Big Data for Climate Smart Agriculture Case study : Rice Systems in Latin America

5th Annual Workshop on Understanding Climate Change from Data, Minneapolis, MN
4th -5th August 2015

What need are we responding to ?

¿What, When, Where to grow?

In terms of agricultural research mostly based on a top-down (from controlled conditions – technologies are passed onto farmers)

What we propose?

A complementary bottom-up approach: Information from commercial fields - Taking advantage of modern information technologies


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Climate	**Soil**	**Crop management (including varieties)**	**Crop response (productivity/ha)**
% ?	**% ?**	**%?**	**To Explain (100 %)**

Empirical modelling approaches aimed to identify the patterns that lead to either high or low productivities (mostly based on machine learning techniques) **as strategy to climate change adaptation!!!**

How ?

FEDEARROZ
FEDERACIÓN NACIONAL DE ARROCEROS

Main site-specific climatic limiting factors

Databases used	Initial purpose	N
National Rice Survey	Keep the crop sector updated, technological changes	1237
Harvesting records	Monitoring production levels in the regions	6000
Planting dates experiments	Technical research on the best sowing date	600

Information on: Planting and harvesting date, productivity , variety, cropping system

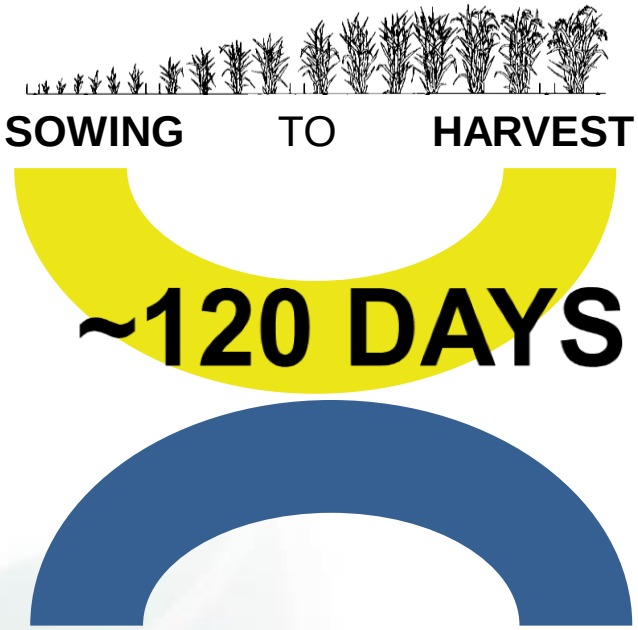
Zones: Caribbean, Andean (Tolima), Plains (Llanos)

Climate

- About **27** weather stations

How ?

Main site-specific climatic limiting factors

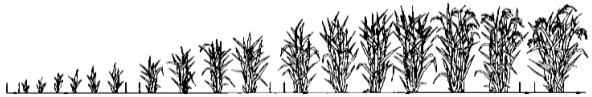


= **SINGLE** RICE **CROPPING EVENT**

Relating daily series of main climate variables to every 120 days cropping events yield, we should be able to characterize the climate-crop relationship

Jiménez et al., (2009). Computers and electronics in agriculture
Jiménez et al., (2011). Agricultural Systems
Cock et al., (2011). Agricultural Systems

How ?



SOWING TO **HARVEST**

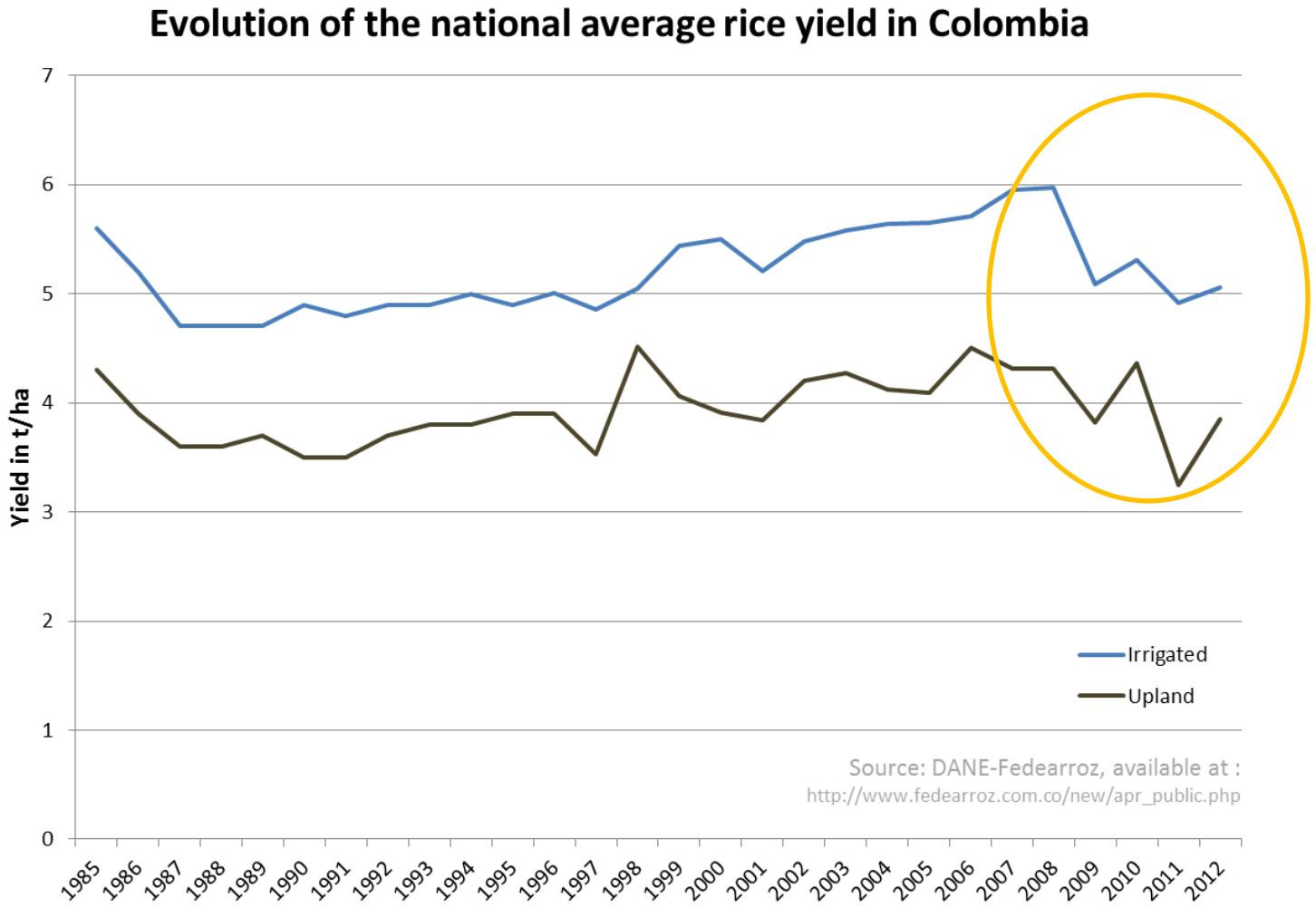
~120 DAYS

DAILY CLIMATE DATA

x N RICE CROPPING EVENTS

Why climate ?

