# ANNEX F  DAY 3 PRESENTATIONS: IRRI FIELD TRIP

IRRI

Annex F1

# Rice, health, and food security


**V. Bruce J. Tolentino, Ph.D.**

Deputy Director-General

International Rice Research Institute

October 2013

Rice Science for a Better World

IRRI

# *IRRI's mission*

**Reduce poverty and hunger, improve health, ensure environmental sustainability through rice science.**

Rice Science for a Better World

IRRI

- Since 1960 by Ford and Rockefeller Foundations, and Philippines;
- 1,300 staff, 32 countries;
- HQ at UPLB; scientists in rice-growing countries;
- Autonomous, non-profit organization;
- Funding by governments, philanthropies

Rice Science for a Better World

# National Year of Rice 2013

## July 2013: Nutrition Month


# IRRI supports P-Noy's Food Staples Sufficiency Program


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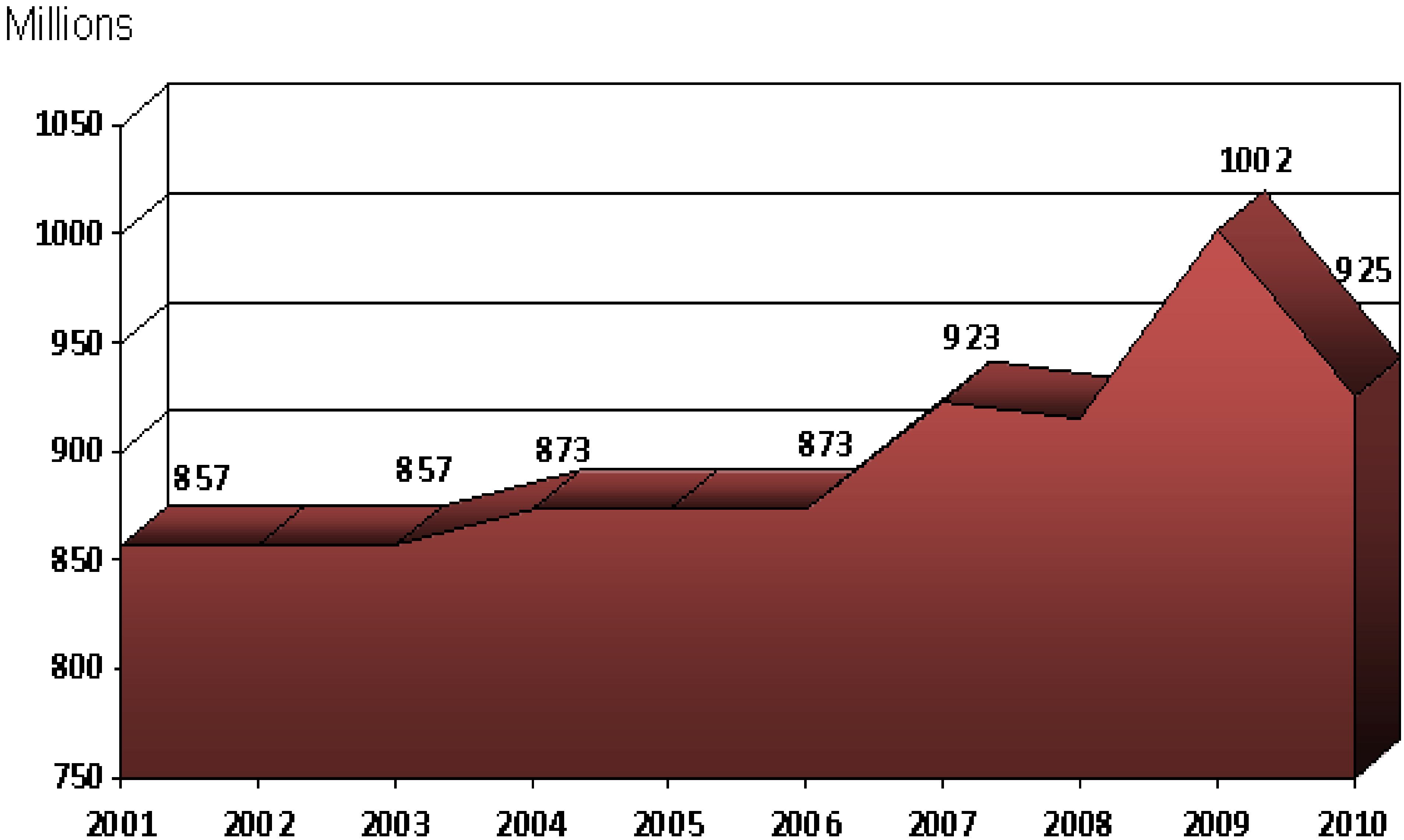
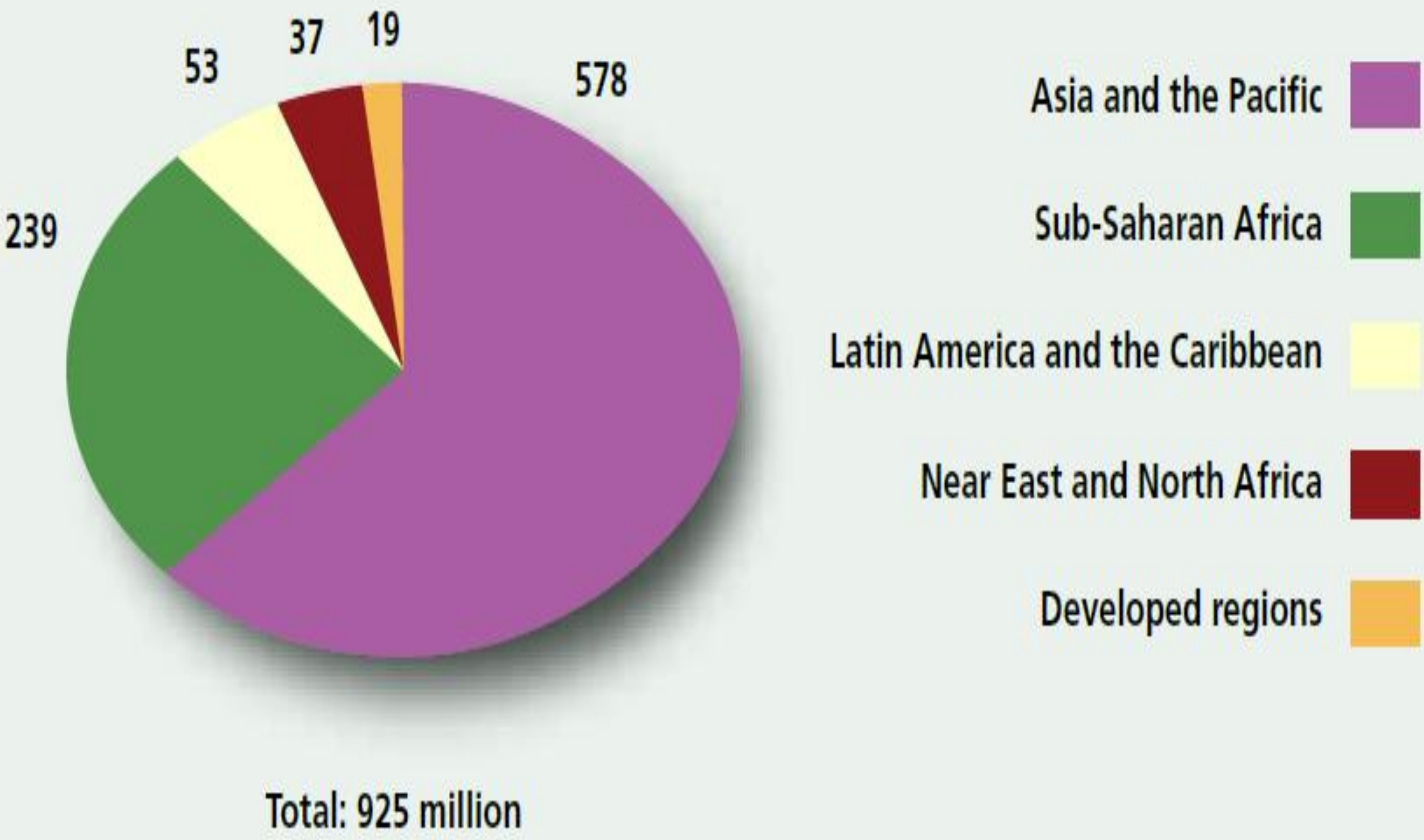
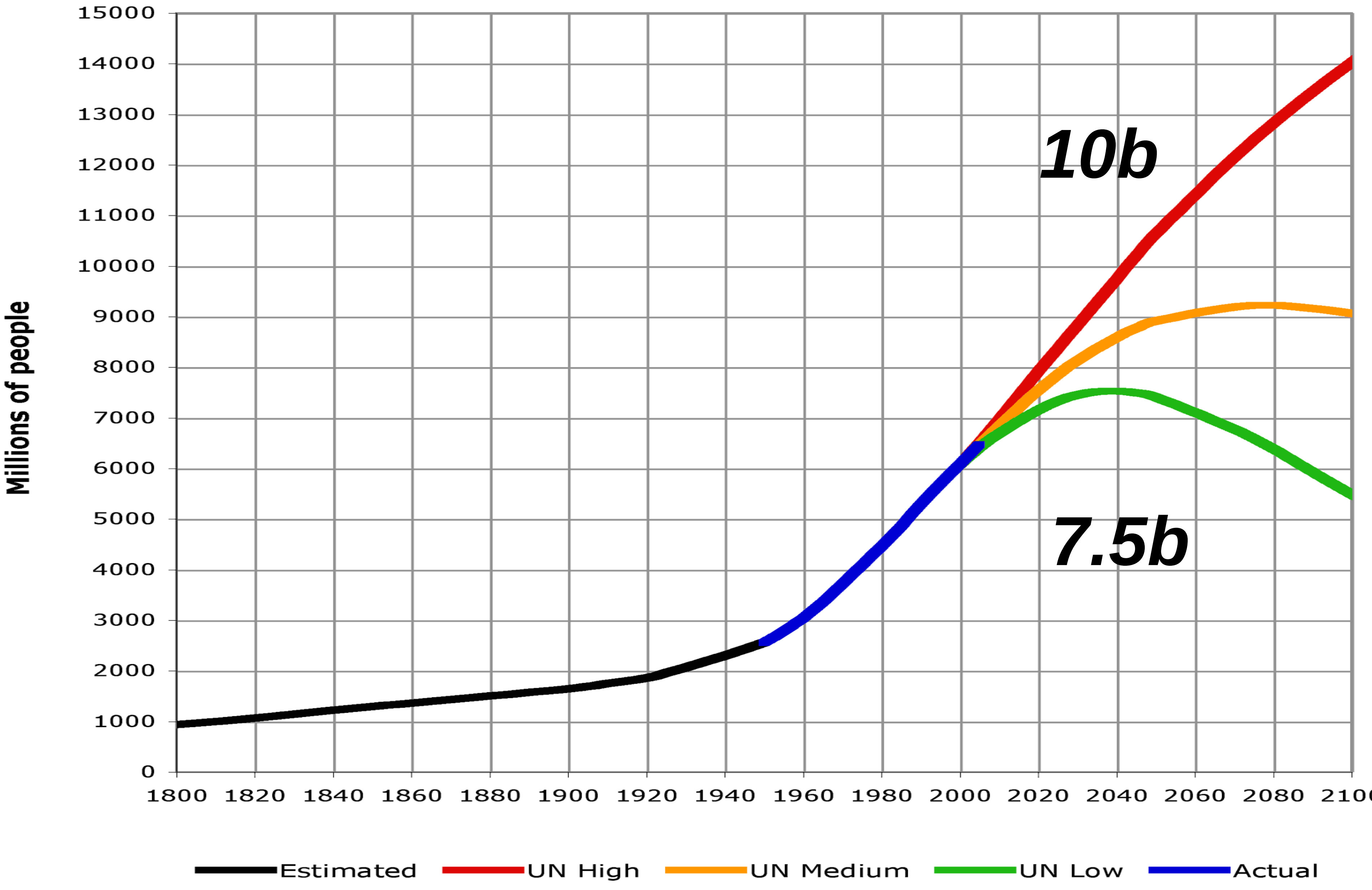
# *1 billion hungry people*



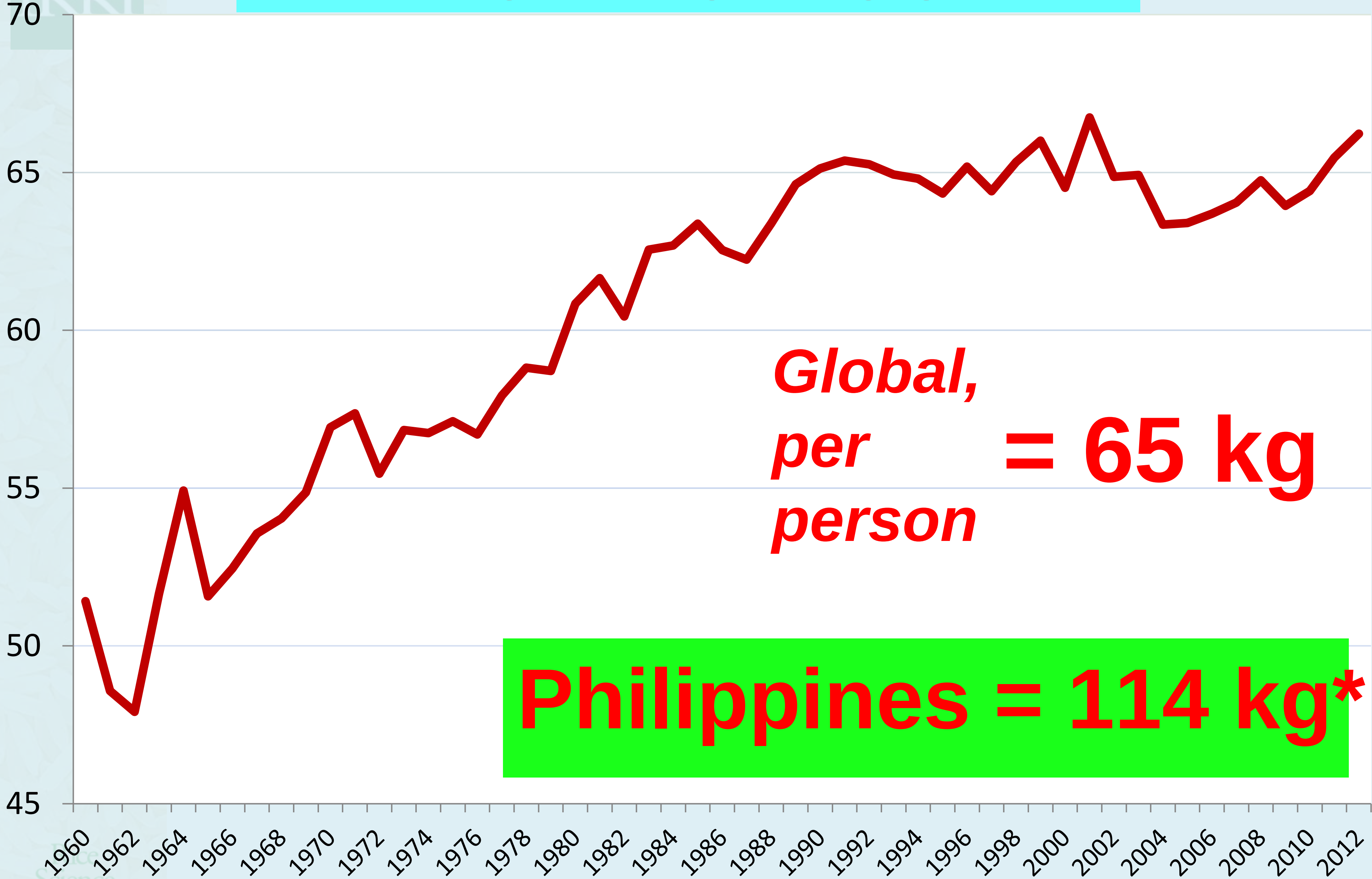
# *Most hungry people in Asia*



# Population by 2040?



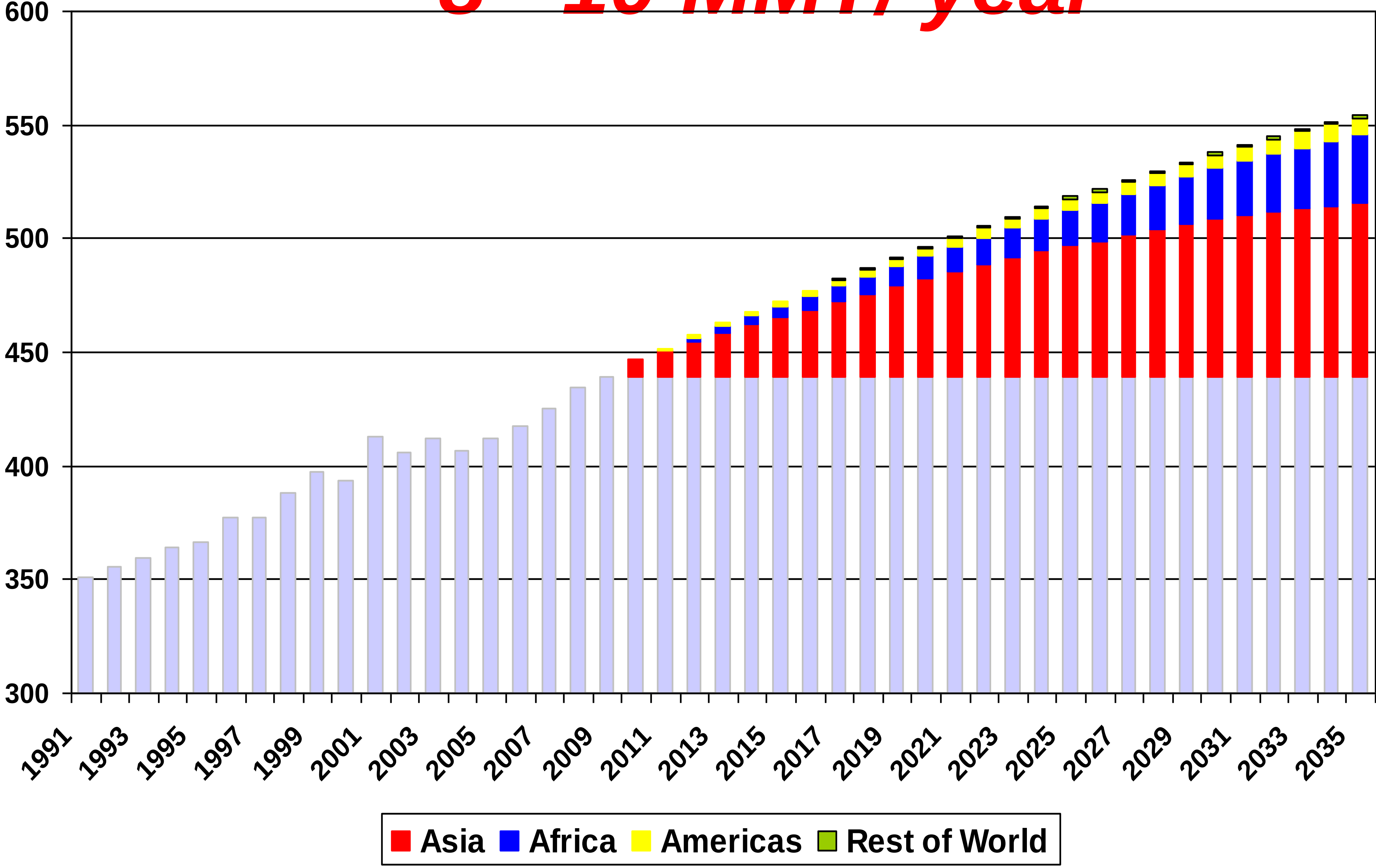
# We like rice!



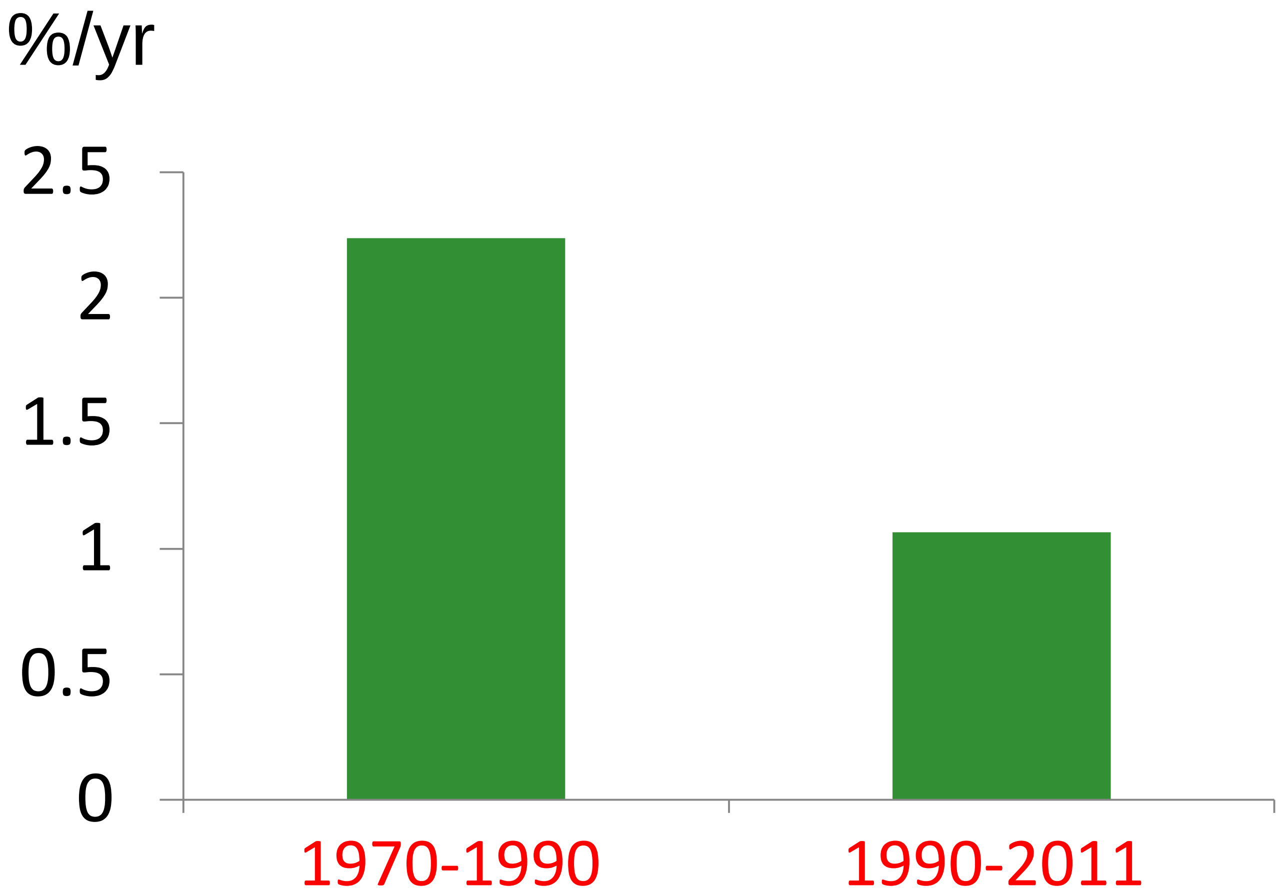

*cial estimate, DA*

Data Source: USDA, 2013

# Additional global rice needs: 8 - 10 MMT/ year



# Growth in rice yield has slowed




**Source of raw data: FAO, 2013**

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# *Worsening resource scarcity*

