# Weather risk and Agriculture, strategic use of climate information


**Marina Baldi**

**IBIMET-CNR, Rome - Italy**

**WMO - Regional Training Center, Italy**



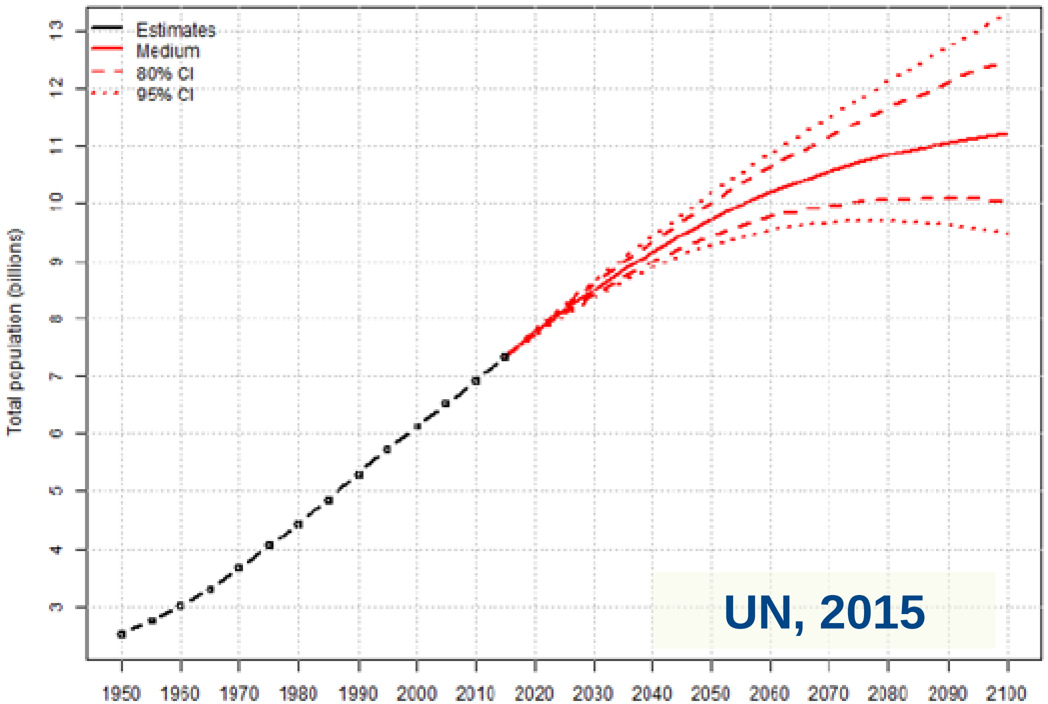
*Agrometeorologists for farmers in hotter, drier, wetter future*
*Lubljana, 9-10 November 2016*

# Pressure on Agriculture


**FAO, 2009**

# Population & Agriculture

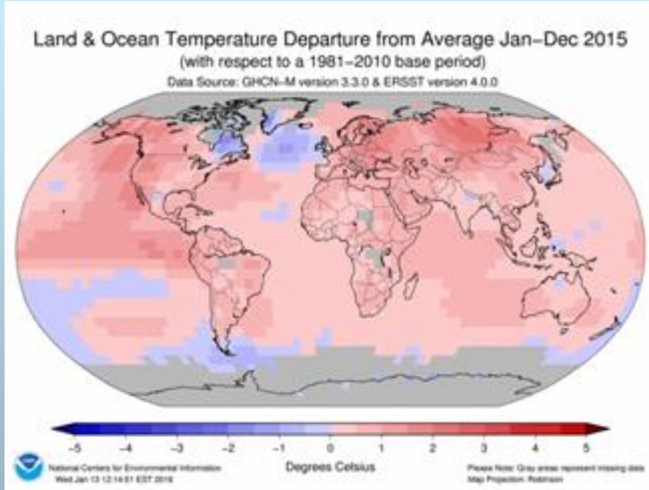
**Figure 2. Population of the world: estimates, 1950-2015, medium-variant projection and 80 and 95 per cent confidence intervals, 2015-2100**



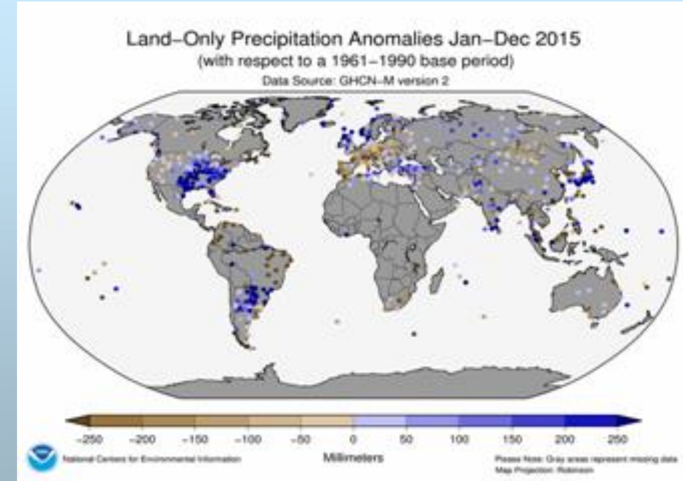

*Source:* United Nations, Department of Economic and Social Affairs, Population Division (2015). *World Population Prospects: The 2015 Revision*. New York: United Nations.

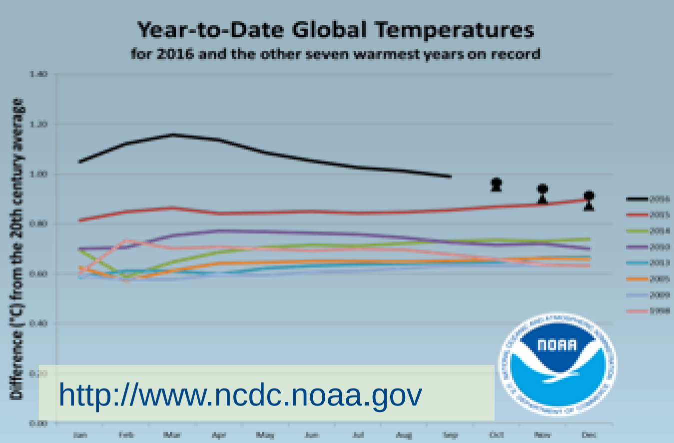
- Currently, the world population continues to grow by 1.18 per cent per year, or approximately an additional 83 million people annually.
- World population is projected to reach 8.5 billion in 2030, and to increase to 9.7 billion in 2050 and 11.2 billion by 2100.
- **FAO estimates that agricultural production will have to increase by 60% by then.**
- Agriculture should undergo a significant transformation to feed the growing global population.
- Climate change adds extra challenges in reaching this goal – esp. developing countries where food insecurity & poverty are prevalent.

# Climate Change




Scientific evidence for warming of the climate system is unequivocal (IPCC).



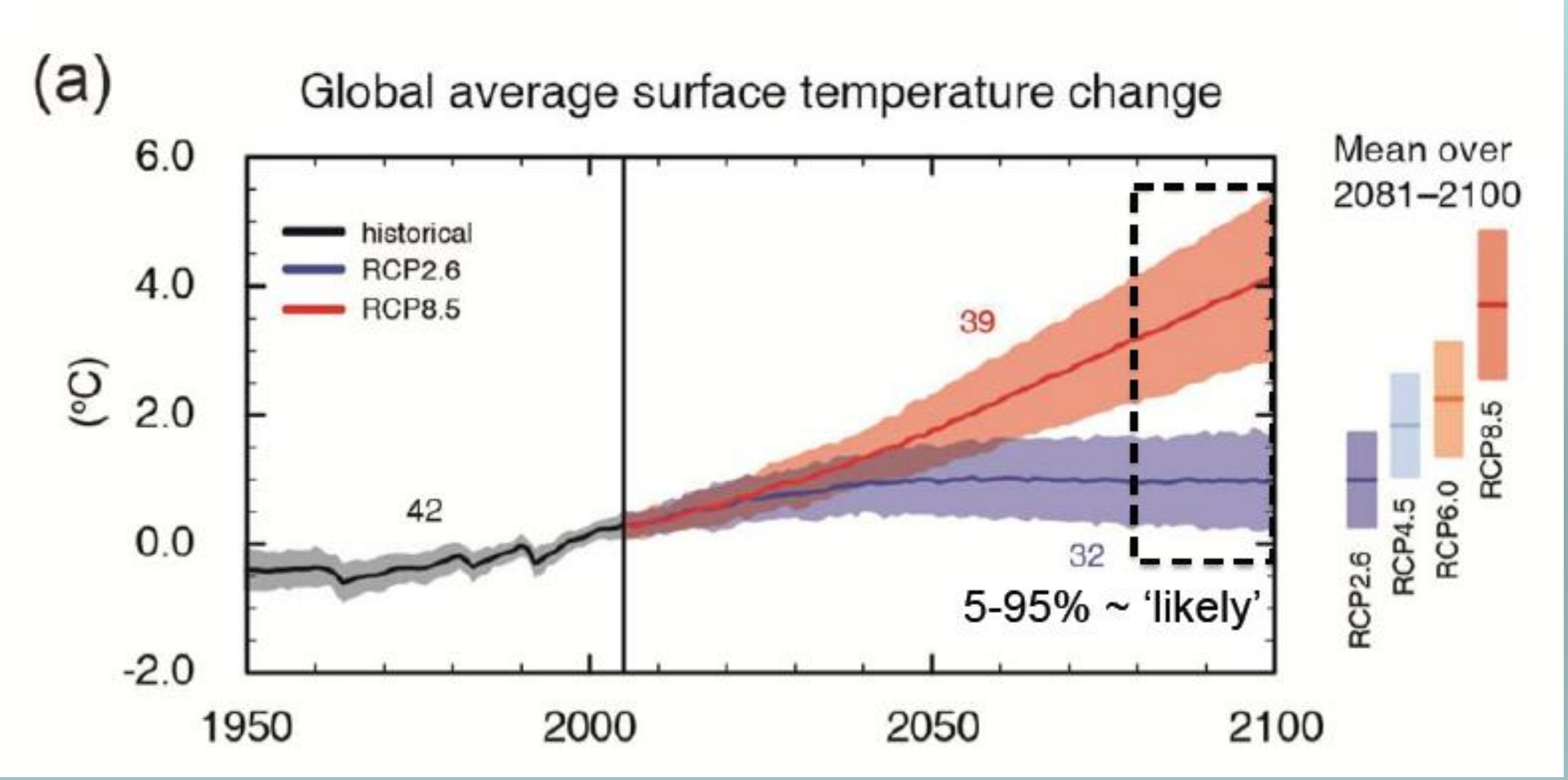

http://www.ncdc.noaa.gov

Today, climate change is one of the major challenges and adds considerable stress to societies and environment: Shifting weather patterns threaten food production, Rising sea levels increase the risk of catastrophic flooding.

Impacts of climate change are global in scope and unprecedented in scale. Without drastic action today, adapting to these impacts in the future will be more difficult and costly.

