CECAR

Climate and Ecosystems Change Adaptation and Resilience Research

Building Resilience in Rural Asia

- Combining Traditional and Modern Bio-Production Systems -

(CECAR-Asia)

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UNITED NATIONS UNIVERSITY

MARCO Symposium 2015
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Tsukuba International Congress Hall

IR3S
Integrated Research System for Sustainability Science

International Context

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The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES)

- Provides regular updates on the scientific status and trend of biodiversity and ecosystem services, and their relationship with human well-being,
- Thereby supporting several multilateral agreements and other policy processes.

IPBES-1, 21-26 Jan 2013

CBD

- Aichi Biodiversity Targets (by 2020)
- SATOYAMA Initiative (from 2010)
- National Biodiversity Strategy

UNFCCC

IPCC

Future Earth

[Agenda] Scientific assessment and policymaking support from the more transdisciplinary and integrated perspective22

- Strengthen science-policy interface (Priority: Scientific assessments and knowledge foundation by collecting credible indigenous local knowledge (ILK).
- Implement scientific assessments on biodiversity and ecosystem services at and across sub-regional, regional and global levels. (Asia-Pacific regional assessments)
- Address methodological issues (Priority: Study on tools and methodologies for scenario analysis and modelling of biodiversity and ecosystem services)
- Communicate and evaluate Platform activities, deliverables and findings.

Aims and Structure of the CECAR-Asia Project

Aims of the Project

- Quantitative and qualitative assessment of resilience to climate and ecosystem changes in rural Asia (focused on Vietnam, Indonesia, Sri Lanka)
- Proposal of bio-production systems to enhance local resilience, utilizing biodiversity and ecosystem services and traditional knowledge and technologies

Structure of the Project

Adapting to Climate and Ecosystem Changes in Bio-production Systems

IR3S, The University of Tokyo / Vietnam National University, Hanoi

Bio-production in Harmony with Biodiversity Conservation

Research Institute for Humanity and Nature / Gadjah Mada University (Indonesia)

Enhancing Resilience Utilizing Traditional Knowledge and Technologies

United Nations University / University of Peradeniya (Sri Lanka)

Concept of Mosaic Systems for Crop Production

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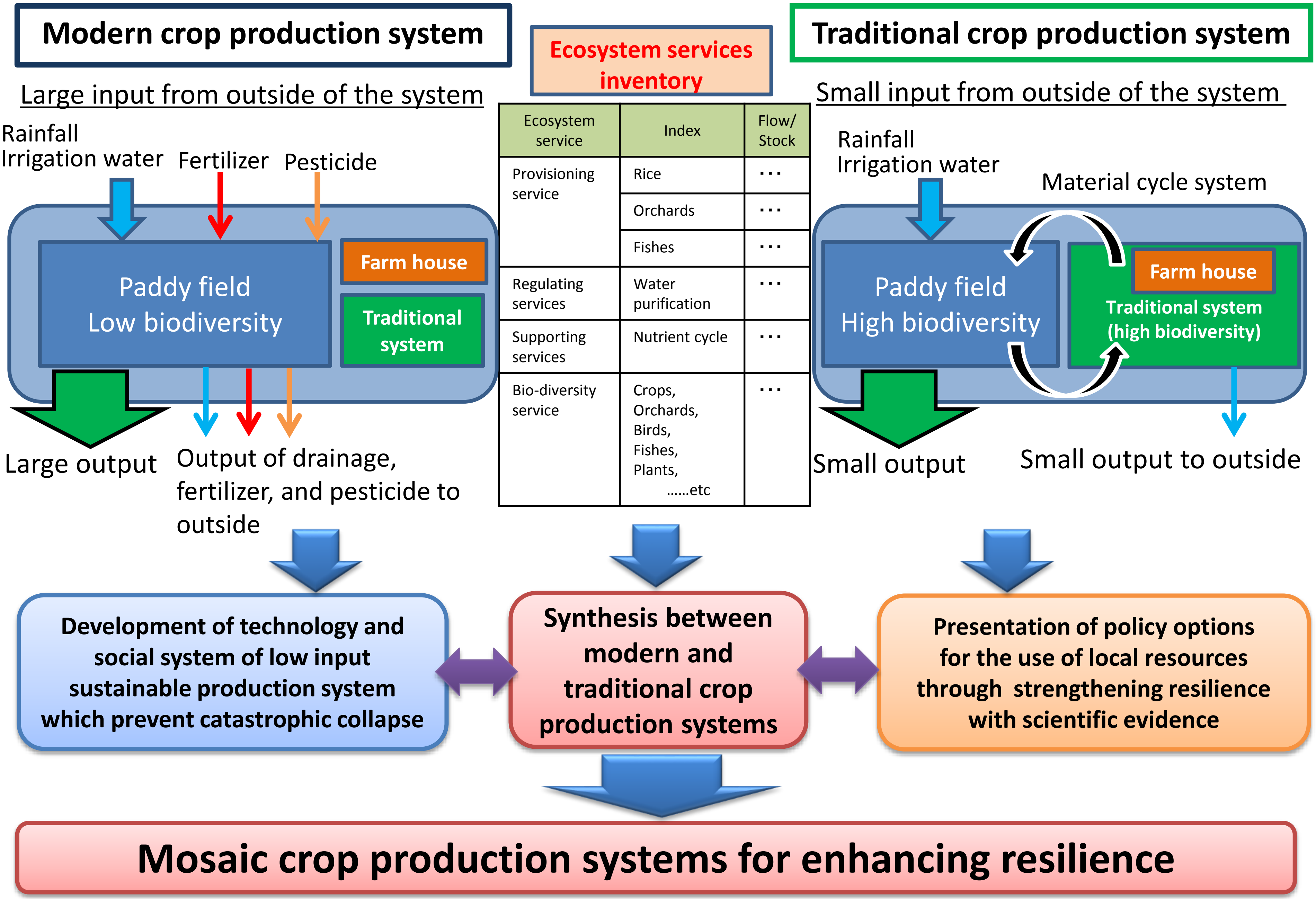