**Land** →

**Labor** →

**Water** →

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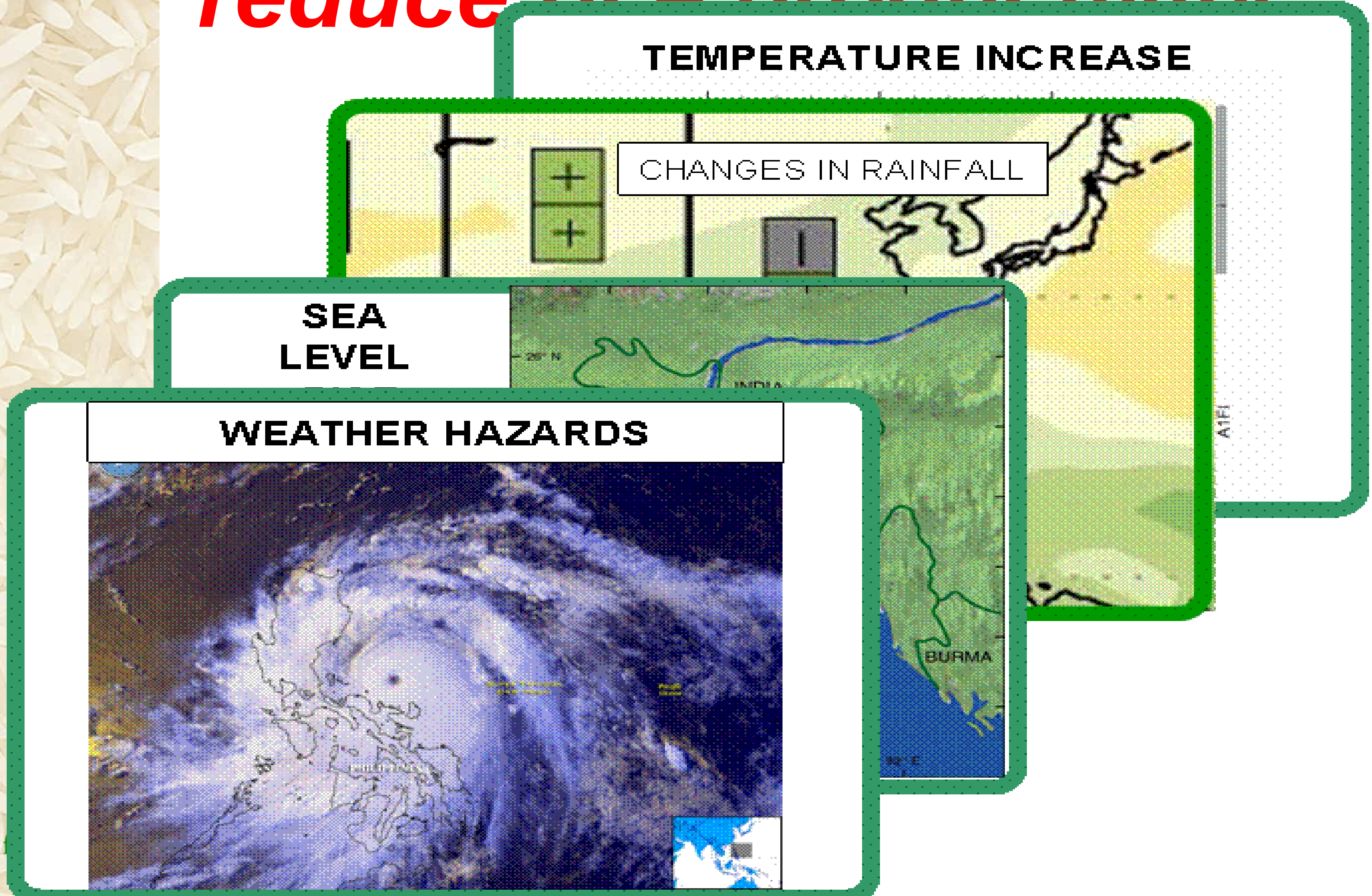
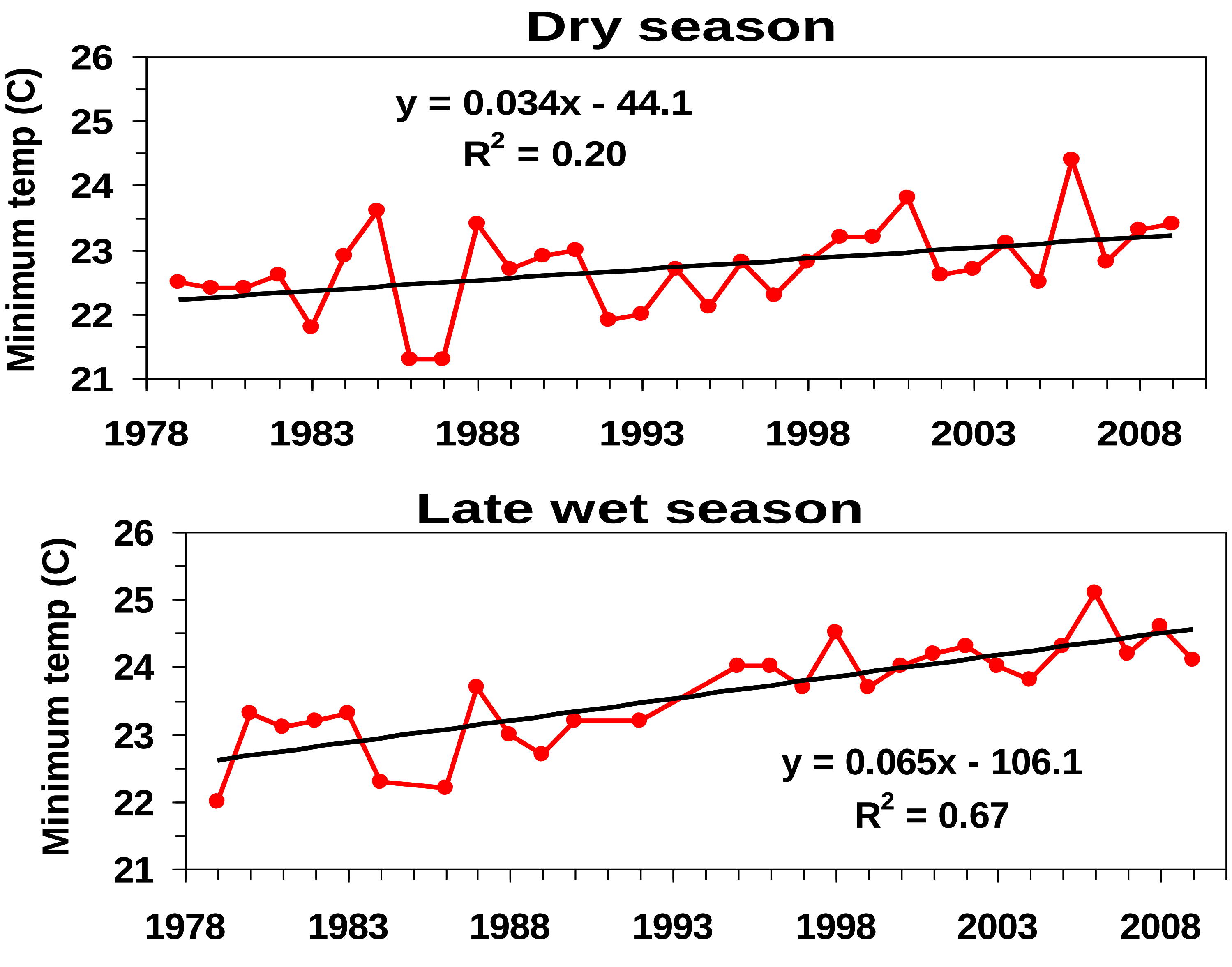
# Climate change WILL reduce rice productivity

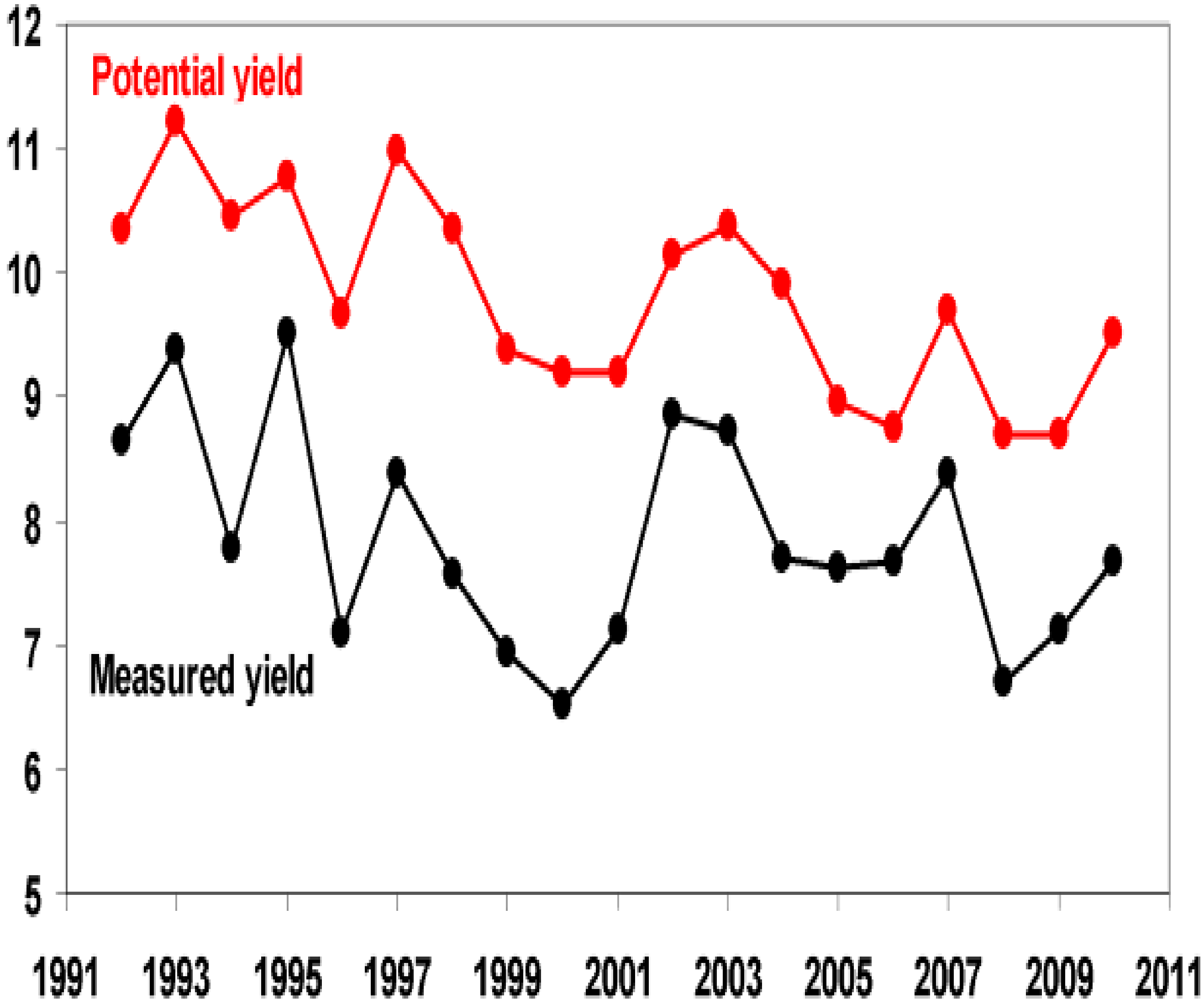


# *Global warming is <u>real</u>*



# *Higher temperature, lower yields*

Grain yield (t ha$^{-1}$) of the highest yielding entry, 1992-2010 dry seasons




**6.5 to 9.5 tons/ha.**

**Depends on climate and manage-ment.**

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# *Rice paddy yields*

| | 1961 | 1970 | 1980 | 1990 | 2000 | 2010 | 2012 |
|---|---|---|---|---|---|---|---|
| **Rice Yield (average, ton/ha)** | | | | | | | |
| **Philippines** | 1.2 | 1.7 | 2.2 | 3.0 | 3.1 | 3.6 | 3.8 |
| **Thailand** | 1.7 | 2.0 | 1.9 | 2.0 | 2.6 | 2.9 | 2.8 |
| **Vietnam** | 1.9 | 2.2 | 2.1 | 3.2 | 4.2 | 5.3 | 5.7 |

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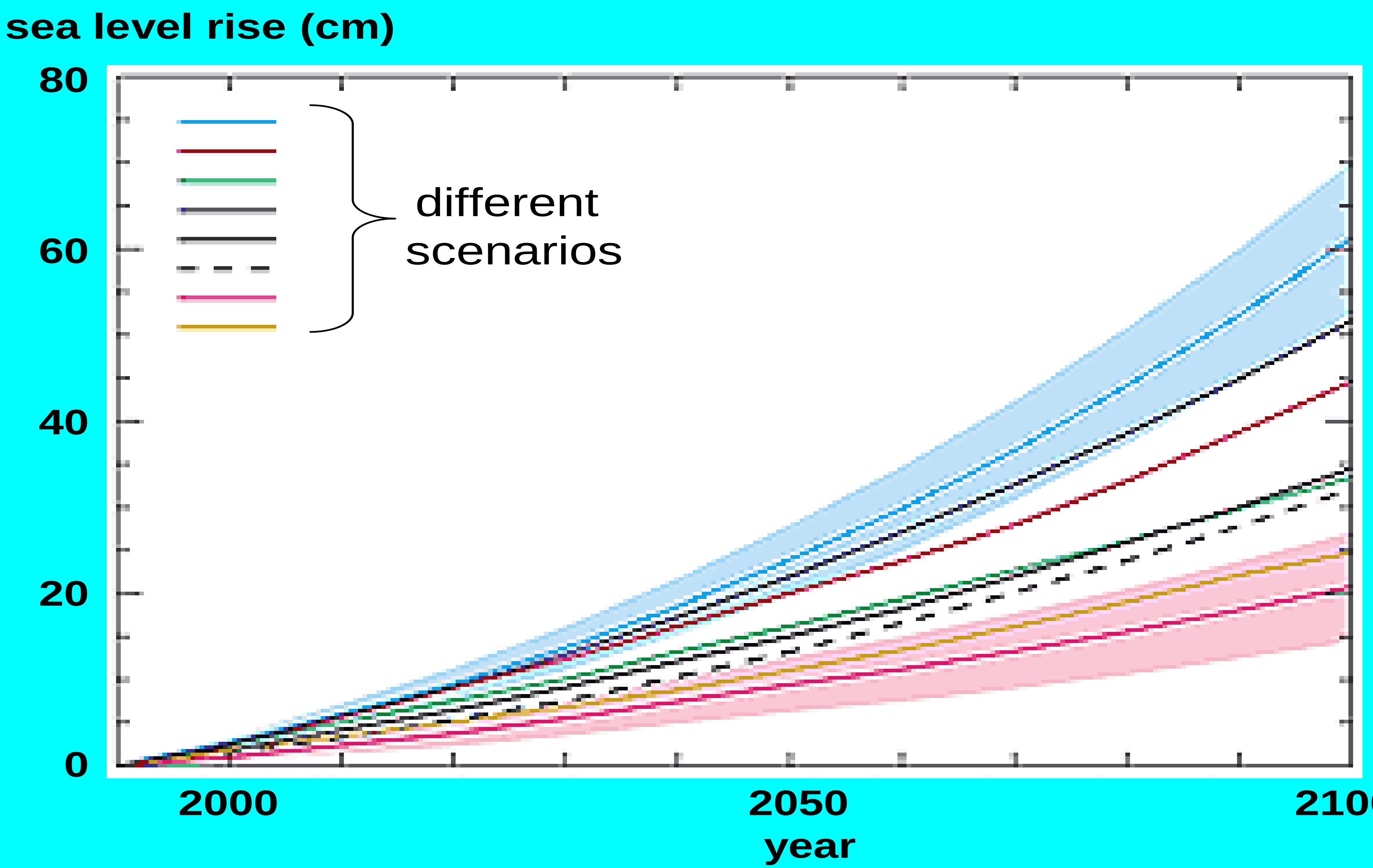
# Rice area and production

| | 1961 | 1970 | 1980 | 1990 | 2000 | 2010 | 2012 |
|---|---|---|---|---|---|---|---|
| **Harvested Rice Area (million ha)** | | | | | | | |
| Philippines | 3.2 | 3.2 | 3.5 | 3.3 | 4.0 | 4.4 | 4.7 |
| Thailand | 6.1 | 6.9 | 9.2 | 8.8 | 9.9 | 12.1 | 10.8 |
| Vietnam | 4.7 | 4.7 | 5.6 | 6.0 | 7.7 | 7.5 | 7.7 |
| **Rice Production (paddy, million ton)** | | | | | | | |
| Philippines | 3.9 | 5.6 | 7.6 | 9.9 | 12.4 | 15.8 | 18.0 |
| Thailand | 10.2 | 13.9 | 17.4 | 17.2 | 25.8 | 31.6 | 30.6 |
| Vietnam | 9.0 | 10.2 | 11.6 | 19.2 | 32.5 | 40.0 | 44.2 |

# Population

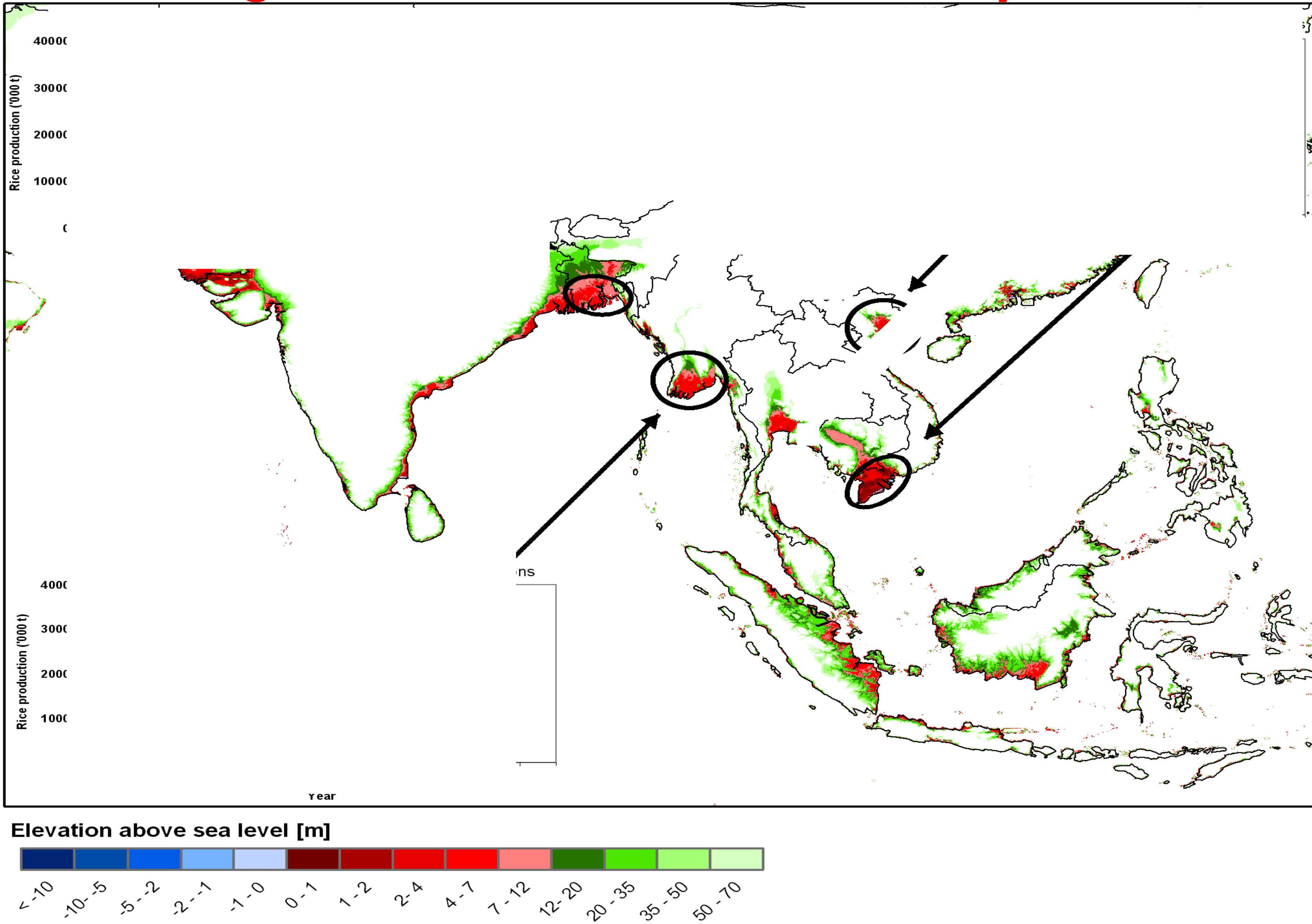
| Country | 1970 | 1980 | 1990 | 2000 | 2010 | 2012 |
|---|---|---|---|---|---|---|
| PHILIPPINES | 36.7 | 48.1 | 60.7 | 76.5 | 92.3 | 100.0 |
| VIETNAM | 44.9 | 54.0 | 67.1 | 78.8 | 87.1 | 88.8 |
| THAILAND | 36.9 | 47.5 | 54.5 | 61.4 | 65.5 | 64.5 |

# Sea level is rising




IPCC 2001

# Asia's mega-deltas: 50% of world rice production



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# *Rice ready for climate change*




# *Rice genetic diversity*

**120,000+** varieties of rice conserved in IRRI's **International Rice Genebank**

# *Conserving traditional / heirloom rices*

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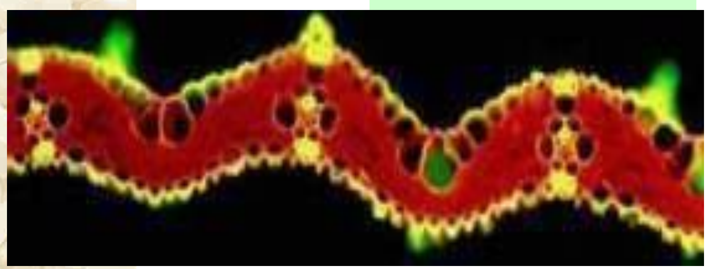
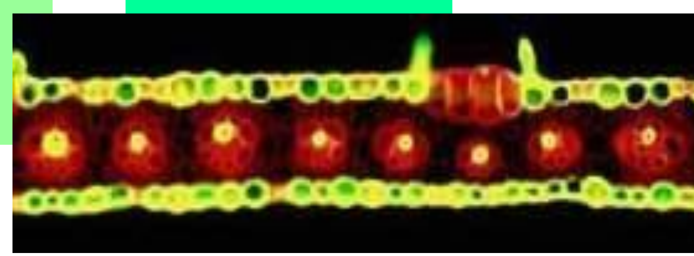
# *C4-photosynthesis rice could increase yield, water and nitrogen use efficiency by 30-50%.*

**C3 + Anatomy Change + Biochem Change + Fine Tuning =C4**





**15-20 years of research needed**

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# *Submarino rice – 17 days after flooding*

# *Flood-tolerant rice*


**India**


***Now used by 4m++ farmers***

# 2 in 1: drought + submergence tolerance


# 3 in 1


**3 traits combined in 1 variety**

# AWD: Smarter water management

***Alternate wetting and drying can reduce water use by 30% without yield loss.***

# The perfect variety

**More nutritious!**

No Chalk
(except Arborio and Sake varieties)

Good color

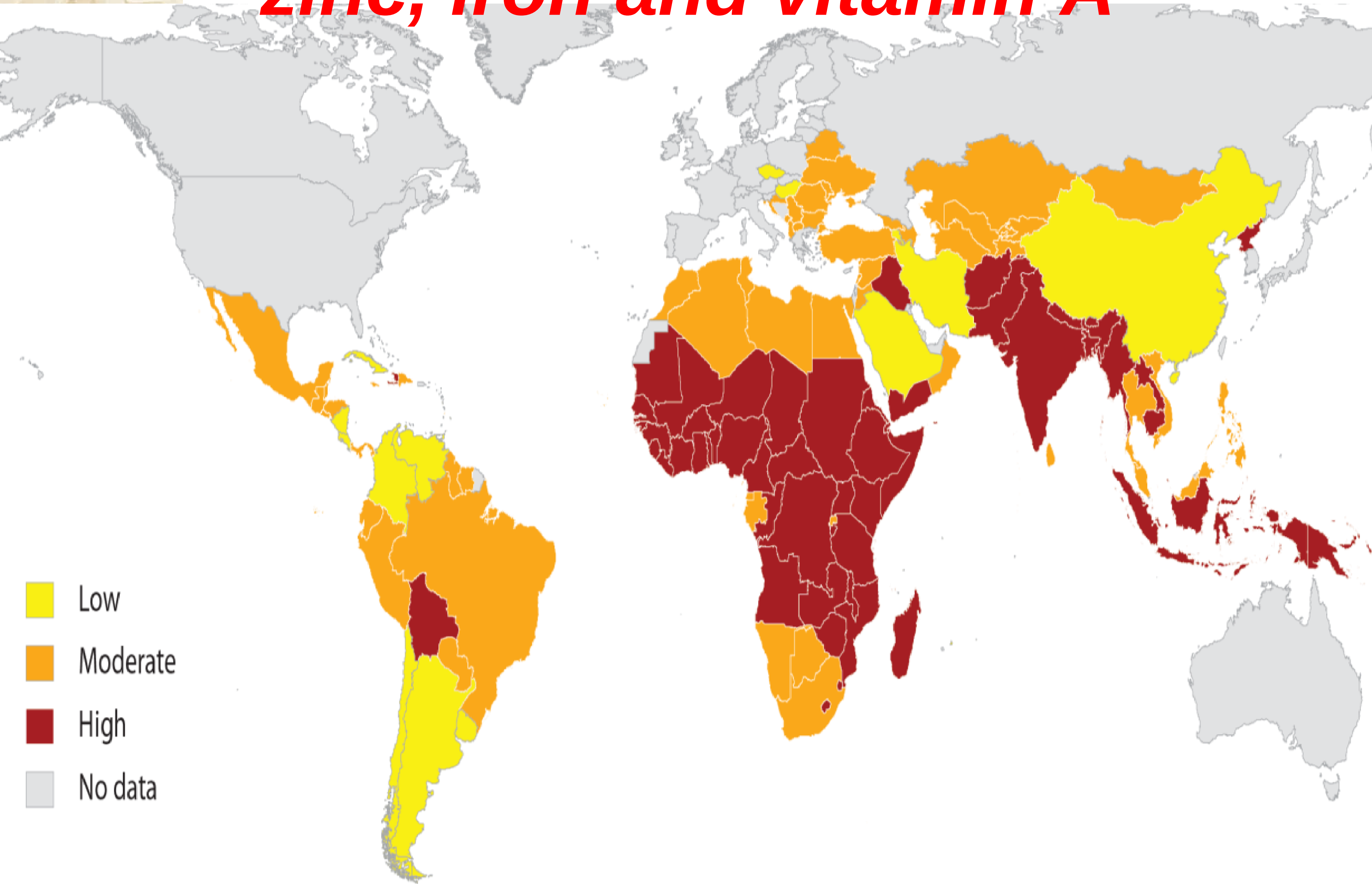
Translucent

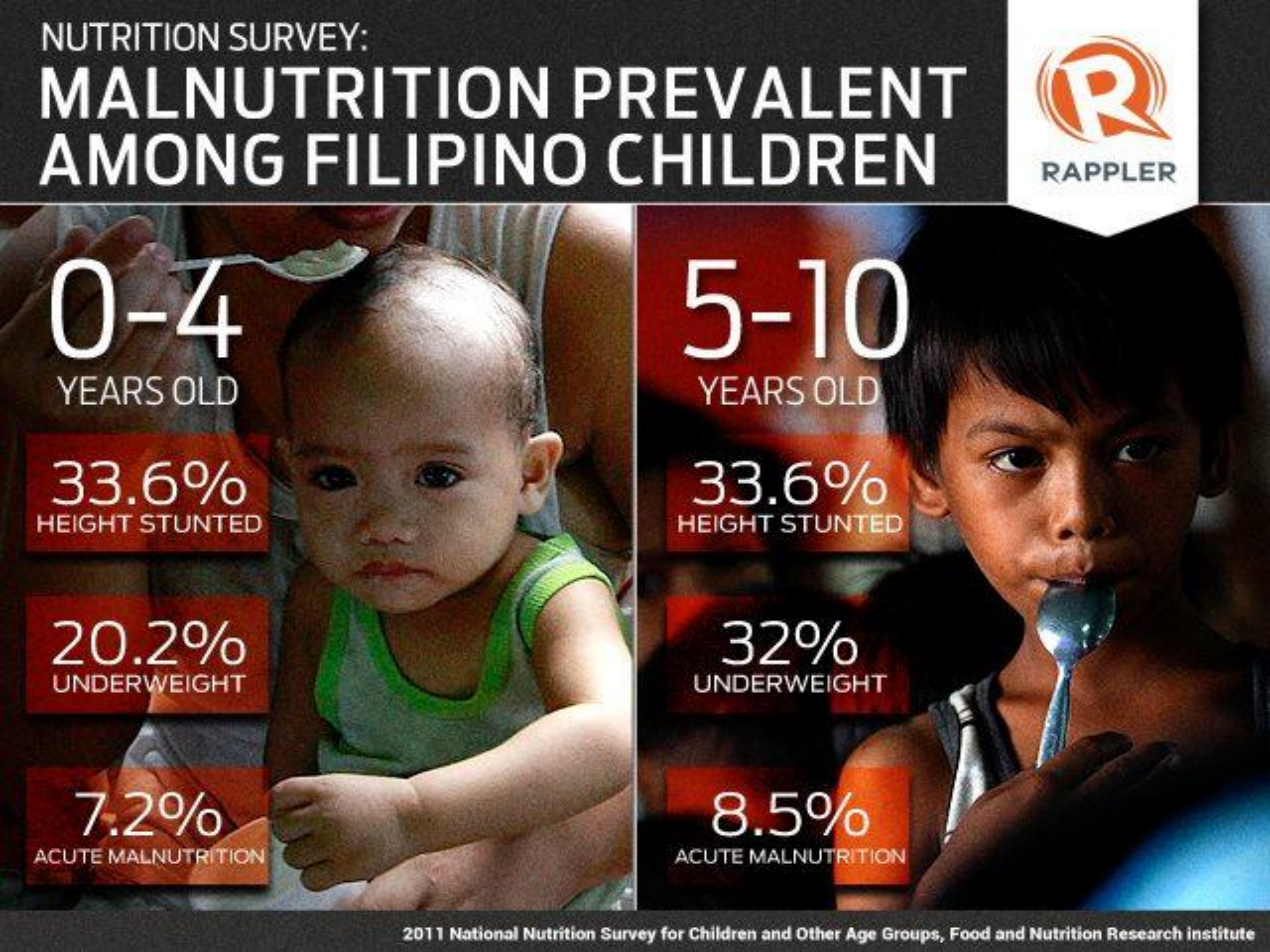
High whole grain return

Right shape for variety type

Excellent cooking properties

# Global micronutrient deficiency – zinc, iron and vitamin A




NUTRITION SURVEY:
MALNUTRITION PREVALENT AMONG FILIPINO CHILDREN
RAPPLER
0-4
YEARS OLD
33.6%
HEIGHT STUNTED
20.2%
UNDERWEIGHT
7.2%
ACUTE MALNUTRITION
5-10
YEARS OLD
33.6%
HEIGHT STUNTED
32%
UNDERWEIGHT
8.5%
ACUTE MALNUTRITION
2011 National Nutrition Survey for Children and Other Age Groups, Food and Nutrition Research institute


SOURCE: 2011 survey nutritional status of Filipino children and other population groups - Food and Nutrition Research Institute (FNRI)

# <u>High-nutrient rice</u> - with zinc, iron, and beta-carotene in the grain!

# *New food system challenge*

- Change behavior: healthier diets, reduced loss and waste;
- Increase productivity by 60%++ on existing cropland by 2050;
- Preserve  environment through lower intensity and sound input use, and
- Make farming attractive to (young) people in rural areas

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# *Science and technology will play a leading role*

We need to make **deep changes** in technologies and policies to **decouple** future economic growth from unsustainable use of fossil fuels, land, oceans, freshwater, and other resources.