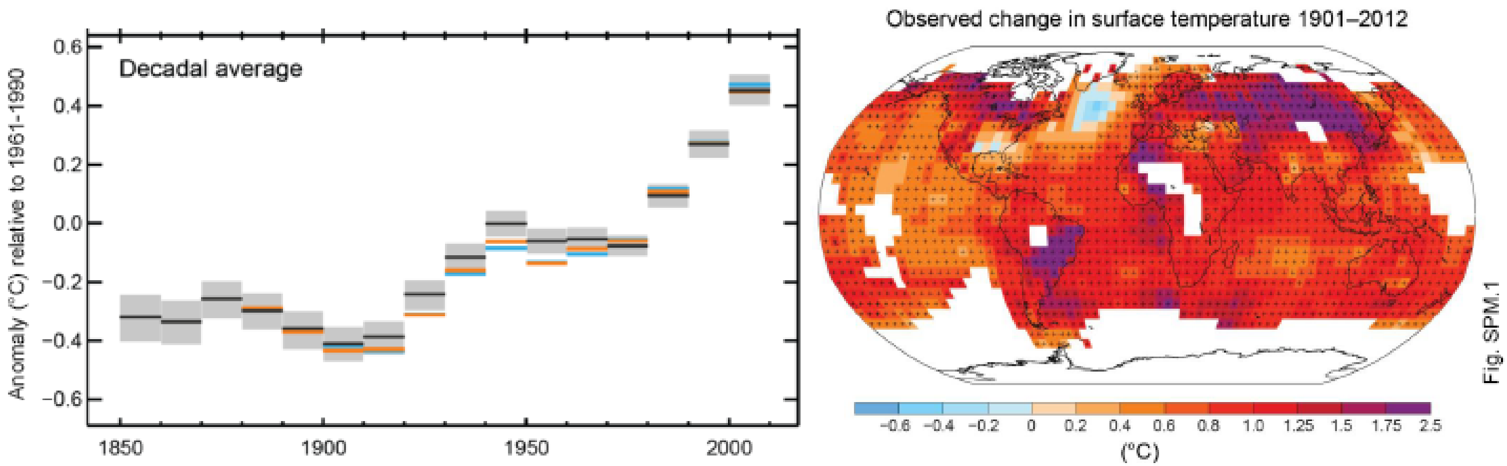
## **Global Mean Surface Air Temperature Change**

Anomalies w.r.t 1986-2005 average




- More hot and fewer cold extremes
- Global mean precipitation increases
- Regional patterns of precipitation change not uniform
- N. Hemisphere storm track changes – *low confidence*

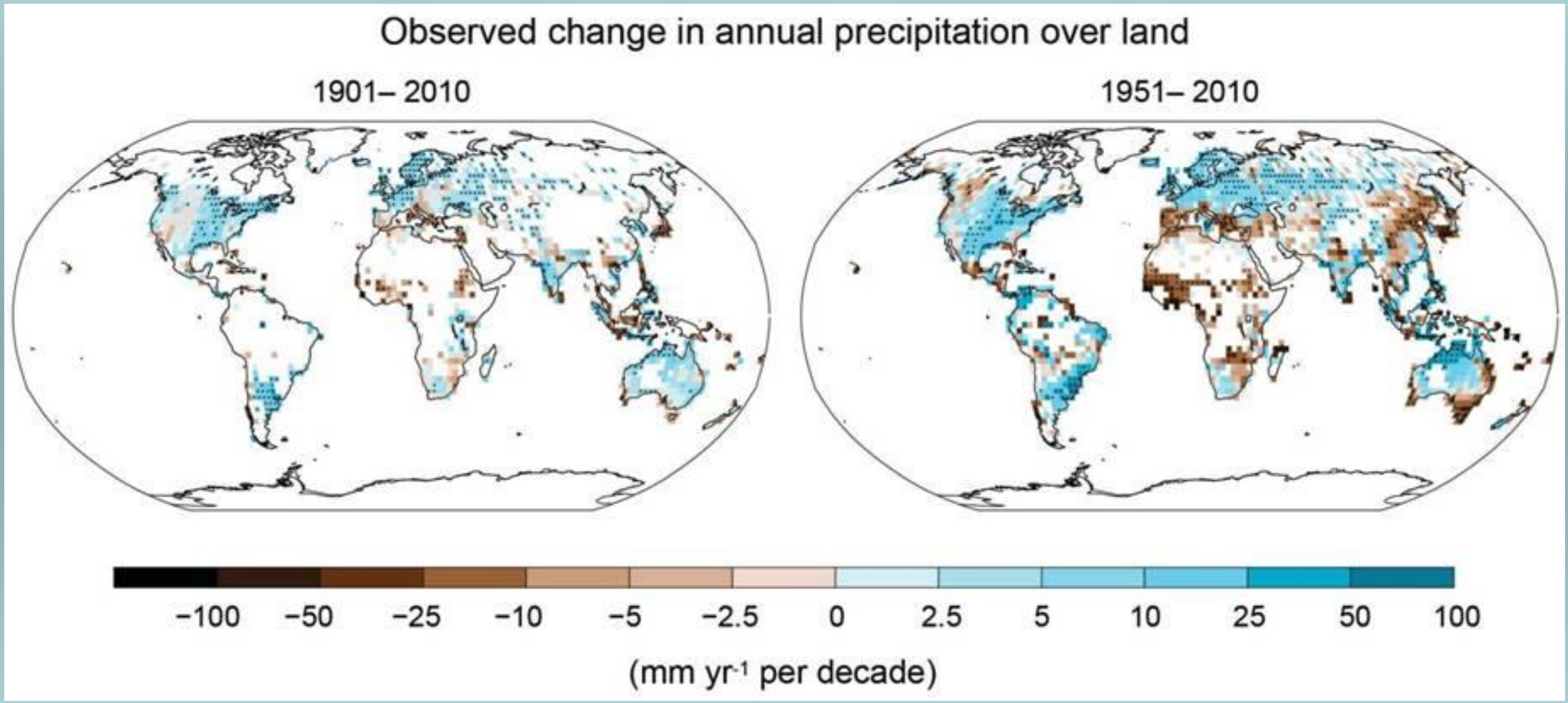
# Global temperature - Observed trend




Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.

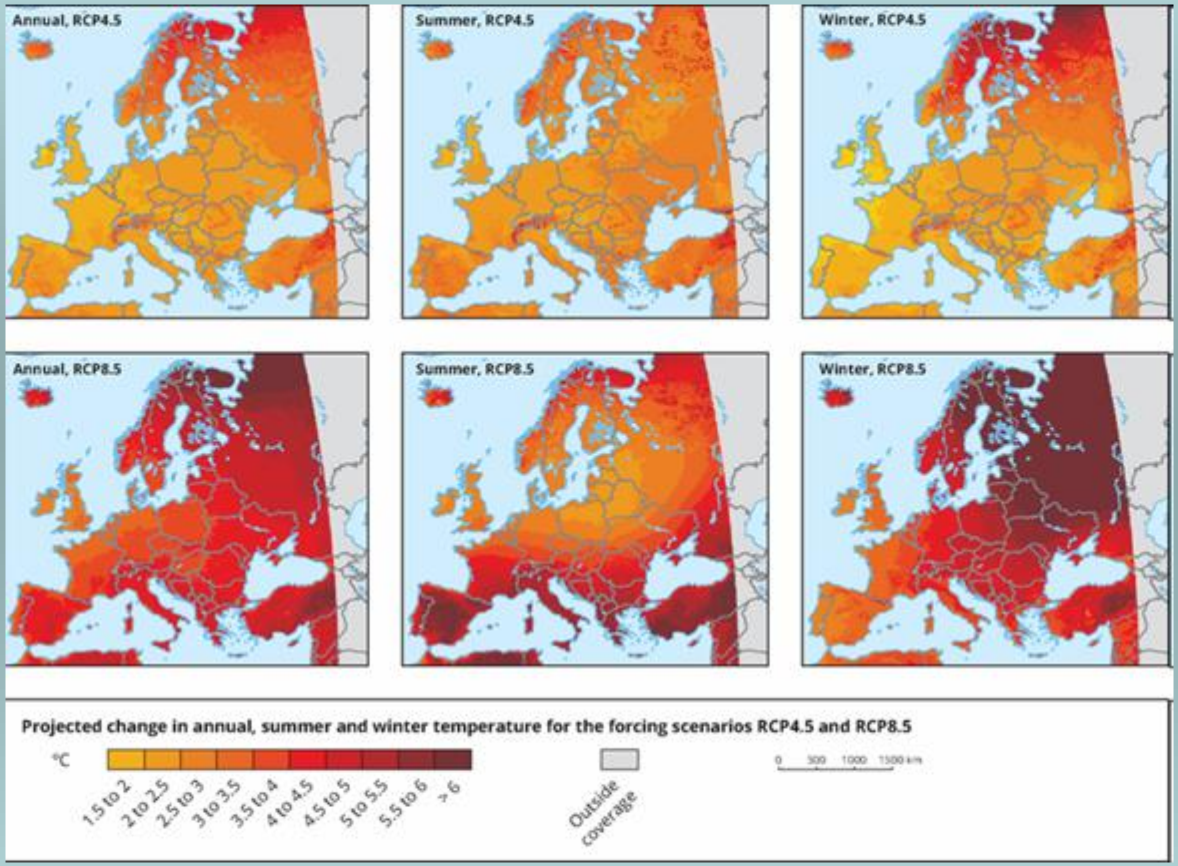
**The observed warming 1951−2010 is approx 0.6°C to 0.7°C. In the Northern Hemisphere, 1983–2012 was likely the warmest 30-year period of the last 1400 years**

# Global precipitation over land Observed trend



European Environment Agency

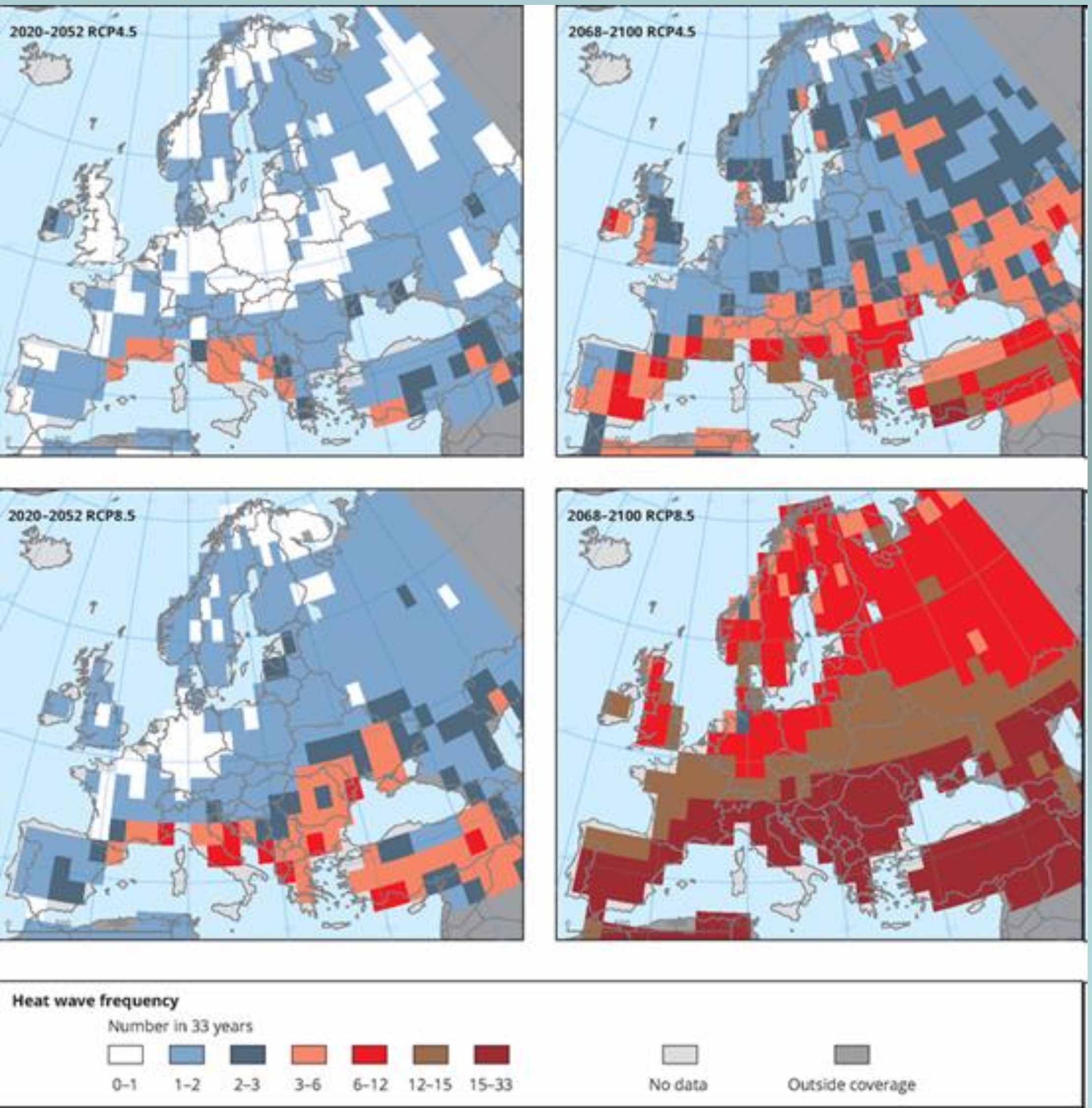
# Projected changes in annual, summer and winter temperature: 2071-2100




Projected changes in annual (left), summer (middle) and winter (right) near-surface air temperature (°C) in the period 2071-2100, compared to the baseline period 1971-2000 for the forcing scenarios RCP 4.5 (top) and RCP 8.5 (bottom). Model simulations are based on the multi-model ensemble average of RCM simulations from the EURO-CORDEX initiative.