Ecosystem service	Index	Flow/ Stock
Provisioning service	Rice	・・・
	Orchards	・・・
	Fishes	・・・
Regulating services	Water purification	・・・
Supporting services	Nutrient cycle	・・・
Bio-diversity service	Crops, Orchards, Birds, Fishes, Plants, ...etc	・・・

Proposal of Mosaic Systems for Sustainability in Rural Asia

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Shaping resilient societies by means of mosaic systems that combine traditional and modern knowledge and technologies to address climate and ecosystem change

Adapting to Climate and Ecosystem Changes in Bio-production Systems

VAC System + Commercial Rice Farming (Vietnam)

Agroforestry + Commercial Forestry Production (Indonesia)

Bio-production in Harmony with Biodiversity Conservation

VAC system

Commercial rice farming

Proposal of Mosaic Systems

Traditional Irrigation System + Modern Irrigation System (Sri Lanka)

Pekarangan

Commercial forestry production

Climate and Ecosystem Changes

Enhancing Resilience Utilizing Traditional Knowledge and Technologies

Socio-Economic Changes

Traditional irrigation system

Modern irrigation system

Predicted Impact of Climate Change on Rice Production

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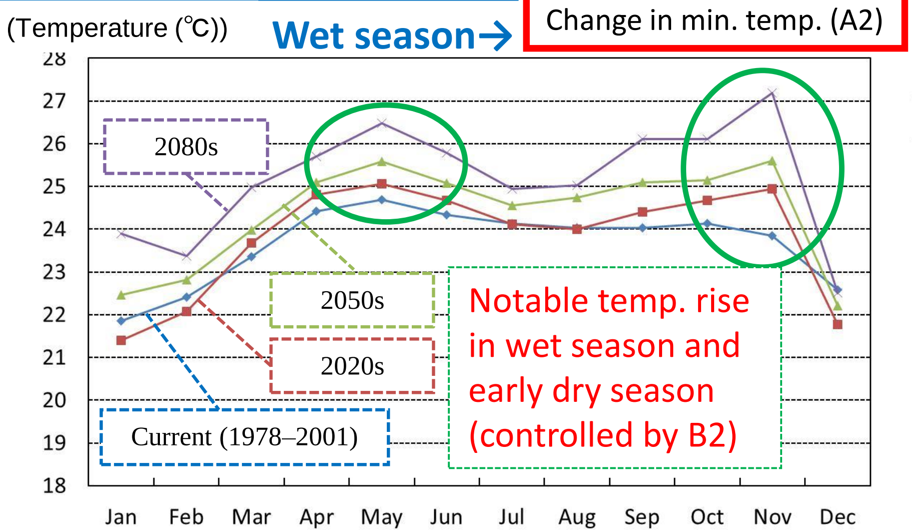
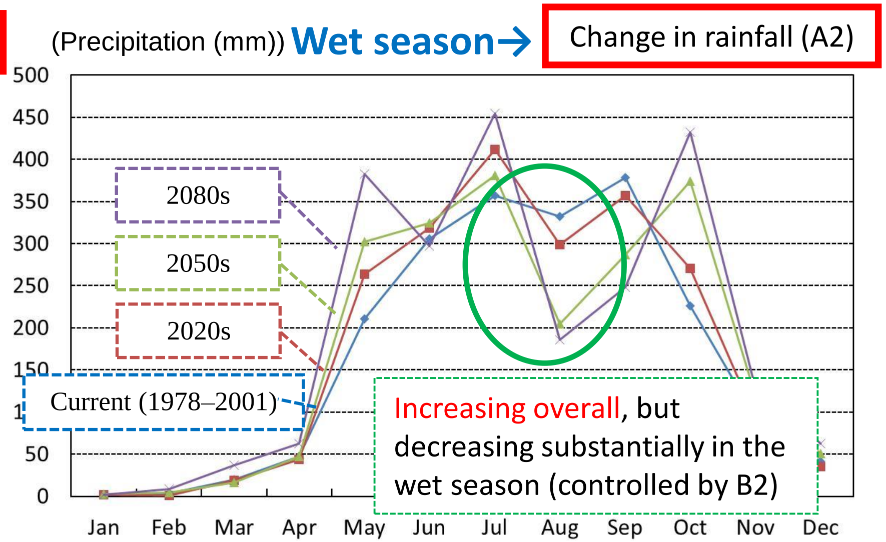
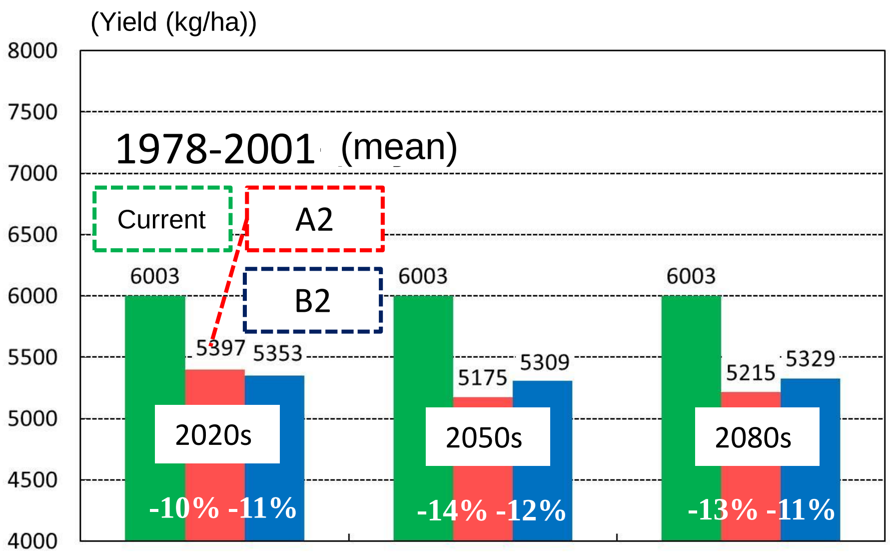
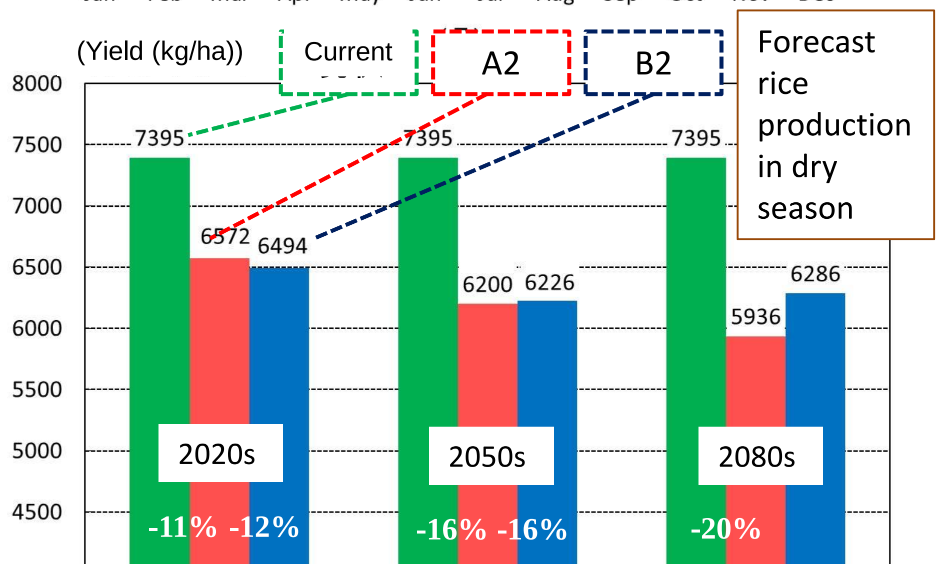
Case of Vietnam









