
2. More unruly/unnegociable dams and diversion channels everywhere in the river system.
3. Reforestation will be slow.
4. **Consequence of 1+2+3** : annual severe drought and low flow of the river.
5. **Consequence of 4** : salinity intrusion.

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Mekong Delta Living with New Realities

• **Fresh water use:**

- Fishing in main river (with reduced species and quantities;
- Aquaculture in cages, inland fish pond;
- Reduce rice areas wherever less suitable conditions (eg. Drought prone, salinity prone;)
- Intermittent irrigation for high yielding rice;
- Diversification to less water consuming valued crops:
- Possibility to convert three-rice crop polders into valued crops production, such as fruit trees, cash crops...
- Application of rainwater harvesting techniques (dry seeding early summer rice followed by main season high quality rice);
- Ponding of fresh water during the rainy season for domestic use, or irrigation to dry season cash crops.

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Mekong Delta Living with New Realities

- **Saline/Marine water:**

- No more diking to freshen saline zone or to prevent salinity intrusion;
- Consolidation of mangrove zone;
- On potential acid sulphate soils along the coasts:
 - Practice of mangrove-shrimp aquaculture system;
 - Practice of rice fb. shrimp farming system;
 - Practice of rice with giant prawn fb. Marine shrimp system. The freshwater giant prawn (*Macrobrachium*) can grow in water w/ 1.5% salt
- Wherever possible, practice intensive shrimp aquaculture technology.
- On sand bars along coastal zone: Growing of high value fruit trees or cash crops.
- On ridges: fruit trees, coconut-cum-cocoa,...

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How present agriculture in the Mekong Delta is contributing to present global warming.

- Land uses
 - Lost mangrove forests > CO₂ increases
 - Extensive rice growing > CH₄, NO₂, N₂O increase;
 - Livestock raising > NH₃, CH₄ increase
 - Increase aquaculture > NH₃, CH₄ increase
- Agricultural technology
 - Fertilizers application > NO₂, N₂O increase
- Use of fossil fuel (pumps; thermal power...)
 - Emission of CO₂ and other gases

We still need quantitative data.

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Climate change impacts on agriculture

- Increase in air temperature
 - Crop yields may be affected adversely
 - More insects and diseases expected
- Changes in water level
 - More frequent floods during rainy season
 - More severe drought during dry season
 - Salinity intrusion further inland (2009: 120 km, 2016: 100 km)

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Short term impacts of saline intrusion

- No impact when soils are continuously kept wet first with rainwater during the rainy season, then with saltwater at the end of the rainy season. Action:
 - Rice-aquaculture system:
 - During rainy season: Rice for food security grown with rainwater, postlarvae of the giant prawn (*Macrobrachium rosengerii*) can be inoculated to raise together with rice.
 - At the end of the rainy season, while the rice field is still wet, saltwater is allowed enter the system.
 - In the saltwater direct from the sea, there are natural shrimp fries, elongatus fries, and others will be allowed to grow naturally.
 - Or Penaeus shrimp postlarvae can be inoculated in the ditches around the rice field.
 - Blue crabs also can be grown successfully.

Adaptation to CC (1)

- Reforestation of the coastal mangroves and conserving their biodiversity will
 - enhance environmental resilience,
 - reduce national net contribution to climate change
 - provide valuable community assets, tourism resources and even saleable pollution offsets via Clean Development Mechanism schemes.

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Adaptation to CC (2)

- Policy makers to provide better farm infrastructures and research facilities:
 - Develop more sustainable farming systems using appropriate crop-animal-aquaculture integration.
 - Breed crops for tolerance to heat, submergence, or salinity; resistance to new species of insects and diseases.
 - Construct empoldered areas to grow valuable fruit trees replacing rice.
 - Construct empoldered residential areas.

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Mitigation measures (1)

- Farmers adjusting cultivation practices:
 - Rice farmers:
 - Stop over fertilizing; apply balanced fertilizers
 - Apply safe pesticides.
 - Apply intermittent irrigation.
 - Apply zero-tillage seeding technique.
 - Apply direct dry seeding rice early rainy season; then followed by transplanting the main season rice crop.
 - Use all straw and stubbles for feeding to buffaloes or cows, then use livestock manure for biogas production and organic fertilizer to return to soil.
 - Use straw for mushroom production, then return the depleted straw to soil.

