Resource Conservation, Tools for Screening Climate Smart Practices and Role of Communities

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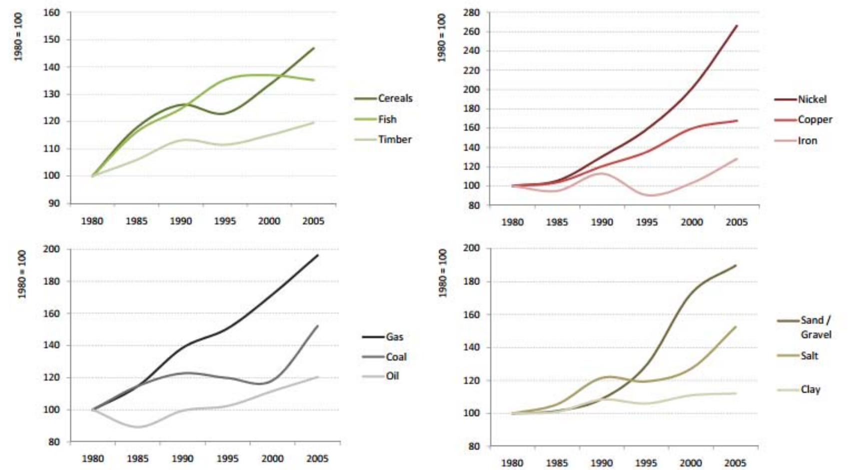
OUTLINE

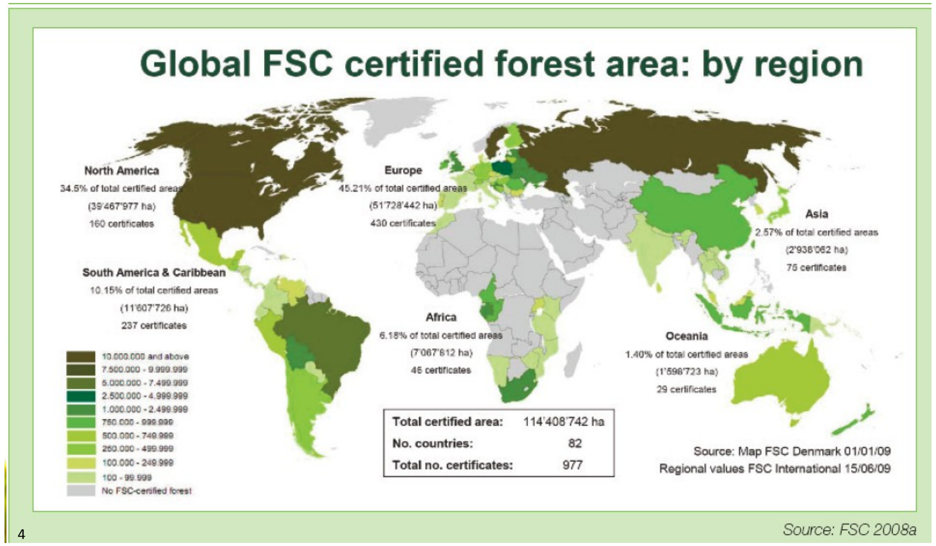
- Trends in natural resource use and global change impacts
- Resource conservation technologies for climate smart agriculture
- Tools for identifying appropriate technologies
- Role of communities in resource conservation
- Concluding thoughts

NATURAL RESOURCE DEPENDENCY AND DEPLETION



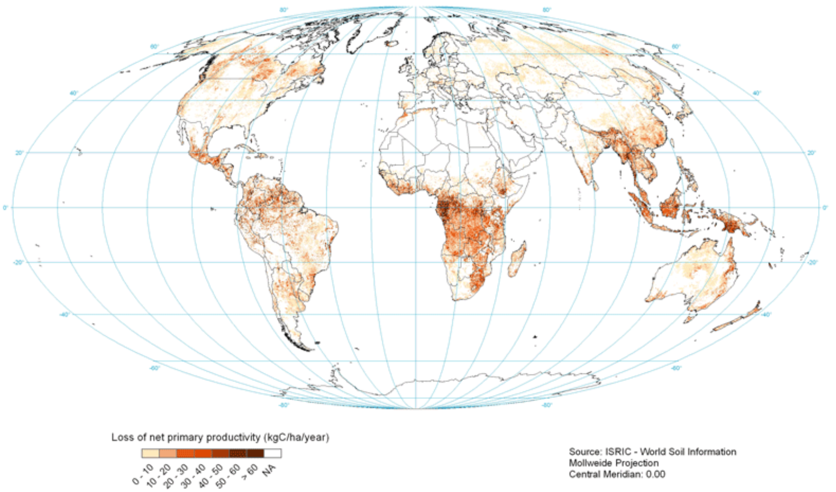
Friends of the Earth, 2009

NATURAL RESOURCE TRENDS LAND: FORESTS



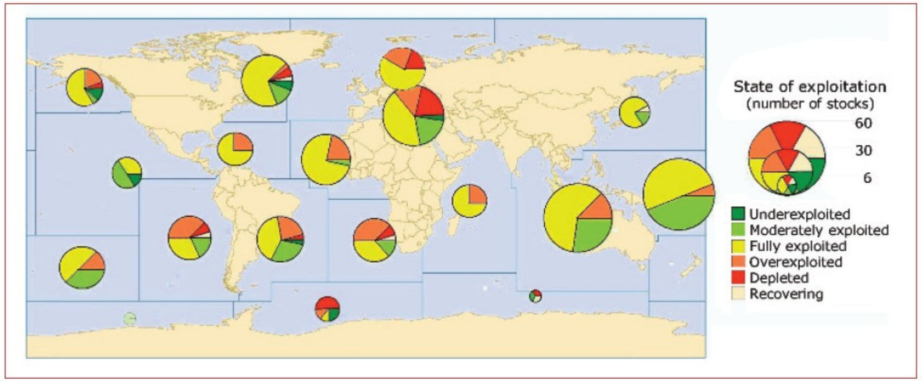
LAND: NET PRIMARY PRODUCTIVITY

Global loss of annual net primary productivity between 1981 and 2003



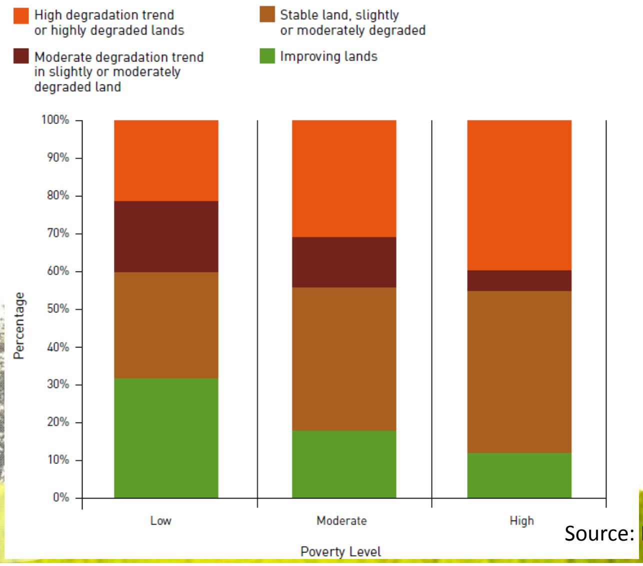
MARINE: FISHING

Figure 1.4: State of exploitation of selected stock or species groups for which assessment information is available, by major marine fishing areas, 2004