- A2 (Multipolar society): Political and economic blocs (restrictions on flow of goods, people, and technology), relatively little interest in environment (sustained rise in CO_2 emissions and temperature increase of 3.4°C (2.0–5.4°C) (by year 2100))
- B2 (Regional coexistence society): Local solutions to problems, emphasis on international fairness, slightly lower economic growth, environment problems solved locally (sustained rise in CO_2 emissions and temperature increase of 2.8°C (1.4–3.8°C) (by year 2100))

Adaptation to Climate Change by Selecting Rice Varieties

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Forecast change in rice yields by variety in Sri Lanka

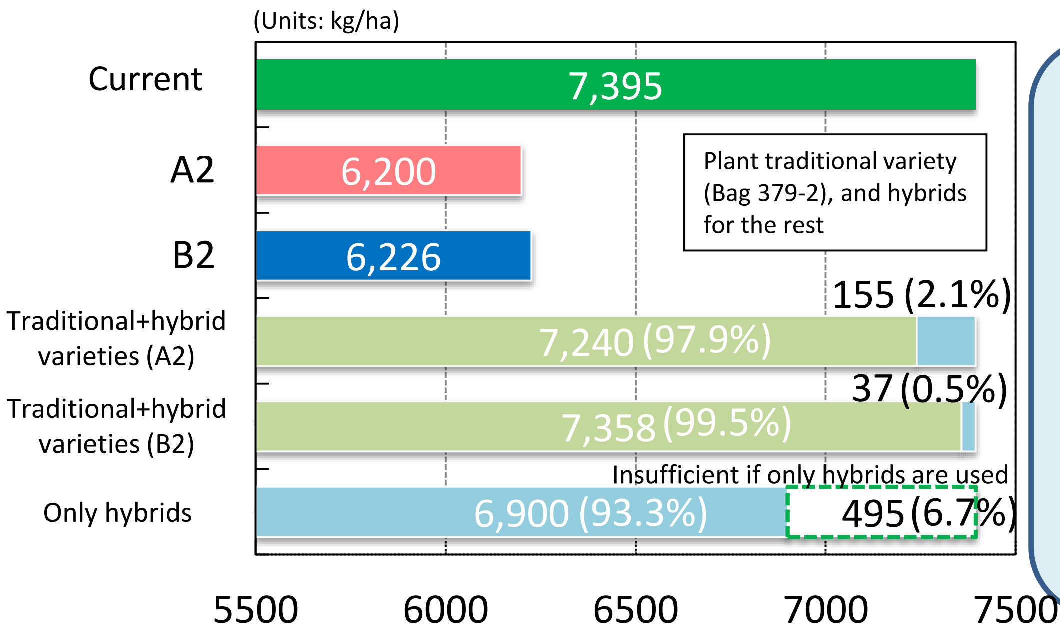
Emissions scenario	Rice variety			
	Early varieties		Late varieties	
	Bg 250 (2.5 months)	At 307 (3 months)	Bg 357 (3.5 months)	Bg 379-2 (4 months)
A2	-13.6	-10.3	-6.0	-2.1
B2	-6.2	-5.1	-1.8	-0.5

Late varieties will suffer less loss in yield.

Difference in yields between rice varieties in Vietnam (2010)

	Rice variety	
	Normal varieties (inbred)	Hybrid rice
Yield (t/ha)	5.2	6.9
Crop area (%)	92	8

Hybrid rice varieties can achieve higher yields.



Decrease in production can be offset by combing traditional and hybrid varieties (for dry season in 2050)

- Suggests that loss in yield is less for traditional late varieties (Sri Lanka)
- Production maintained by increasing hybrid rice cultivation (8%↗) (Vietnam)
- Adoption of new flood-resistant varieties (Indonesia)
- Conclusion: By primarily using traditional varieties, but also combining them with modern hybrid varieties, it is possible to enhance resilience to climate change

Traditional Home Garden Systems in Rural Asia

Common features and issues

[Features]

- Cultivate many varieties in small quantities
- Use of diverse ecosystem services
- High biodiversity
- Ensuring multiple options to respond to various shocks and disturbances
- Predominance of small farmers