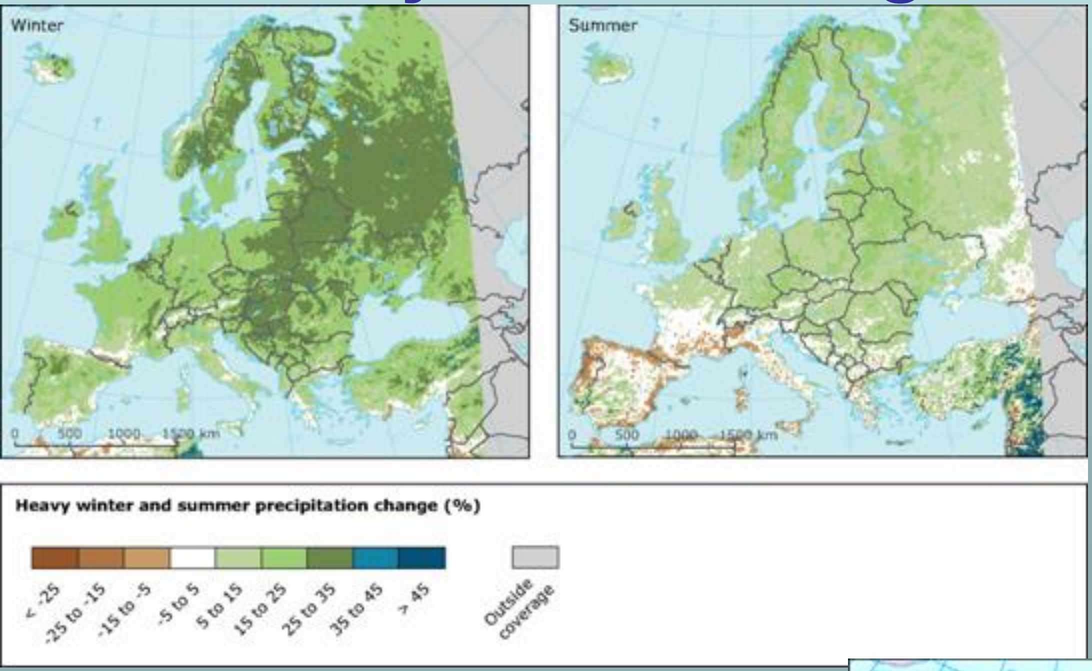
European Environment Agency

# **Number of extreme heat waves in future climates under two different climate forcing scenarios i**n the near future (2020–2052) and the latter half of the century (2068–2100)



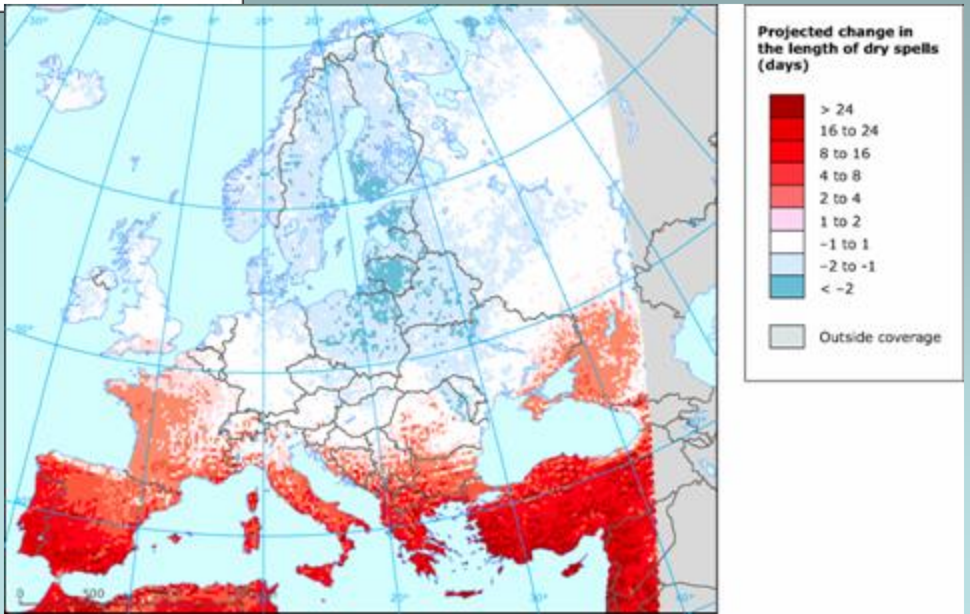

The top maps show the median of the number of heat waves in a multi-model ensemble of the near future (2020–2052) and the latter half of the century (2068–2100) under the RCP4.5 scenario, and the lower maps are for the same time periods but under RCP8.5

# Projected changes in precipitation




Projected changes in heavy precipitation from 1971-2000 to 2071–2100

Projected changes in dry days from 1971-2000 to 2071–2100



# Climate Change: Why a half-degree temperature rise is a big deal

The Paris Agreement calls for limiting the increase in global temperature by the end of this century to no more than 1.5 to 2 degrees Celsius.

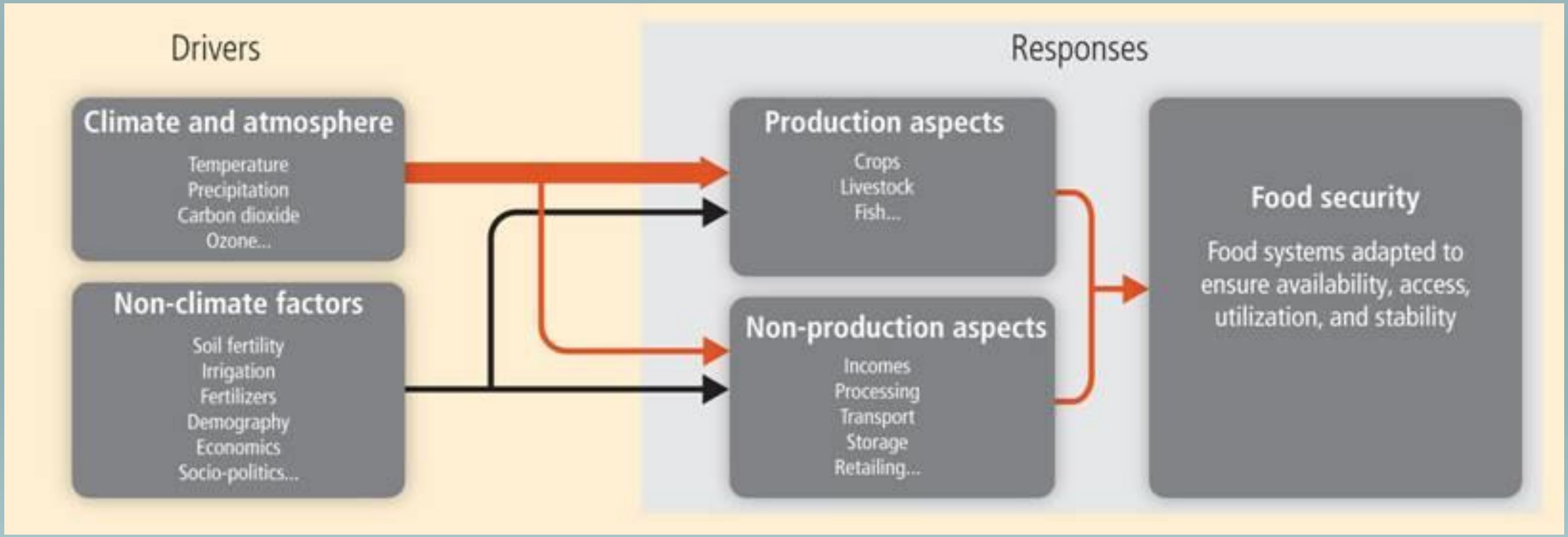
A recent study projects the following impact of a 2-degree rise compared to a rise of 1.5 degrees:

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

- Heat-wave duration, rainstorm intensity and sea-level rise would increase by roughly a third (and sea level is likely to continue rising long after air temperature is stabilized).
- There would be a disproportionately greater impact on certain basic crops.
- **The Mediterranean area's reduction in fresh water would double.**
- Tropical coral reefs would be wiped out.

# Climate Change Impacts on Agriculture

A food system is all processes and infrastructure involved in satisfying a population's food security, that is, the gathering/catching, growing, harvesting (production aspects), storing, processing, packaging, transporting, marketing, and consuming of food, and disposing of food waste (non-production aspects)




The impacts of climate change on food systems are expected to be widespread, complex, geographically and temporally variable, and profoundly influenced by socioeconomic conditions.

Risks to food security are generally greater in low latitude areas.