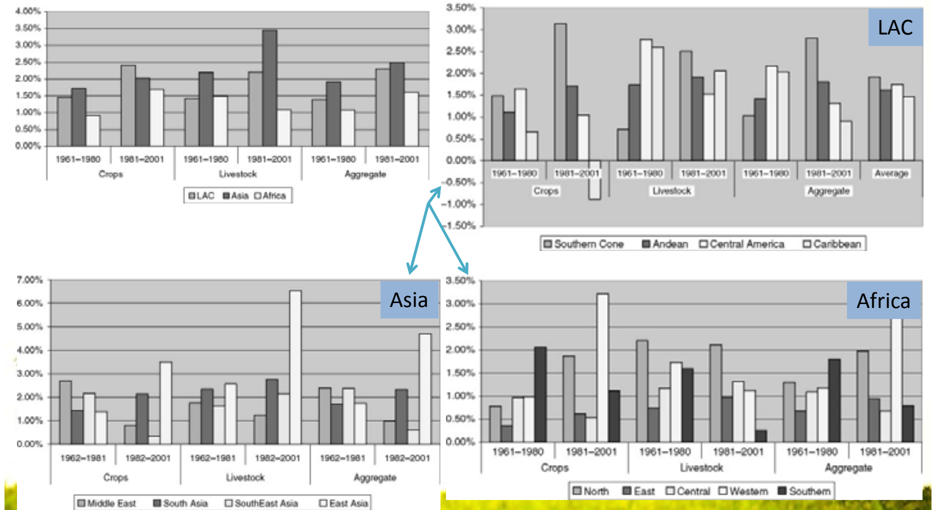
Source: adapted from FAO 2005a: 7

RESOURCE DEGRADATION AND POVERTY: RESOURCE CURSE



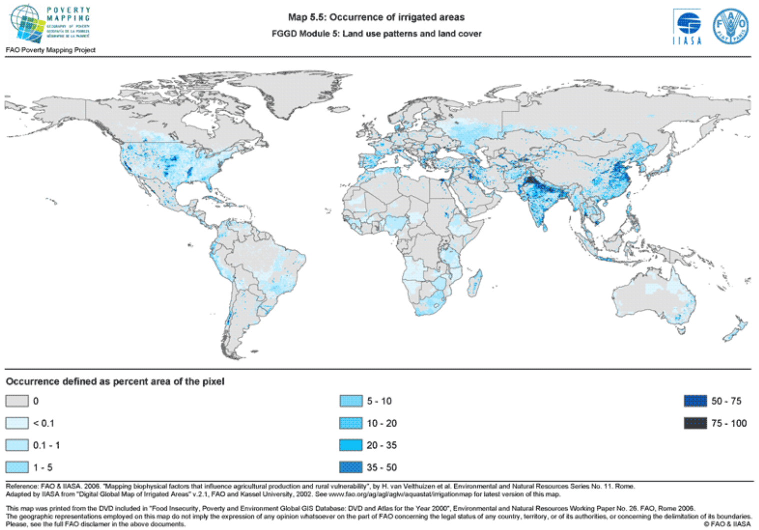
Source: FAO, 2011

TRENDS IN TOTAL FACTOR PRODUCTIVITY

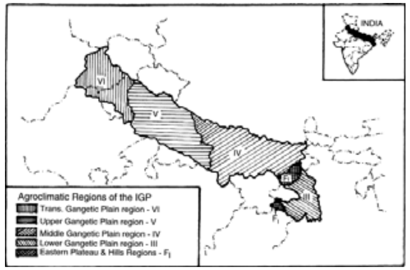


Source: Avila and Evenson, 2010

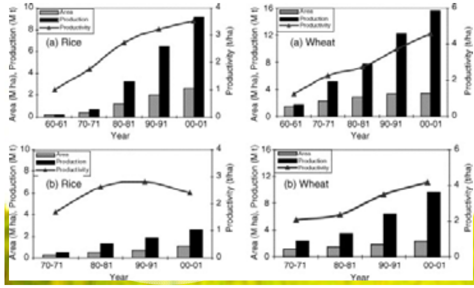
GLOBAL IRRIGATED AREAS



TFP IN INDO-GANGETIC PLAINS

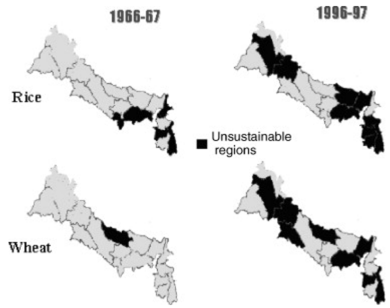


Trend in Trans-Gangetic area



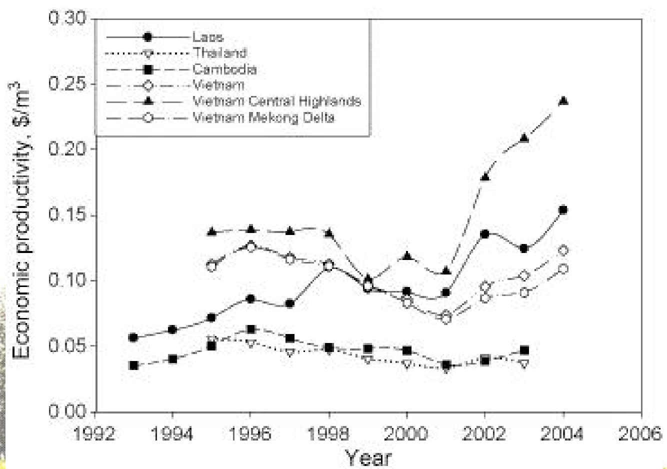
Source: Ambast et al., 2006

Overall Trend



Source: Aggarwal et al., 2004

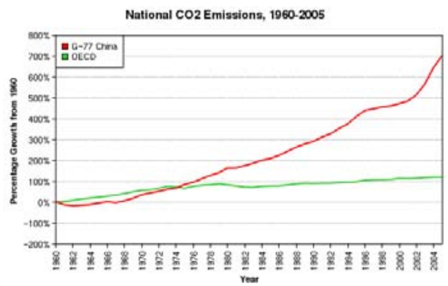
TRENDS IN MEKONG DELTA: ECONOMIC PRODUCTIVITY OF WATER