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# *Rice challenges we face: 1*

**Rice demand vs supply:**

- Need at least 8M-10M mt MORE of palay per year for next 10 years;
- Little change in harvested area (155-160 million ha);
- Annual yield growth of 1.2-1.5% until 2020, 1.0-1.2% after 2020.

# Rice challenges we face: 2

## Change how we grow rice:

- New seeds adapted to changing climate and agro-ecology;
- Less tillage, less water, less labor, less pesticides, more efficient fertilizer use;
- More resilient, diversified rice-based farming systems.

***Smarter farmers and agriculturists***

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# Socio-Economic Research Agenda

- Integrative food policy analysis across:
    - Agri productivity, including post-harvest, processing;
    - Food price stability, and
    - Safety nets for the food insecure.
- Broader issues of factor markets, rural livelihoods, climate change, vulnerability, etc.

# *"macro food system" research priorities*

- Data for policy analysis;
- Food demand and diversification dynamics;
- Yield gaps for staples (not just rice);
- Implications of changing value chains and role of private sector, and
- Understanding Philippines' role in regional and world food markets.

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Please visit IRRI!

Annex F2

# Overview of IRRI's activities on Climate Change and Rice

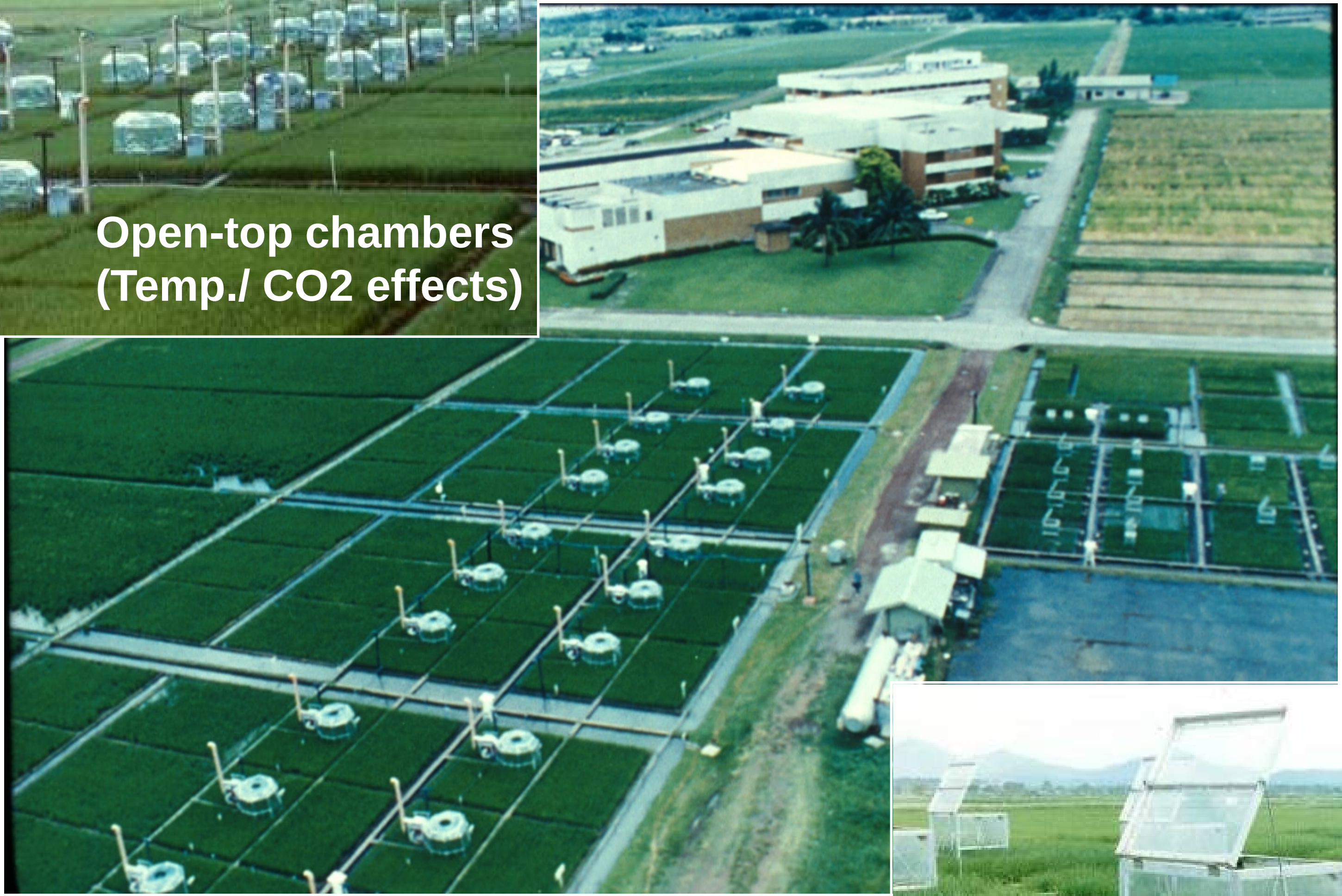
Reiner Wassmann
International Rice Research Institute (IRRI)

# IRRI's Previous Projects on Climate/ Climate Change

- **In 1961-62, studies on the effect of temperature on rice in the growth chamber**
- **In 1971-72, studies on the effect of $CO_2$ enrichment on rice in open-top chambers**
- **1991-1999, studies on $CH_4$ emissions, Temp/$CO_2$ + UV-B effects and modeling**
- **Since 2006: Comprehensive program on mitigation, adaptation and impacts assessments in close collaboration with national partners**

# US-EPA project (1991-1995)

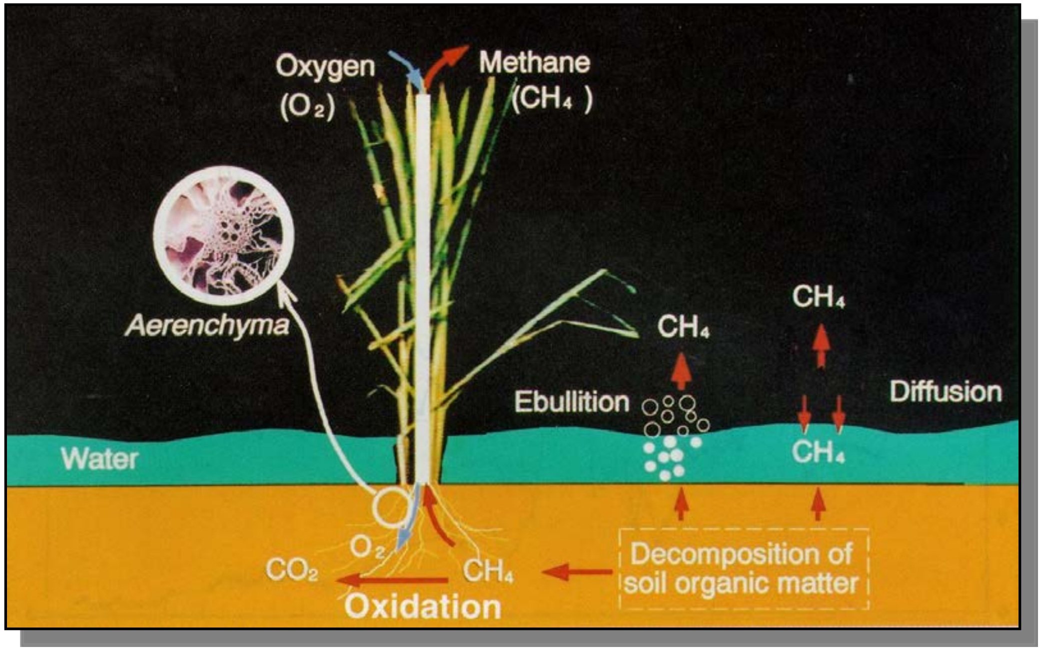
Open-top chambers
(Temp./ CO2 effects)



Closed chambers
(Methane emissions)

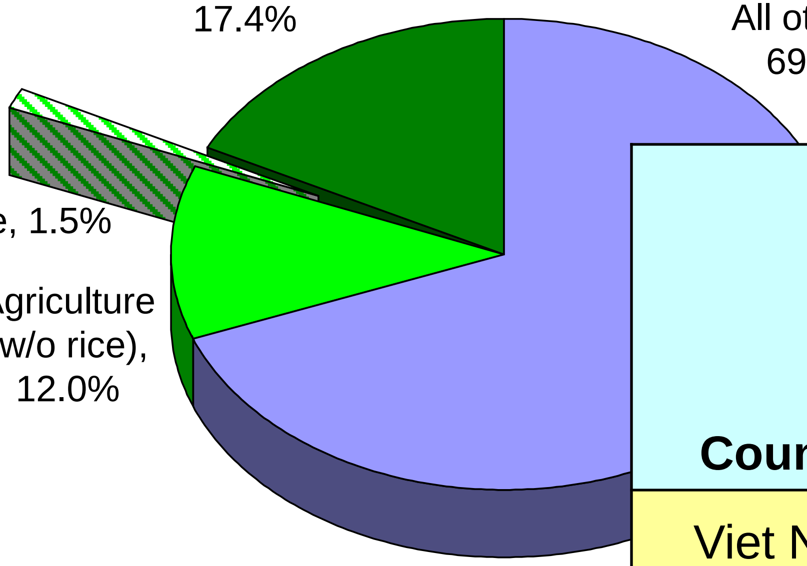
# Emissions from Rice Fields

## Methane




Global Warming Potential: $CH_4$ = 21 $CO_2$eq
$N_2O$ = 298 $CO_2$eq

# Significance of Rice Fields for GHG budgets

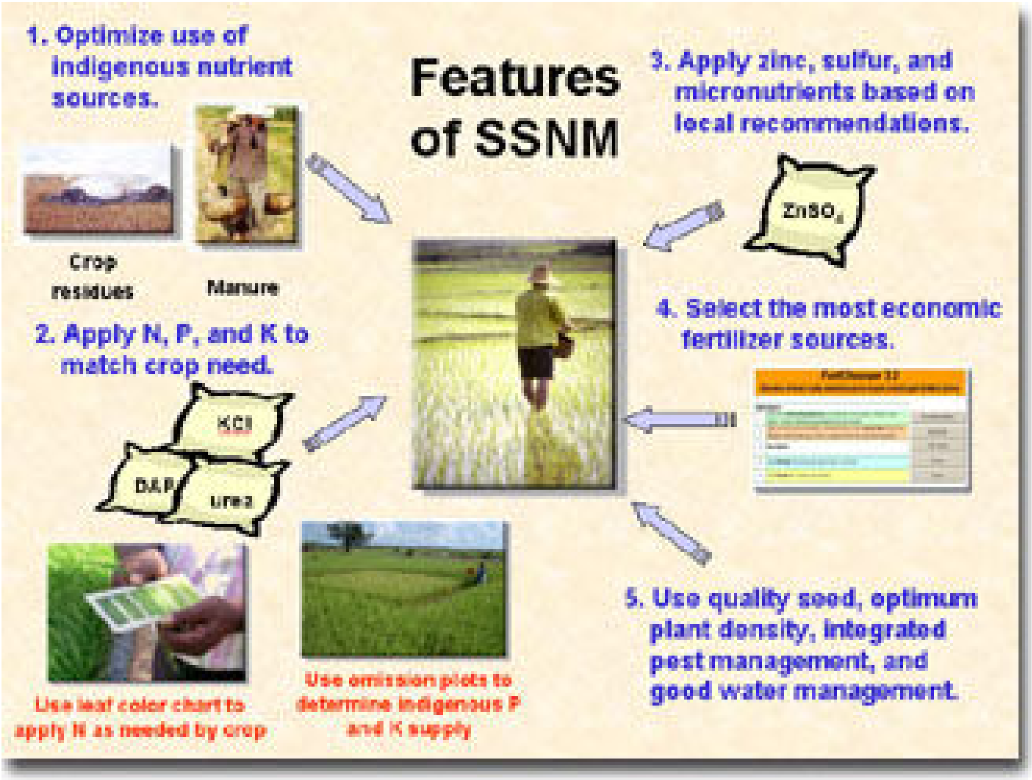



(IPCC 4th AR, 2007)

| Country | National Scale in Asia: Emissions from rice production (selected) (Mt CO2eq) | Perc. of total |
|---|---|---|
| Viet Nam | 38.199 | 24.8 % |
| Indonesia | 53.856 | 1.9 % |
| Philippines | 21.706 | 16.0 % |

Data from the most recent
National Communication submitted to UNFCCC

# ‘Site-Specific Nutrient Management’ (SSNM)




- Applying nutrients as and when needed
- Adjusting nutrient application to crop needs in given location and season

# Mobile Phone Application for Rice Crop Management

Obtain site-specific information from farmer/ operator

## Mobile Phone App (and CD-ROM)

**Rice Crop Manager**
- Nutrients
- Field Preparation
- Crop Establishm.
- ….

**New Modules**
- GHG emission calculator
- Climate-adjusted yield targets

**Climate-Informed Rice Crop and Low Emission Manager**
**=> CIRCLE Manager**

Provide management recommen-dation

# NAMA

## Nationally Appropriate Mitigation Actions

- NAMAs are voluntary country engagement proposals
- They are expected to become the main vehicle for mitigation action in developing countries in the future
- Funding should come from the newly established “Green Fund” (target: 100 bn USD by 2020)

# Obstacles of Mitigation in Rice Production

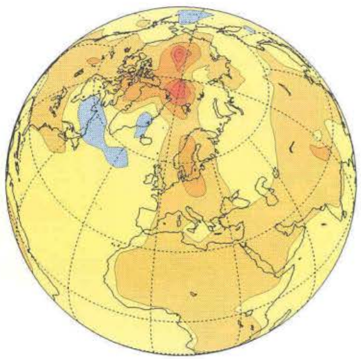
Involvement of many stakeholders/ transaction costs

Unclear guidelines on Measurement/ Reporting/ Verification (MRV)

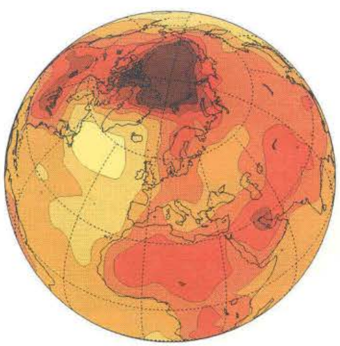
Emission savings based on area – and not on unit of food produced

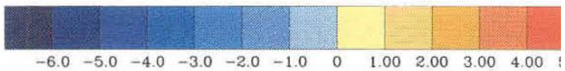
# Uncertainties in Climate Change Scenarios

Best case scenario



Worst case scenario






## How to deal with these uncertainties on Climate Change in developing adaptation options in rice production?

➡ **Focussing on universal trends:**

- **Temperature increase**
- **Aggravating climate extremes**

➡ **Focussing on existing climate variability**

Spikelet sterility induced by high temperature at flowering

**Temperature threshold** depends on humidity (ca. 34-35ºC in humid tropics)

**Sterility**
Leading to significant yield reduction

# Heat escape through early morning flowering


**EMF QTL obtained from *O. officinalis***

**Ishimaru et al.**

# High night temperature impacts

High night temperature tents

## Recent findings

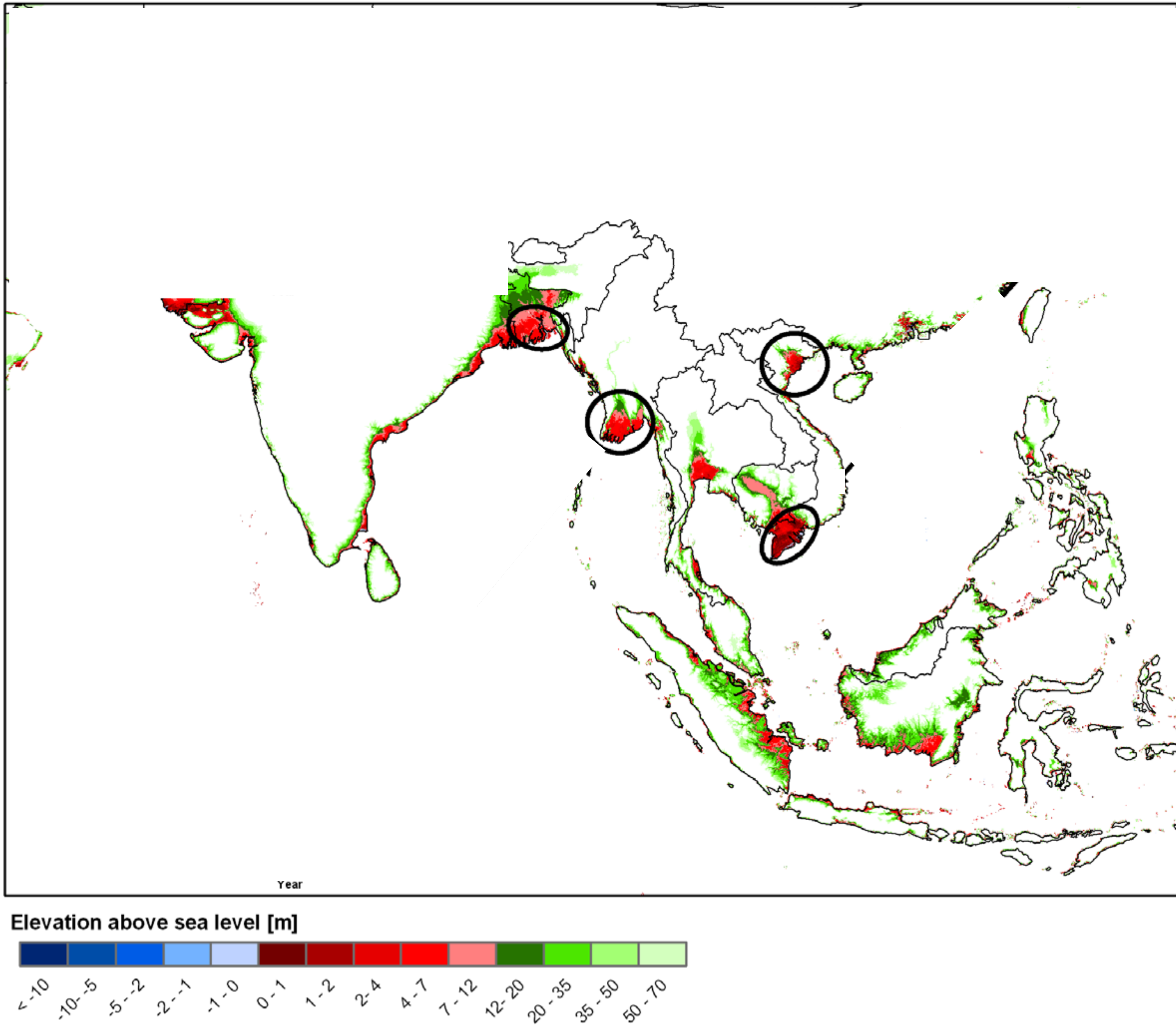
-43 varieties screened

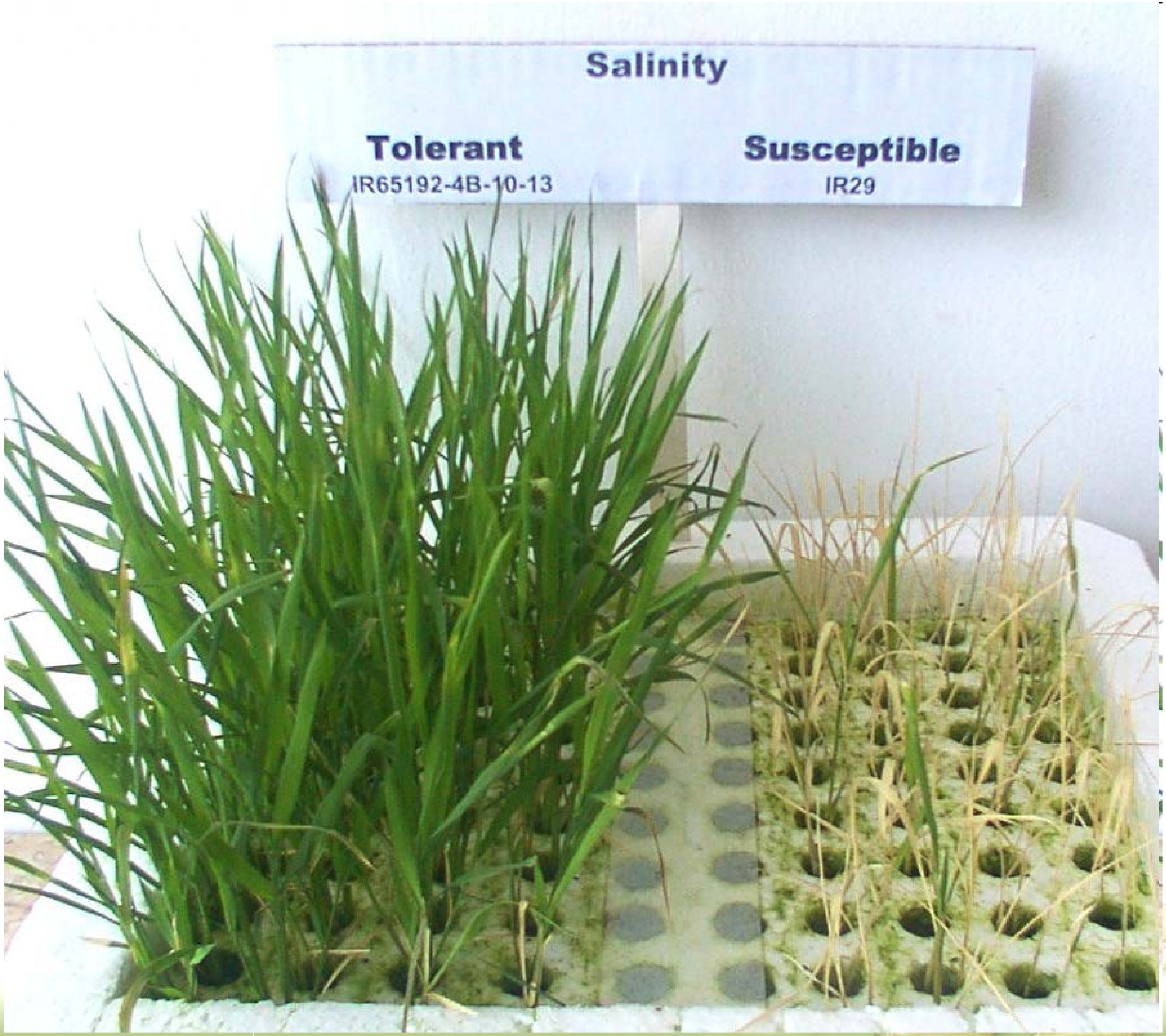
-In susceptible varieties:

- Biomass reduced
- Rate of grain filling reduced
- Grain width reduced
- Quality deteriorated

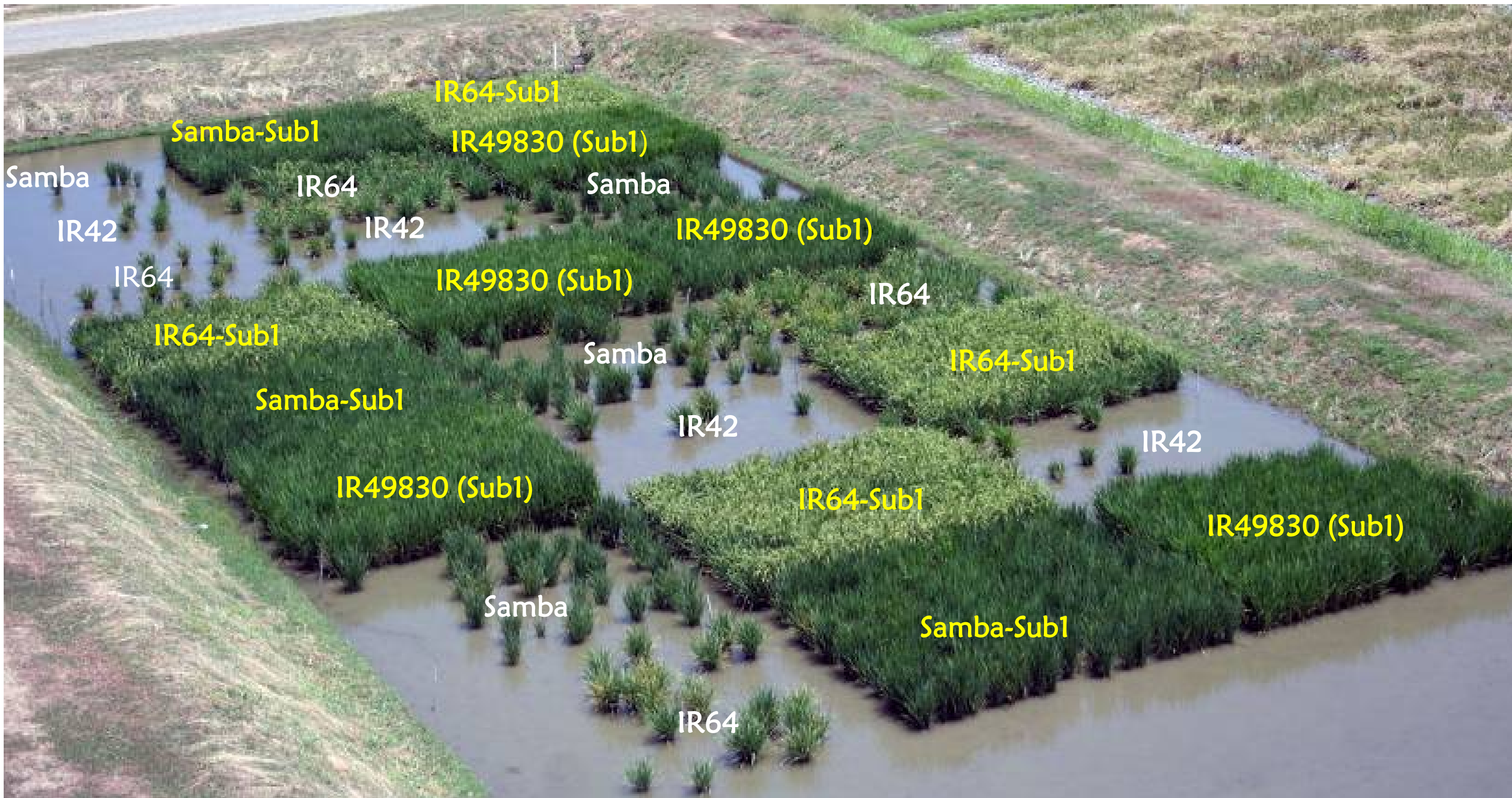
Jagadish et al.