# Climate Change Impacts on Agriculture

- **Climate change has already significantly impacted agriculture and is expected to further impact directly and indirectly food production.**

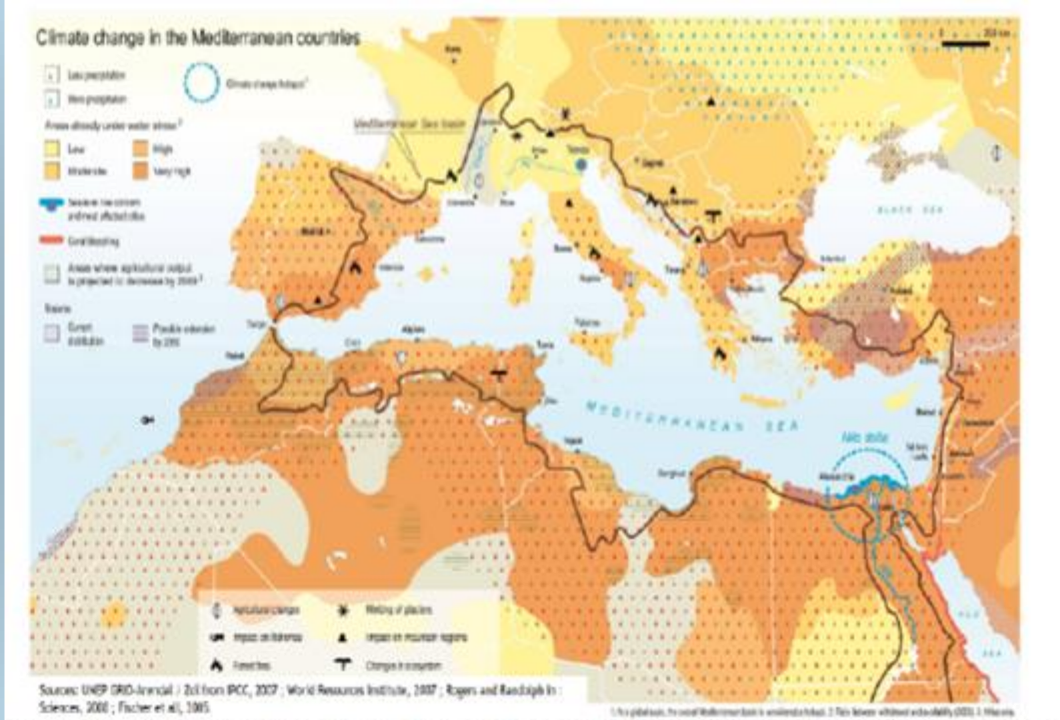
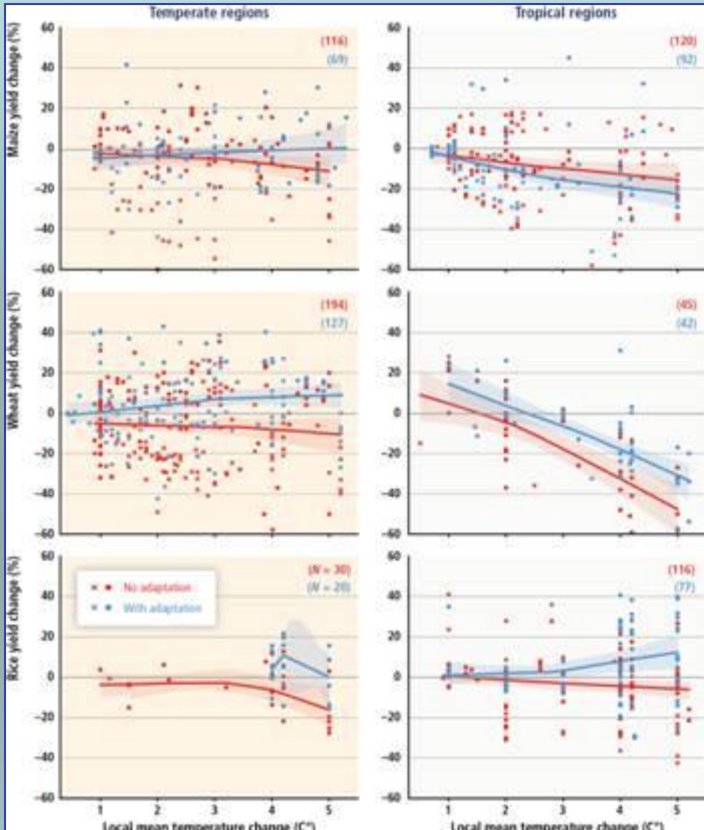
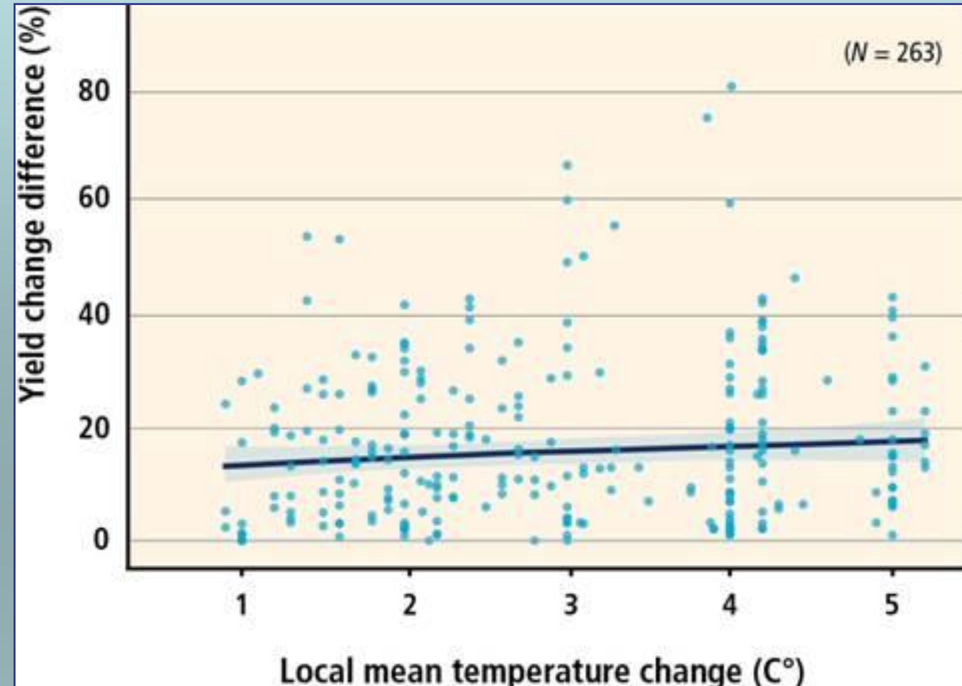



Figure 1.1. Synthesis of the climate change effects and vulnerabilities in the Mediterranean (Plan Blue 2009)

- **The extent of these impacts will depend not only on the intensity and timing (periodicity) of the changes but also on their combination, which are more uncertain, and on local conditions.**

# Climate Change Impacts on Agriculture




Percentage simulated yield change as a function of local temperature change for Maize, Wheat, Rice in temperate and tropical regions.

Simulated yield benefit from adaptation calculated as the difference between the yield change from baseline (%) for paired non-adapted and adapted cases as affected by temperature and aggregated across all crops.

# Climate-Smart Agriculture

Agriculture must undergo significant productivity improvements to meet the three growing and intertwined challenges: population growth, food insecurity and climate change.

Challenges are even more aggravated in developing Countries.

Consequently, there is a need to simultaneously improve agricultural productivity and reduce yield variability over time under adverse climatic conditions.

A proposed means of achieving such improvements is an increased use of a *Climate-Smart Agriculture (CSA)* approach which emphasizes the use of farming techniques that:

- sustainably increase agricultural productivity and incomes;
- adapt and build resilience to climate change, then reducing vulnerability;
- reduce and/or remove greenhouse gas emissions, where possible.

# Climate-Smart Agriculture

**In order to reduce vulnerability to climate risks it is necessary to adopt climate-smart production practices, and develop climate-resilient livelihoods, and therefore it is necessary to:**

**Work to improve farmers' ability to access and use climate-related information and tools**

**Develop interactive communication channels (mobile phones, interactive radio programming, ….)**

**Develop and provide tailored and "usable" climate information and services**

**Narrow the climate information usability gap (potentially useful climate information often goes unused)**

**Capacity building for climate services developers/providers in order to achieve an adequate set of competencies as recommended by WMO**

# Climate Services

What do an air conditioning engineer, a farmer and a city planner have in common?

Each uses climate information to do his or her job properly.

Making climate data and information available to these professionals – and to countless millions of others facing diverse questions and decisions – is the task of climate services.

# Climate Services: fact sheet

**A climate service delivers tailored climate information, consulting, training and customized decision tools to end users aiming at reducing the vulnerability of their actvities and optimize investments in view of climate variability**

**A climate service is built upon an iterative and mutual learning process involving end users and providers.**

**The key is the development of stakeholder-led climate services**

**<u>Who are the climate services stakeholders?</u>**

**– Why is climate variability and change relevant to them?**

**– How do climate issues fit within their decision making mechanisms**

**and their perception of risk?**

**<u>What do they need/want from climate services?</u>**

**– Specific data**

**– Analysis tools**

**– Guidance and training**

**– Other …..**

# Climate Services for Agriculture

With frequent references in the media to climate change, the public requests of information on climate and its impacts has increased and continues to increase rapidly

Climate analysis tools need to be implemented and developed in order to respond to the increased demand for local climate information, specifically tailored on User needs.

Climate tools provide rapid responses to climate questions that in the past required an extensive data search, a research on analysis techniques and complex graphical rendering

Climate tools offer easy and efficient access to scientifically sound analytical capabilities and trusted climate data.

Results obtained from climate tools provide relevant climate information on climate impacts for water and weather events to local technical users, decision makers, and educators that will help build a healthy population, create resilient communities, and contributes to preparedness activities and advance planning in the face of our changing climate.

At the present time, the climate community continues to investigate methods for better communicating climate information.

# Global Framework for Climate Services: fact sheet

Climate services provide climate information in a way that assists decision making by individuals and organizations.

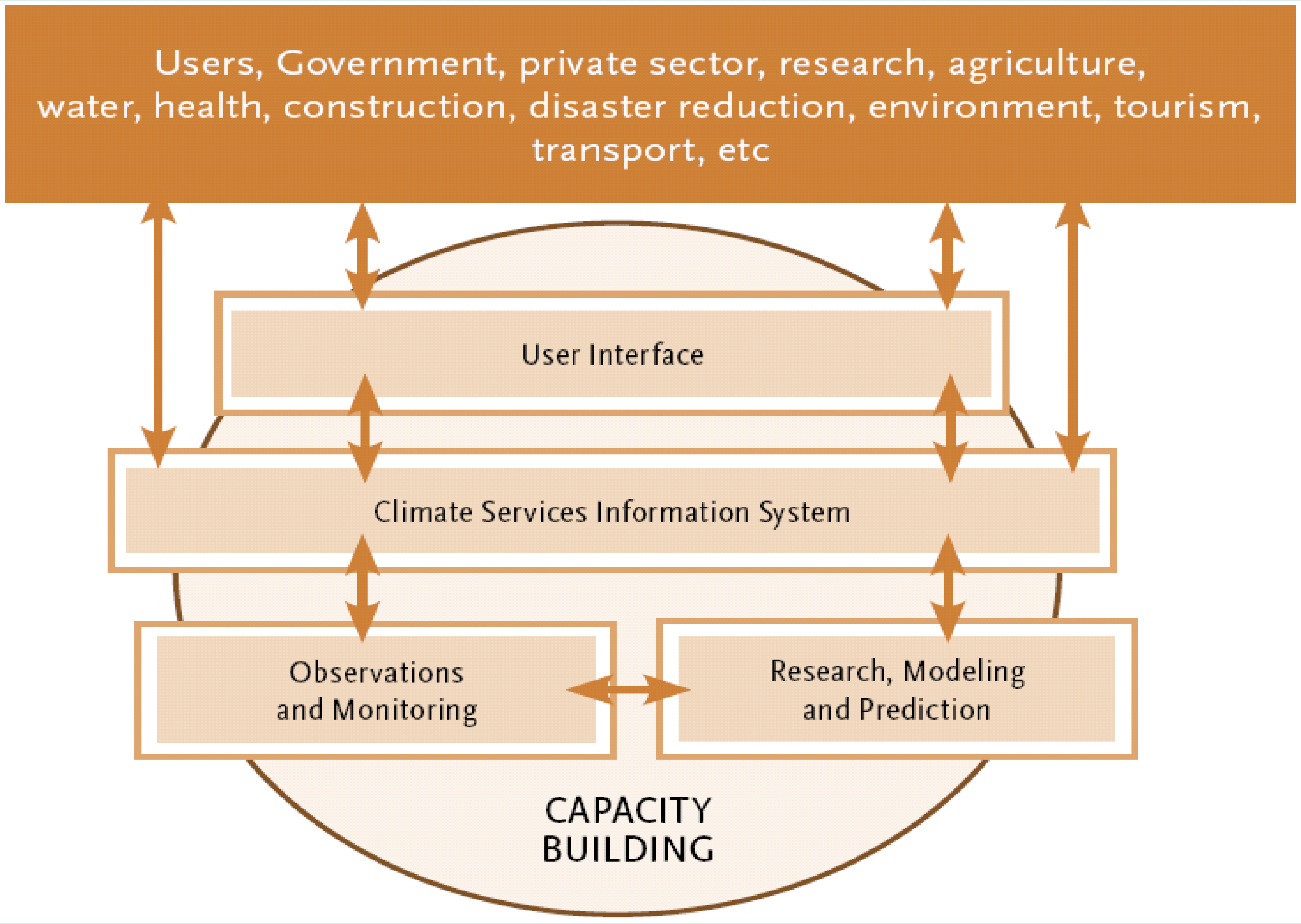
Depending on the user's needs, these data and information products may be combined with non-meteorological data, such as agricultural production, health trends, population distributions in high-risk areas, road and infrastructure maps for the delivery of goods, and other socio-economic variables.