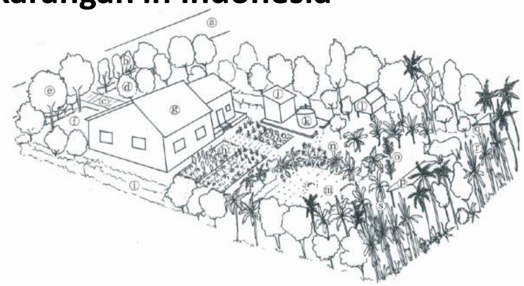
[Issues (Variable factors)]

- Climate/ecosystem change
- Urbanization and population outflow
- Increase scale, commercialization, and monoculture of farming
- International market pressure
- Passing on traditional knowledge to next generation

Typical arrangement

VAC system in Vietnam

Pekarangan in Indonesia



Kandyan home garden in Sri Lanka

Mohri et al. (2013) *Ecosystem Services*, 5: 124-136.

Options to enhance resilience

Addressing climate and ecosystem change

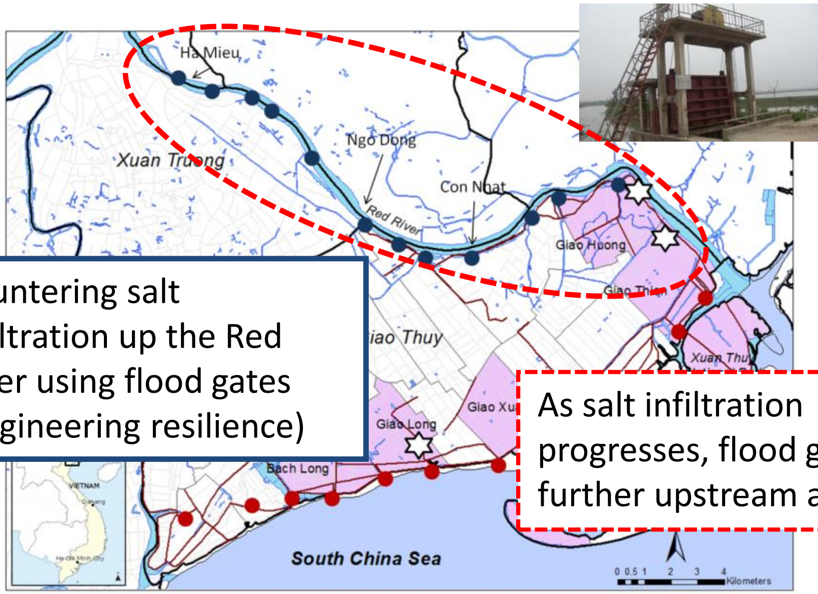
- Diversity of cultivation, from traditional varieties to varieties resistant to environmental change
- Improve material cycling within households and settlements, through mixed production systems combining agroforestry, aquaculture ponds, and livestock
- Improve soil erosion and rainwater catchment using community-pooled labor

Addressing socio-economic changes

- Sell high value-added products to the international market by acquiring international certification
- Offer incentives to small-scale farmers by paying for ecosystem services and introducing a system for purchasing local products

The above options make it possible to sustain the high resilience of traditional systems in any kind of home garden system, as well as to adapt to socio-economic changes, thereby improving overall resilience.

Integrating Traditional and Modern Bio-production Systems



Countering salt infiltration up the Red River using flood gates (engineering resilience)

As salt infiltration progresses, flood gates further upstream are used.

- **Crop planting to address salinization (ecological resilience)**
  - Switch from high-yield varieties (in fields not damaged by salt, far from rivers) to traditional varieties or to glutinous rice, or switch from rice to rushes (in fields affected by salt, close to the river)

    →Tackling climate and ecosystem change

- **Bio-production systems to address socio-economic change (socio-economic resilience)**
  - Modify traditional VAC systems to suit increasingly market-oriented economics

    →Address not just climate and ecosystem changes but also socio-economic risks
  - Cater to markets by adopting certification systems for international markets, such as the Vietnamese version of good agricultural practices (GAP) and focusing on quality to offer high value-added products

    →Achieve high profits while holding back from pursuing excessive efficiency

The above strategies increase resilience to climate and ecosystem changes and to socio-economic changes.