# Mega-Deltas of Asia

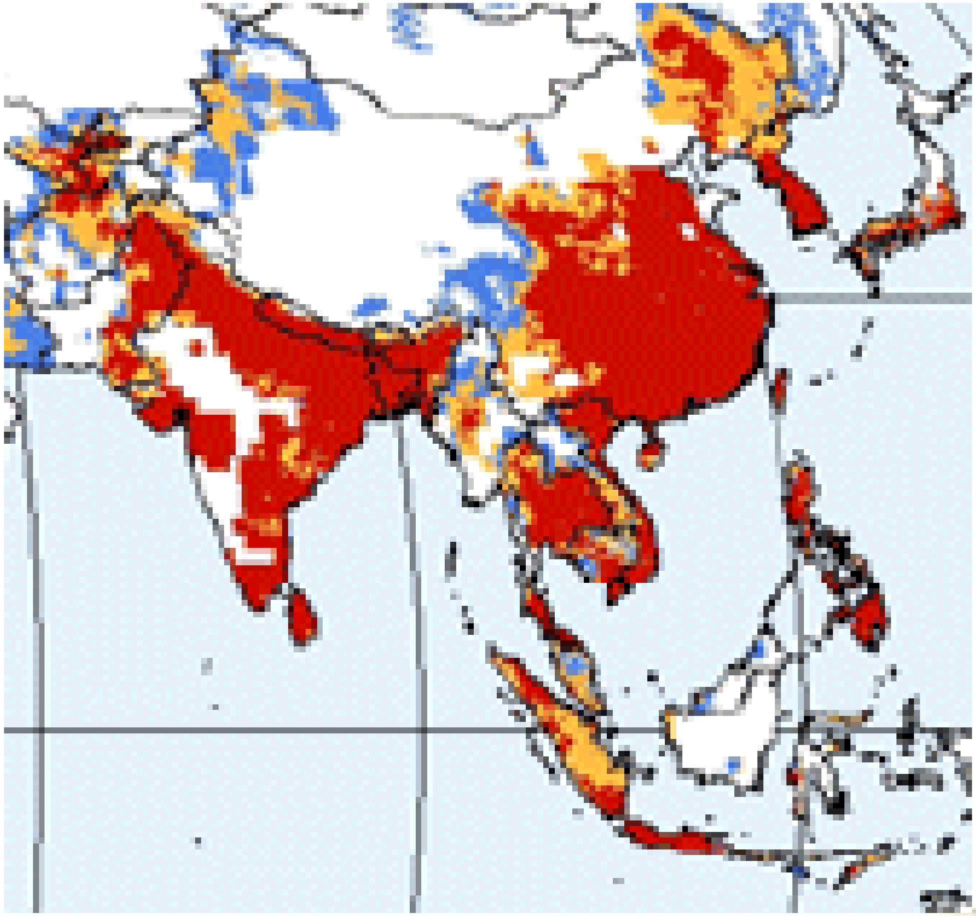



Salinity
Tolerant
IR65192-4B-10-13
Susceptible
IR29

# New *Sub1* lines after 17 days submergence in field at IRRI



# Flood risk: 20 million hectares of rice



Flood risk

Low

Medium

High

# Participatory Variety Selection

# Rice price and market blog

Keeping rice prices affordable for everyone - including the poorest rice consumers - is an underlying aim for IRRI.

In this blog our economic and policy experts will share their expertise and views on issues related to rice prices, the supply and demand of rice, and rice market and policy issues. Key contributors include economist Dr. Samarendu Mohanty who heads up IRRI's Social Science Division and regularly contributes articles on the rice market to *Rice Today*: Rice Facts.

Monday, September 26, 2011

## Thailand's rice mortgage program: Is it really that bad for global food security?

Written by Sam Mohanty

Thailand recently approved a program to pay farmers more for their rice. Despite concerns this would lead to higher rice prices, the market reaction has been subdued and prices may even fall.

# Policy Information and Response Platform on Climate Change and Rice in ASEAN and its Member Countries (PIRCCA)

**Policymakers of ASEAN and its member countries will be able to make informed decisions on:**

- specific policy measures in the rice sector -- including input subsidies, price supports, national procurement/stocks etc.,
- possible adaptation options to enhance resilience to climate variability, shocks, and progressive climate change, and
- related policies such as mitigation programs

# Conclusion I

## Climate Change Adaptation:

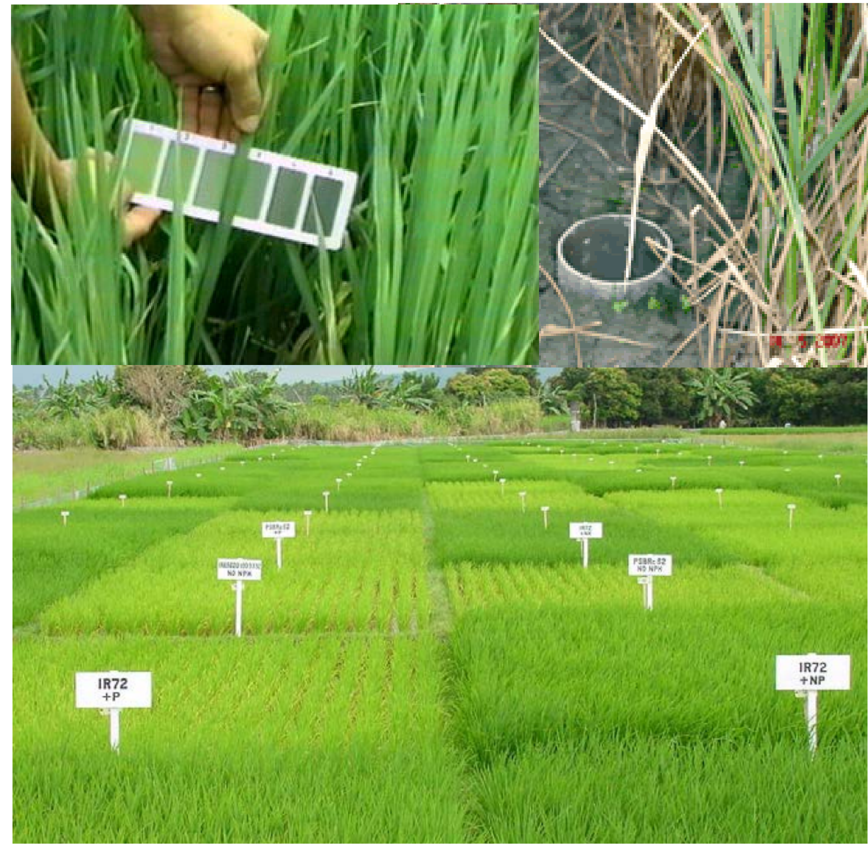
**Rice systems have to become more resilient to…**

- **Heat waves**
- **Salinity**
- **Submergence**
- **Drought**

**Entry Point:**
**IRRI's Research on Climate Variability**

# Conclusion II

## Climate Change **Mitigation:**




**Rice systems have to become more efficient in terms of…**

- **Water use**
- **Fertilizer uptake**
- **Precise timing of management procedures**

**Entry Point:**
**IRRI's Research on Advanced Resource Management**

# Thank you

Rice Science for a Better World

**Annex F3**

# Geo-spatial analysis in support of climate change adaptation in rice production

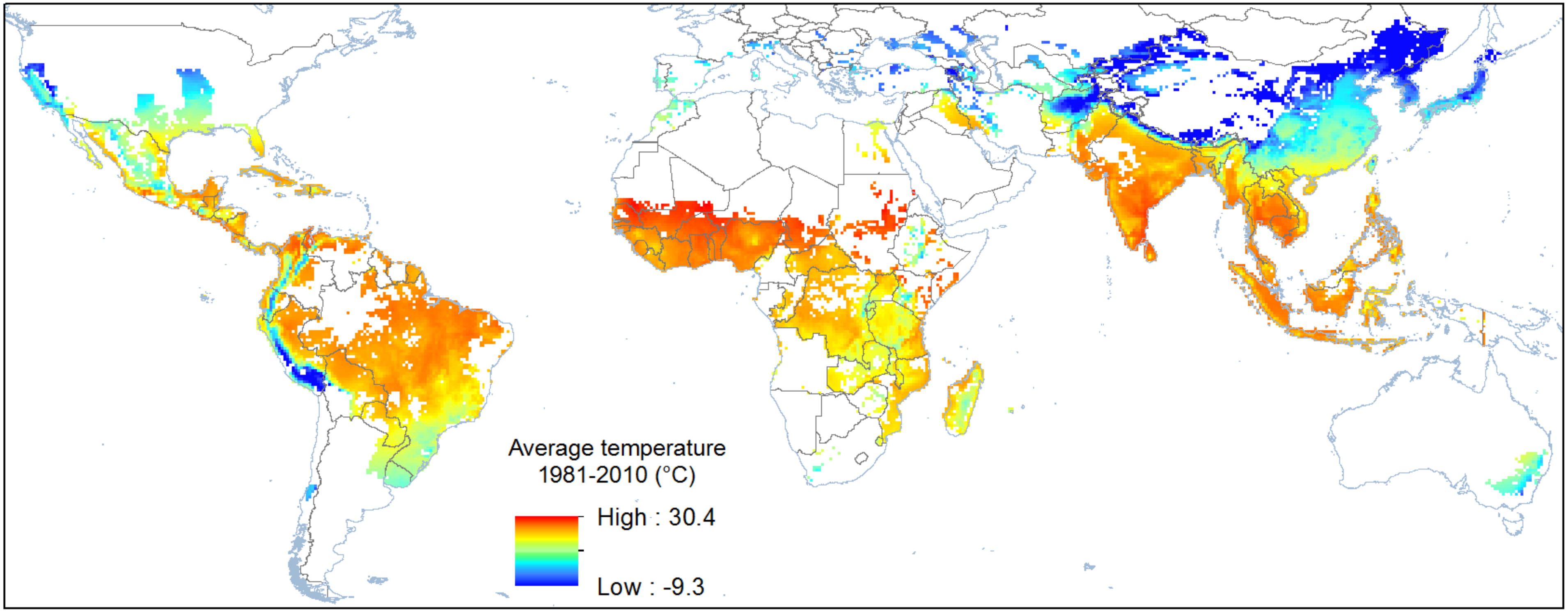

Alice G. Laborte
Social Sciences Division


IRRI

*APEC visit, 24 October 2013, IRRI*

# Average temperatures in rice growing regions

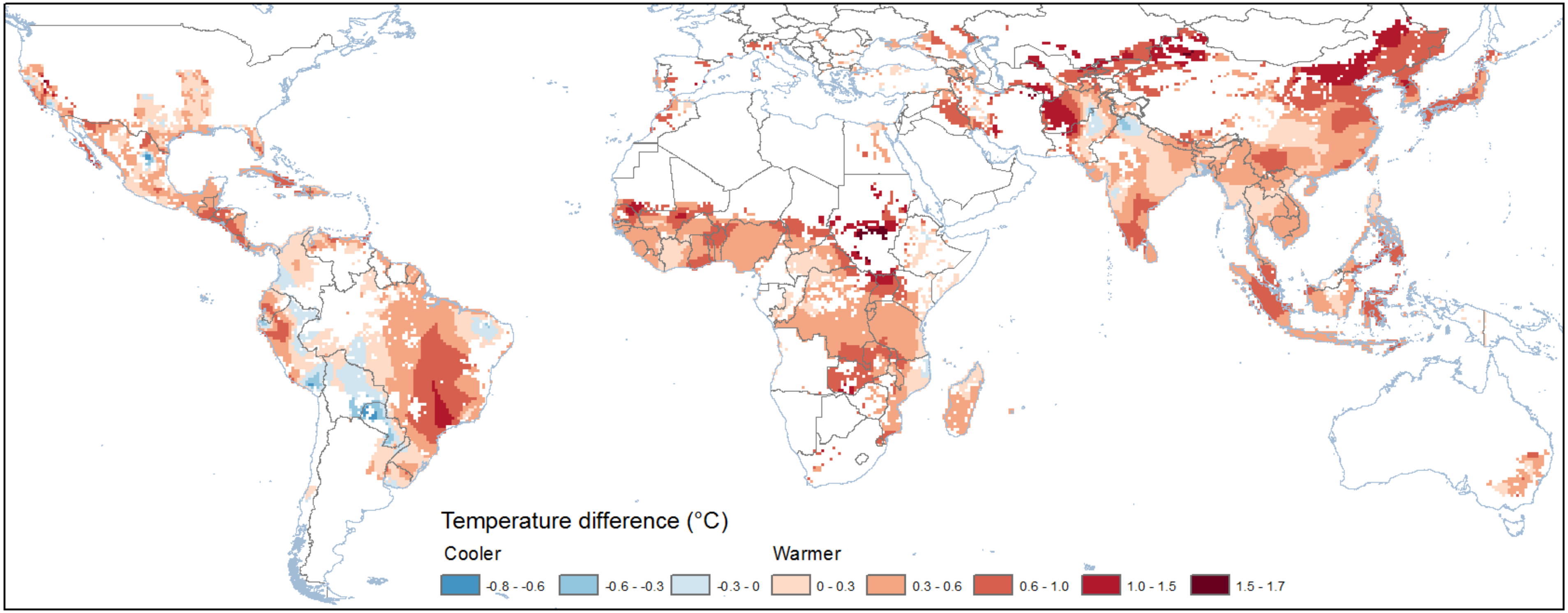
1981-2010




Source of temperature data: CRU TS 3.2

# Rice growing regions are getting warmer

30-year average temperature differences (1951-1980 vs 1981-2010)

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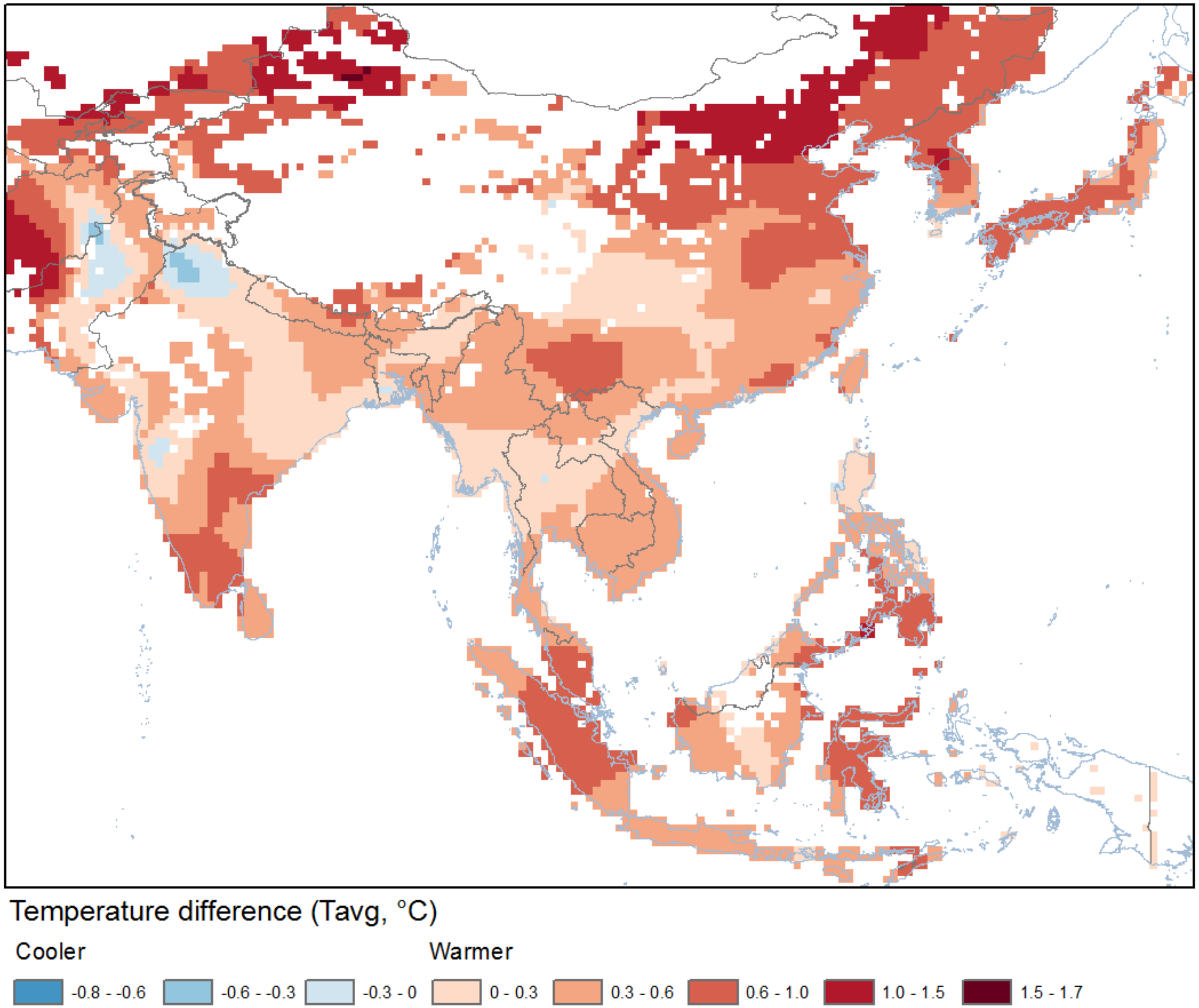
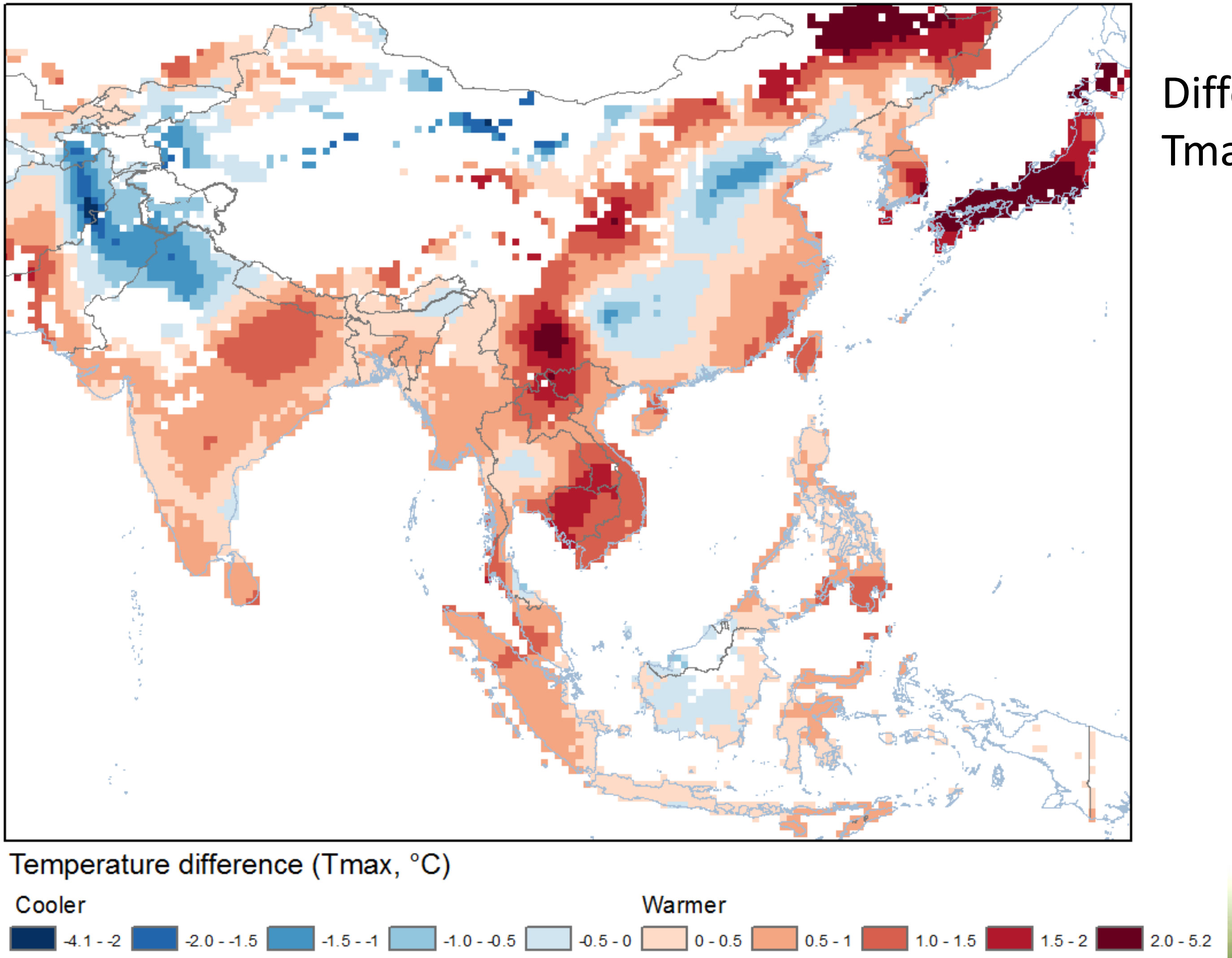



30-year average temperature differences (1951-1980 vs 1981-2010)

Source of temperature data: CRU TS 3.2

# Temperature anomalies September 2010




Difference with average Tmax for Sept, 1951-1980

Source of temperature data: CRU TS 3.2

# Effect of high temperatures on rice production

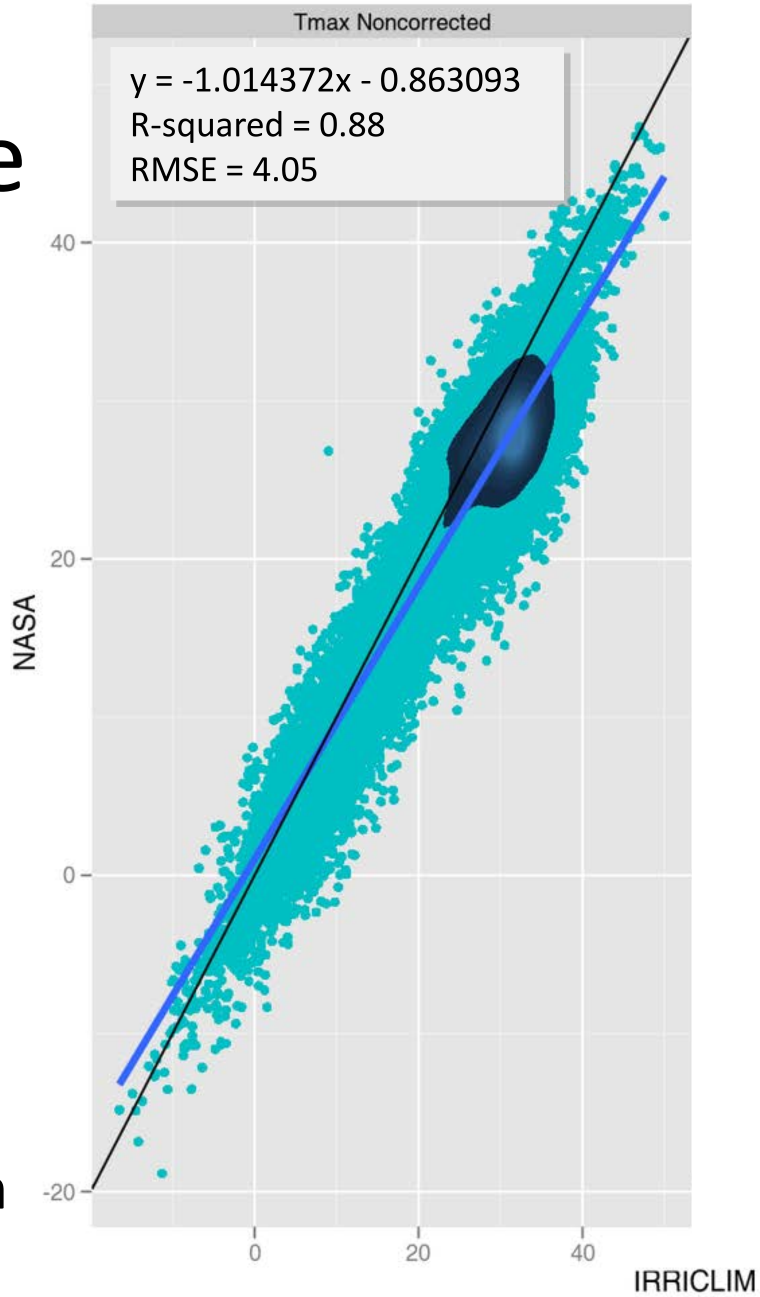
- During flowering stage: sterility
- During ripening stage: reduced grain filling and poor milling quality
- 10% reduction in yield for every 1°C increase in nighttime temperature (Peng et al., 2004)
- In 2003, heat stress affected 3 million ha of rice, resulting in losses of 5.2 million t in the Yangtze River Valley in China (Tian et al., 2009)
- In 2010, extreme nighttime temperatures affected milling quality of rice in Arkansas, US (Lanning et al., 2011)

Spatial assessment of rice areas vulnerable to heat stress is important for planning and targeting appropriate strategies to ensure food security

# Data and sources

| Data | Spatial and temporal resolution | Source |
| --- | --- | --- |
| Temperature (minimum, maximum) | 1 degree<br>Daily, 1983-2011 | NASA POWER, http://power.larc.nasa.gov/ corrected using station data (Sparks A, unpublished data) |

# Global daily temperature data




Bias reduction using independent station dataset.