Many countries lack the infrastructural, technical, human and institutional capacities to provide high quality climate services.

The international community established the Global Framework for Climate Services (GFCS) to promote operational climate services at the national and regional levels.

GFCS provides a worldwide mechanism for coordinated actions to enhance the quality, quantity and application of climate services.

# Pillars of the GFCS



# Users needs:
# temporal and spatial scales

Table 1. *Agricultural decisions at a range of temporal and spatial scales that could benefit from targeted climate forecasts (Meinke & Stone 2005).*

| Farming decision type | Climate system frequency (years) |
|---|---|
| Logistics (e.g., scheduling of planting/harvest operations) | Intraseasonal (> 0.2) |
| Tactical crop management (e.g., fertiliser/pesticide use) | Intraseasonal (0.2–0.5) |
| Crop type (e.g., wheat or chickpeas) or herd management | Seasonal (0.5–1.0) |
| Crop sequence (e.g., long or short fallows) or stocking rates | Interannual (0.5–2.0) |
| Crop rotations (e.g., Winter or summer crops) | Annual/bi-annual (1–2) |
| Crop industry (e.g., grain or cotton; native or improved pastures) | Decadal (~10) |
| Agricultural industry (e.g., crops or pastures) | Interdecadal (10–20) |
| Landuse (e.g., agriculture or natural systems) | Multidecadal (>20) |
| Landuse and adaptation of current systems | Climate change |

# Users needs

**Three main climate services are required for agriculture:**

Assessment of extreme weather and climate events

- make informed decisions
- long-term investment in infrastructure and land settlements
- making cost-effective choices for which construction methods to use, and how much heating and cooling is needed for critical infrastructure.

Climate predictions on monthly to seasonal to decadal (10-year) time scales help to make decisions on

- which variety to plant and when,
- how much water is needed for irrigation,
- when and where disease outbreaks are likely to occur,
- whether to reduce livestock numbers in case of drought.

Climate change projections on precipitation and temperature patterns in the time frame of 30–50 years help

- to guide major investment decisions relating to long-term water management,
- to guide policy on food security aspects.

# Climate information needs of users and related knowledge gaps

## Decision-making process and user information gaps

1 **Strategic ahead-of-season planning**

**(1- 12 month lead time)**

2 **Risk monitoring and management: intra-season operations**

**(1wk to 40 days range)**

- timing/duration/intensity of dry/ wet spells

3 **Longer-term strategic planning/policy development (next 1-10 years)**

- Trends/frequencies of rainfall/temperature over next 5-10 years

4 **Climate change adaptation policy development/planning (next 50 years)**

- Robust climate change projections
- Information on the role of climate change in observed events

## Climate Research Frontier

1 **Improving Seasonal prediction**

Remote drivers of variability (SSTs, teleconnections, MJO, etc)

Local drivers of variability (land-atmosphere coupling)

2 **Sub-seasonal prediction**

Improved understanding of sources of sub-seasonal predictability

3 **Decadal prediction**

Drivers of decadal and multi-decadal variability

Role of GHG, aerosols

4 **Climate change scenarios**

Earth System Modelling

Attribution methodology

Understanding Uncertainty

# Linking Scientists, NMHS, Farmers: a 3 steps process

1. Weather, Climate, and Climate Change of the Region and Farming Risks

Provide information on weather and climate in the region:

a) Weather

- Short term weather forecasts
- Clouds
- Weather maps
- Weather forecasting terms

b) Climate

- Seasonal climate patterns
- forecasting
- drought alerts
- using rainfall records

c) Future climate change in their region and implications

d) Climatic risk in production of different crops in each region

e) Better risk management

# Linking Scientists, NMHS, Farmers: a 3 steps process

## 2. Farmer Perception of Weather and Climate Information Provision and Feedback

Obtain feedback from the farmers on the weather and climate issues in their farming operations and the nature of assistance they need.

Exchange of ideas and information.

Engagement of all the actors in discussions in order to obtain full information from the farmers on their needs for weather and climate information and the ways and means to improve future communication of weather and climate information to them to facilitate effective operational decision making.

# Linking Scientists, NMHS, Farmers: a 3 steps process

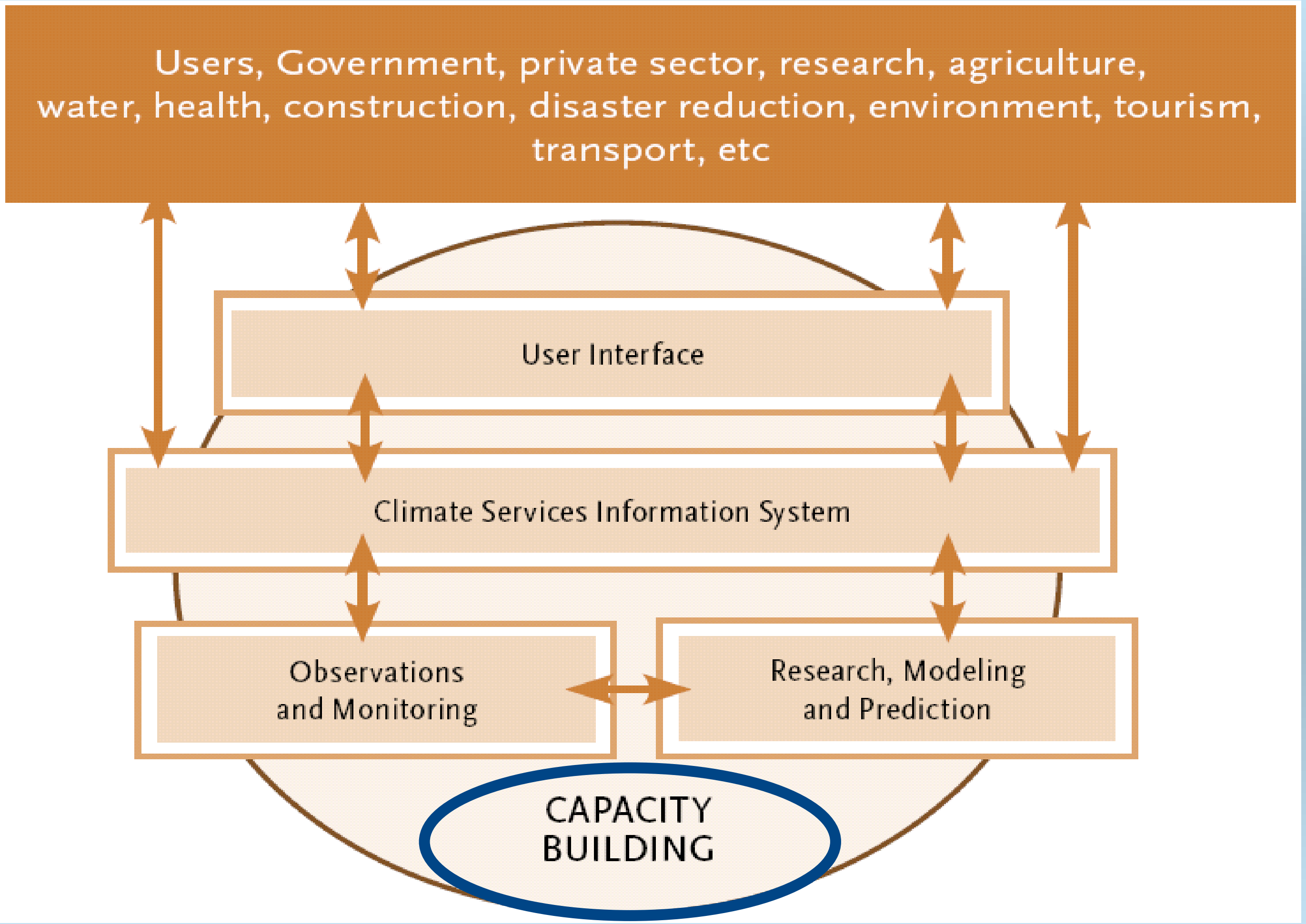
## 3. Implementation and distribution of tailored Climate Services

- Capacity Building
- Communication
- Timely provision of location-specific forecasts, early warnings, & advisories
- Enhancing capacities of met services, communicators, farmers, climate and agriculture scientists
- Use of crop & climate information services to transform climate risk agriculture to climate smart agriculture
- Enhance infrastructure and human capacities to improve delivery of agro-climatic service

**Climate prediction for agriculture**

Climate prediction information has the potential to reduce the impact of adverse weather events.  This will occur because the advance notice will allow decision makers the opportunity to implement plans to minimize the impact of adverse events and find opportunities within favorable events.

# Pillars of the GFCS



# Competency framework for the provision of Climate Services

**The institutions (*NMHS, Research Institutes, Universities*), through collective skill of their staff, should demonstrate the following competencies, or an appropriate set of them, according to their mission and institutional capacity:**

- **Create and manage climate data sets;**
- **Derive products from climate data;**
- **Create and/or interpret climate forecasts and model output;**
- **Ensure the quality of climate information and services;**
- **Communicate climatological information with users.**


Agriculture and food security


Disaster risk reduction

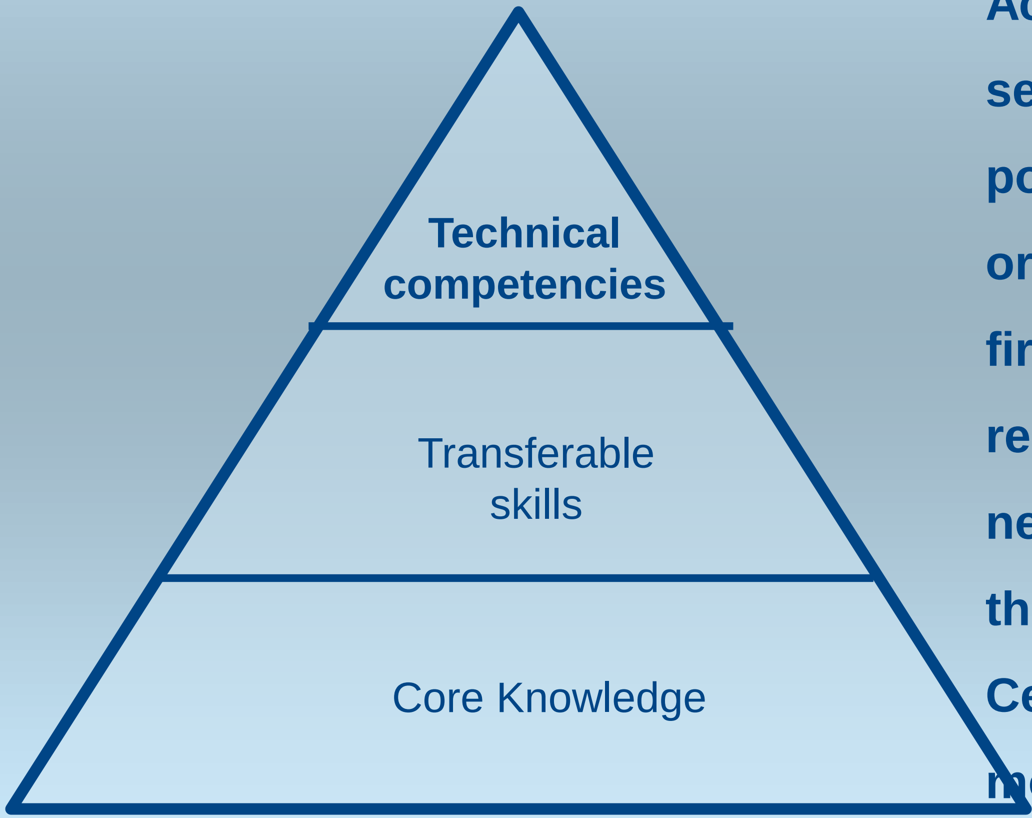

Water


Health


Energy

# Competency framework for the provision of Climate Services

- **Competencies Hierarchy shows how the technical competences are the uttermost competencies needed to acquire the ability to do something successfully or efficiently.**