Hypothesis: Variation in crop yield is associated with climate



Free trade agreements : sector is threatened by the commercialization of rice produced in more efficient countries

How ?

Traditional methods

- Multiple linear regression (OLS)
- Factorial analysis (PCA, MCA, CATPCA…)
- Generalized linear model
- Mixed Models
- Time series

- ***Challenges in data-driven analysis:***

Both quantitative and qualitative,

noisy, non-linear, incomplete,

heterogeneous, often non-parametric ,

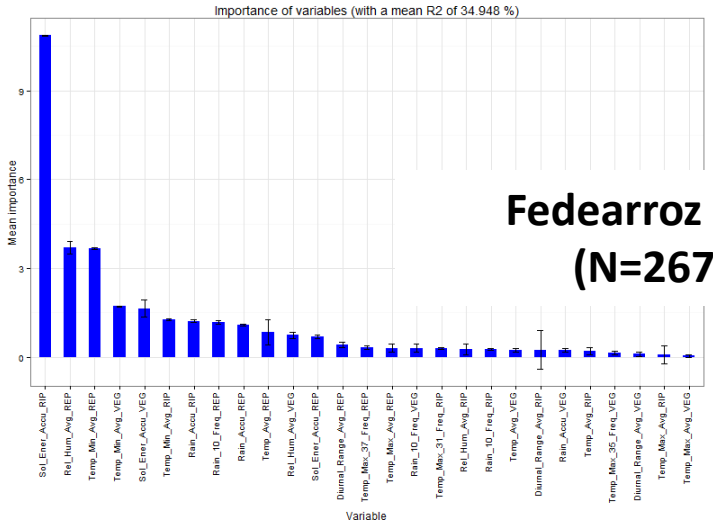
(y) transformation, etc.,

Methods based o machine learning

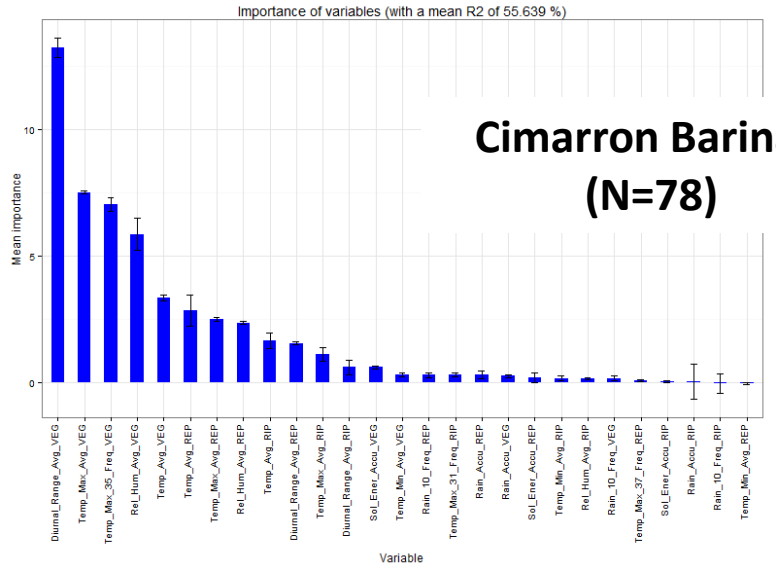
- Supervised and unnsupervised ANNS (MLP, SOM)
- Random Forest
- C-Forest
- Fuzzy Logic

Main site-specific climatic limiting factors

Multivariate analysis for Saldaña (research station- Andean zone): cropping events (2007 to 2012) – Irrigated rice – Technique: C-Forest- Relevance metric: Partial dependence plots



Fedearroz 733 (N=267)



Cimarron Barinas (N=78)

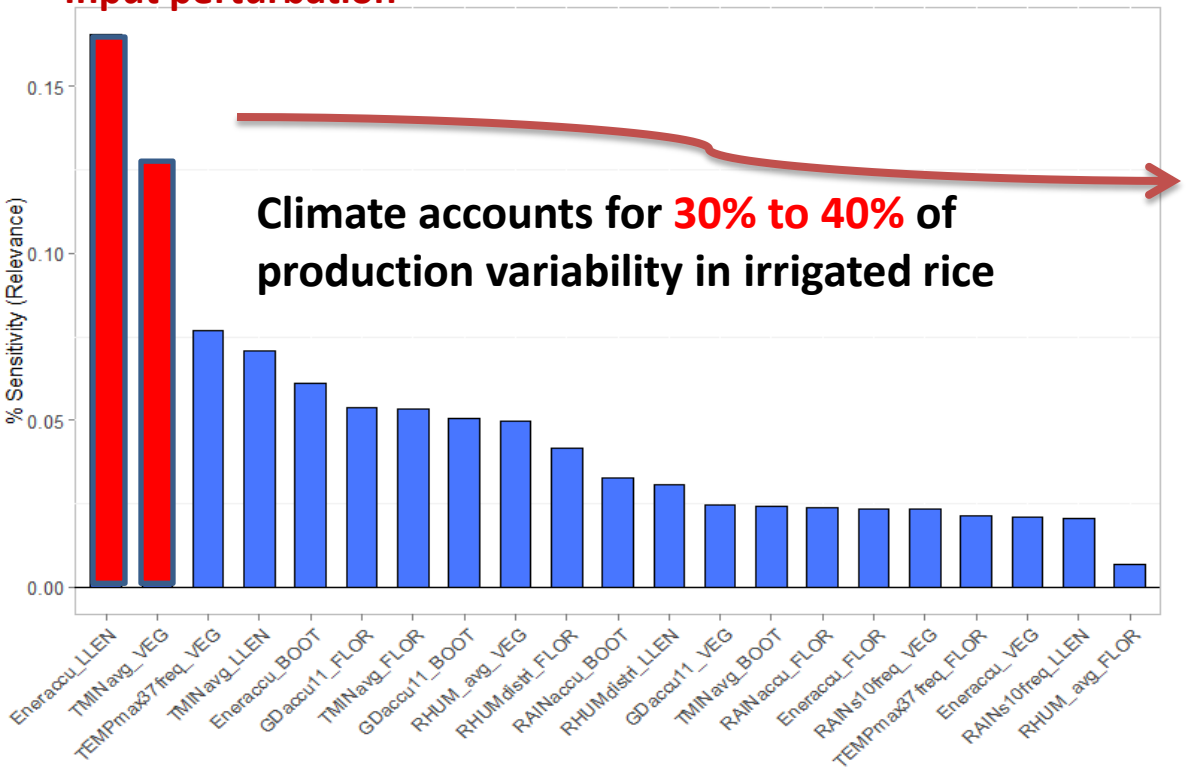
FEDEARROZ 733 - **34 %** of productivity variation explained