Bio-Production Systems in Harmony with Biodiversity

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Traditional bio-production

Example of Gunung Kidul, Indonesia

Modern bio-production

Pekarangan

Teak planting by residents, mainly in pekarangan (in woods around their homes)

High biodiversity features

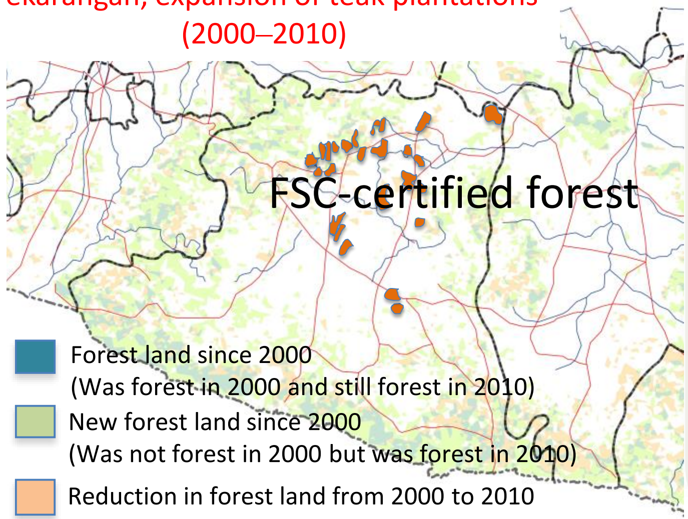
- Diversity of plants (49 types)
- Variety of biota (10 species of mammals, 30 species of birds, 15 species of amphibians)

Role of pekarangans

- Community use
- Trees can be cut to sell high-priced materials such as teak and mahogany when needed to cover expenses of healthcare, education, disaster recovery (saving function)

A huge tree said to be 300 years old

Pekarangan, expansion of teak plantations (2000–2010)



- Pekarangans are traditional home gardens that protect against various kinds of shock
- Pekarangans also protect against socio-economic changes
- Biodiversity conservation by means of agroforestry and forest certification, while enhancing protection against socio-economic changes by commercial reforestation (correction of excessive focus on efficiency and economics)
- Increasing resilience by combining the two

HTI (Hutan Tanaman Industry)
Commercial reforestation
Sengon (*Albizia chinensis)*
Kayu Putih (*Melaleuca leucadendron*)

Soil erosion/agrochemicals/excess fertilizer

Managed as shrubs to press oil from branches and leaves.
External output is high. Disease-pest damage.

Encourage farming between forests (agroforestry)

Forest Certification System (FSC)

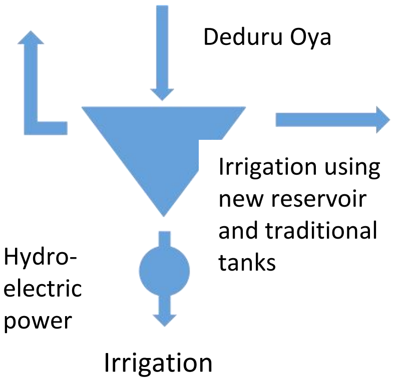
Putting a premium on certified materials, expanding sales channels, regulating the use of agrochemicals on seedlings, protect forests of high conservation value, contribute to biodiversity conservation

Acquired group certification for a small teak forest in 2012
Certified area: 330.5 ha
Total of 96 groups of farmers in the alliance
Price of certified material: 30% higher