**Acquisition of technical climate services competencies is only possible in an complex organizational context, which needs first to identify current training resources and then develop the necessary specific programmes in the framework of Regional Training Centers (WMO-RTC) network and, more, in the framework of the WMO Global Campus.**

## IBIMET-CNR and WMO-RTC – Italy will host the

# MedCOF7

# The Second MedCOF Training Workshop on “Verification of Operational Seasonal Forecasts in the Mediterranean Region”

**The 7th session of the Mediterranean Climate Outlook Forum (MedCOF 7)**

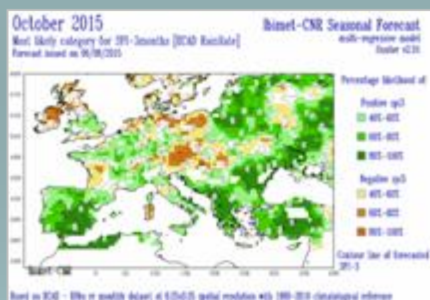
**The 16th session of the South East European Climate Outlook Forum (SEECOF 16)**

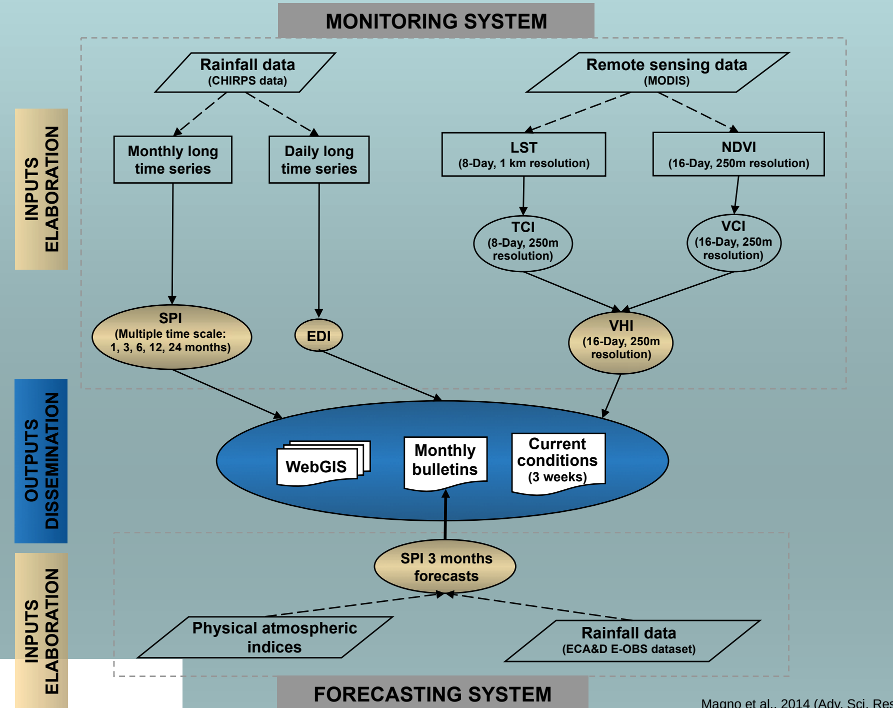
**The 10th session of the Northern African Climate Out- look Forum (PRESANORD 10)**

## Rome, 15-23 Novembre 2016

(M. Pasqui et al.)

# Climate variability and extreme events: implementation of a monitoring and forecasting system for drought

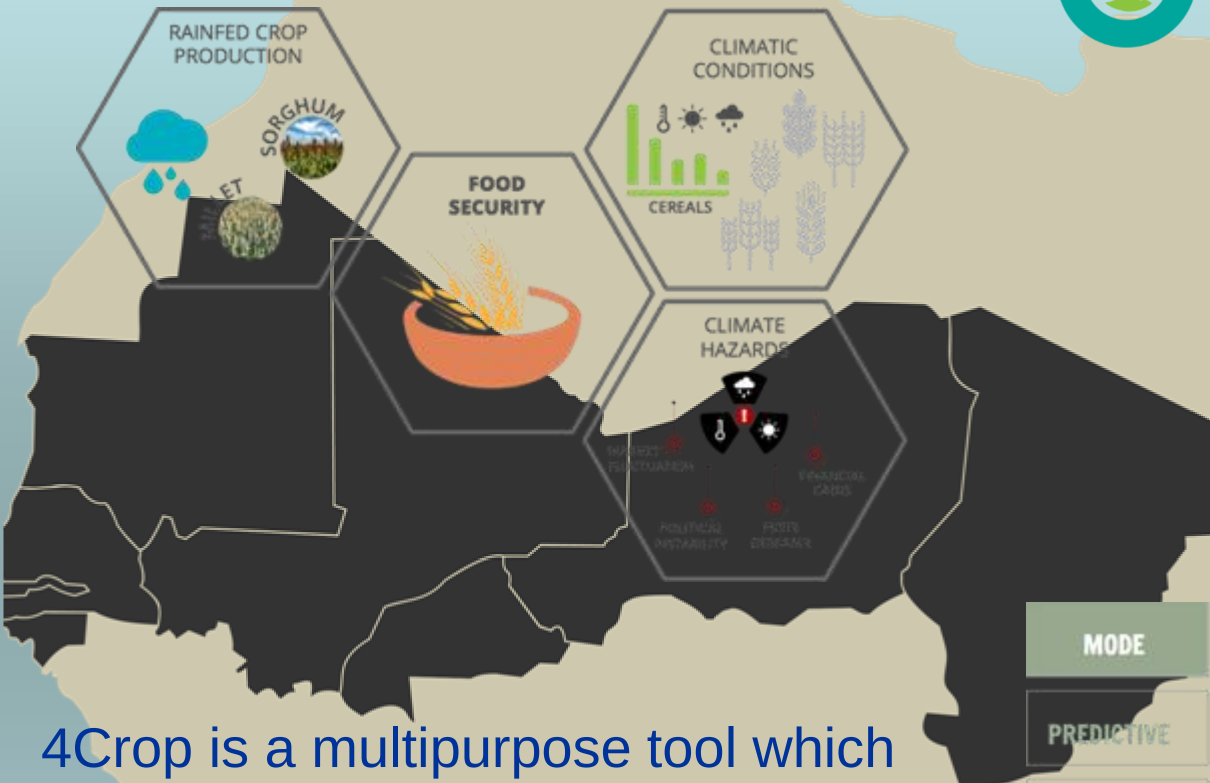

Magno et al., 2014 (Adv. Sci. Res.)

- **Development of a Country wide monitoring and forecasting system for dry conditions based on climate indices: EDI** - Effective Drought Index, **SPI** - Standardized Precipitation Index, **VHI** - Vegetation Health Index
- **Communication to users of forecast information and probability of agricultural risk areas and timing**

(T. De Filippis et al.)

4Crop

Suivi Zones à Risque




4Crop is a coherent Open Source web-based Spatial Data Infrastructure for agricultural drought monitoring and crop risk zones identification in Sub-Saharan Africa (Sahelian Region)

| MODE | SCOPE | ACTION | USERS |
|---|---|---|---|
| PREDICTIVE | SOWING ADVICE | PLANNING FIELD WORK REDUCE SOWING FAILURE | FARMERS EXTENSION SERVICES |
| | CROP STATUS PREDICTION | CROP RISK ZONES MONITORING | NATIONAL & REGIONAL EWSs |
| DIAGNOSTIC | DROUGHT MONITORING | DROUGHT MANAGEMENT | EXTENSION SERVICES AGRICULTURAL SERVICES |
| | CROP RISK ZONES IDENTIFICATION | FOOD INSECURITY VULNERABILITY ASSESSMENT | NATIONAL EWSs REG/INT ORGANIZATIONS & DONORS NAT/REG NETWORKS FOR FOOD CRISIS PREVENTION |

4Crop is a multipurpose tool which provides different categories of stakeholder - from farmers to policy makers - with effective and useful information for climate risk reduction and drought resilience improvement.

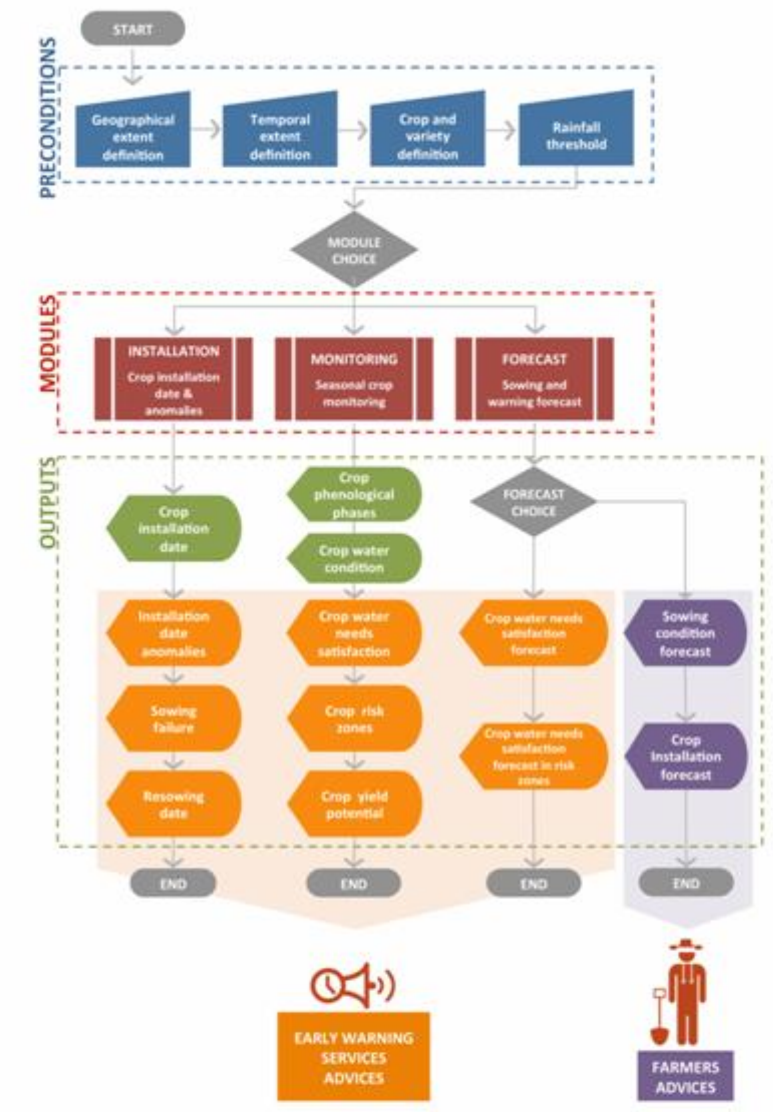
Consiglio Nazionale delle Ricerche
Istituto di Biometeorologia

GFDRR
Global Facility for Disaster Reduction and Recovery

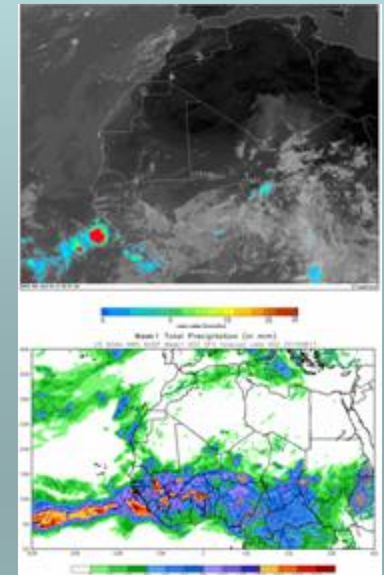
(T. De Filippis et al.)