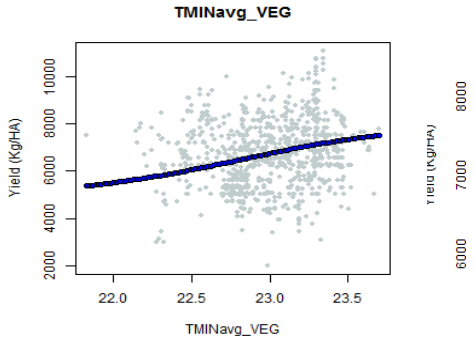
From data to action!!! Varieties perform differently under identical climatic conditions

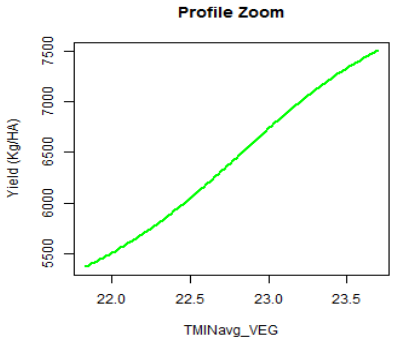
Cimarron Barinas - **56 %** of productivity variation explained

Main site-specific climatic limiting factors

Climate and analysis based on phenological stages in Saldaña (research station) Andean zone 2007 – 2012 (N= about 800 cropping events – irrigated rice), ANNs – Relevance metric: Input perturbation







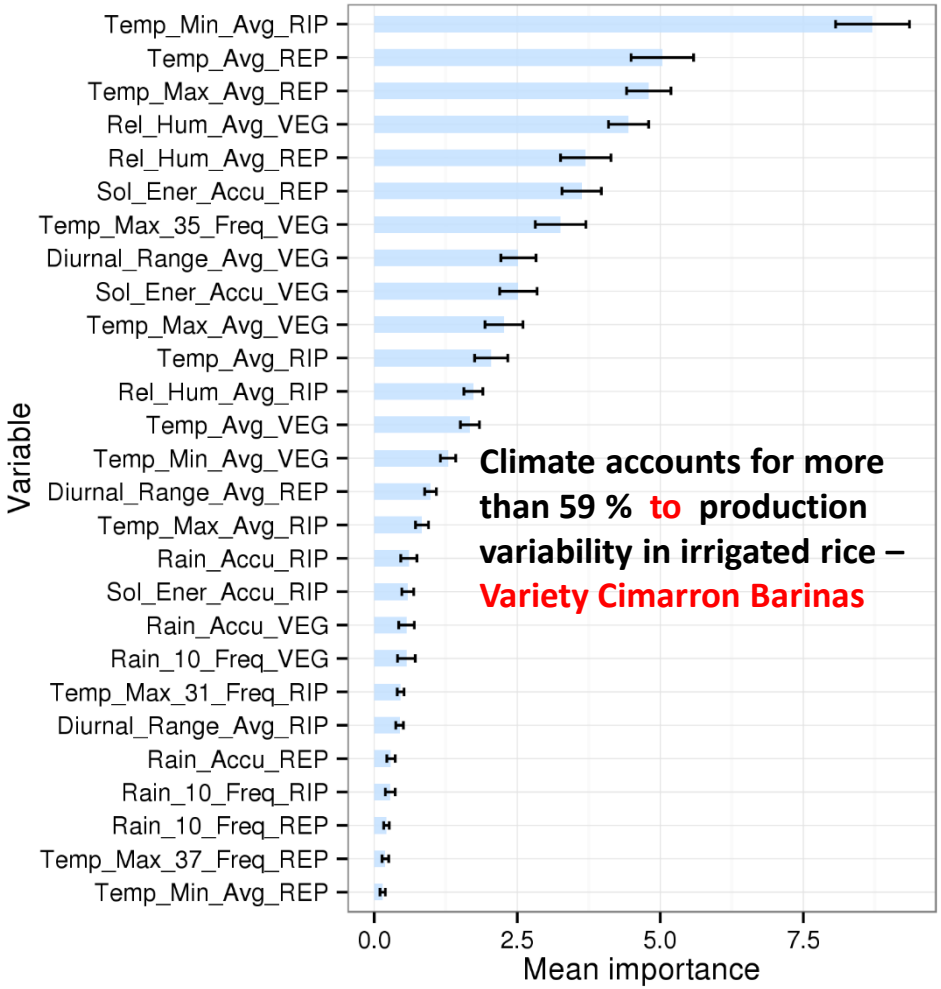
- **The crop sector can suggest to farmers the best planting date (when to grow)**
- **By assessing the same approach in other stations (enviroments) – New insights for future breeding**
- **Adaptation strategy for climate change**

Main site-specific climatic limiting factors

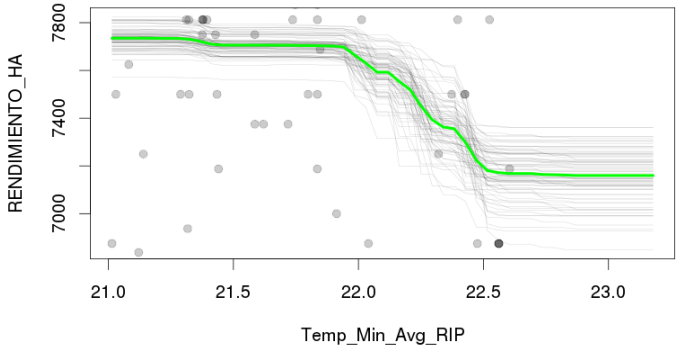
Case study: Espinal (Tolima Department)- Data: 2007 – 2013