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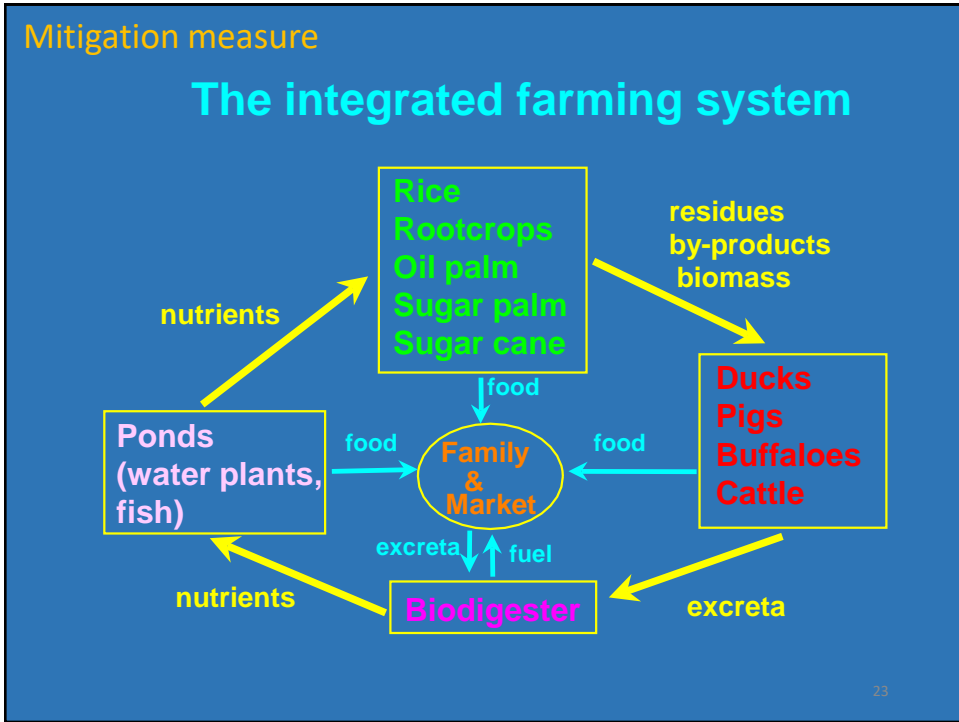


PHOTO: Nông thôn Mới.

MEKONG DELTA: The rice bowl of Southeast Asia, has increased rice production 5-fold from 4.5 mmt in 1975 to 25.5 mmt in 2015.

With new realities of the Mekong system, it will not seek to export 6-7 mmt/year while its rice farmers only earn about 500 USD per capita while their neighbors can earn more than USD 2,500 per capita by growing higher value crops.

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Saving fresh water: Diversification to fruit trees.



Mitigation measures (2)

Livestock producers:

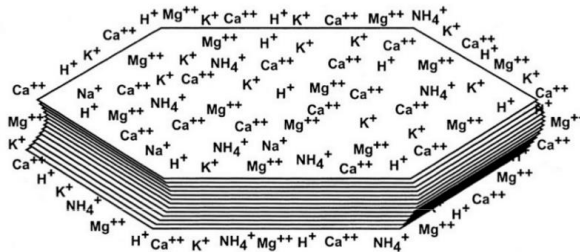
- Use rice straw as much as possible to feed livestock, or for mushroom culture.
- Use appropriate feed plants for farm yard animals (*Stylosanthes guianensis*, *Gliricida sepium*, Cassava leaves, Sweet potato leaves, water spinach, Duckweed, *Moringa oleifera*, jackfruit leaves)



WARNING TO ALL RICE FARMERS:
 Stop polluting the atmosphere with
 greenhouse gases!
 Use fertilizers correctly to minimize
 denitrification.
 Use rice straw profitably.

Basal application of complete fertilizer (N-P-K) for rice.

- to improved fertilizer use efficiency due to better prevention of denitrification, saving cost for farmers.



Adsorption of cations in soil colloids = Plates of clay are negatively charged adsorb positively charged cation nutrient elements.

Source: *Managing Healthy Sport Fields*, Paul D. Sachs, 2004





RAIN HARVESTING FOR RICE PRODUCTION

1. Dry seeding early summer-autumn rice

crop: the land is prepared in dry condition, basal fertilizers applied. As the first rain comes, immediately sow dry rice seeds and wait for rice growth. Topdressing necessary quantity of fertilizers as needed.

2. After harvesting rice, follow by transplanting the main season rice crop.

An effective rainwater saving rice cultivation: Direct dry seeding in early rainy season.

The rice land is prepared dry before the rainy season arrives. Shallow drains are made to flush away rainwater (to avoid salinity/acidity that rises to soil surface

by capillary action during the dry period). As soon as the first rain comes, immediately sow dry rice seeds and wait for rice to grow



DRY SEEDING: Rice seeds right after seeding



DRY SEEDING: rice growth at one week after seeding.