Integration of Traditional and Modern Irrigation Systems

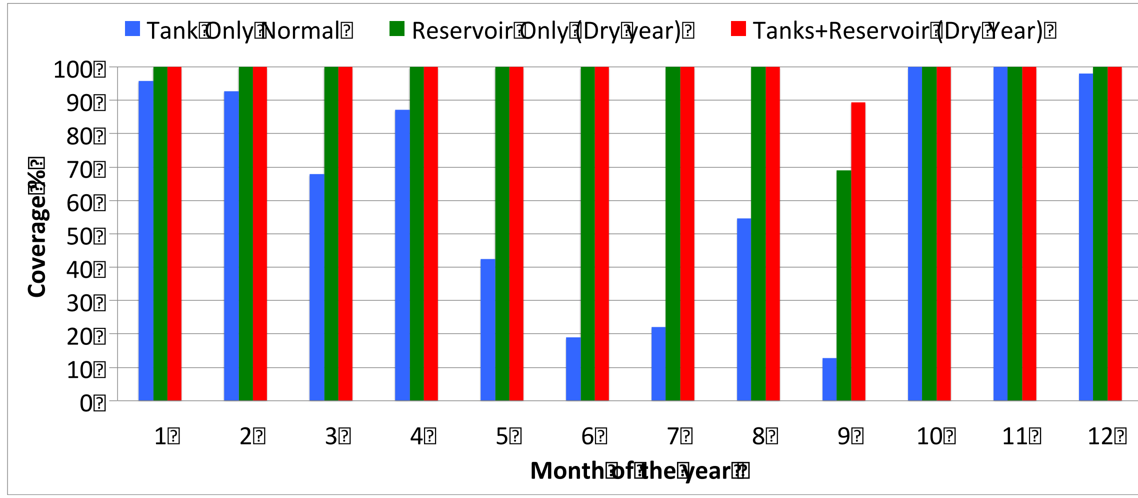
Traditional tank

New reservoir



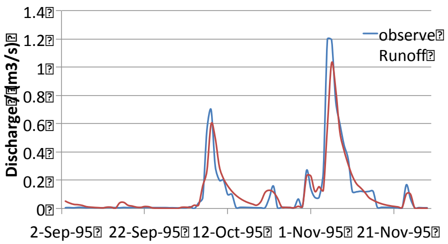
Trial of mosaic system in water catchment (Deduru Oya, Sri Lanka)

- Test of mosaic system in water catchment of Deduru Oya, Sri Lanka
- Sixth largest river in Sri Lanka
  Catchment – 2,620 km^2
  90% - Intermediate
  10% - Wetlands
- Construction began in 2007; scheduled for completion in 2014

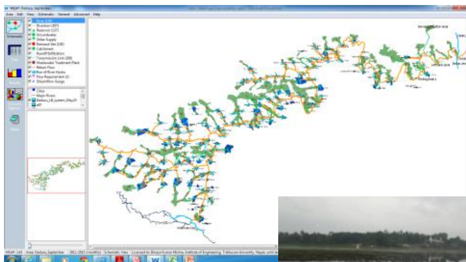


- Traditional systems alone cannot meet the irrigation needs of both existing and new rice crop production.
- A new reservoir (modern) can meet all the demand in a normal year, but it is not sufficient for drought years (approx. 1 every 5 years)
- The combination of traditional tanks and a new reservoir can improve on this, but if water distribution is conducted separately, the water demand cannot be met.
- Analyze the flow of the river in detail for each reservoir, and create a model of the operation of the overall system when the new reservoir and traditional tanks are combined.

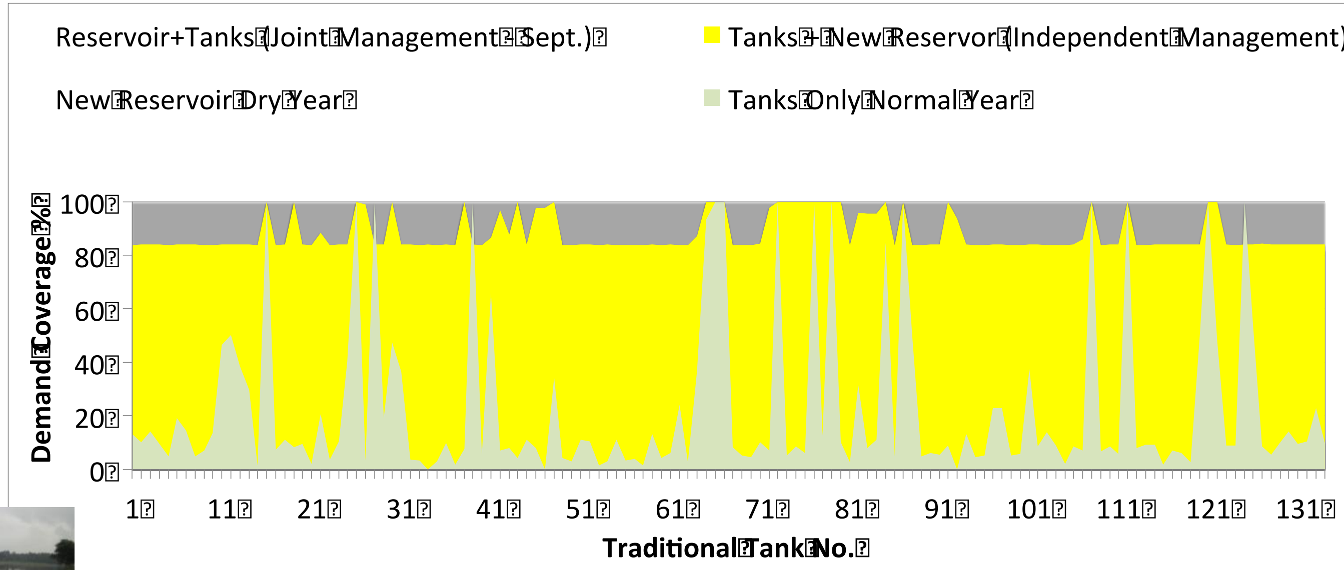
Joint Management Options to Avoid Drought



Creation of a simulation model and simulation of inflow to reservoir



Simulation model of combination of new water reservoir and traditional tanks



Joint management to meet demand in September of drought year

A detailed analysis and estimate was made of total demand and river flows into each reservoir and a model of combined operation of the traditional tanks and the new reservoir was created, and a simulation was conducted of the operation to satisfy total water demand in a drought period.