N= 180 harvesting events- Variety Cimarron Barinas – Irrigated rice

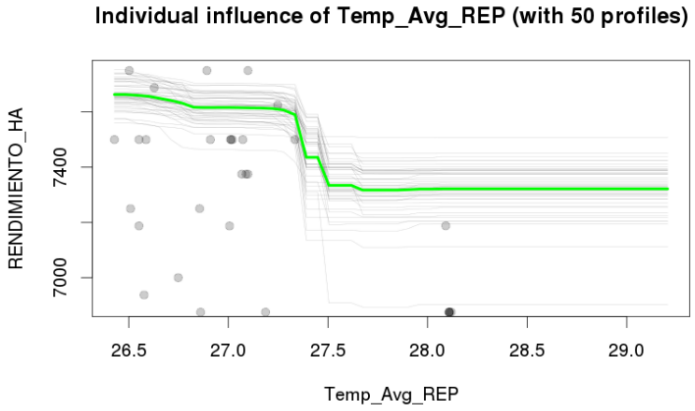
C- Forest– Relevance metric: Partial dependence plots



Climate accounts for more than 59 % to production variability in irrigated rice – Variety Cimarron Barinas



Average minimum temperature in ripening stage is a critical factor for variety Cimarron Barinas



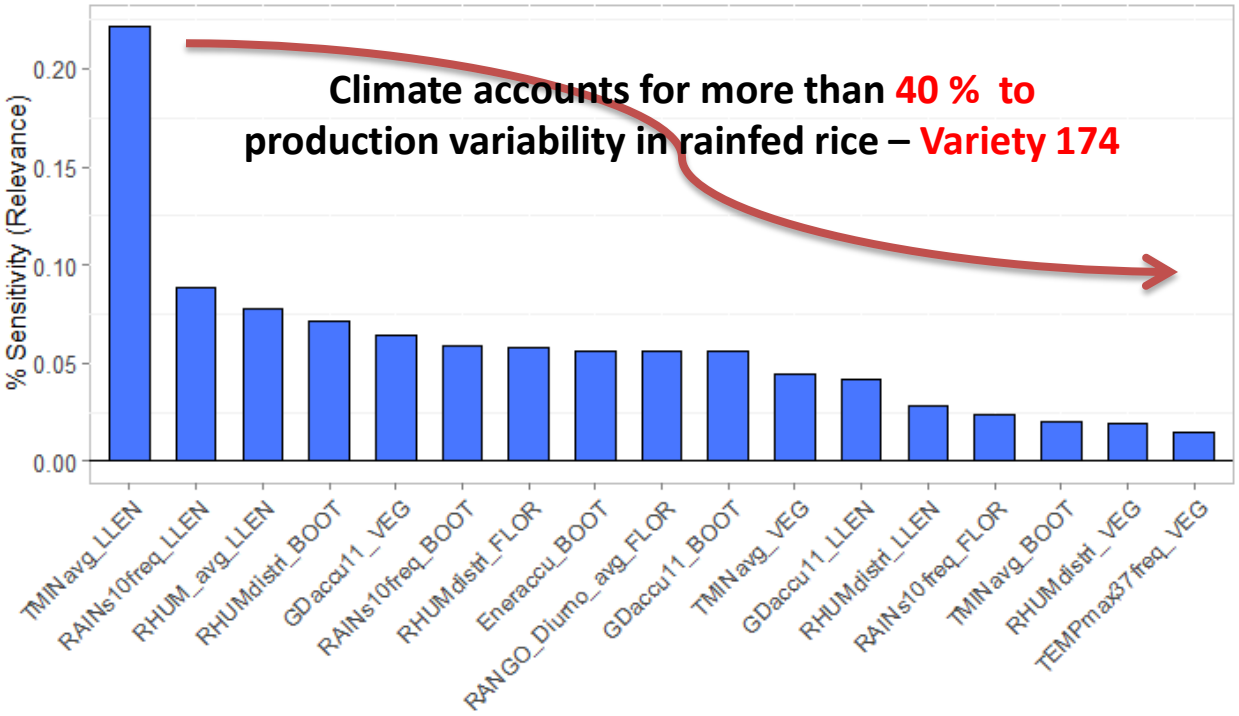
Average temperature in reproductive stage is a critical factor for variety Cimarron Barinas

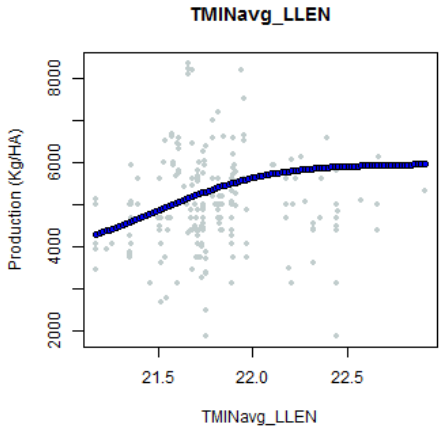
Main site-specific climatic limiting factors