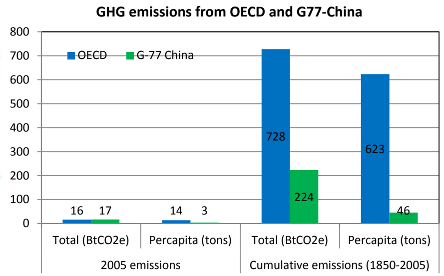


Mainuddin and Kirby, 2009

CLIMATE CHANGE AND NATURAL RESOURCES

GHG Emissions

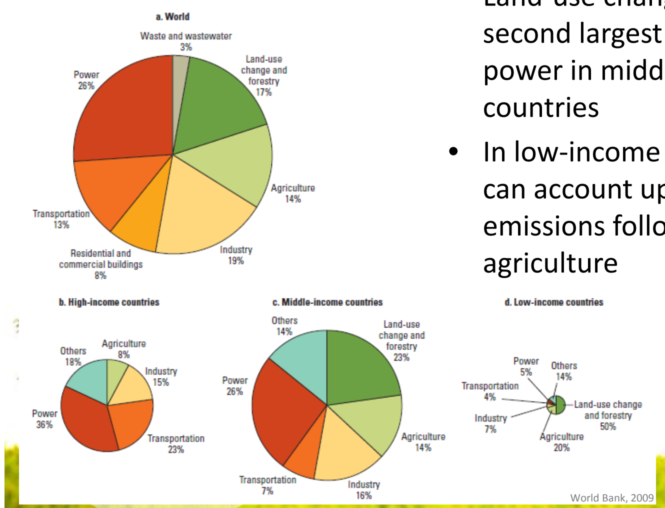




Data source: WRI CAIT, 2009

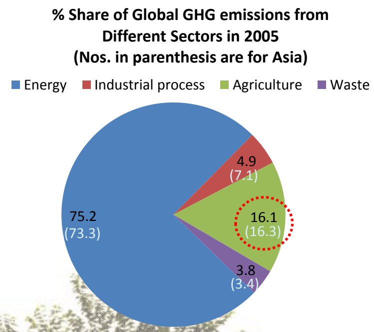
- GHG emissions are rapidly growing for all countries with higher rate in developing countries after 1975
- However, per capita emissions of developing countries are 1/4th of the developed countries (historically it is 1/13th)

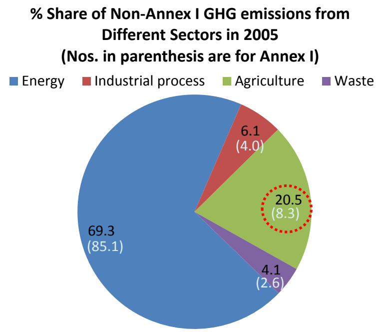
GHG EMISSIONS



- Land-use changes contribute to second largest emissions after power in middle income countries
- In low-income countries, LUCs can account up to 50% of total emissions followed by agriculture

AGRICULTURE ACCOUNTS TO SIGNIFICANT GHG EMISSIONS





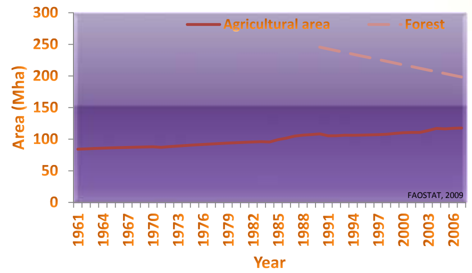
- In terms of absolute quantity, 20.5% GHG emissions from non-Annex I countries is equivalent to 3748.5 MtCO2e which is double the GHG emissions from Agriculture sector from Annex-1 countries.
- Globally, agriculture accounts to 47% and 58% of global anthropogenic methane and nitrous oxide emissions.

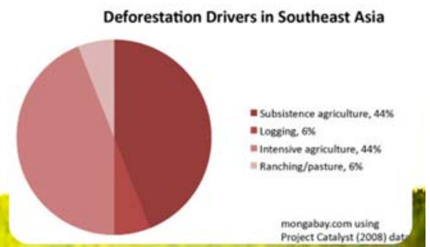
LAND USE EMISSIONS

- Significant land use emissions are CO_2, CH_4 and N_2O.
- CO_2 emissions are not considered since the crop is expected to sequester the emissions in the next season.
- Most of the CH_4 and N_2O emissions can be attributed to paddy cultivation, residue burning, composting, use of manures and nutrients, irrigation water management.

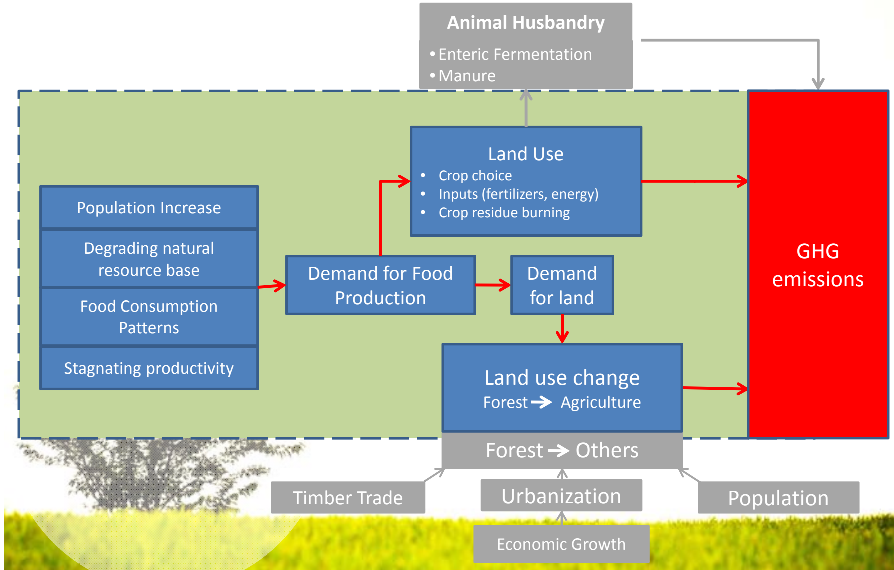
AGRICULTURE AS A DRIVER OF LAND USE CHANGE AND RELATED EMISSIONS

- That fraction of land use changes attributed to pressure from agricultural demand for land (agriculture as driver), mostly CO_2.
- Mostly estimated from actual land expansion under agriculture.