# THE CROP RISK ZONE MODEL

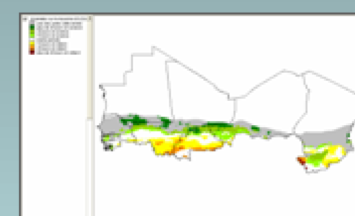
## For Sahelian Countries

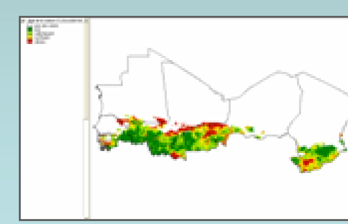



INPUT



OUTPUT





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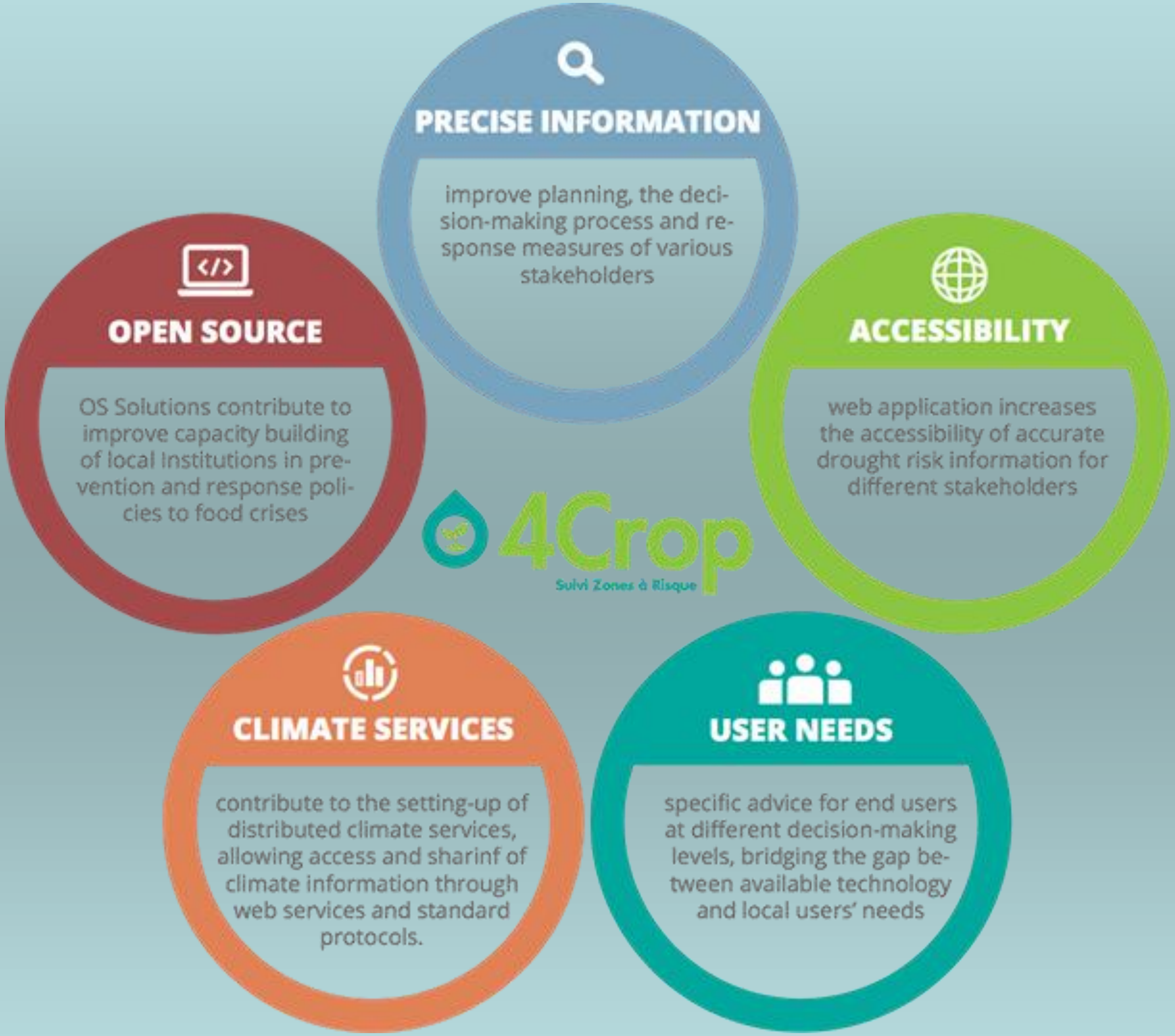
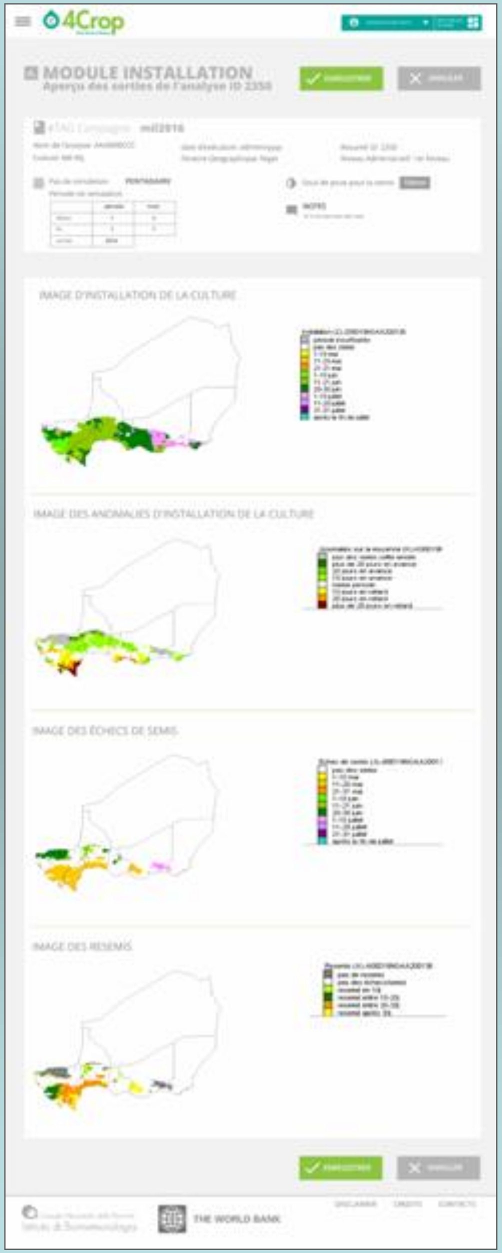
(T. De Filippis et al.)

4Crop
Suivi Zones à Risque



http://cma.entecra.it/sac/

# Forecast of heat stress risk for milk production

# Reciprocally beneficial actions/requirements

Linking meteorological and climate information with a wide range of farming decisions is a major challenge

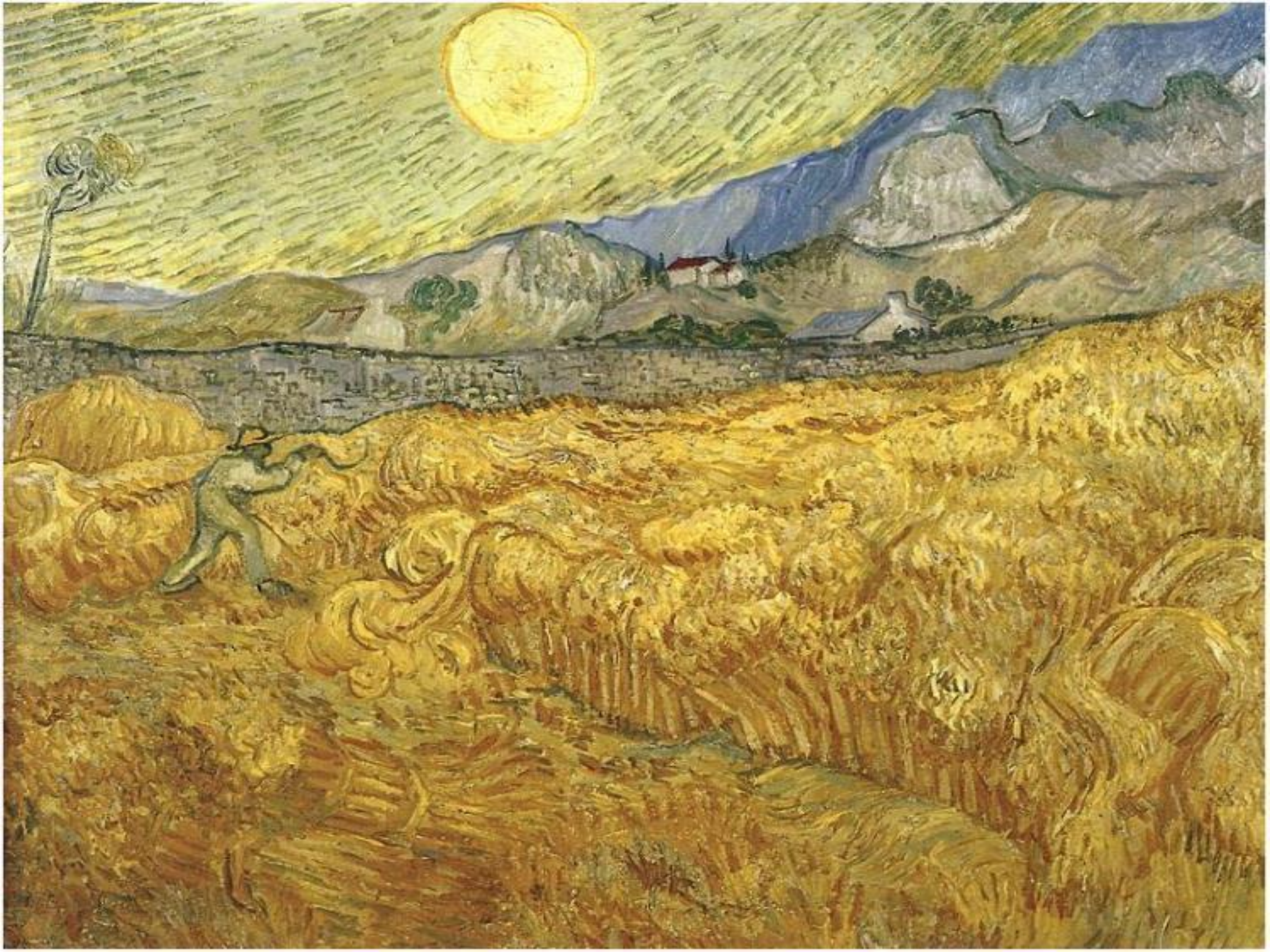
- Spaces for dialogue between farmers, communication agents, met services, scientists
- Use and understanding of cultural styles of participation and knowledge sharing as a basis for interaction
- Work at different scales: on both local and regional levels
- **Bridge the gap between Met and Agr research communities to integrate climate information into larger agricultural and rural development packages**
- Integrate Climate Services into National Plans: Create an institutional framework for the production of farmer focused climate services
- Multidisciplinary approach in producing climate services, and involve farmers and other disciplines from the beginning
- Participatory approach to provide farmers with ownership of the processes associated with development of weather and climate information and facilitates advances in linking climate and weather information and forecasts to farm decisions
- Co-production of climate services: engaging farmers in determining information packages via participatory platforms
- Capacity building