Tmax in 1985

RMSE reduced from 4°C to 2°C

A. Sparks et al.

# Data and sources

| Data | Spatial and temporal resolution | Source |
|---|---|---|
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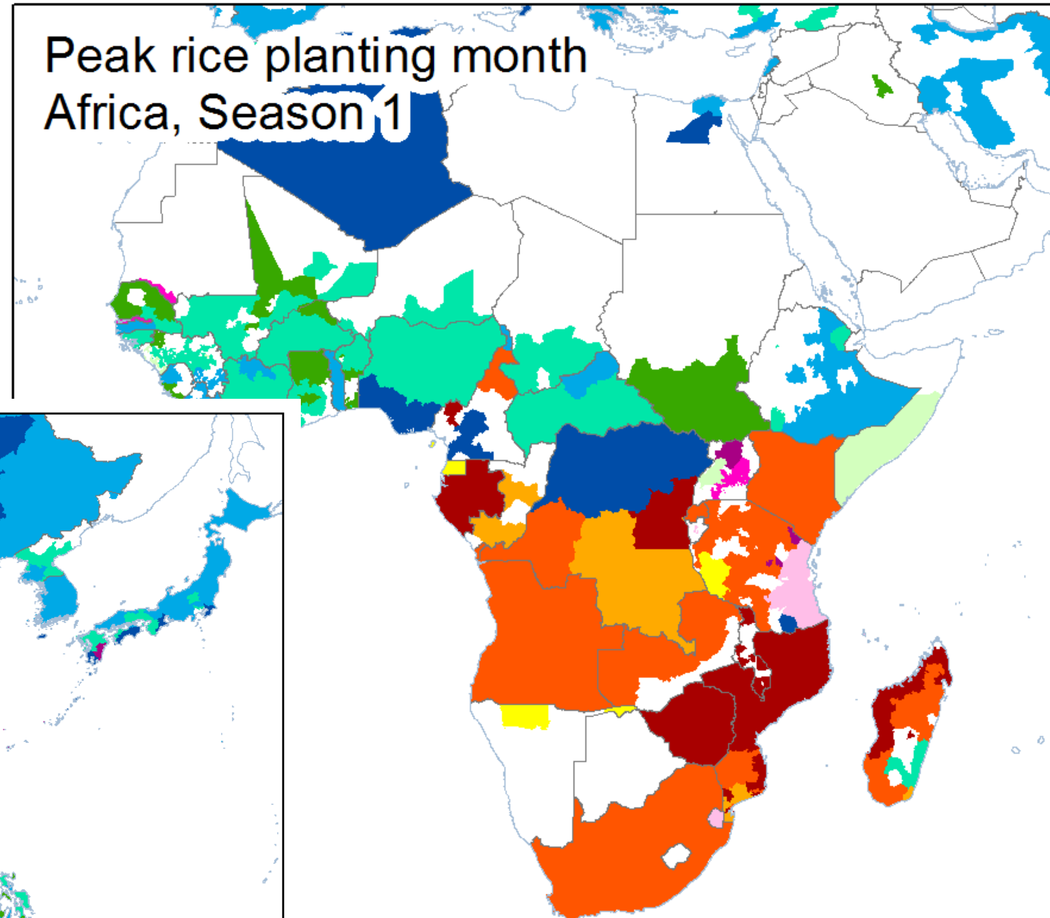
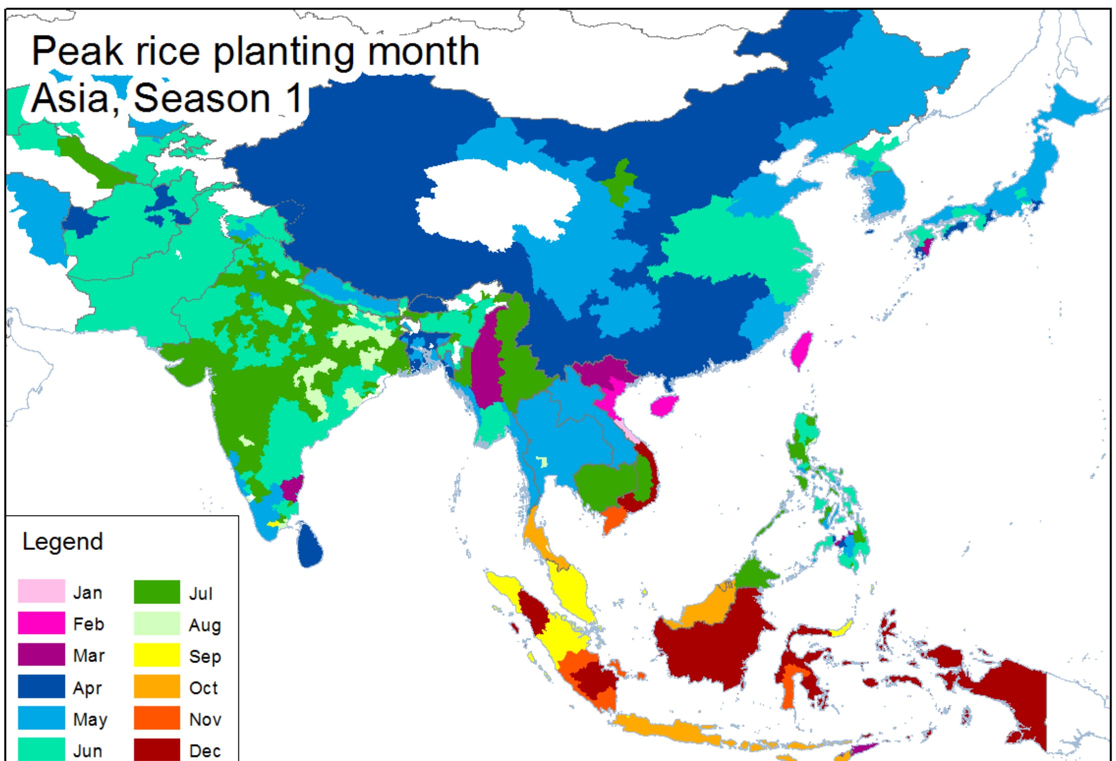
| Rice calendar | Sub-national where available<br>By season | Compiled from various international and national sources, expert knowledge |

# Global crop calendar

- 2,152 spatial units
- By season
- Onset, peak and end of planting and harvesting



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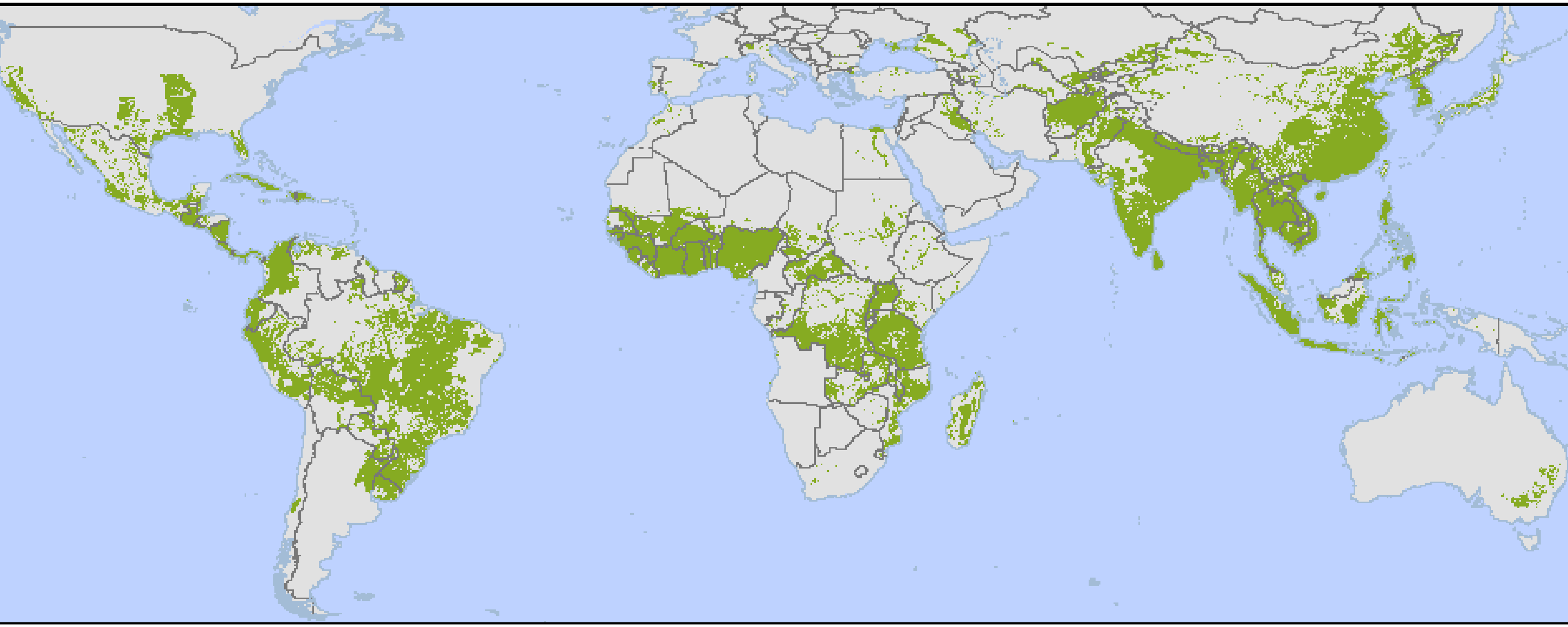
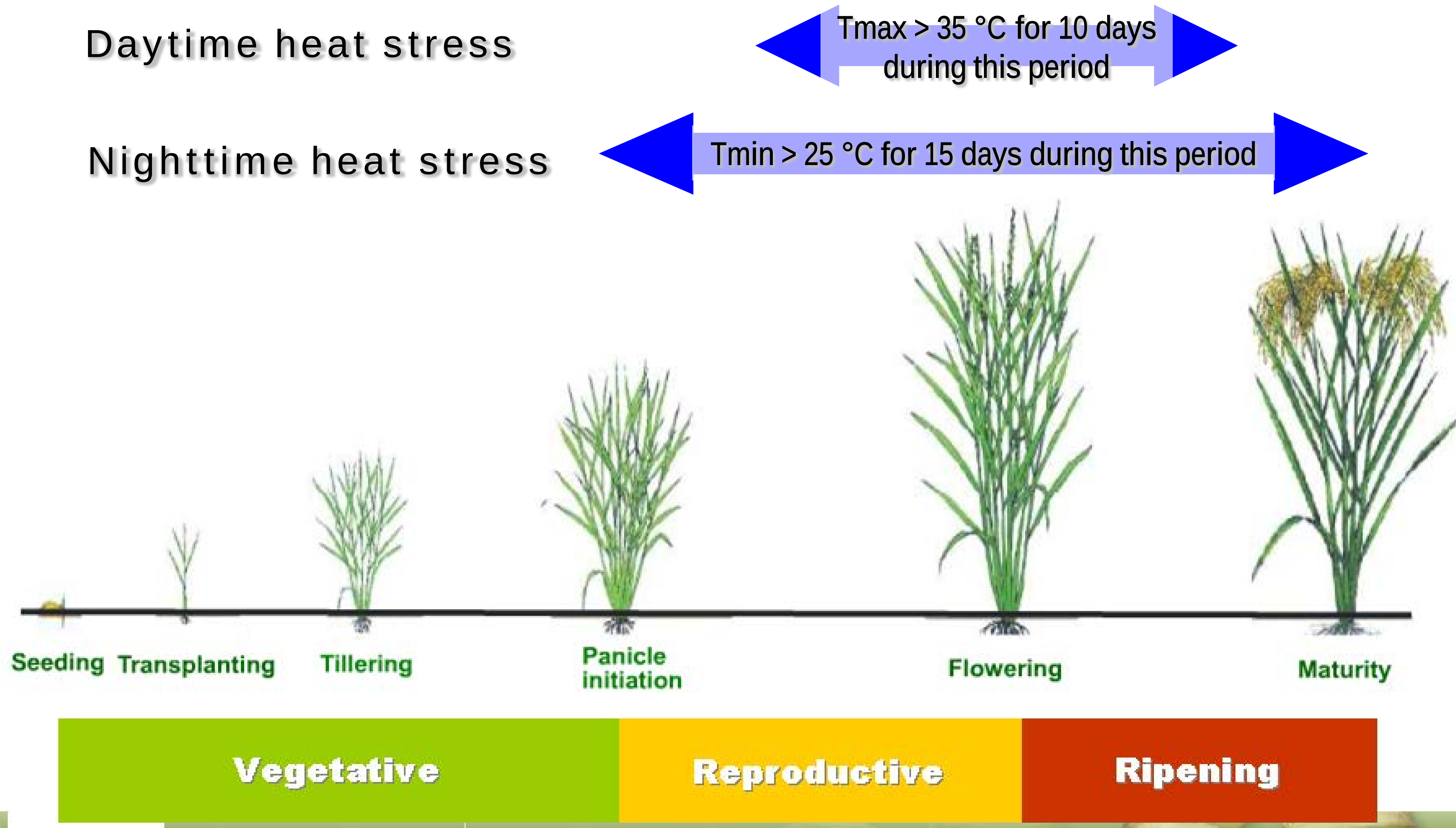
| Rice calendar | Sub-national where available<br>By season | Compiled from various international and national sources, expert knowledge and remote sensing data |
| Rice extent | 5 min | MIRCA, Corine (Europe)<br>Boschetti et al. (Central Asia) |

# Global map of rice areas



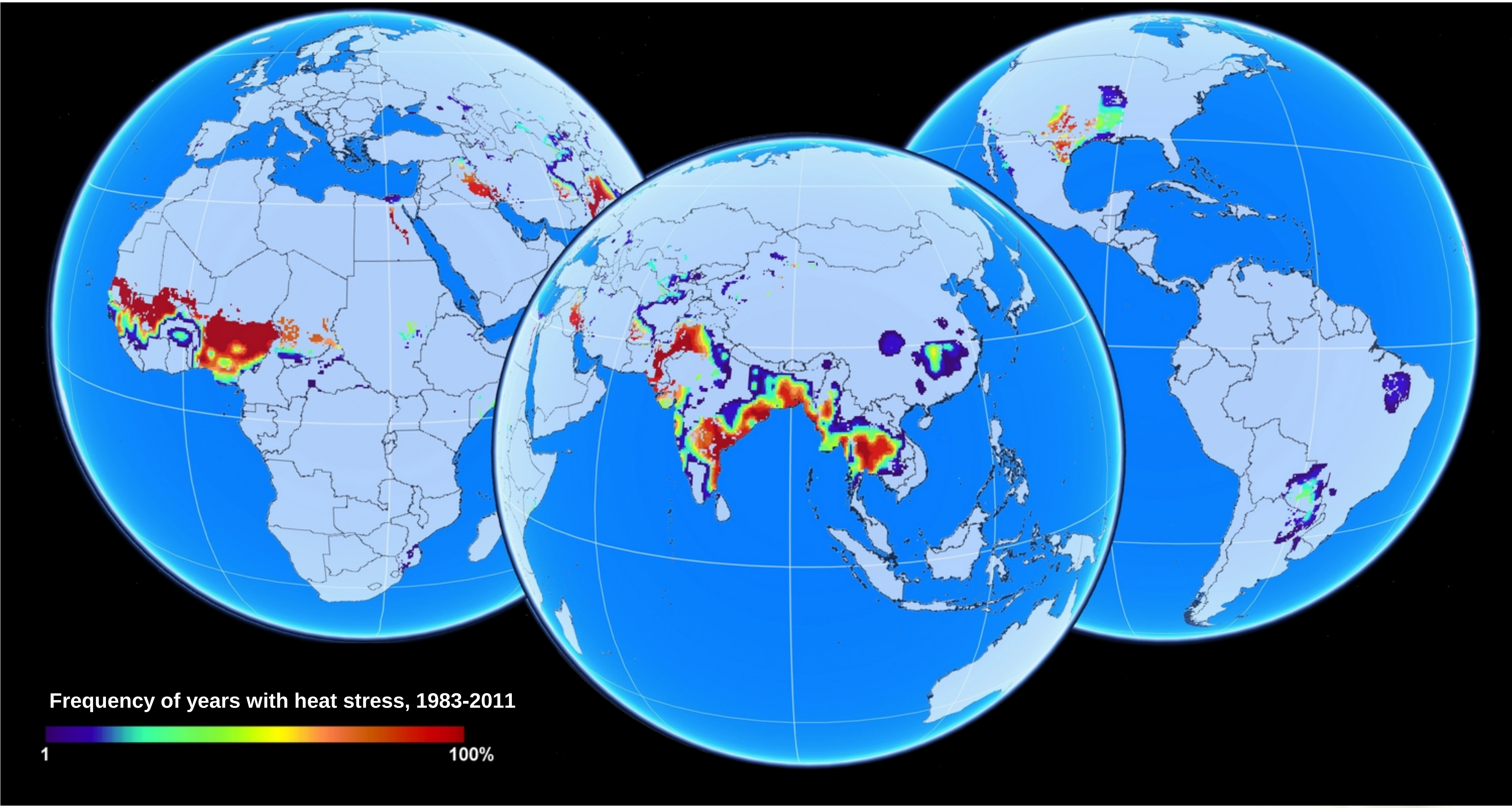
- 5 minute resolution
- Based on various sources

# Assumptions: threshold, duration and critical rice growth stage



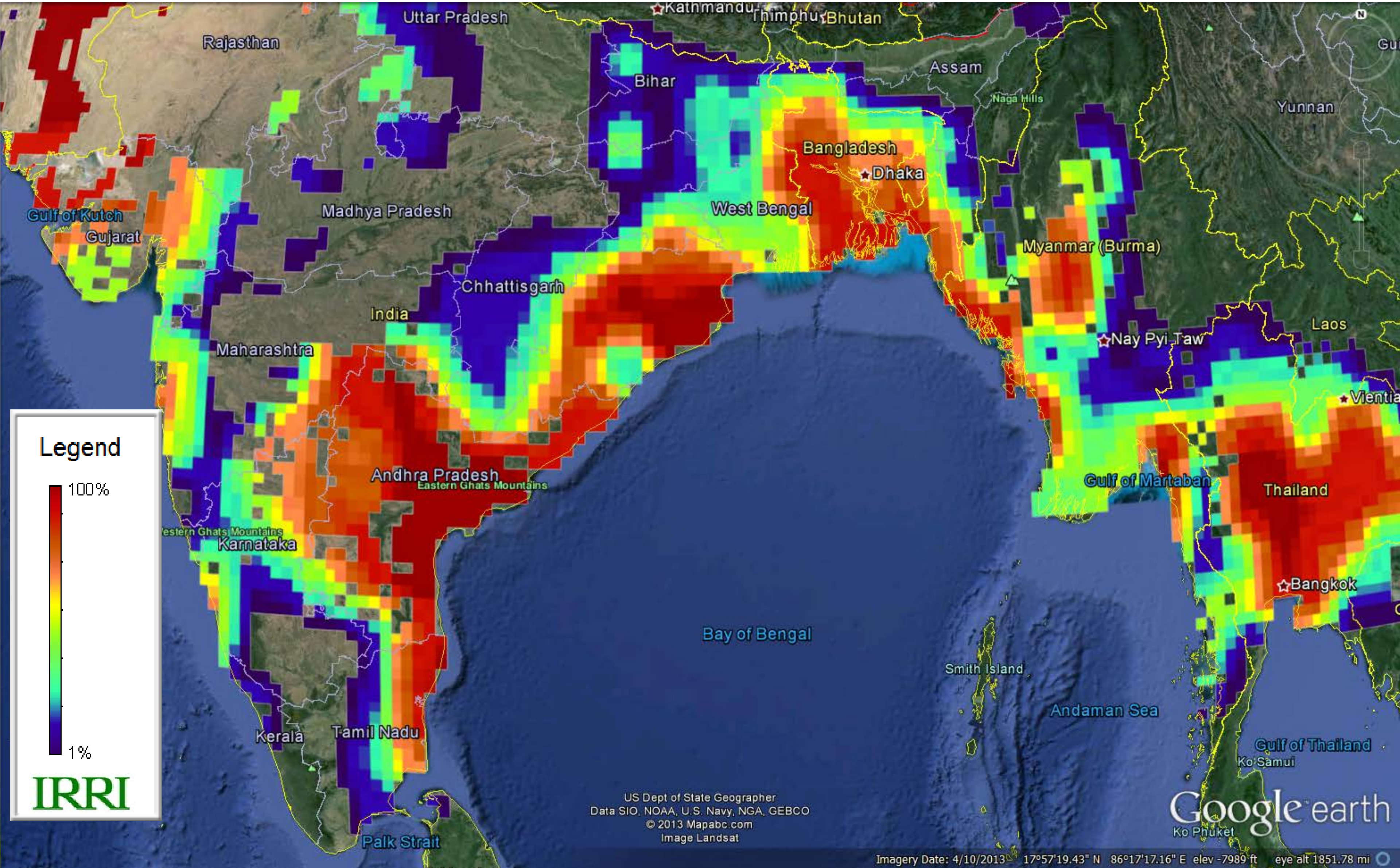
Preliminary results

# Frequency of daytime heat stress



Preliminary results

# Frequency of daytime heat stress



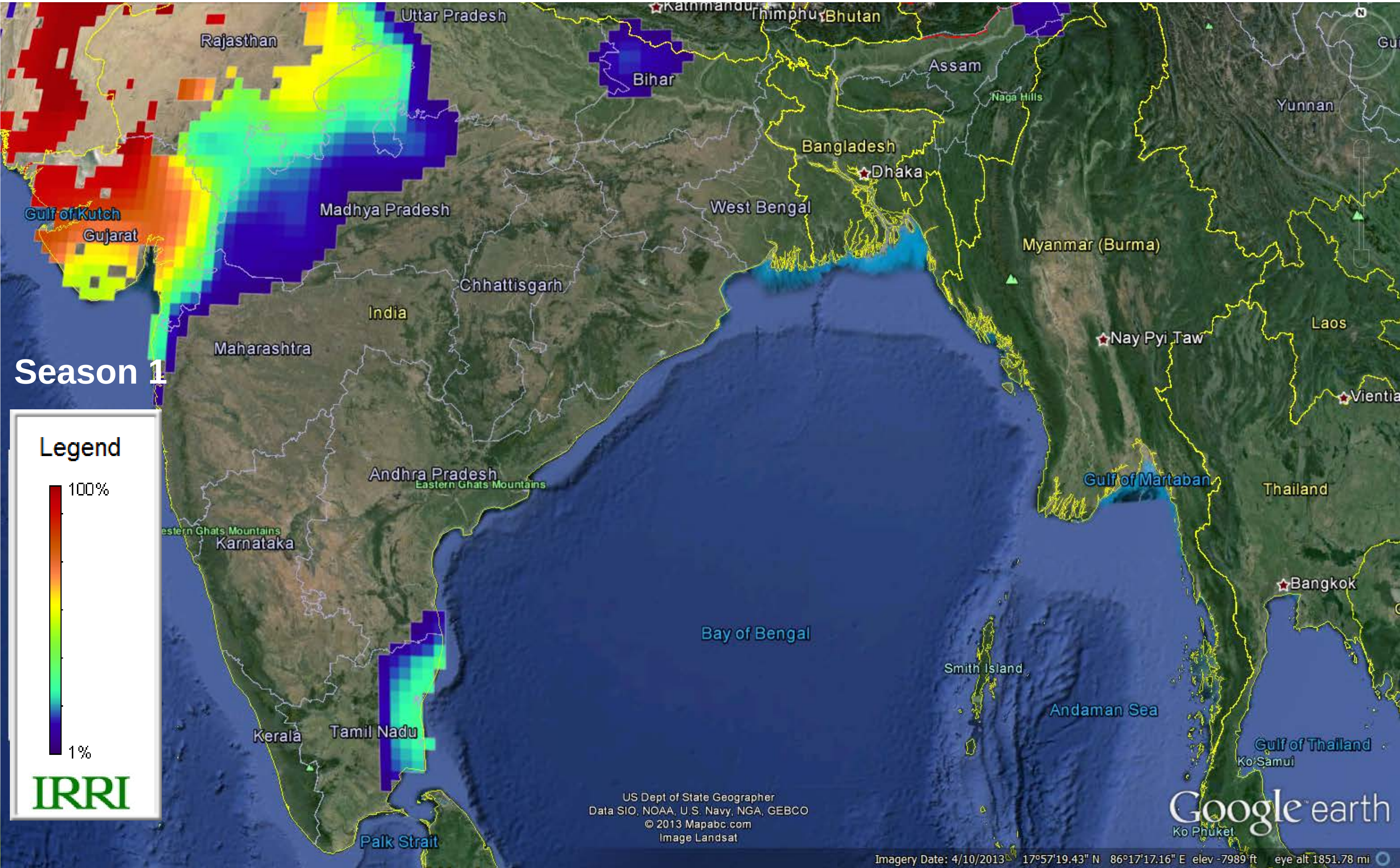
Preliminary results

# Daytime heat stress prone rice areas

| State | Physical rice area (million ha) | Rice areas affected (%) by frequency of occurrence | | | | |
|---|---|---|---|---|---|---|
| | | 1 in 4 yrs | 2 in 4 yrs | 3 in 4 yrs | 4 in 4 yrs | Total |
| **Andhra Pradesh** | 3.0 | 1 | 0 | 11 | 88 | 99 |
| **Bihar** | 3.2 | 55 | 33 | 12 | 0 | 68 |
| **Chhattisgarh** | 3.7 | 92 | 2 | 6 | 0 | 79 |
| **Orissa** | 4.2 | 11 | 9 | 13 | 68 | 94 |
| **Punjab** | 2.6 | 2 | 39 | 58 | 1 | 98 |
| **Tamil Nadu** | 1.4 | 35 | 0 | 30 | 35 | 84 |
| **Uttar Pradesh** | 5.9 | 68 | 32 | 0 | 0 | 34 |
| **West Bengal** | 5.7 | 28 | 39 | 13 | 20 | 89 |
| **Other states** | 11.1 | 42 | 17 | 29 | 13 | 49 |
| **ALL INDIA** | 40.9 | 33 | 19 | 19 | 30 | 71 |