TRENDS LEADING TO INCREASED GHG EMISSIONS



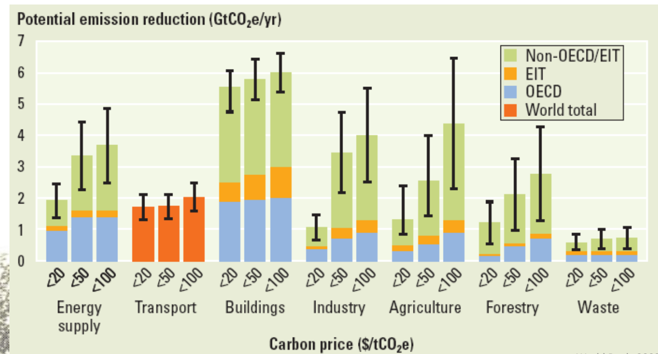
OTHER TRENDS THAT CAN IMPACT GHG EMISSIONS

- Continuous increase in **farm mechanization** with decline in farm animal draft power.
- Decline in **organic matter input** and more reliance on inorganic fertilizers.
- Over exploitation of groundwater for irrigation which needs **substantial pumping**.
- Increasing **burning of paddy straw** and other farm residues due to increased cropping intensity.

FUTURE PROJECTIONS

- Non-CO2 emissions will continue to increase in agriculture sector (US-EPA 2006, IPCC 2007, Stern 2007)
- Most increases are to come from
  - Methane: rice paddies, enteric fermentation, manure, and burning straw
  - N_2O: fertilizations, manure, soils, straw burning

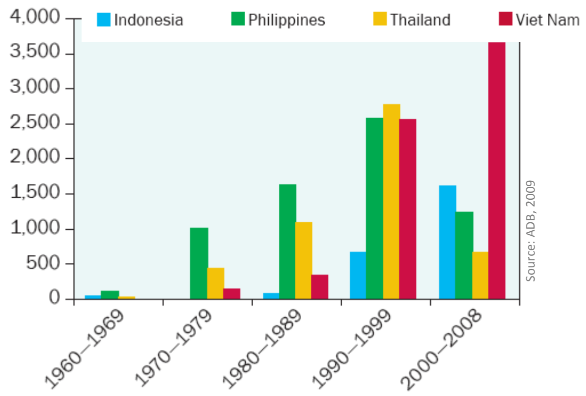
POTENTIAL SECTORS FOR GHG MITIGATION IN THE DEVELOPING WORLD



World Bank, 2009

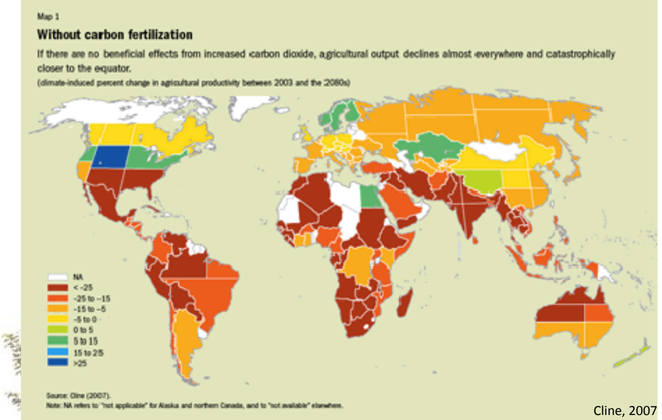
- There is high potential for low cost mitigation options in developing countries
- Agriculture and forestry form some of the low-cost mitigation options

COSTS OF NATURAL HAZARDS ARE INCREASING



Estimated costs of damage from floods and storms

FUTURE IMPACTS OF CLIMATE CHANGE



Cline, 2007

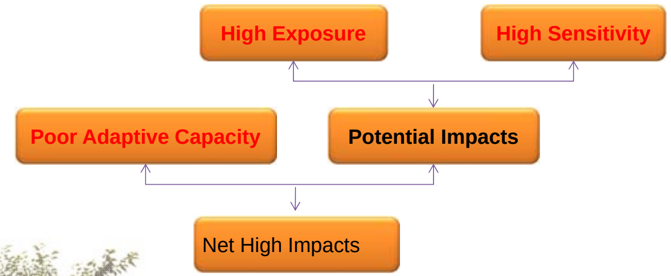
Global warming would negatively impact agricultural yields in most of the developing world

Negative impacts are higher in absence of carbon dioxide fertilization

KEY FUTURE IMPACTS IN AP REGION

- Greater food security challenges for South Asia due to decline in rice and wheat yields and area under wheat
- Decline in freshwater availability in many parts of Asia
- Spring flooding and irrigation shortage in South Asia
- Coastal flooding due to SLR in South, East and South-East Asia with –ve impact on Asian Megadeltas
- Enhanced glacial melt and related outbursts in Himalayan region
- Change in natural vegetation types
- Increase in malaria and cholera in South and Central Asia

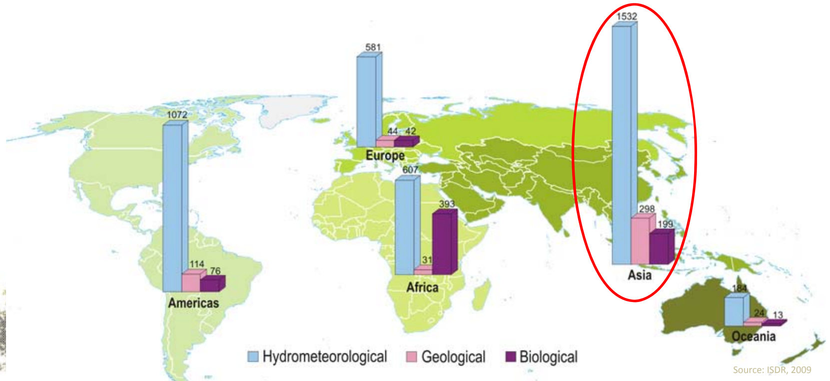
HIGH CC IMPACTS IN COUNTRIES WITH HIGH NAT. RES. DEPENDENCY



Net high impacts in Asia Pacific region due to high exposure, high sensitivity and poor adaptive capacity

- Climate change impacts are function of exposure, sensitivity, and adaptive capacity.
- Impacts are directly proportional to exposure and sensitivity and indirectly proportional to adaptive capacity.

HIGH EXPOSURE OF ASIA TO CLIMATIC EVENTS



Source: ISDR, 2009

- High incidence of hydro-met events such as droughts, floods, cyclones/typhoons, heat waves etc in the highly populated Asia.