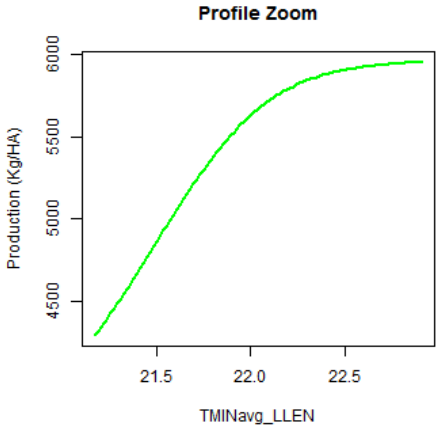
Case study : llanos Data: 2007 – 2012

N= 200 harvesting events – Variety F174 – Rainfed rice

ANNs – Relevance metric: Input perturbation



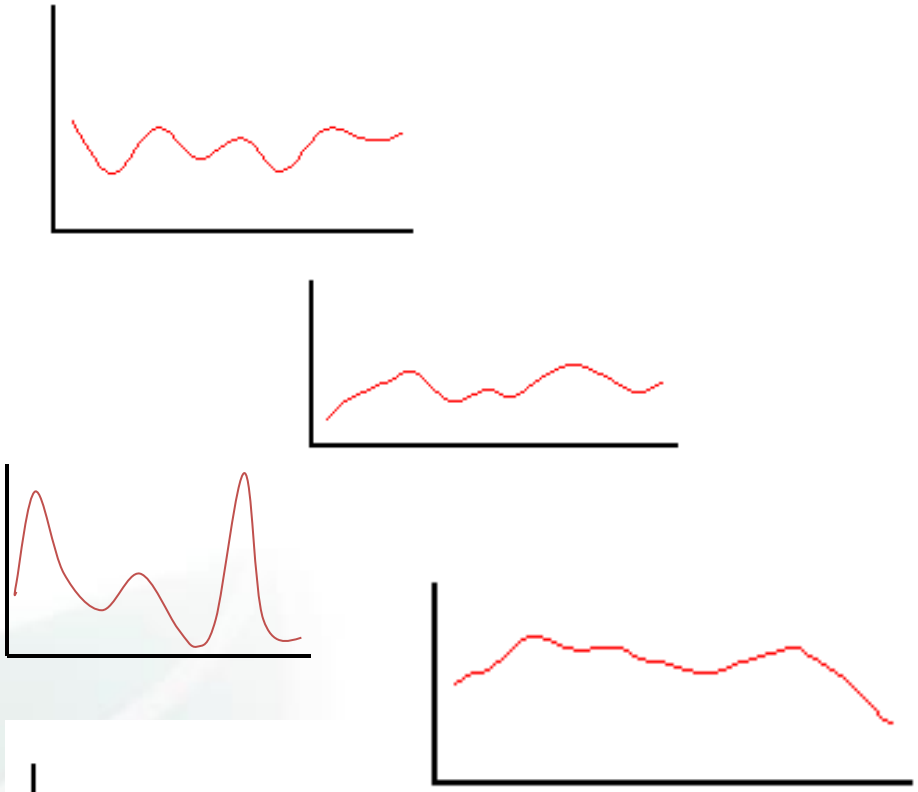




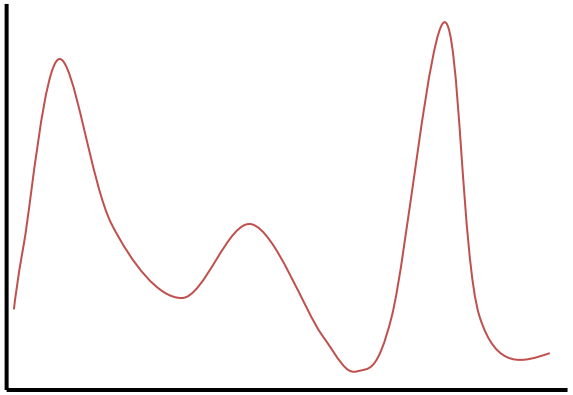
- **Average temperature during grain filling is a critical factor for variety 174**

Historical profiling

Climatic profiles



Seasonal forecast

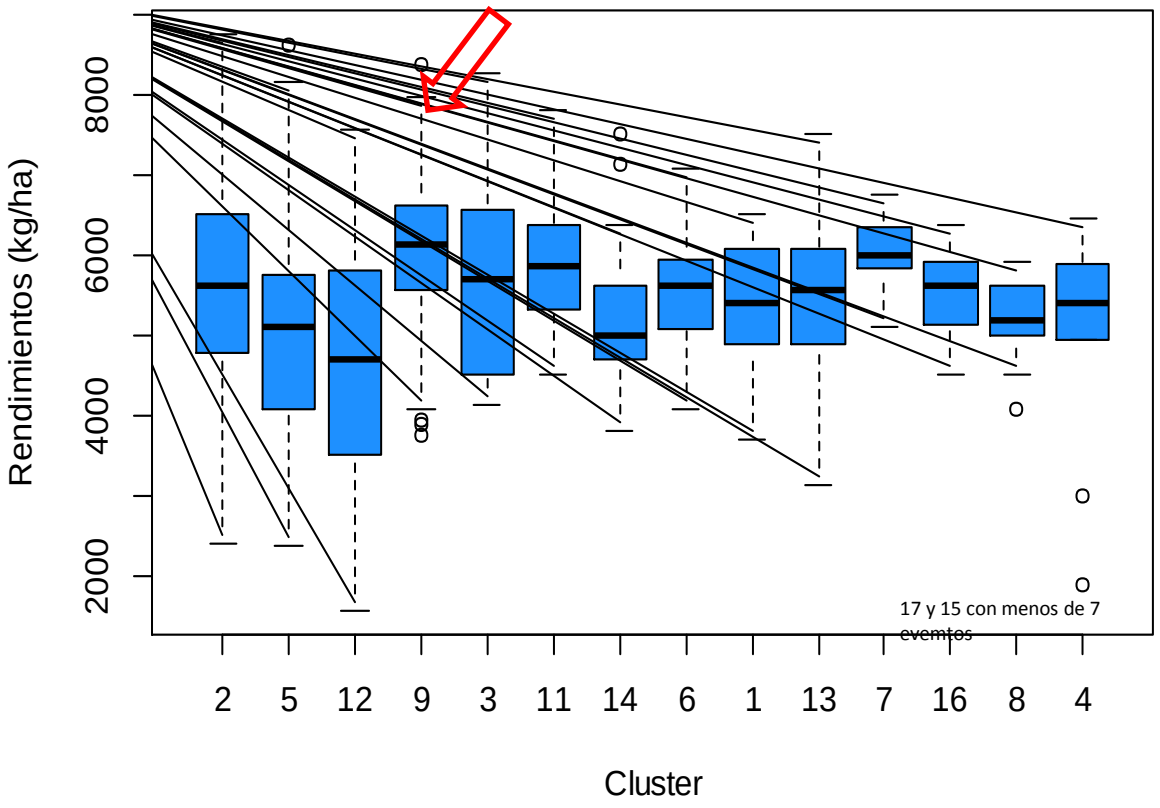


Historical profiling

Region: Casanare: 2007 – 2014 – Irrigated
Weather stations from FEDEARROZ e IDEAM
(N= about 756 cropping events) – 17 clusters
Dynamic Time Wrapping (DTW)

Cluster	Number of cropping events	Productivity (kg/Ha)
1	18	5,354
2	238	5,653
3	51	5,821
4	9	4,913
5	148	4,946
6	30	5,557
7	15	6,041
8	10	5,174
9	60	6,000
10	6	5,726
11	42	5,898
12	65	4,688
13	18	5,469
14	33	5,222
15	1	5,312
16	15	5,521
17	6	5,053
Total	**765**	**5,438**