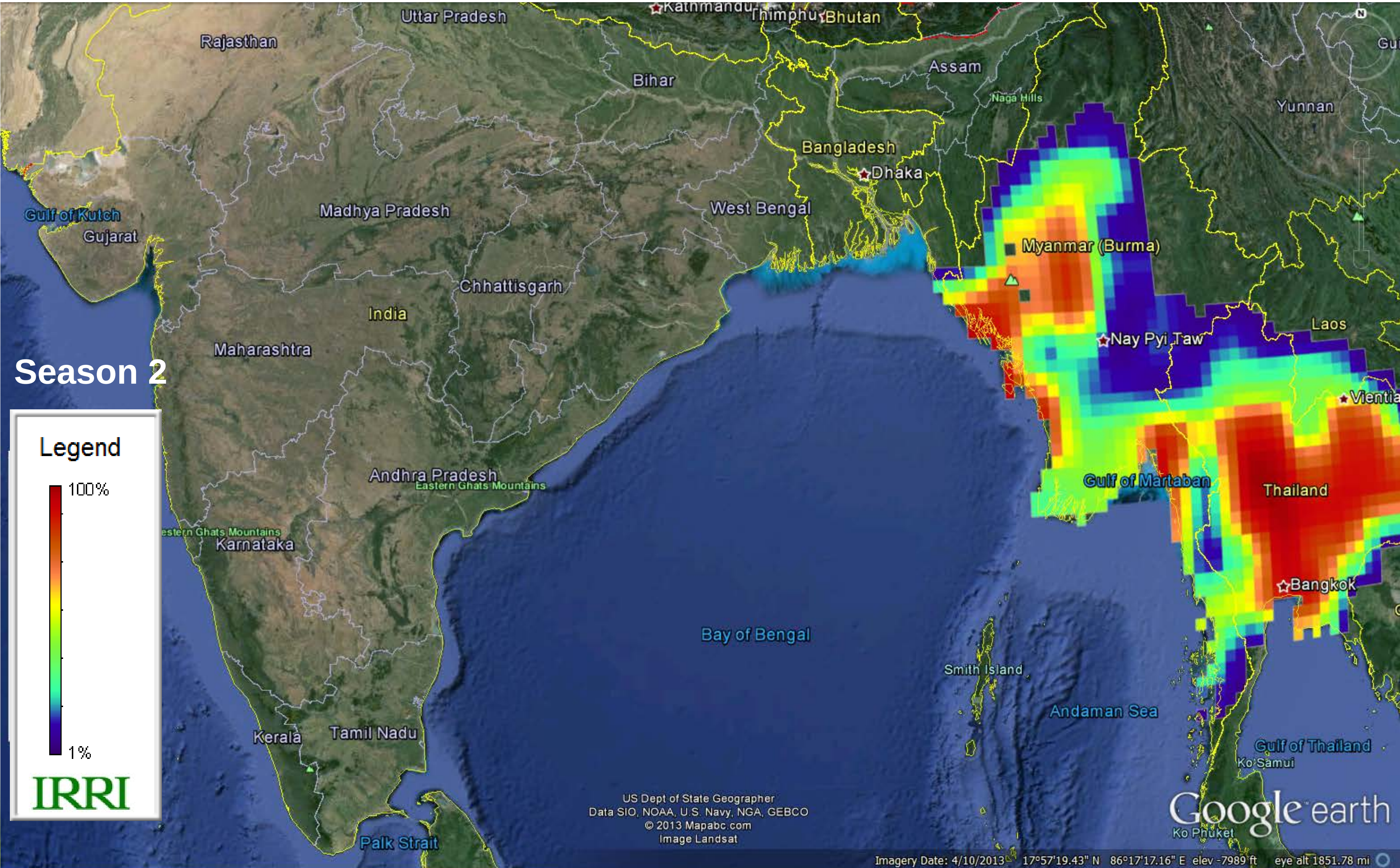
Preliminary results

# Frequency of daytime heat stress



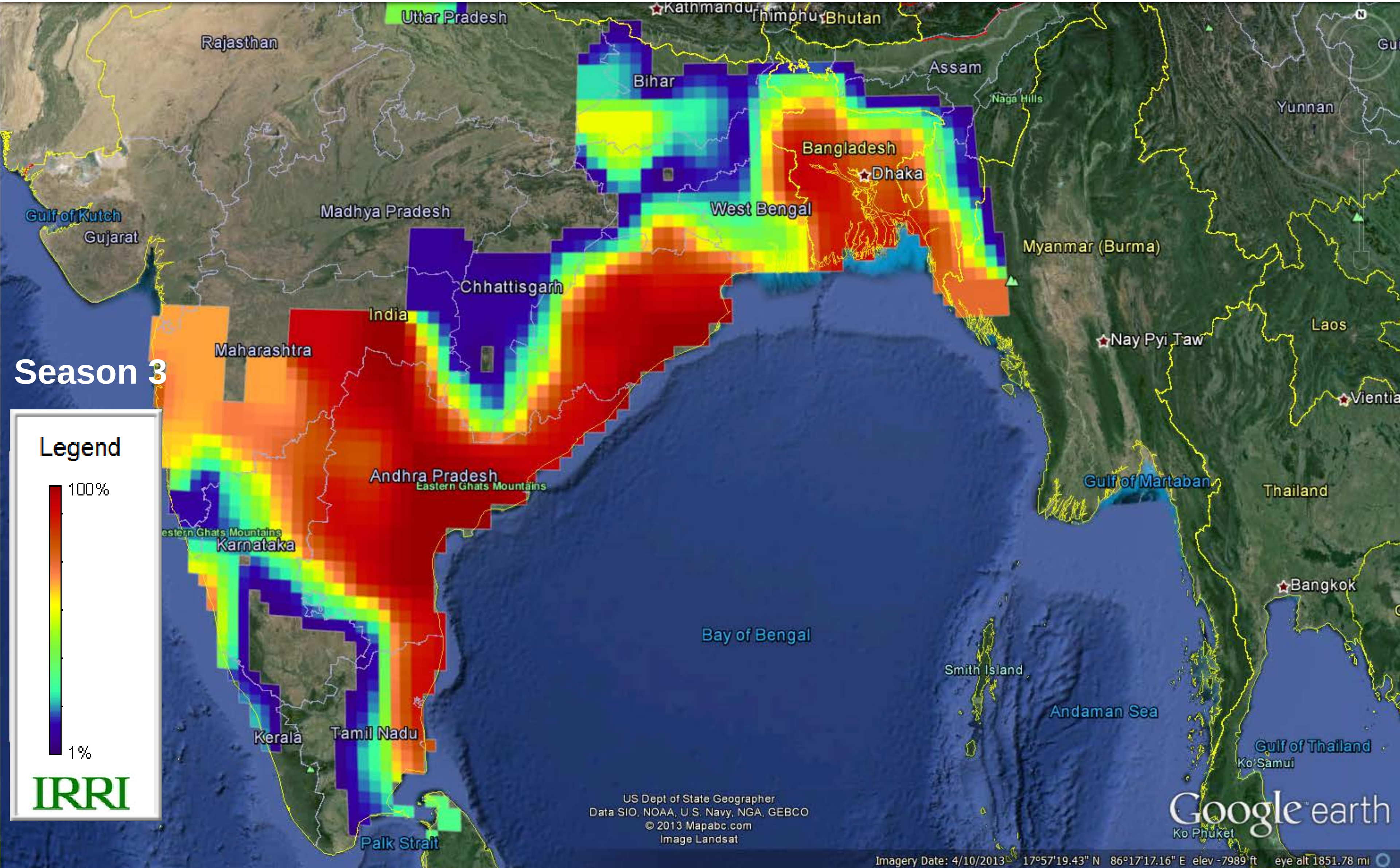
Preliminary results

# Frequency of daytime heat stress



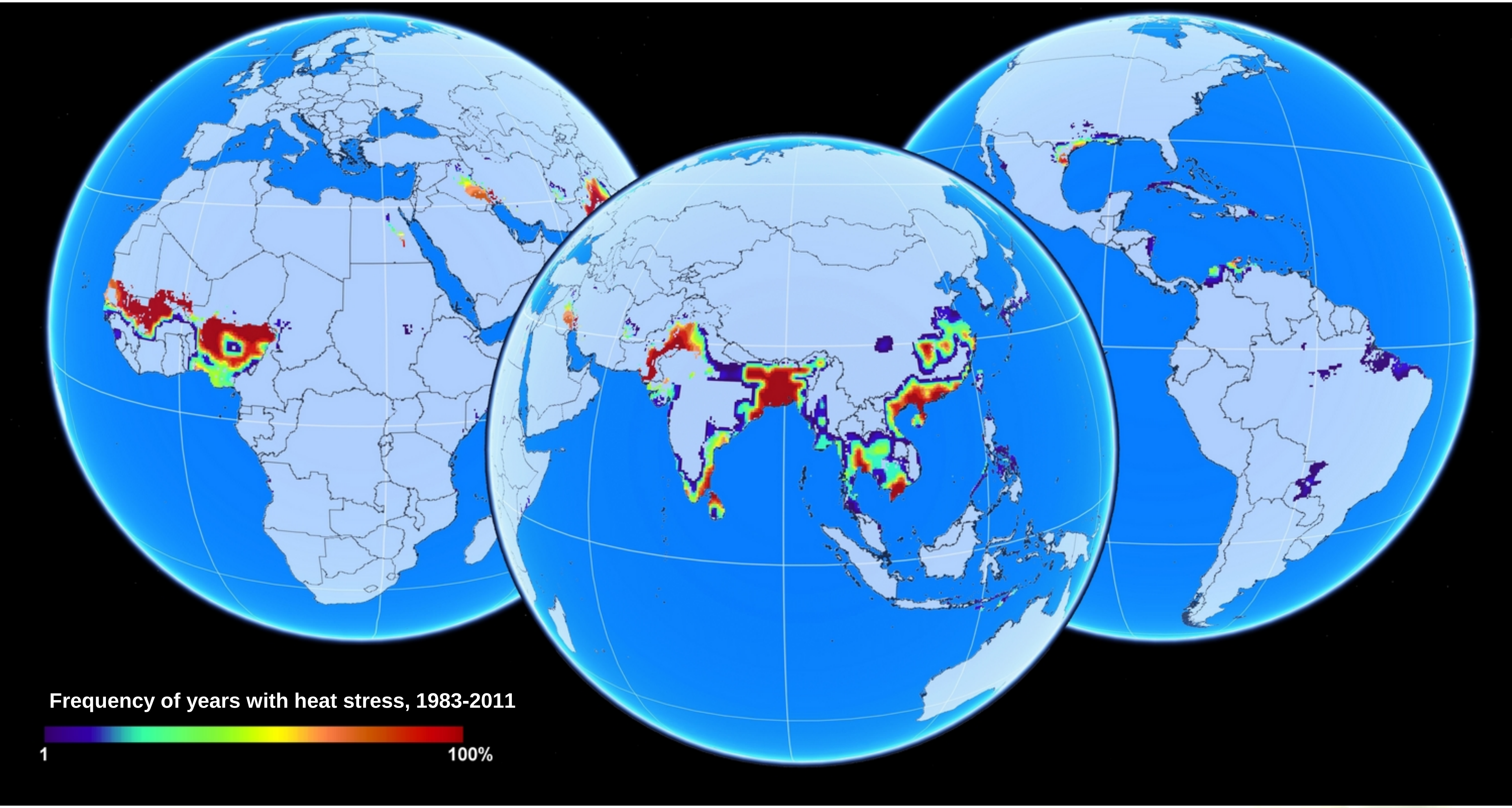
Preliminary results

# Frequency of daytime heat stress



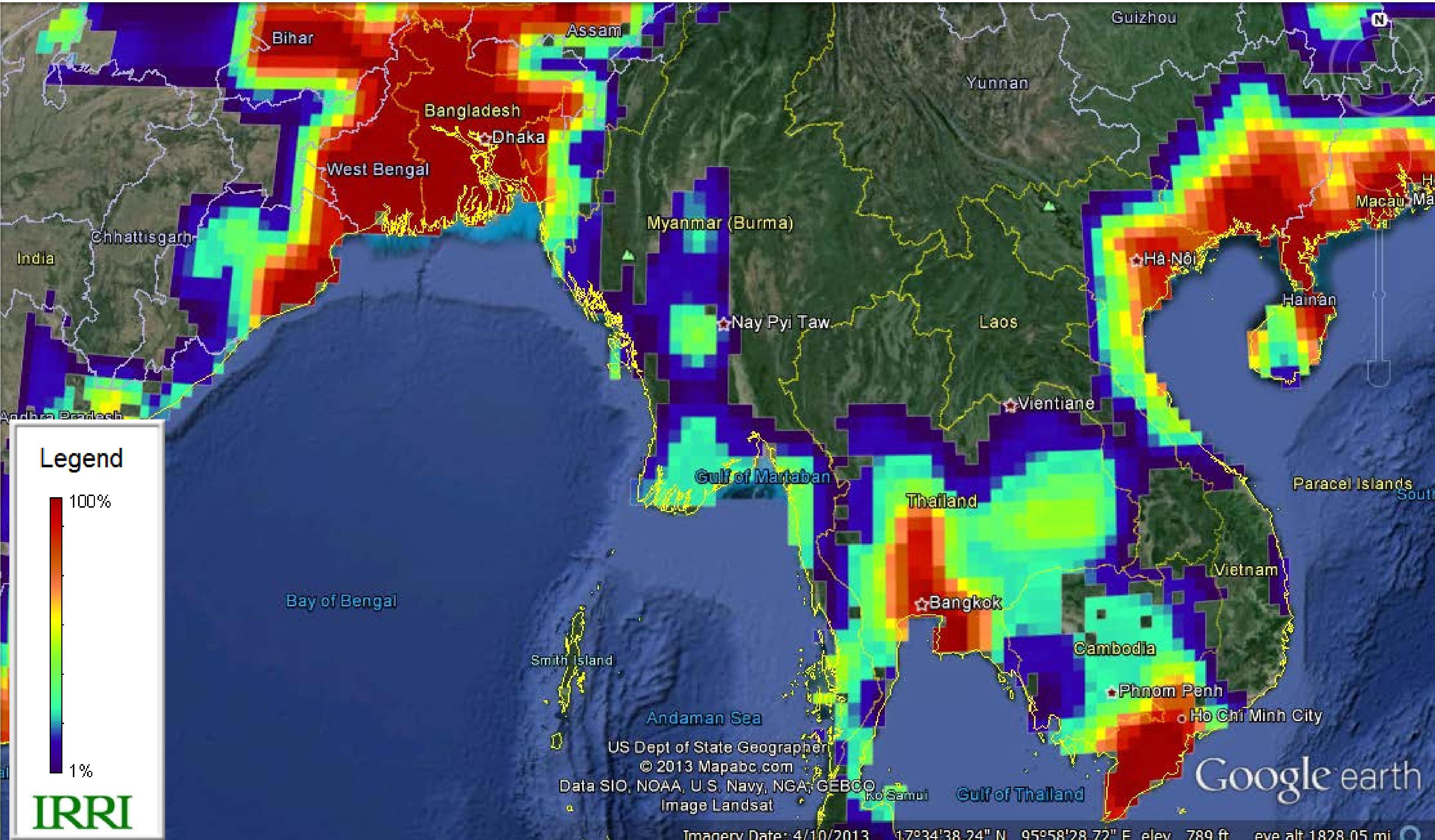
Preliminary results

# Frequency of nighttime heat stress



Preliminary results

# Frequency of nighttime heat stress



Preliminary results

# Nighttime heat stress prone rice areas

| Country | Physical rice area (million ha) | Rice areas affected (%) by frequency of occurrence | | | | |
|---|---|---|---|---|---|---|
| | | 1 in 4 yrs | 2 in 4 yrs | 3 in 4 yrs | 4 in 4 yrs | Total |
| **South Asia** | | | | | | |
| **Bangladesh** | 8.4 | 2 | 1 | 0 | 95 | 98 |
| **India** | 40.9 | 15 | 10 | 8 | 34 | 67 |
| **Nepal** | 1.6 | 11 | 12 | 0 | 19 | 42 |
| **Pakistan** | 3.0 | 1 | 2 | 20 | 72 | 95 |
| **Sri Lanka** | 0.6 | 0 | 6 | 20 | 35 | 62 |
| **Southeast Asia** | | | | | | |
| **Cambodia** | 2.6 | 44 | 48 | 0 | 5 | 97 |
| **Myanmar** | 5.6 | 33 | 30 | 6 | 0 | 69 |
| **Philippines** | 2.6 | 30 | 1 | 0 | 0 | 31 |
| **Thailand** | 9.8 | 33 | 20 | 10 | 21 | 83 |
| **Vietnam** | 3.9 | 4 | 12 | 5 | 65 | 86 |

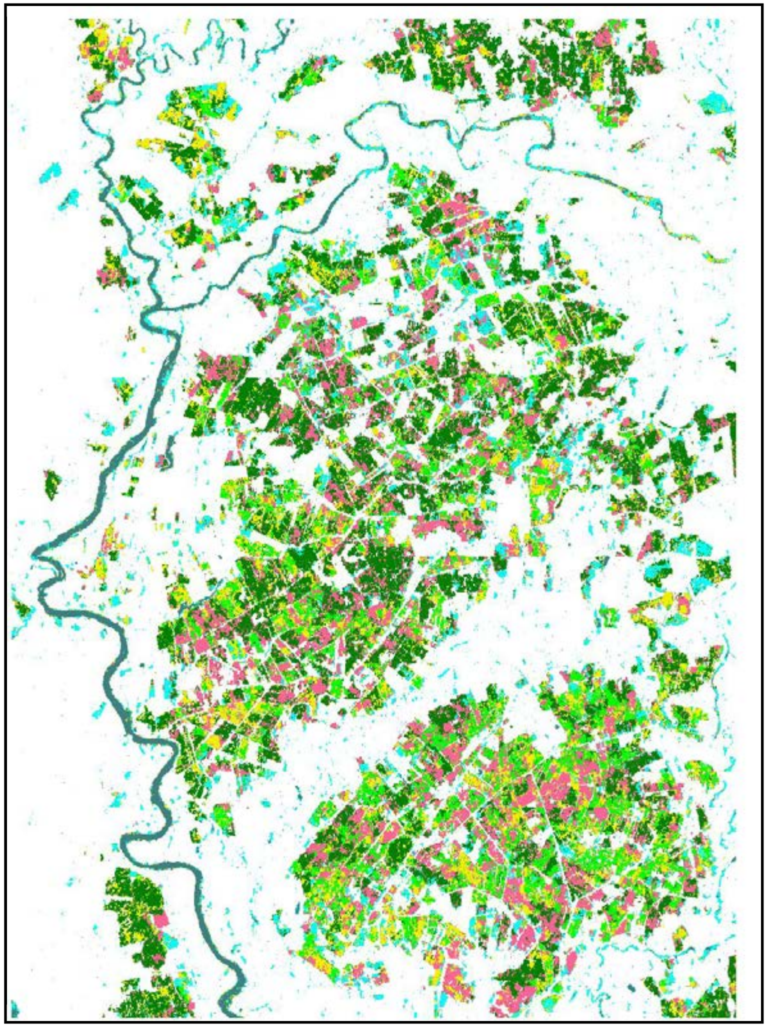
# Further work

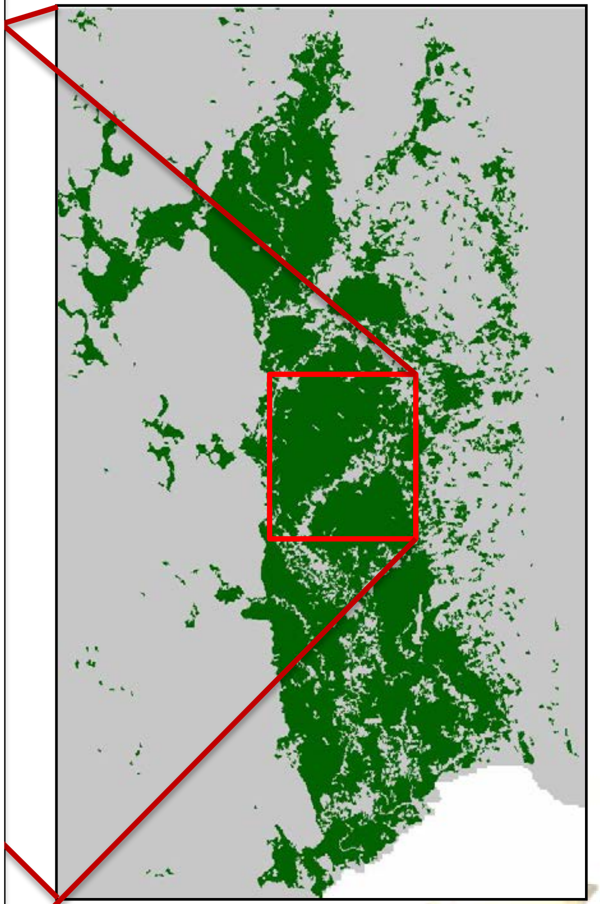
- Improve model on heat stress in collaboration with M. Yoshimoto (NIAES, Japan)
- Verify results
- Simulate the effect of shorter duration varieties and shifted planting dates
- Identify dissemination areas for rice varieties with improved heat tolerance

# Rice Mapping at different scales

**High resolution information on crop status -- Can be used for yield forecasts**

harvest
senescence
peak
tillering –
flooding
water
bare soil





Annex F4

# Mitigating Greenhouse Gas Emissions in Rice Production through Water Saving Techniques

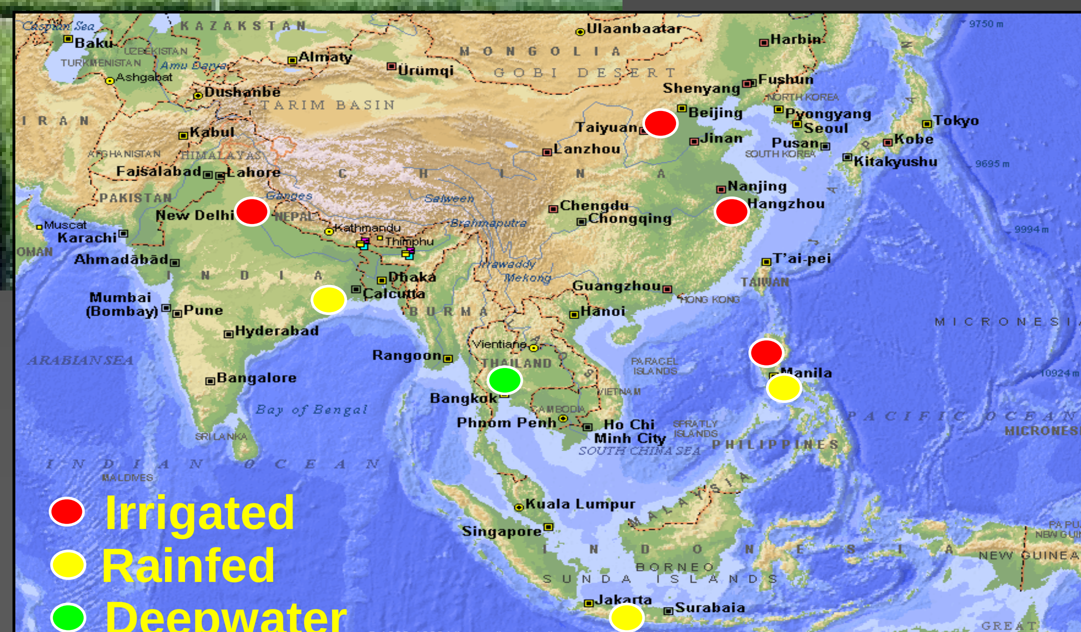
**Dr. Björn Ole Sander**
**International Rice Research Institute**

(funded by CCAFS Theme 3)

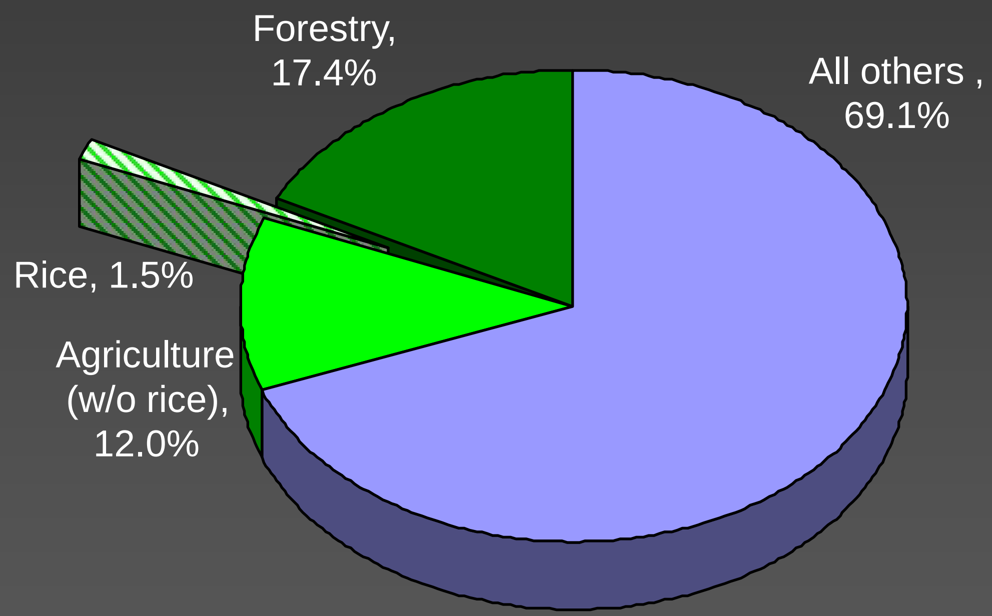
IRRI
INTERNATIONAL RICE RESEARCH INSTITUTE