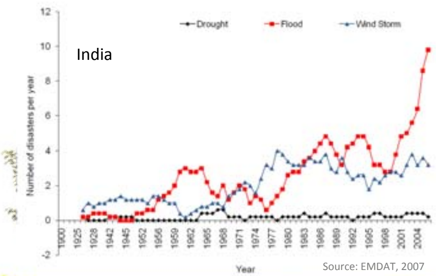
HIGH SENSITIVITY OF COUNTRIES WITH HIGH NATURAL RESOURCE DEPENDENCY

- **High poverty levels**, especially in rural areas (500 million subsistence farmers in AP region), characterized by low human development index
- **High dependency on primary production sectors** such as agriculture and animal husbandry (nearly 60% of total population), that are directly impacted by climate change, coupled with lack of diversified livelihood options
- **Least access to resources** (inequality) coupled with rapid degradation of natural resource base including forests
- **Poor governance** and institutional systems (political, social, environmental and economic) reflecting fragmented and slow progress in development

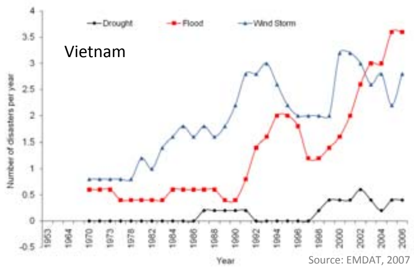
DEVELOPMENTAL STATE AND IMPACTS

Country	GDP per capita (USD)	Population (million)	Number of typhoons	Fatalities	Fatalities per event
Japan	38,160	126	13	352	27
Philippines	1,200	74	39	6,835	175
Bangladesh	360	124	14	151,045	10,788

Source: Mechler, 2004



Source: EMDAT, 2007



Source: EMDAT, 2007

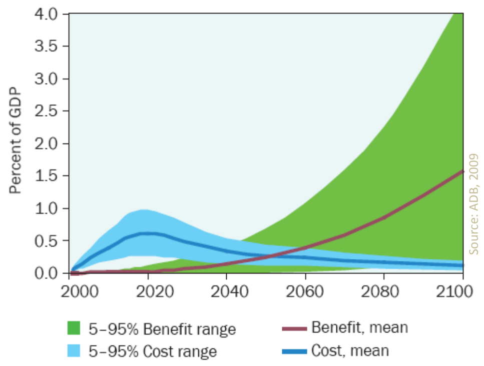
ADAPTIVE CAPACITY IN DEVELOPING AND DEVELOPED ASIA AND PACIFIC

Determinants of adaptive capacity	Developing South Asia	Developing East Asia Pacific	World
Per capita GNI, PPP basis (USD)	2733	5399	10,357
Technology patent applications (total since 2000)	129,035	1,214,326	12,420,319
% of paved roads in total (proxy)	30.8 (2000) [57 (2004)]	11.4 (2000)	36 (2000)
Resource allocation (IRAI, rated on 1-6 scale)	3.5 (IDA countries)	3.3 (IDA countries)	3.3 (IDA countries)

The World Bank, 2009; WIPO, 2009

- Developing South Asia lag in economic development and technology exports
- Developing East Asia Pacific lag in infrastructure and resource allocation

COST-BENEFIT OF ADAPTATION

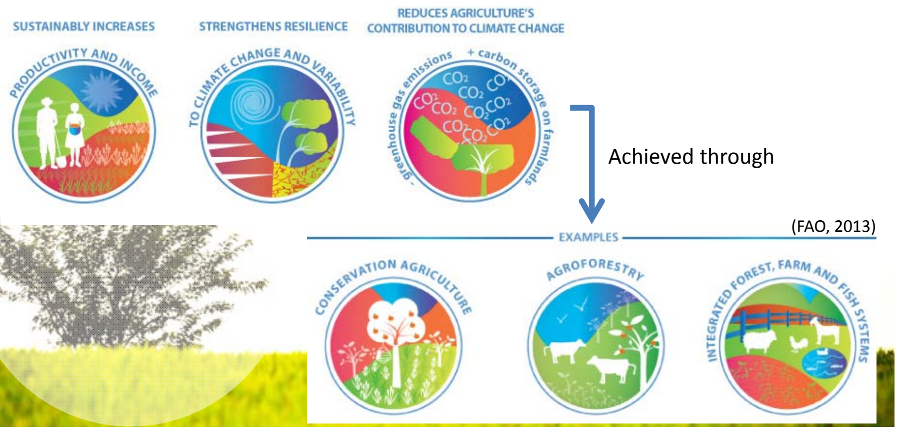


- Adaptation benefits are much higher than the costs in the 4 countries of South East Asia (Indonesia, Philippines, Thailand, and Vietnam; Figure on left)
- By 2100, the benefits of adaptation would reach to the tune of 1.9% of GDP when compared to costs at 0.2%

CLIMATE SMART TECHNOLOGIES

CLIMATE SMARTNESS

- “An agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes GHGs (mitigation), and enhances the achievement of national food security and development goals” (FAO, 2010)



POTENTIAL TECHNOLOGIES WITH MULTIPLE BENEFITS

- Zero-tillage (or) conservation tillage (wheat)
- Windrow Composting (Paddy straw)
- Leaf color charts (Rice)
- System Rice Intensification (Rice)
- Alternative nutrient sources and amendments (Rice)
- Carbon sequestration
- Use of RE in agriculture
- Mid-season drainage
- Alternate flooding and drying

ZERO-TILLAGE

- Zero-Tillage saves 70-90 L of diesel/ha
- Saves water (to the tune of ~$1.0x10^6$ L water)
- Farmers save USD 40-55/ha.
- Reduced/ eliminate burning of crop residues

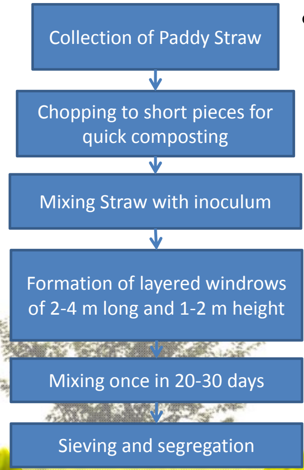
↓

Climate and economic benefits

Rice stubbles retained/ mulched

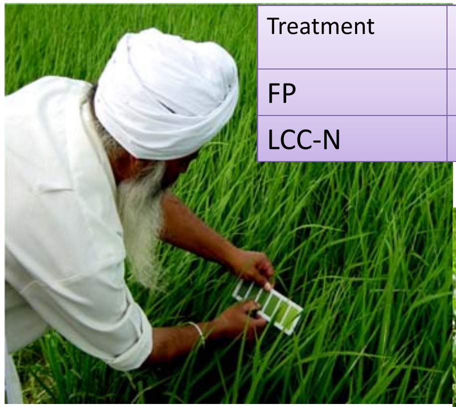
Source: RWC, 2005

AEROBIC WINDROW COMPOSTING RICE STRAW



- US Environmental Protection Agency and US Composting Council:
  - Aerobic composting doest contribute to CO_2 emissions
  - It is considered as natural cycle
  - Eliminates CH_4 and N_2O emissions

LEAF COLOR CHARTS: N SAVED IS N PRODUCED



Treatment	N applied kg ha^{-1}	Gr. Yield, kg ha^{-1}	PFP-N	N saved, kg ha^{-1}
FP	149	6359	42.7	-
LCC-N	124	6371	51.4	25

Source: RWC, 2005

SYSTEM OF RICE INTENSIFICATION

- Refers to a combination of technologies for saving irrigation water, fertilizer inputs and increase farm profitability.
- Involves transplanting of young seedlings in one seedling per hill in rows, intermittent irrigation and drainage practice.
- Substantial gains in yields, reduced losses from leaching, reduced methane emissions.