- It was shown that by combined operation in September of a drought year, it is possible to meet total water demand, by preferentially using water stored in traditional tanks, and then operating these in complement with the new reservoir.
- Study the joint management options and create a methodology and guidelines.
- A memorandum of understanding (MoU) was concluded with the Sri Lankan irrigation authority, and agreement was obtained to use the results of this study (the agreement was formally concluded with the director of the irrigation authority in Feb. 2014 in Colombo).

MoU with the Sri Lankan irrigation authority

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Assessment of Resilience Based on Field Surveys

Survey location	Climate-ecosystem/socio-economic change	Systems	Shock-resistance	Resilience rating (current)	Intervention options	Resilience rating (after intervention)
Home gardens Vietnam Indonesia Sri Lanka	☐ Flooding/long dry season /rainfall pattern change/pest damage/saltwater infiltration ☐ Market adaptation/market economy penetration	VAC/ Pekarangan/ Kandyan home garden	☐ Cash crops, commercial livestock production, food self-sufficiency	Ecological: High ↘ Socio-econom: Low ↗	☐ Use certification system ☐ Form communities ☐ Enhance material cycling by mixed production ☐ Strengthen safety net	Ecological: High Socio-econom: Med.
Vietnam Xuan Thuy	☐ Rainstorm/flooding ☐ Disease-pest damage ☐ Saltwater infiltration ☐ International market adaptation ☐ Market economy penetration	VAC	☐ Commercial livestock production	Ecological: Med. ↘ Socio-econom: Med. ↗	☐ Use certification system ☐ More stable operation by combining VAC and rice farming ☐ Combine traditional and modern varieties ☐ Improve quality	Ecological: Med. Socio-econom: High
		Rice cultivation	☐ Moving irrigation water source upstream ☐ Selection of varieties	Ecological: Low ↘ Socio-econom: Med. ↘		Climate-eco: Med. Socio-econom: Med.
Indonesia Gunung Kidul	☐ Long dry season ☐ Lack of rain/change in rainfall pattern ☐ Flooding ☐ International market adaptation ☐ Market economy penetration	Social forestry/ Pekarangan	☐ Diversify livelihood ☐ Biodiversity	Ecological: High → Socio-econom: Low →	☐ Use forest certification system ☐ Create resource management system ☐ Move to agroforestry by commercial reforestation	Ecological: Med. Socio-econom: Med.
		Commercial reforestation	☐ Sale of high value-added wood products	Ecological: Low → Socio-econom: High →		Ecological: Med. Socio-econom: High
Sri Lanka Kilinochchi Deduru Oya Mahaweli H	☐ Dryness/declining rainfall ☐ Damage to irrigation infrastructure due to civil war ☐ International market adaptation ☐ Market economy penetration	Traditional storage water tanks	☐ Restore/use traditional irrigation systems ☐ Multi-functionality	Ecological: Med. → Socio-econom: Low ↘	☐ Integrate new and old irrigation systems ☐ Create communities ☐ Appropriate resource management system to avoid drought	Ecological: High Socio-econom: High
		New irrigation system	☐ Efficient use ☐ Collaborative management	Ecological: Low → Socio-econom: Low →		Climate-eco: High Socio-econom: High

Conclusion

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- On the basis of previous research, a framework was developed for assessing and analyzing resilience in specific detail, not just conceptually, and concrete strategies to enhance resilience were formulated in accordance with case studies for which field surveys and analyses were conducted.
- Field surveys and statistical analysis demonstrated that it is possible to develop strategies to adapt to climate and ecosystem change by primarily using traditional varieties of crops that can adapt better to climate change, in combination with modern varieties. This is different to the strategy of improved varieties on which the success of the Green Revolution was based.
- It was proved that home garden systems are generally highly resilient systems in the face of climate and ecosystem change or socio-economic change. At the same time, it was shown that enhancing the features of home garden systems to adapt them to particular natural and socio-economic changes makes them more resilient systems.
- As seen in the VAC systems and rice cultivation of Vietnam, the pekarangans and commercial reforestation of Indonesia, and the traditional tanks and new reservoir of Sri Lanka, it is possible to develop resilience-enhancing measures that depend on ecosystem services and which are quite different to conventional technological solutions, by means of mosaic systems that integrate traditional and modern systems.