CLIMATE CHANGE
AGRICULTURE AND FOOD SECURITY

# IRRI Projects on Methane Emissions 1991-1999



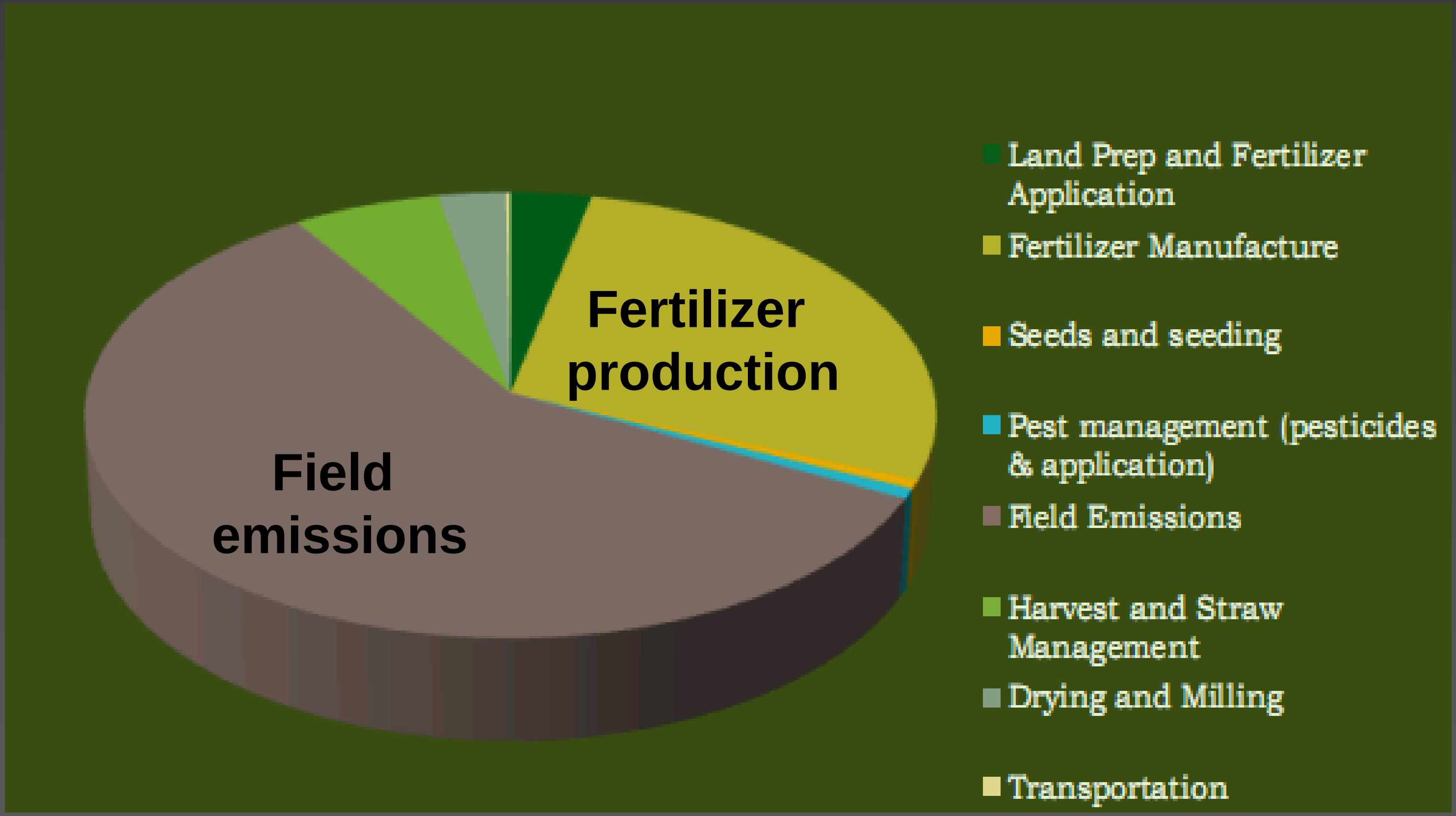
# Significance of Rice Fields for GHG budgets

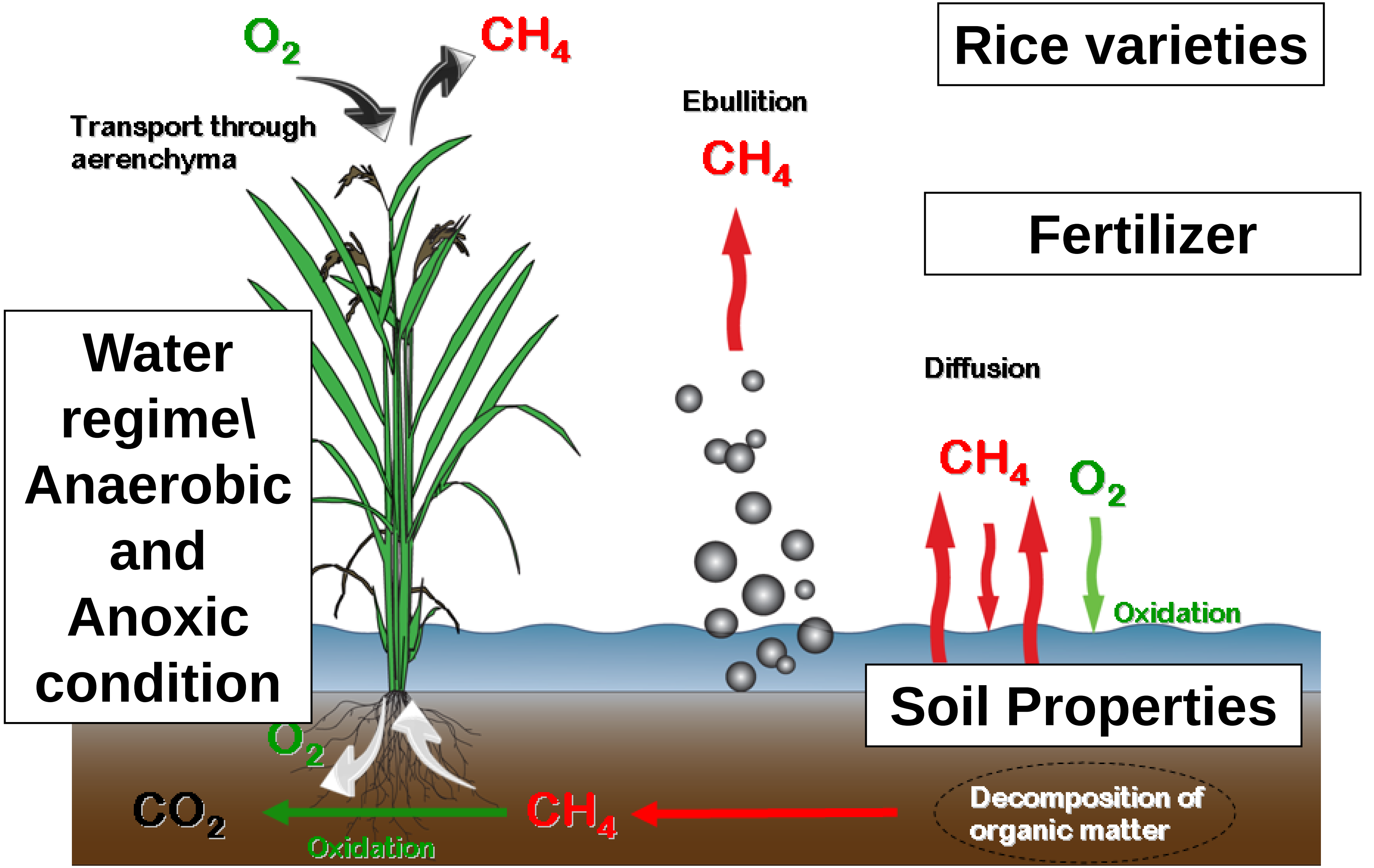



(IPCC 4th AR, 2007)

# Total GHG emission from rice production

2kg $CO_2$-eq/kg milled rice






Methane oxidation:

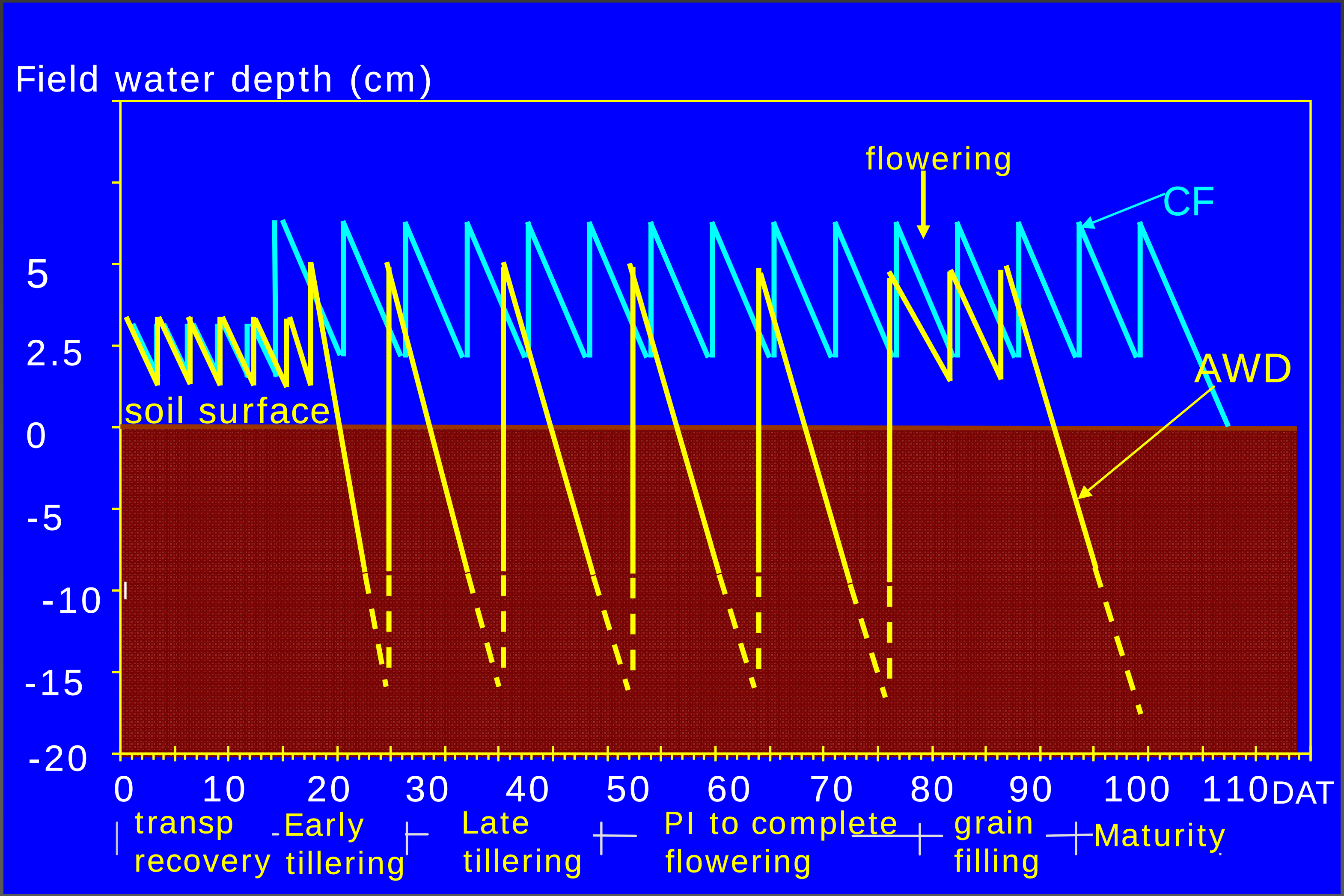
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Methanogenesis:

Hydrogenotrophic: $CO_2 + 4H_2 \rightarrow 2\ H_2O + CH_4$

Acetotrophic: $CH_3COOH \rightarrow CO_2 + CH_4$

# Alternate Wetting and Drying (AWD)

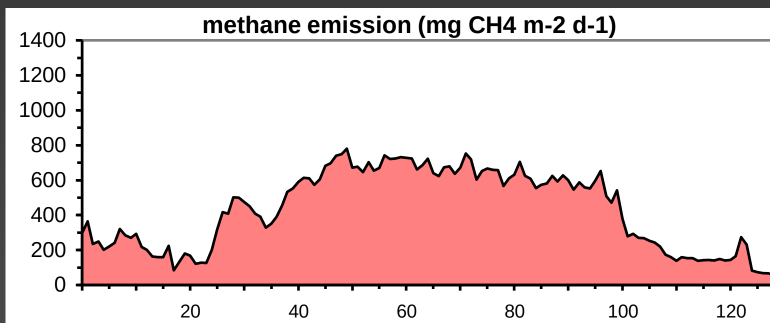


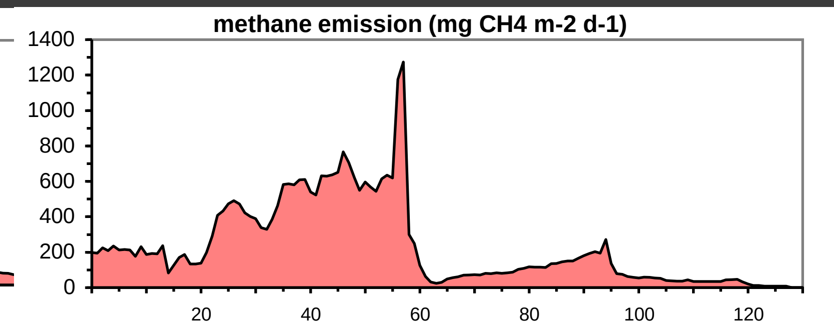
# Alternate-Wetting- and-Drying (AWD)

- Safe AWD = Irrigate when water depth ~ -15 cm
- Keep flooded until 15 DAT (weeds) and at flowering

# $CH_4$ mitigation and water management

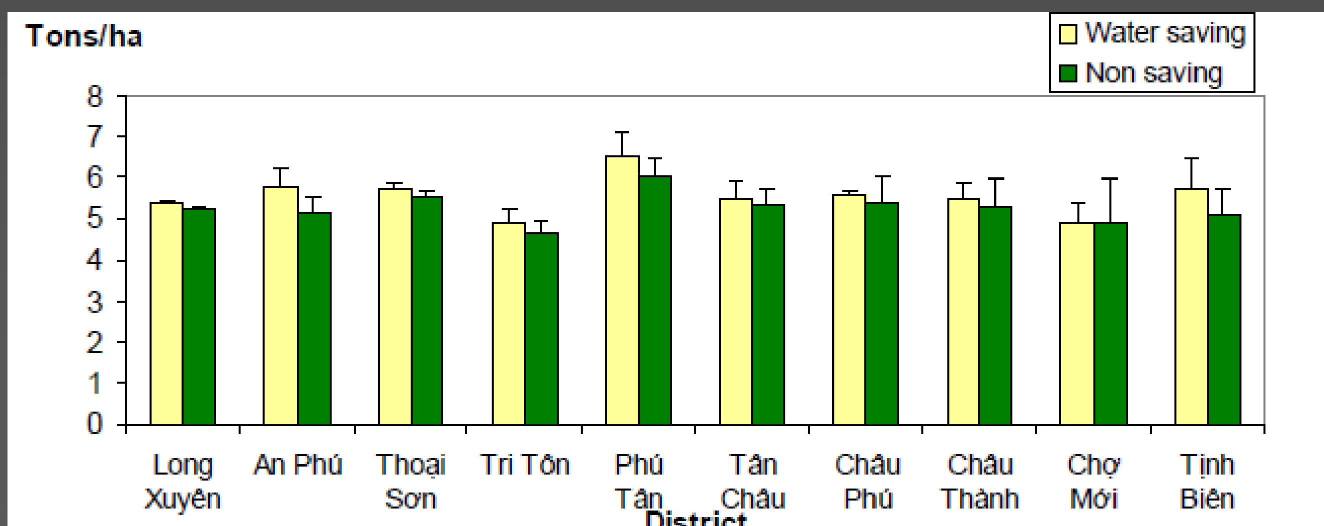
midseason drainage: saves around 40% $CH_4$ emissions




Hangzhou, China (Lu et al. 2000)

AWD: no significant yield difference



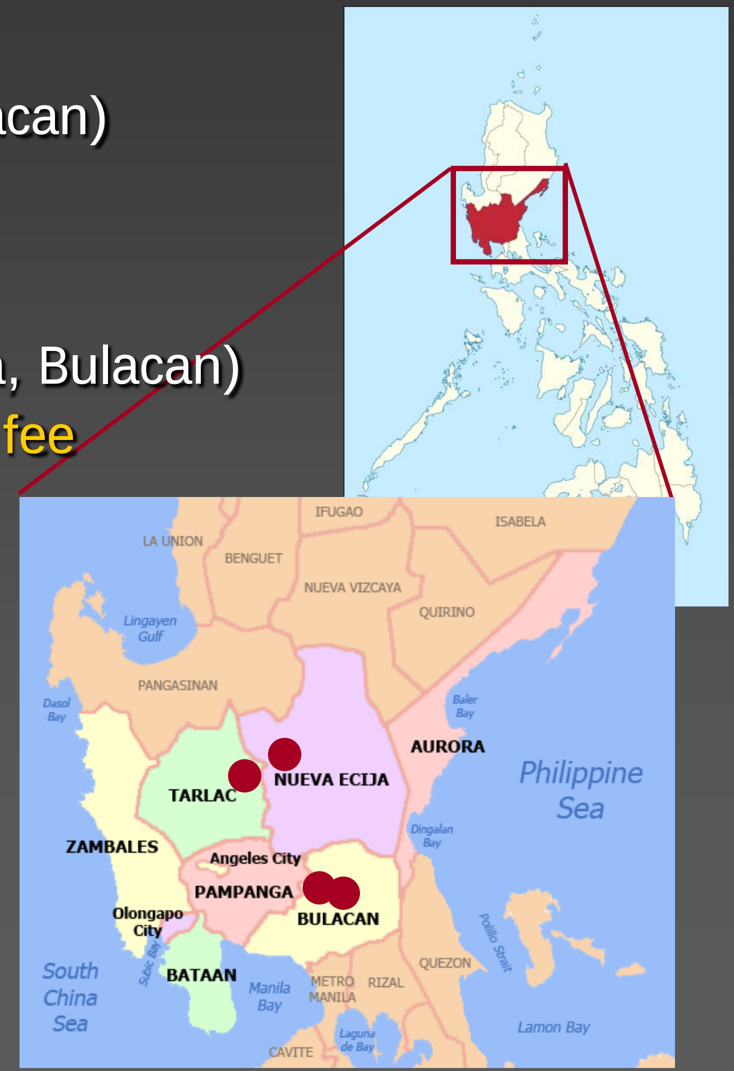
# Farmers' fields sites Philippines

1) Canal irrigation (upstream, low area, Bulacan)
→ Should always have sufficient water

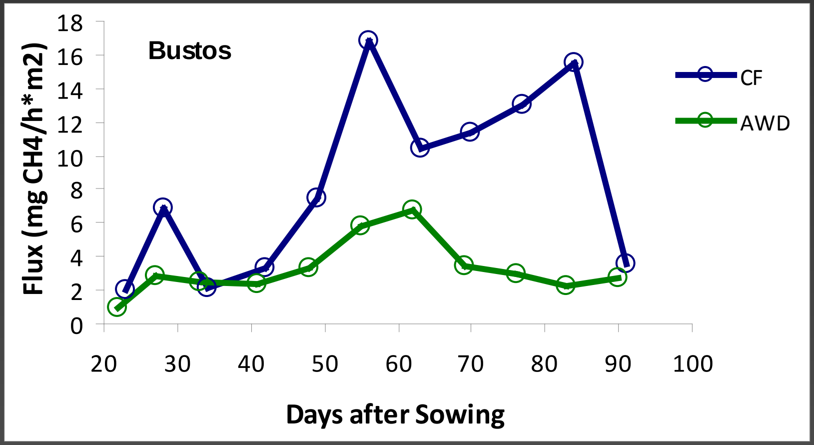
2) State owned water pump (high-lying area, Bulacan)
→ Pumps water 24/7 to higher area, electr. fee

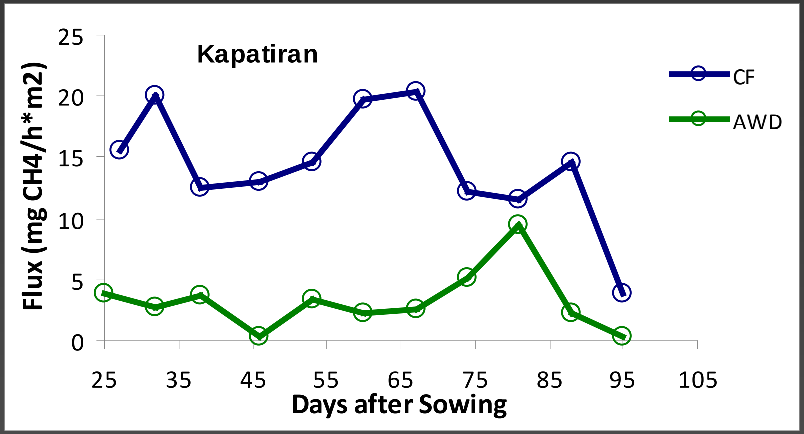
3) Community owned water pump (Tarlac)
→ Farmer buys diesel for usage of pump

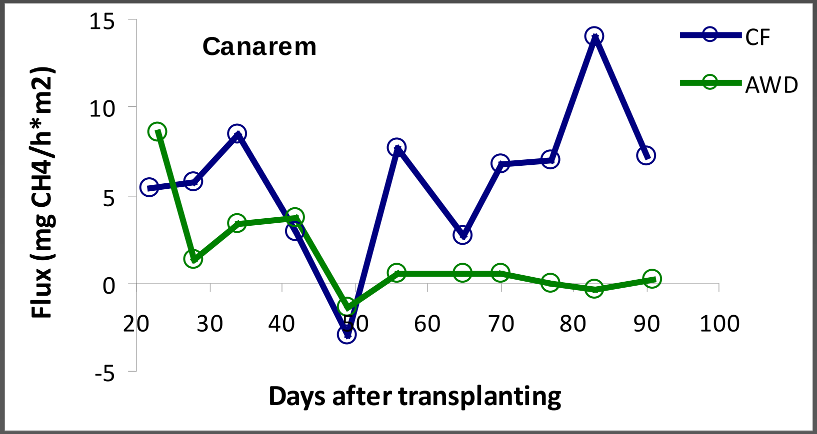
4) Imposed AWD (canal end, Nueva Ecija)
→ Water is supplied every other week