TOOLS FOR SCREENING PRACTICES

MARGINAL ABATEMENT COSTS

$$MAC = \frac{Mc}{M_{GHG}}$$

MAC = Marginal abatement cost ($\$t^{-1}$)

Mct = Marginal cost of the new technology when compared to the baseline technology

M_{GHG}= Marginal reductions in GHG emissions

$$Mc = C_a - C_b$$

C_a= Cost of technology a

C_b = Cost of technology b

$$M_{GHG} = GHG_a - GHG_b$$

GHG EMISSIONS

$$GHG_a = Activity \times Ef \times Sf$$

Activity data: E.g. area under particular technology or amount of biomass burnt or amount of particular fertilizer type used

Ef: Emission factor, factor that provides GHG quantity by multiplication with the activity data

Sf: Scaling factor, factor that modifies a sub-practice from the base line practice (e.g. intermittent irrigation as against continuous flooding)

Notes:

- Data sources: 2006 IPCC guidelines for national GHG inventories, Secondary sources such as journal papers
- Logic: Urea not used is not produced! (different from IPCC approach)
- Currently the calculations are between Tier I and Tier II approaches suggested by IPCC. Need to be standardized to either one of the Tiers.

BENEFIT-COST RATIO

Costs

Operational costs

Human labor
Bullock labor
Machine labor
Seed

Fertilizers and manures

Fertilizers
Manure

Insecticide

Irrigation

Interest on working capital

Fixed cost

Rental value of owned land
Land tax
Depreciation on implements and farm buildings
Interest on fixed capital

Gross Income (GI)

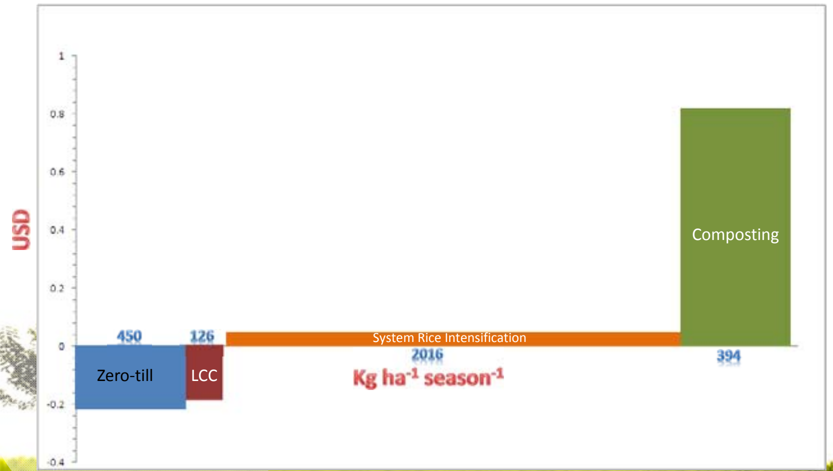
Yield per ha (t/ha)
Value of main product per ha
Value of by product per ha

Cost : Benefit Ratio

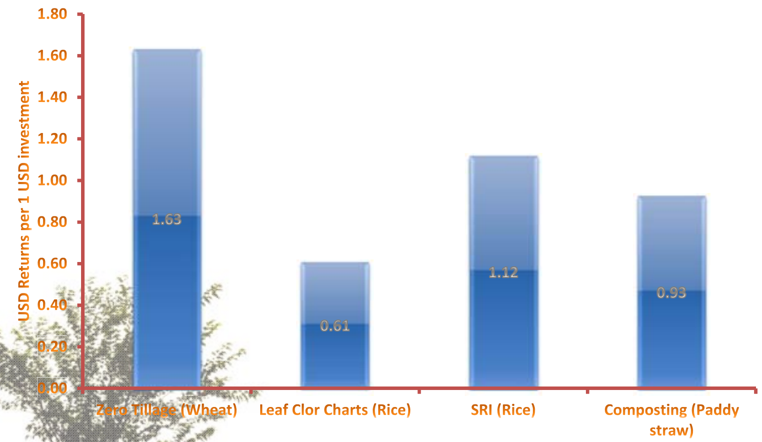
$$BCR = \frac{TotalBenefits}{TotalCosts}$$

- **Notes:** Positive and negative externalities can also be considered

MARGINAL ABATEMENT COST FOR CONSERVATION TECHNOLOGIES



BENEFIT : COST ANALYSIS



COUNTRYWIDE GHG MITIGATION POTENTIAL (E.G. INDIA)

- India's agricultural GHG emissions in 2005 were 402.7 Mt CO2-e per year.
- Compare 116 Mt CO2-e mitigation potential of the above 4 technologies alone.

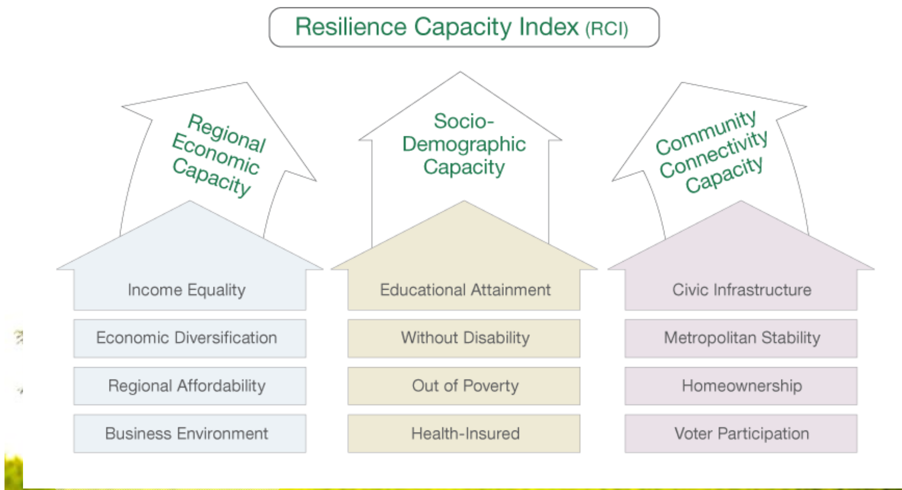
EX-ANTE CARBON BALANCE TOOL (EX-ACT, FAO): PROS