Yield associated with each historical profile (cluster) presented in the region



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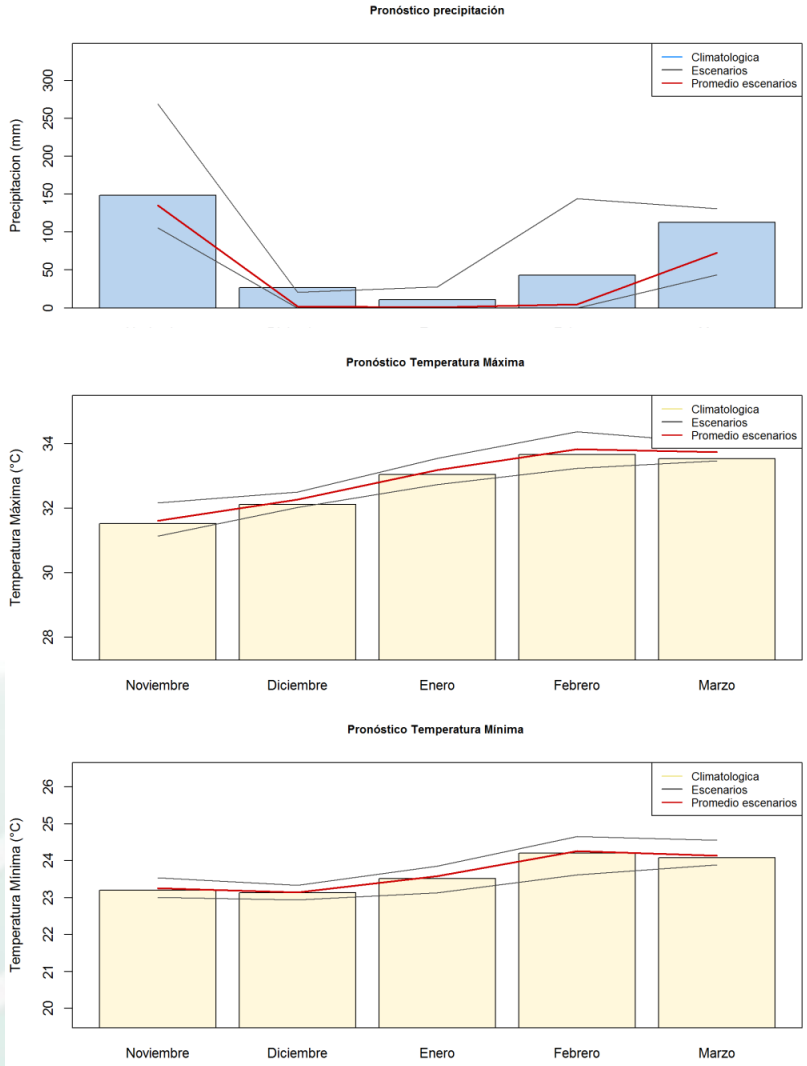
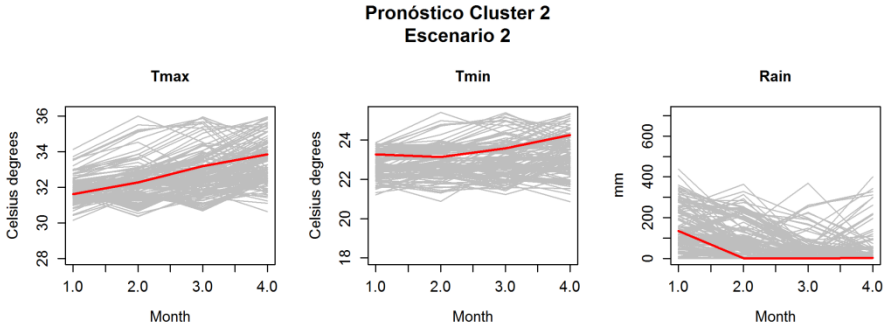
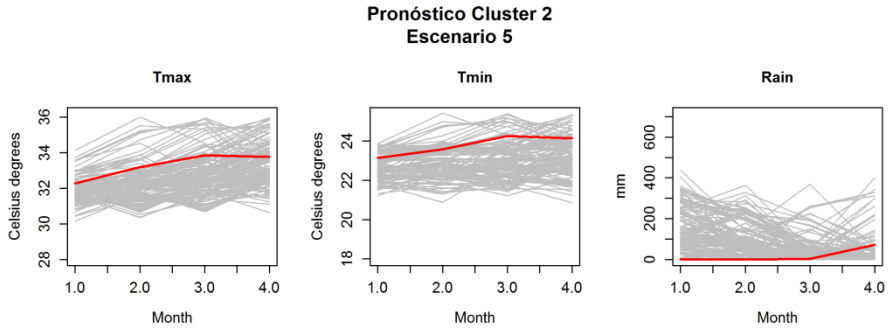