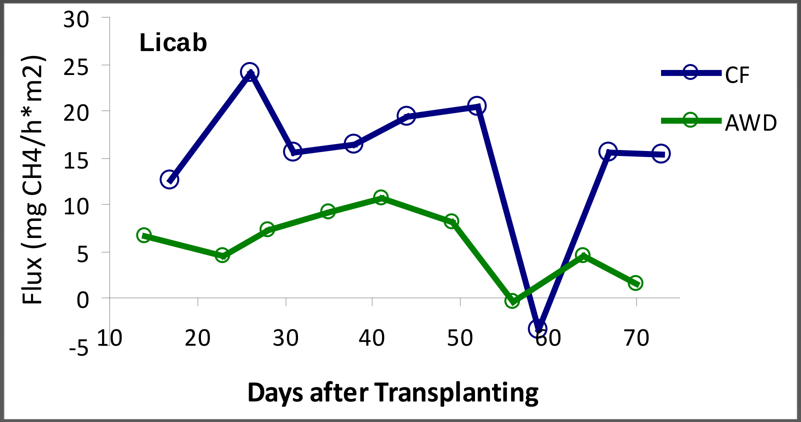


# Seasonal $CH_4$ emissions, Philippines

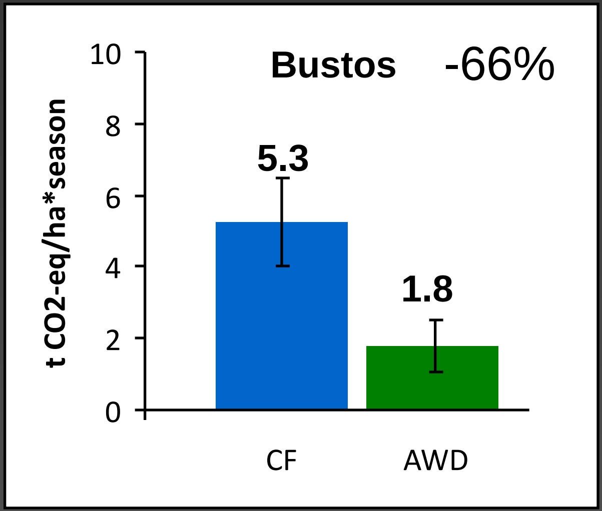


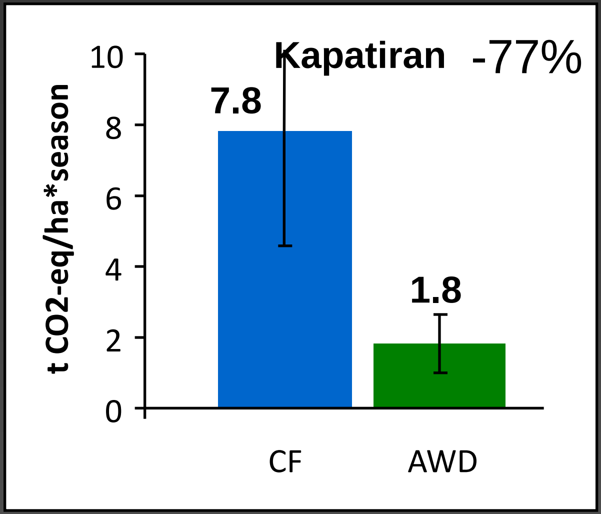



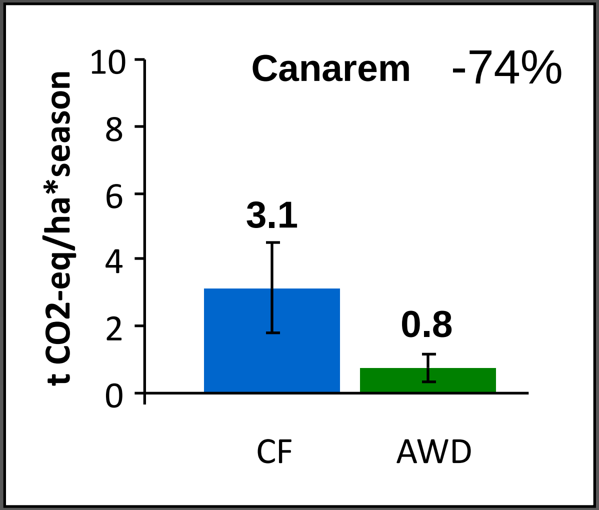



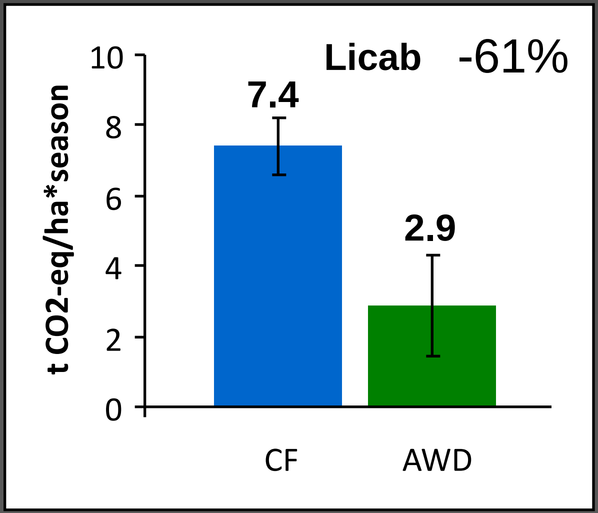



# Cumulative $CH_4$ emissions, Philippines

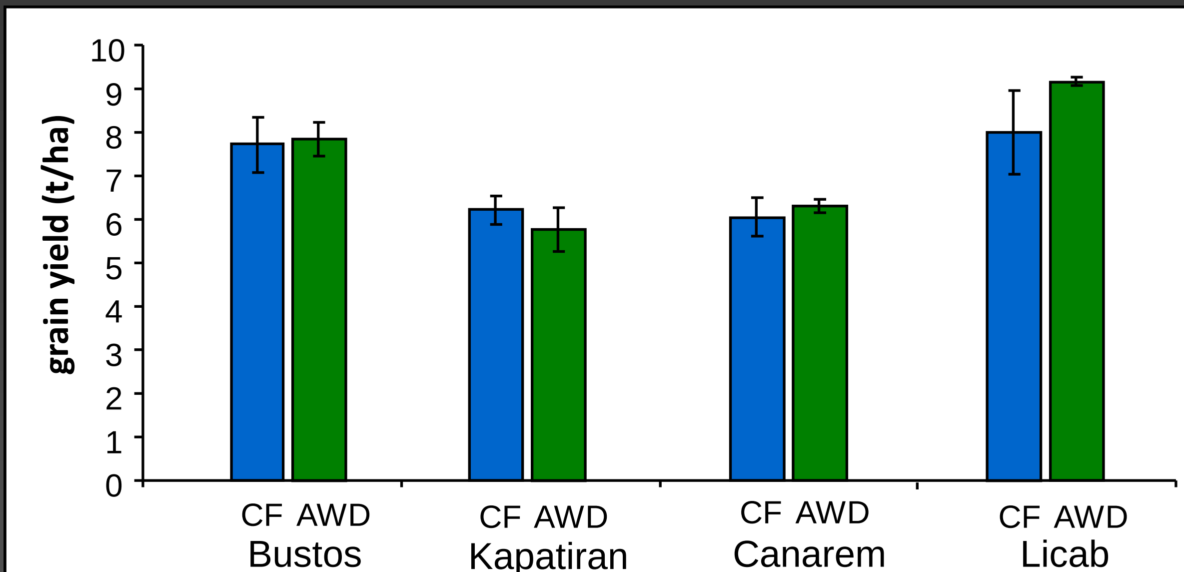


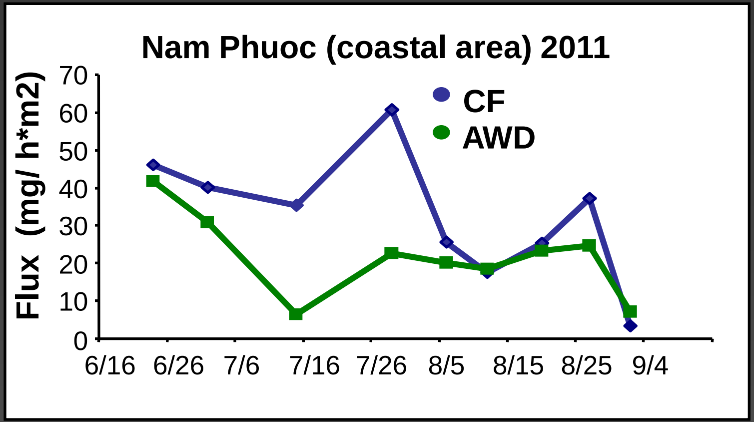
# No significant yield differences

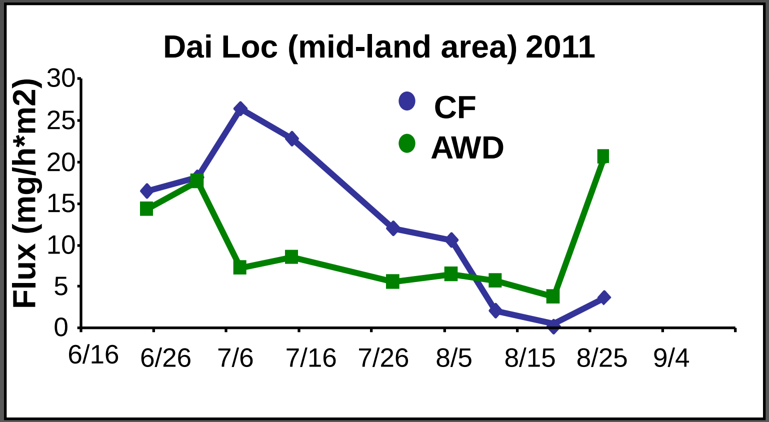



# Mitigation activities in Vietnam

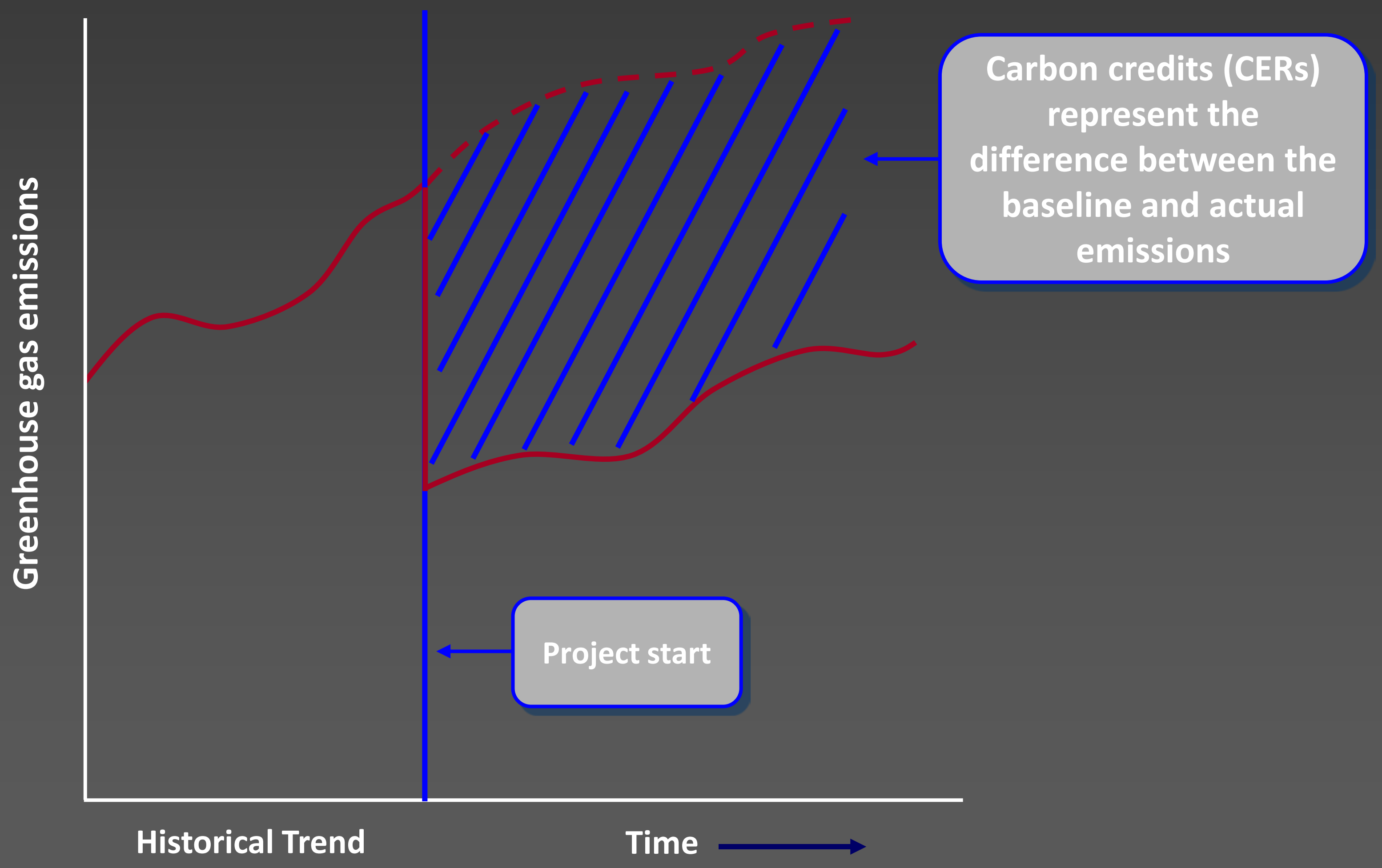

- One GHG lab at each station (Hue and O Mon)
- GHG measurements from CF and AWD fields under different salinity levels

# Seasonal $CH_4$ emissions, Vietnam




# ‘Clean Development Mechanism (CDM)’: Generating carbon credits



# Latest version of CDM methodology for rice production

Default values for shifting from continuous flooding to intermitted flooding:

*"For regions/countries where double cropping is practiced:*

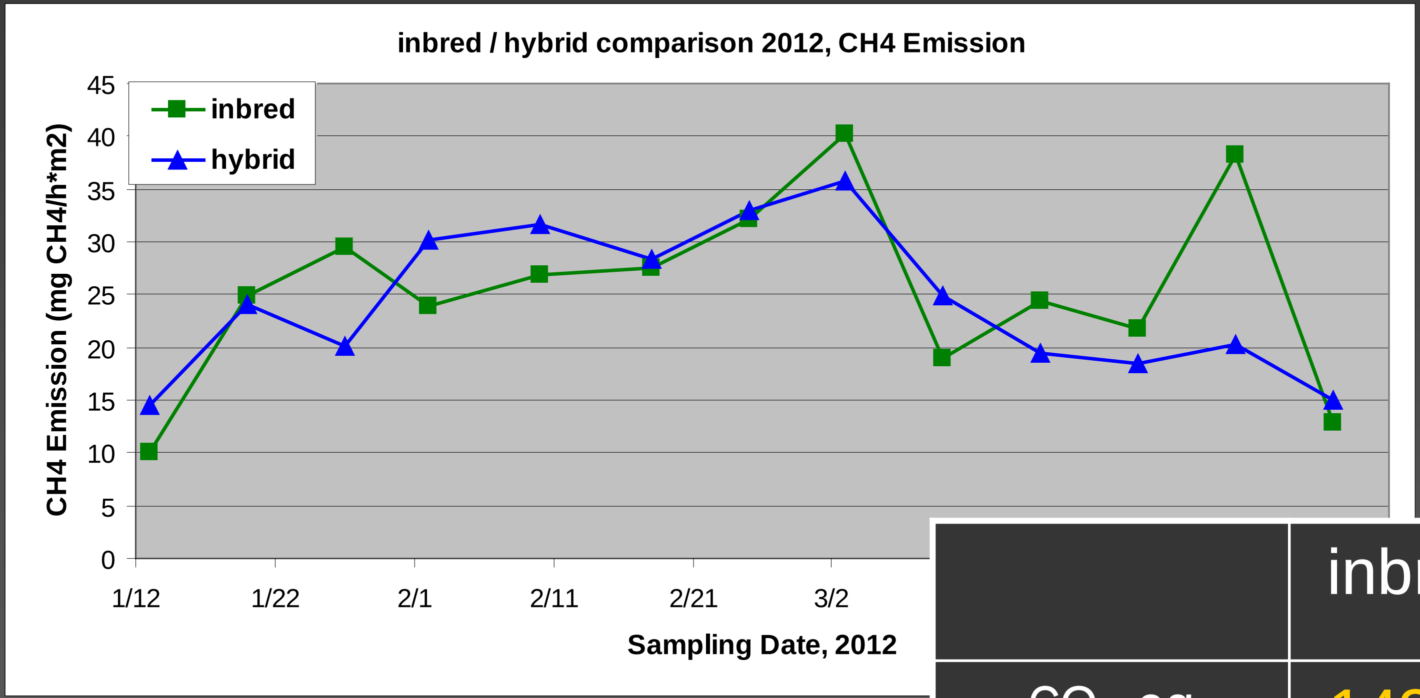
*(i) Use reduction of 1.50 (kg$CH_4$/ha/day) for project activities that shift to intermittent flooding (single aeration);*

*(ii) Use reduction of 1.80 (kg$CH_4$/ha/day) for project activities that shift to intermittent flooding (multiple aeration);"*

# IRRI Climate Change Group

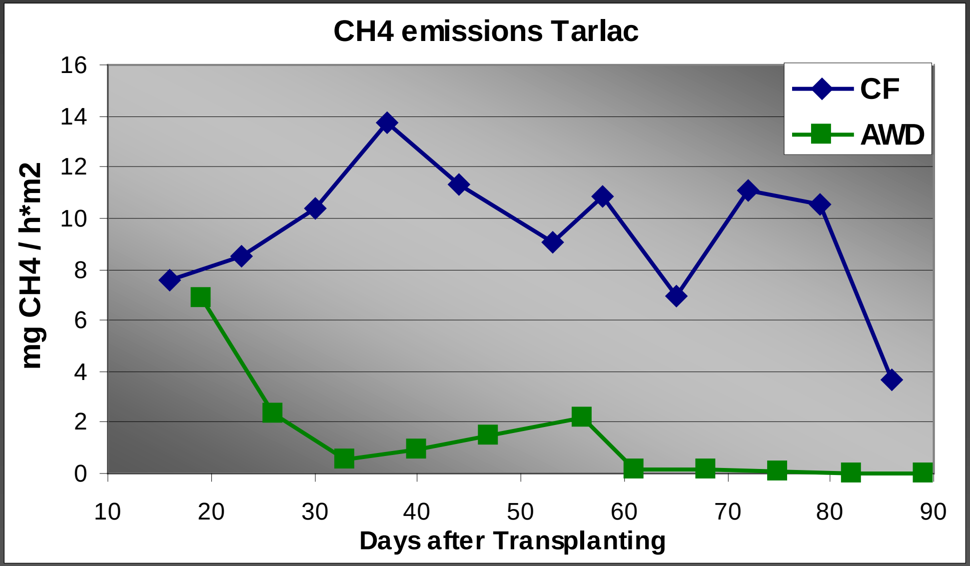

**Thank you for your attention!**

# Comparison: GWP of inbreds and hybrids



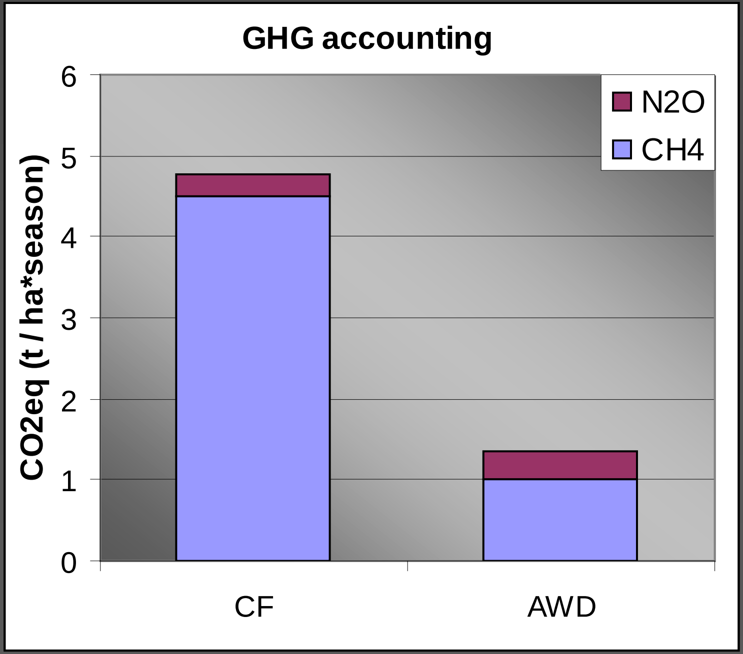

| | inbred | hybrid |
|---|---|---|
| $CO_2$-eq (kg/ha) | 14307 | 13965 |
| $CO_2$-eq (kg/kg grain) | 2.14 | 1.7 (-20%) |

# GHG Emission Reduction in Farmers' Fields (Philippines)



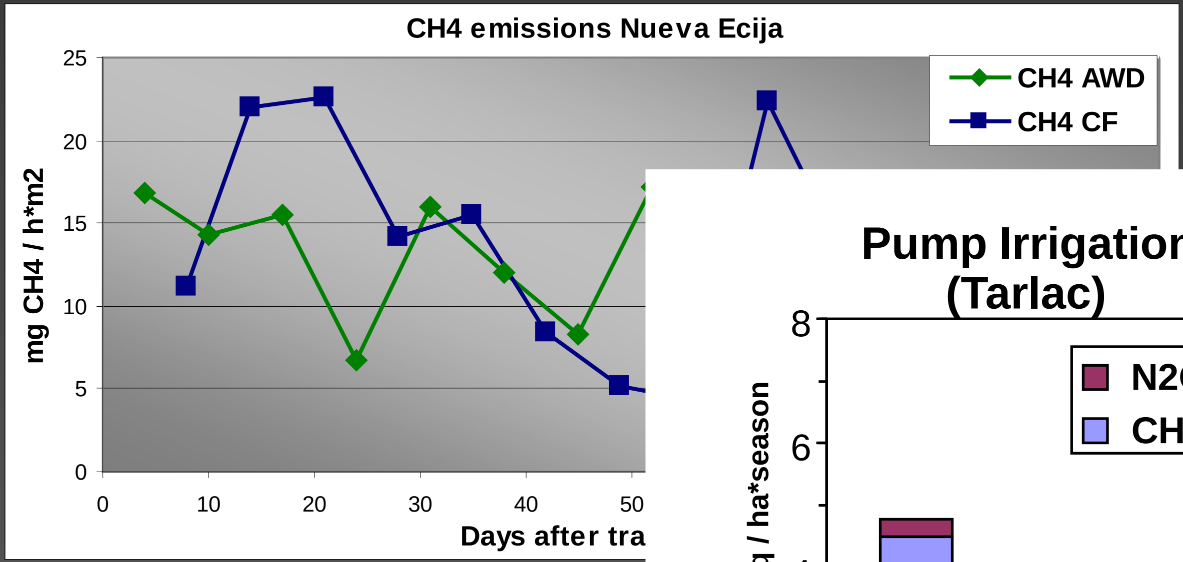

Seasonal $CH_4$ emissions
in Farmers' Rice Fields 2012

"Global Warming Potential"
of Tarlac Rice Fields



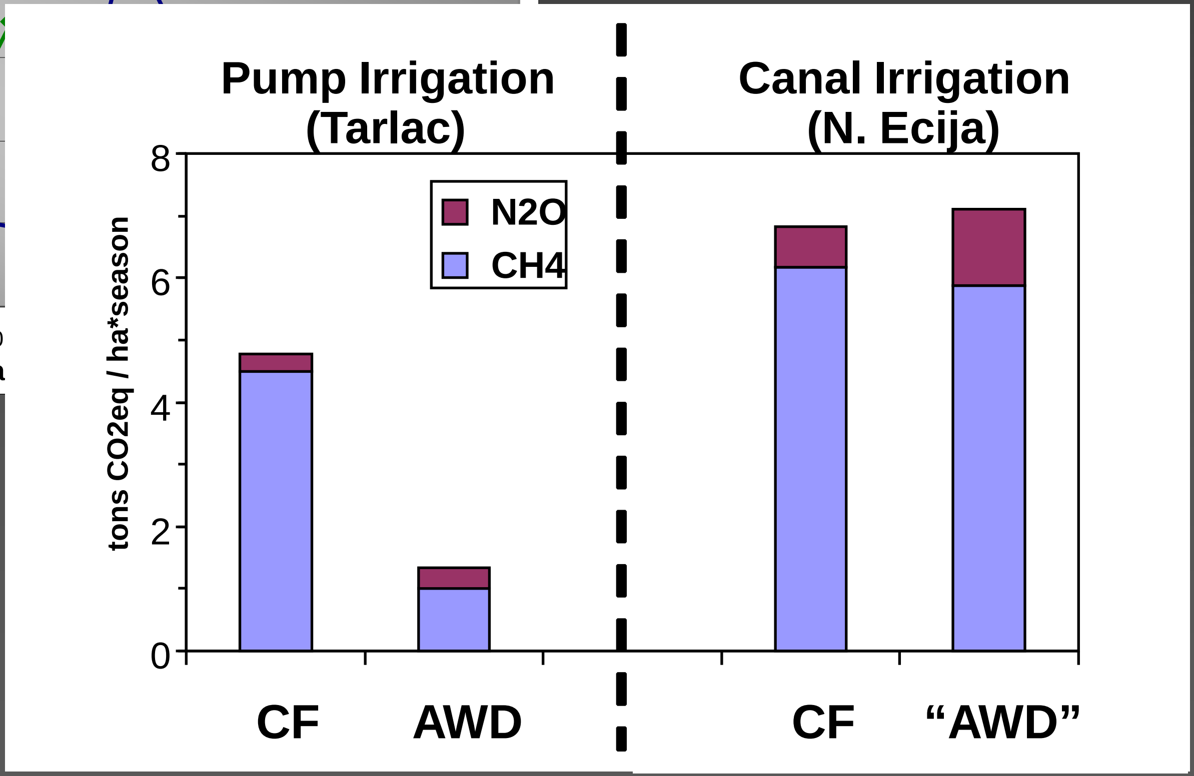

Sander et al.,unpublished preliminary results

# GHG Emission Reduction in Farmers' Fields (Philippines) II



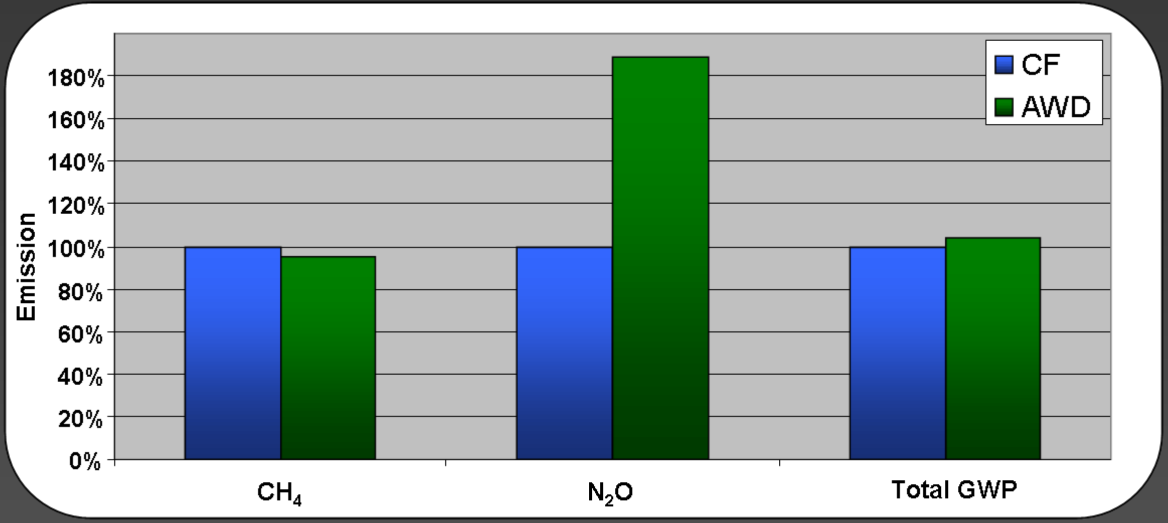

Seasonal $CH_4$ emissions
in Farmers' Rice Fields 2011

"Global Warming Potential"
of Nueva Ecija Rice Fields

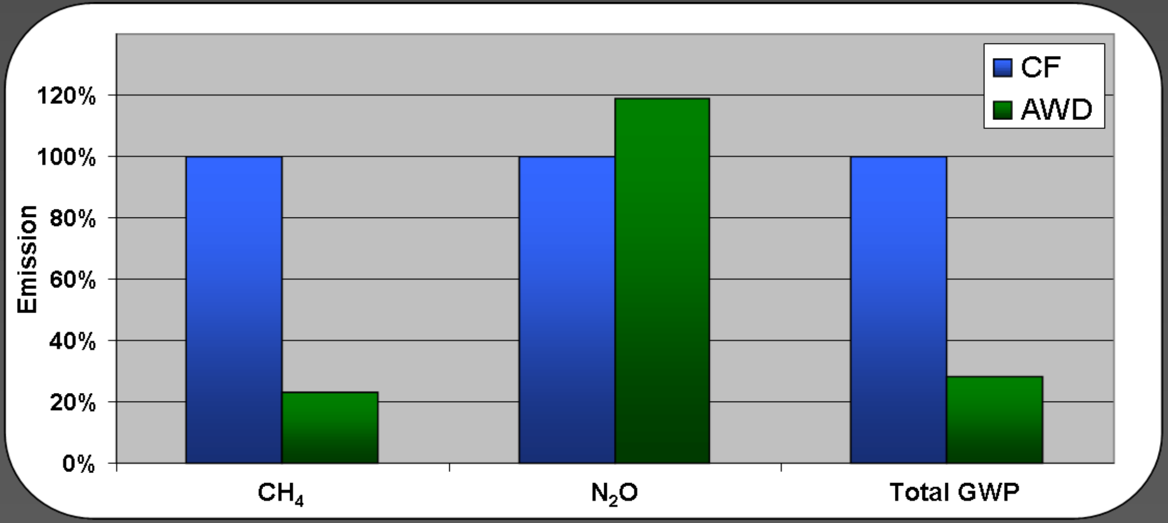



Sander et al., manuscript in preparation

# Comparison




Site A:
Irrigation canals




Site B:
Pump irrigation