- Provides ex-ante estimations of net carbon balance of GHG estimations and sequestration in agriculture and forestry development projects
- Aimed at
  - increasing the accuracy of carbon accounting
  - Supports investments in climate smart agriculture
  - useful in policy analysis
- Land-based accounting system that compares land management options with BAU scenario

EX-ACT TOOL: CONS

- Resilience/adaptation components are still being developed
- No cost-benefit analysis for comparing options
- Requires a good training for getting full potential out of the tool
- Appears to be daunting and only suitable for medium to large sized projects (con) but one can soon familiarize with it

RESILIENCE TOOLS: RCI



RESILIENCE TOOLS: IUPA

- Index of Usefulness of Practices for Adaptation to climate change (IUPA) Index (Claudio Szlafsztein, Federal University of Para, Brazil)
  - Integrates both qualitative and quantitative parameters into a single index
  - Choosing the weightings for individual parameters is a question

LOCAL ADAPTATION INDEX (LAIN)

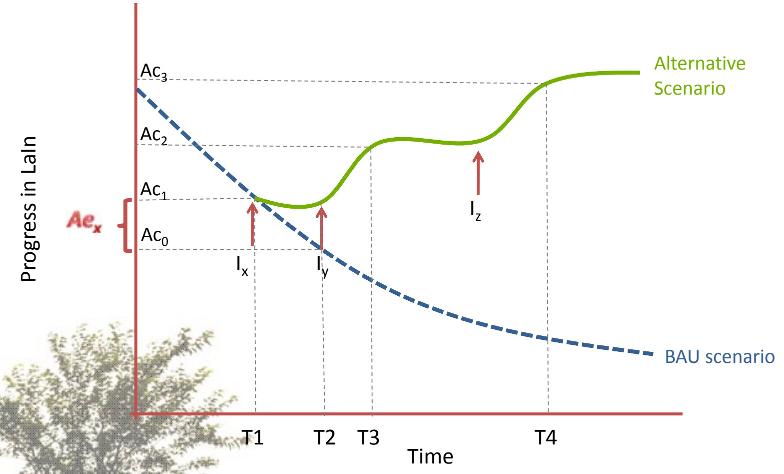
LaIn=

$$\left[\left(\sum_{i}^{Read.} \frac{Index_i - Mean_{all}(Index_i)}{Stdev_{all}(Index_i)} * Weight_{Index}\right) / Max(Score)_{all}\right]_{Read.} * 60 -$$

$$\left[\left(\sum_{i}^{Vuln.} \frac{Index_i - Mean_{all}(Index_i)}{Stdev_{all}(Index_i)} * Weight_{Index}\right) / Max(Score)_{all}\right]_{Vuln.} * 40$$

Source: based on GAIN, 2011

LOCAL ADAPTATION INDEX FOR EVALUATING EFFECTIVENESS OF ADAPTATION OPTIONS?



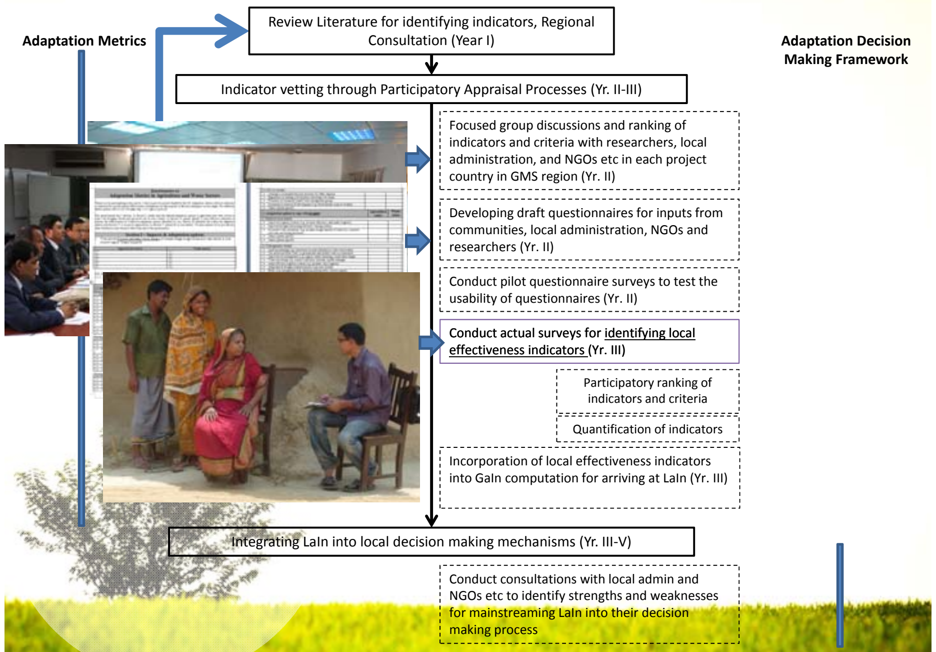
$$Ae_x = Ac_1 - Ac_0$$

Where:

Ae_x: Effectiveness of adaptation action x;

Ac_0, Ac_1: LaIn values at times T1 and T2

Ix, Iy, Iz: adaptation actions



VULNERABILITY AND READINESS INDICATORS FOR LAIN

	Indicators (Bangladesh, based on pilot survey)
Vulnerability	• % farms with soil degradation (exposure) • % soil cover (exposure) • Period of fresh water availability (exposure) • Area under high water use crops (sensitivity) • Area under arable farming (sensitivity) • Soil organic matter content (capacity) • Area under reduced tillage (capacity)
Readiness	• % of households having access to credit (economic) • % of households having access to markets (economic)

MOCK EXERCISE: LAIN

Indicator values for BAU practice

	Indicators (Bangladesh, based on pilot survey)	Value	Range (Min Max)	Score	Weight
Vuln.	•% Soil degradation	20	5-30	0.67	0.14
	•% soil cover	40	10-70	0.57	0.14
	•Period of water availability (days)	120	50-200	0.60	0.14
	•Water int. crops (ha)	50	40-60	0.83	0.14
	•Arable farming (ha)	80	40-90	0.89	0.14
	•Soil OM content (%)	0.5	0.25-1	0.50	0.14
	•Reduced tillage (ha)	10	5-60	0.17	0.14
Read.	•Households credit access (%)	40	10-80	0.50	0.50
	•Farmers access to markets (%)	50	20-80	0.63	0.50