DRY SEEDING
Secret of success:
the granulated dry soil (as opposed to
structure-less wet
puddled soil) allow
rice root to
penetrate deeper in
the soil to find water
to grow during
drought period.

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ROTATION: rice followed by shrimp farming system in saline areas. *As soon as rice is harvested at the end of the rainy season, with the fields still wet and containing ponded fresh water from the rains in the surrounding ditches, saline water is allowed to enter and afterward shrimp post-larva are seeded in the ditches.*





INTER-CROPPING
rice – fishes or
rice – giant prawn.



INTER-CROPPING: Rice with fishes, freshwater giant prawn
(*Macrobrachium rosenbergii*)



Harvesting freshwater giant prawns from rice field.

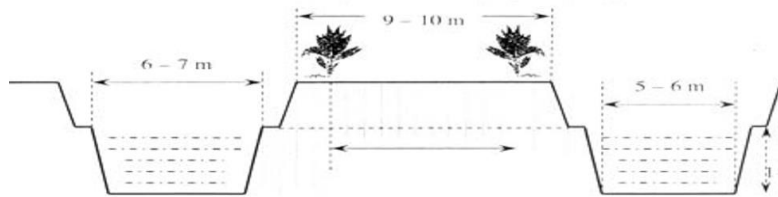


Long term impacts of salinity intrusion

- **Coastal soils are left dried up** before the onset of saltwater >> salt penetrates deep into the soil profile, cannot be flushed away for a long time. Actions:
 - Replant mangrove or
 - Semi-intensive aquaculture: shrimp, blue crab, elongatus (cá bóng kèo *Pseudapocryptes elongatus*),
 - Practice mangrove – shrimp system or fishes, molluscs.
- **Rice soils were submerged in saltwater:** subsoil contaminated with salt, so the saline soil cannot be flushed away for a long time. Measures:
 - Discontinue rice cropping to switch to upland crops after construction to raised beds and *mix topsoil with biochar*.
 - Fruit tree (mango, banana) production on raised beds;
 - Intensive aquaculture, or
 - Semi-intensive aquaculture: shrimp.

Technique of raised bed construction in coastal soils

- Most coastal soils of the Mekong Delta are intertwined between sulfaquents or sulfaquepts with marine alluvium.
- Raised bed construction must pay keen attention to the pyritic or the sulfidic horizon of the soil profile, never excavate this horizon to expose the soil to the air.



TRADITIONAL PRACTICE: Ponding rainwater in empoldered area to irrigate valuable crops during dry season.

Notice the raised beds are made to make room for rainwater storage in the ditches.

In construction the beds and excavating the ditches, one has to pay attention to the soil profile in order to avoid turning up the actual or potential acid soil layers on top of the beds or the dikes



thegioigiongcaitrang.com

BRACKISH WATER ZONE: INTER-CROPPING fishes and freshwater giant prawn in coconut plantation.



PHOTOS: *Internet*

Da Xanh pomelo orchard in saline prone district of Mộ Cày Bắc, Bến Tre province. The raised beds are carefully constructed to keep the potential acid sulphate soil intact.



Cát mango orchard in the district of Bảy Ngàn, Hậu Giang province, is very well watered with fresh water stored in ditches.



Xuân Duy - Báo ảnh DT&NV

ảnh

Fruit tree production on raised beds: Banana



PHOTO: Bao Moi.com 17/06/2016



Restructuring existing shrimp farms

Above, fragmented individual shrimp farms...

.... Should be turned into technically approved GAP procedure (similar to Sumatra, Indonesia, as shown on the right)



Intensive shrimp production scheme (South Sumatra, Indonesia)



Aquaculture with elongatus fish, blue crab, shrimp



INTER-CROPPING: Mangrove and fishes; shrimp, molluses





Photo by *Đặng Quang Minh* in <http://www.tinmoitruong.vn/>

The sustainable mangrove-shrimp aquaculture system instead of pure shrimp aquaculture or just pure mangrove conservation.

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Conclusions

- Living with the new realities of the Mekong river system – more and more severe drought and salinity intrusion – the Mekong Delta of Vietnam will restructure its agricultural and food production with due attention to measures to mitigate CC, to make good use of limited fresh water and the unique opportunity with marine water.

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Conclusions (cont'd)

- We surely keep our food secured, but may not endeavor to produce too much surplus rice in order to save land and water to produce high profit agro-fishery goods.
- I may use the words of Dr. David Tickner of WWF-UK again:

*We're also calling for **the enforcement of a UN convention on rivers that flow through more than one country.** This will help ensure that countries work together for the long-term health of a river, and not allow conflicts of interest to cloud their judgement.*

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