Cluster 2 -Scenario 2 NovDecJanFeb

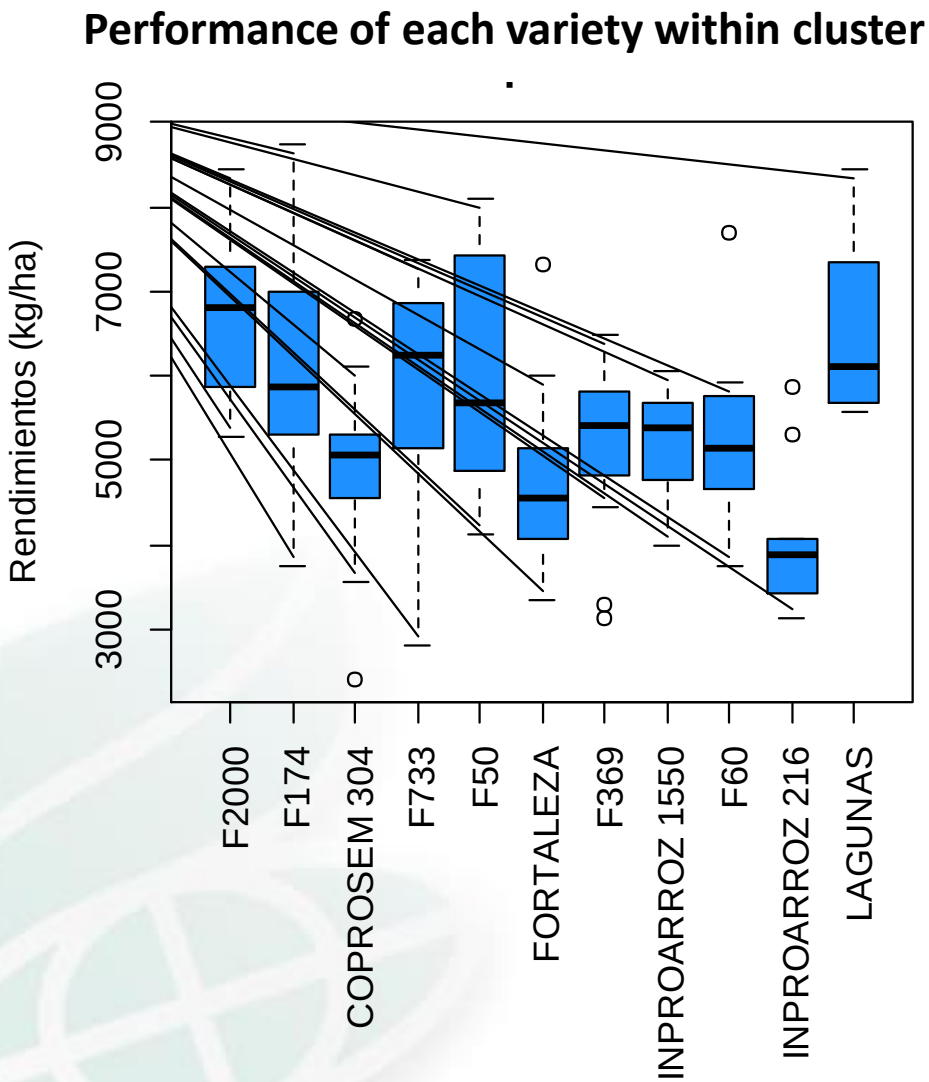


Cluster 2 - Scenario 5 DecJanFebMarch



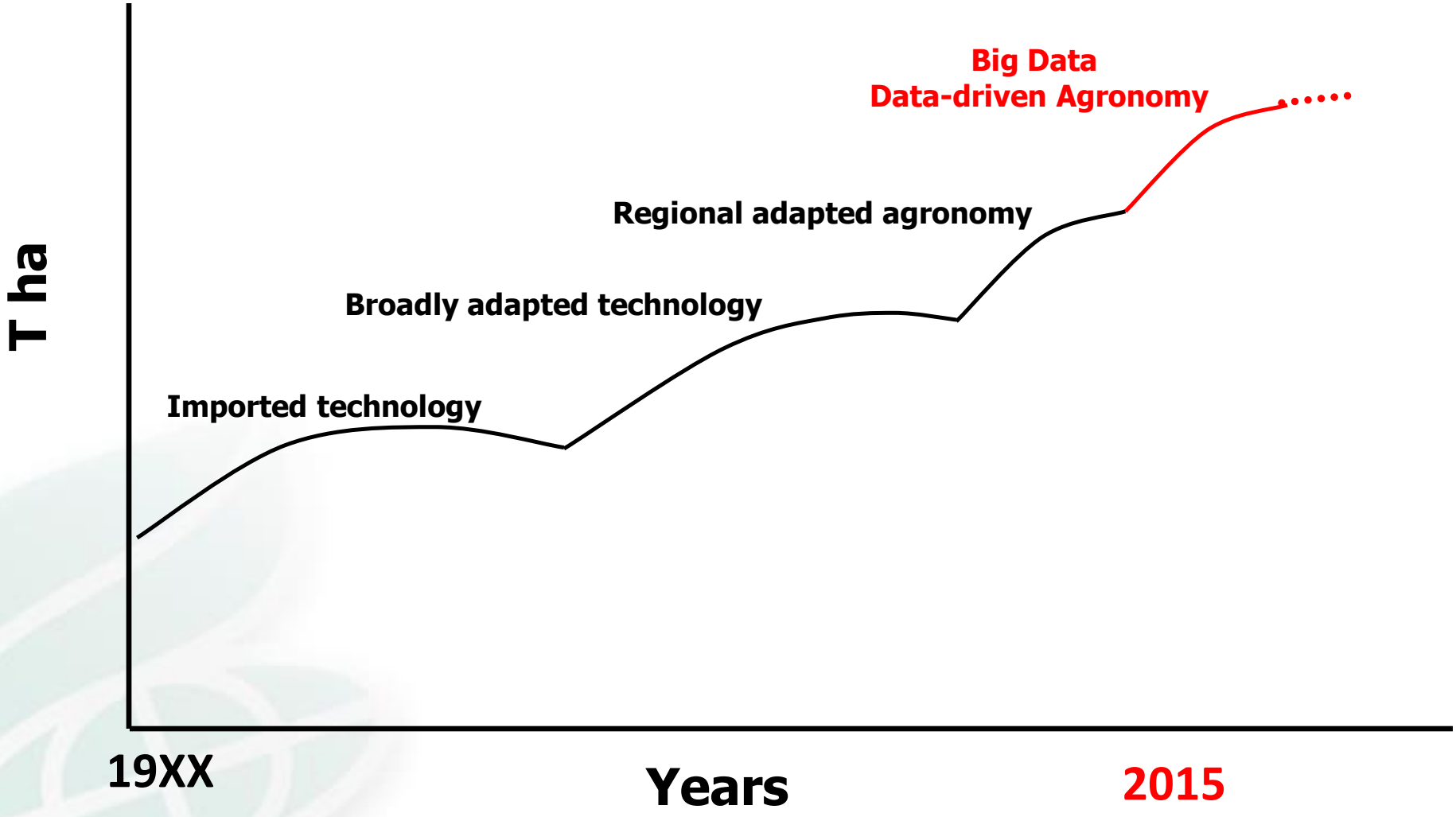
Historical profiling – What to grow?

Region: Casanare: 2007 – 2014 – Irrigated
Weather stations from FEDEARROZ e IDEAM
(N= about 756 cropping events) – 17 clusters



Rice variety	Number of cropping events	Productivity (Kg/Ha)
F2000	39	6,717
F174	27	5,979
COPROSEM 304	25	4,973
F733	23	5,981
F50	22	5,922
FORTALEZA	21	4,641
F369	18	5,244
INPROARROZ 1550	16	5,180
F60	12	5,189
INPROARROZ 216	9	4,104
LAGUNAS	7	6,598
Total	219	5,653

Some of the reasons why this is so exciting!!!



Some of the reasons why this is so exciting!!!

Scalability

Tropics: Climate-smart, site-specific agriculture:

FLAR

Temperate: Big Data for Climate Smart Agriculture - Enhancing & Sustaining Rice Systems for Latin America and the World:

CIAT
International Center for Tropical Agriculture
Since 1967 / Science to cultivate change

CGIAR

RESEARCH PROGRAM ON
Climate Change, Agriculture and Food Security

CCAFS

THE WORLD BAN
IBRD • IDA | WORLD BANK GROUP

CGIAR

Global Rice Science Partnership

Some of the reasons why this is so exciting!!!