Note: Scores are calculated by linear normalization with thresholds

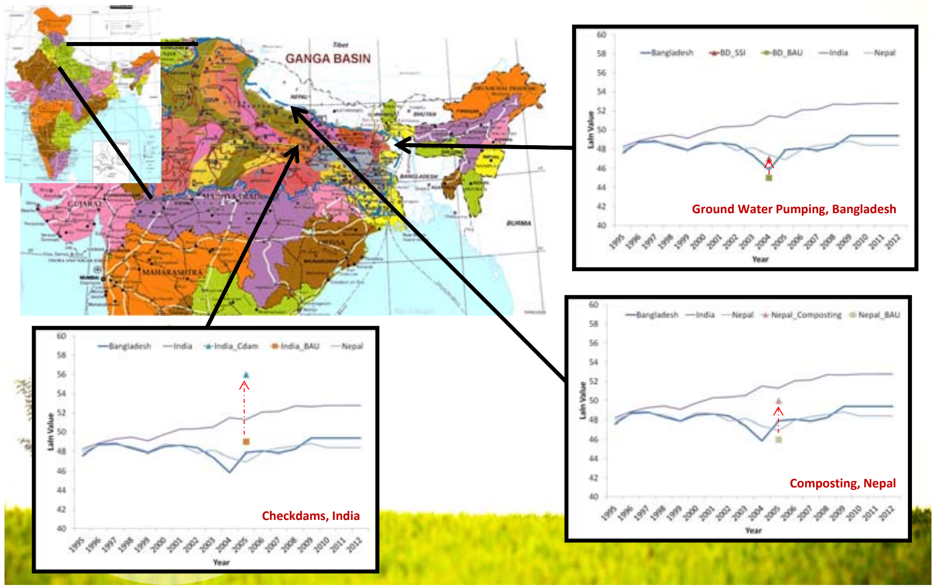
MOCK EXERCISE: LAIN

Indicator values for ZT practice

	Indicators (Bangladesh, based on pilot survey)	Value	Range (Min Max)	Score	Weight
Vuln.	•% Soil degradation	5	5-30	0.17	0.14
	•% soil cover	70	10-70	1.00	0.14
	•Period of water availability (days)	180	50-200	0.90	0.14
	•Water int. crops (ha)	30	40-60	0.50	0.14
	•Arable farming (ha)	80	40-90	0.89	0.14
	•Soil OM content (%)	0.75	0.25-1	0.75	0.14
	•Reduced tillage (ha)	40	5-60	0.67	0.14
Read.	•Households credit access (%)	50	10-80	0.63	0.50
	•Farmers access to markets (%)	60	20-80	0.75	0.50

Note: Scores are calculated by linear normalization with thresholds

THE USE OF LAIN IN THE GANGETIC BASIN



ROLE OF COMMUNITIES IN NATURAL RESOURCE CONSERVATION

WHY CBNRM?

1. Proximity to and dependency on resources: Communities live close to natural resources, they are benefited by them and hence can be effective stewards of those resources
2. Equity: Communities have diverse interests in natural resources and achieving a consensus on benefit sharing is an important aspect
3. Capacity: Communities often have better understanding on resources that they live in proximity than other stakeholders
4. Biodiversity. Multi-purpose management of natural resources by communities often have higher biodiversity benefits than single purpose management by other stakeholders
5. Cost-effectiveness: Local management may help reduce government costs.
6. Development philosophy. Local participation, decentralization, and subsidiarity may, in themselves, be considered important development objectives.

Source: World Bank, 2011

COMMUNITIES AS CENTRAL TO ECOSYSTEM STEWARDSHIP (ESS)

- Conventional NRM that is based on optimizing and maximizing sustainable yield of single resource has met challenges from various global changes being faced
- ESS considers sustaining the capacity of ecosystems to provide services that benefit the society by linking the integrity and diversity of ecosystems with the adaptive capacity and societal wellbeing (Chapin et al., 2009)

COMMUNITY BASED NRM

- Development of technologies and livelihood options by involving communities right from the beginning instead of seeing communities as 'end of the pipe beneficiaries'. Some examples:
  - Chipko movement of forest conservation in Garhwal region of Uttarakhand, India
  - Participatory R&D of resource conservation technologies in the Gangetic basin by the Rice-Wheat Consortium
  - Numerous examples in watershed management, soil conservation, fishery management, payment of ecosystem services, agroforestry, catchment protection, livelihood diversification etc.

CONCLUDING THOUGHTS

CURRENT ADOPTION RATE OF CONSERVATION TECHNOLOGIES

- ZT area in entire South Asia: 2 M ha.
- Adoption of other crop technologies is in sub thousand hectares.
- Annually, an estimated 35 million tons of paddy straw is being burnt in India, Thailand and Philippines even today.

Why these technologies haven't been scale-Up?

ISSUES WITH SCALING UP / TECHNOLOGY ADOPTION

- No incentives for adopting GHG mitigation technologies.
- The technologies with high abatement potential doesn't necessary to have high benefits per unit investment which farmers consider more (e.g. SRI, LCC as against ZT).

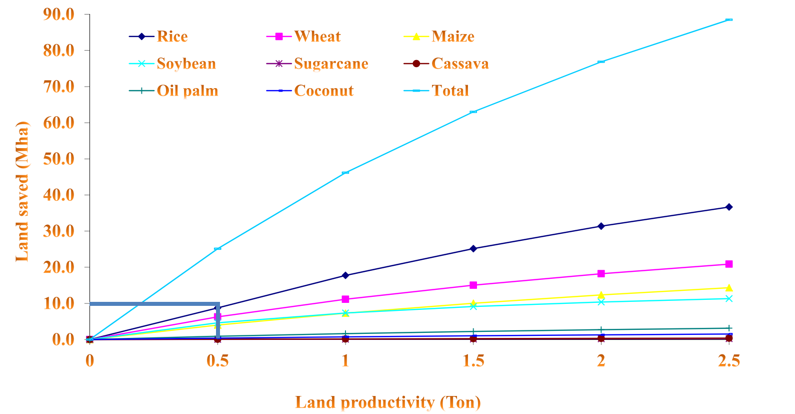
POSSIBLE POLICY MEASURES FOR PROMOTING CLIMATE-SMART AGRICULTURE

- Solving the puzzle of agricultural input subsidies.
- Incentives [and disincentives] for agricultural practices with high [low] conservation benefits.
- Market mechanisms (Carbon sequestration in soil and price on carbon)?
- Enhanced technology transfer from labs to fields.

AGRICULTURE AND LAND USE CHANGES

- Various agricultural drivers leading to land use changes
  - Poor productivity
  - Degrading natural resource base (declining factor productivity: e.g. as in case of Indo-Gangetic Plains)
  - Absence of alternative livelihoods during stress periods (droughts and floods)

REDUCING AGRICULTURE PRESSURE ON LAND



- Increase in productivity of above crops in China, India, Indonesia, Malaysia, Thailand and Vietnam can free a maximum of ~90 Mha of land
- A 0.5% increase in productivity of above key crops can free more land lost to deforestation in the last 15 years in Asia (Asia lost 2.9 Mha of forests during 1990-2005)

Thank You!

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