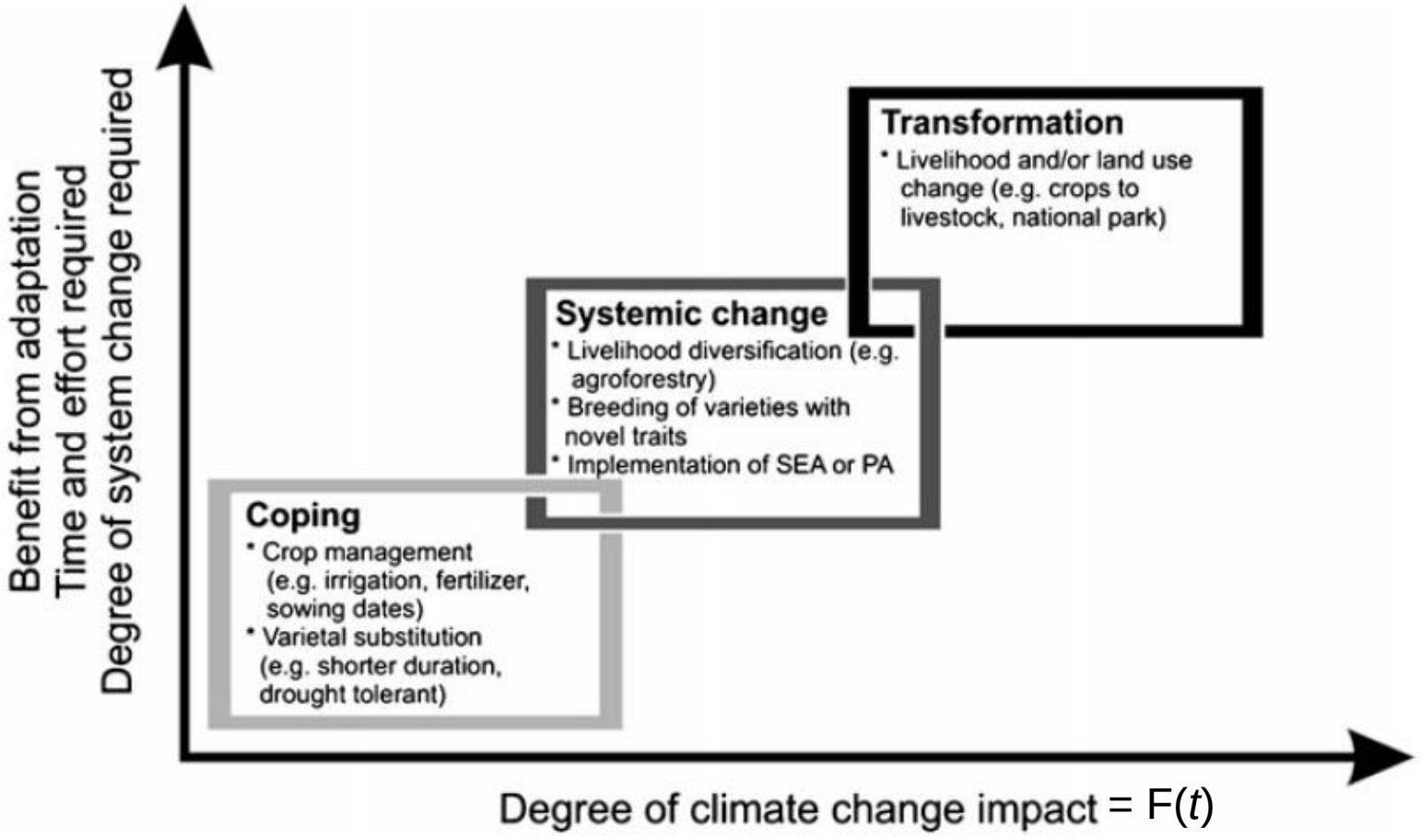
Internationally Recognized

UNITED NATIONS CLIMATE SUMMIT 2014 | BIG DATA CLIMATE CHALLENGE WINNERS

Big Data Climate Challenge Winners

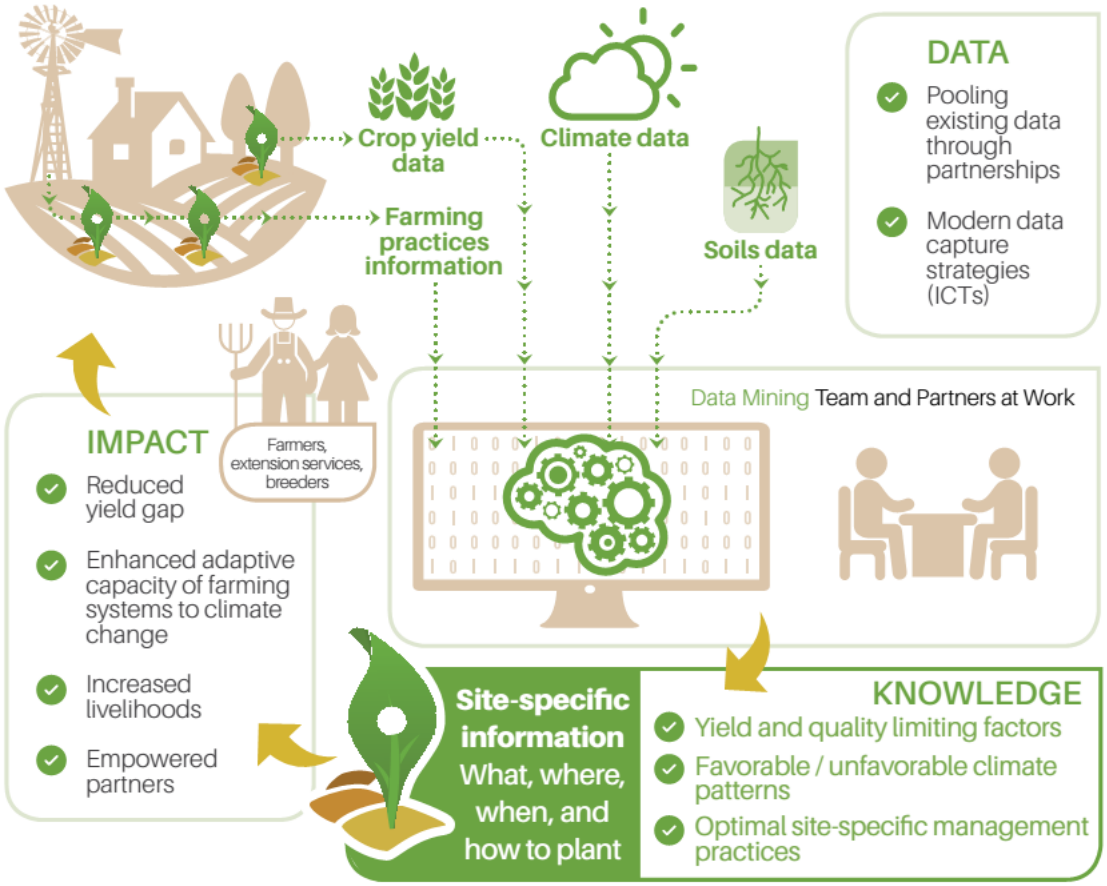
Last but not least….Interdisciplinary effort

Adaptation across timescales



Ramirez-Villegas and Khoury- Climatic Change (2013)

THANK YOU!!!



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