# *Thank you!*

**Marina Baldi**
**IBIMET-CNR, Rome - Italy**
**marina.baldi@cnr.it**

Consiglio Nazionale delle Ricerche
Istituto di Biometeorologia

# Extra slides



# How farmers around the world are making decisions based on weather and climate information

*As climate change threatens food production, climate information services are helping farmers in Africa and South Asia make better decisions in the short and long-term to adapt to changing growing conditions.*

| | Type of information | Vehicles for delivering information | Farmer decisions affected |
|---|---|---|---|
| **WEATHER** Days to weeks | • Observed rainfall and temperature<br>• Daily forecasts up to one week ahead of time<br>• Alerts on pests and diseases<br>• Early warning of extreme weather events | • Mobile phones<br>• Radio<br>• Television | • Timing of planting and harvest<br>• Timing of fertilizer, pesticide, and irrigation application<br>• Protecting lives and property from extreme events |
| **CLIMATE VARIABILITY** Months to Years | • Probabilities for seasonal rainfall and temperature conditions<br>• Seasonal climate variables targeted to particular agricultural risks (dry spells, rainy season start date, etc)<br>• Historical variability of climate variables | • Workshops with experts<br>• Conversations with agricultural extension agents (farm educators) | • Selecting crops and varieties<br>• Livestock stocking rates and feeding strategies<br>• Intensity of input use (fertilizer, pesticides)<br>• Labor or marketing contracts<br>• Intensifying and diversifying crops<br>• Diversifying sources of income |
| **CLIMATE CHANGE** Decades or longer | • Projections of future rainfall and temperature<br>• Historical trends in rainfall and temperature<br>• Historical changes in extreme events | • Workshops with researchers, agricultural extension agents, and meteorological services. | • Major capital investments (buying or expanding landholding, irrigation systems, farm equipment etc)<br>• Changing farming system or livelihood strategy<br>• Deciding whether or not to farm |

CGIAR — Research Program on Climate Change, Agriculture and Food Security — CCAFS

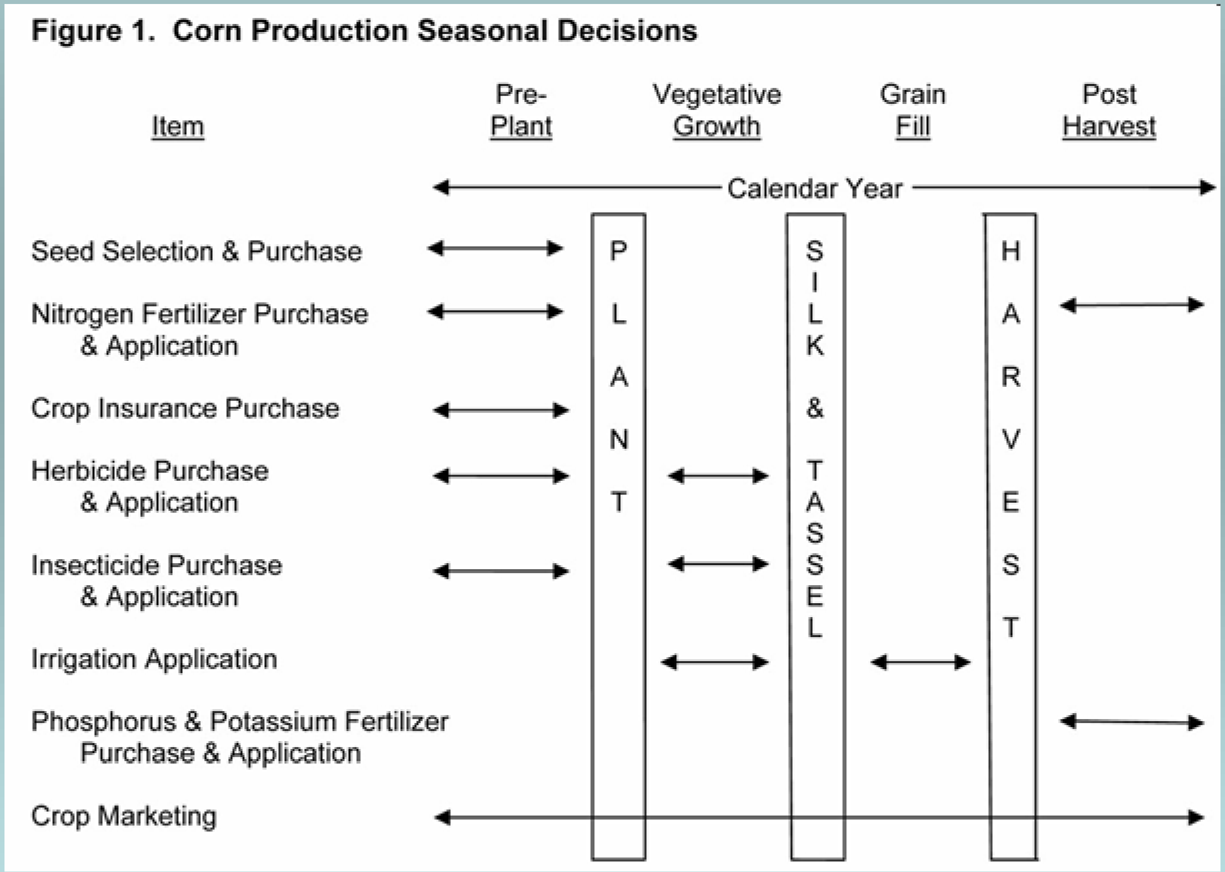
Table 2. *Factors limiting farmers' use of climate and weather forecasts (after Patt & Gwata 2002).*

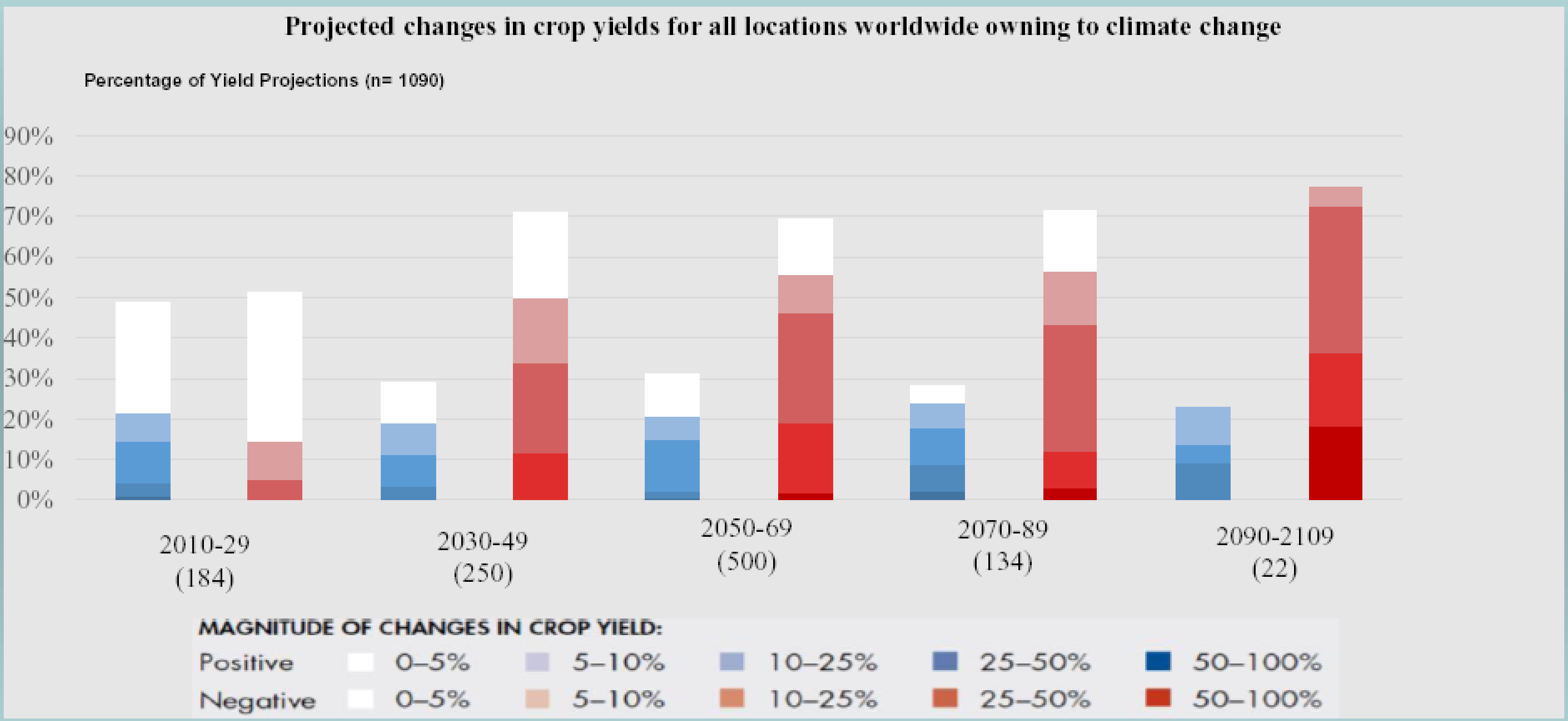
| | Causes | Effects | Corrective action |
|---|---|---|---|
| Credibility | Previous forecasts are perceived as being 'wrong' and the communicator is not generally trusted | Farmers will ignore the forecasts | Give probabilistic forecasts and rely on trusted communicators |
| Legitimacy | Forecasts are perceived as superseding farmers' local knowledge | Farmers will ignore the forecasts and reject any associated advice | Attempt to incorporate local knowledge into the forecast and important to involve farmers in developing the advice information |
| Scale | Forecasts provide no information about events in their local area | Farmers will not incorporate forecasts into their decision-making processes | Need to work with farmers to analyse the implications for the local area. Attempt to provide regional or local scale forecast information, in probabilistic format |
| Procedures | Forecasts produced at the wrong time, to the wrong people, or is unexpected | Farmers will not incorporate forecasts | Repeat communication to resolve the timing, involvement of relevant key players |
| Choices | Forecast information does not contain enough information to alter any specific decision | Farmers will not change decisions in response to a forecast | Need to improve forecast skill and encourage farmers to make incremental decisions ('lean' rather than 'jump') |
| Cognition | Forecasts are new in format, confusing, and different. | Farmers will either not incorporate forecasts or they will do so in a way that is counter-productive | Need to work repetitively with farmers to decipher the meaning of forecasts for their region and to correct mistakes |

Roger C. Stone & Holger Meinke, 2006: Weather, climate, and farmers: an overview

# Improve production planning

Farmers purchase a variety of crop inputs (e.g., fertilizers, pesticides, fungicides) that are utilized during various times of the growing seasons. Timely climate prediction information can provide useful information for the type, amount, timing and type of application of crop inputs.





Projected changes in crop yields for all locations worldwide owning to climate change
Percentage of Yield Projections (n= 1090)
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2010-29 (184)
2030-49 (250)
2050-69 (500)
2070-89 (134)
2090-2109 (22)
MAGNITUDE OF CHANGES IN CROP YIELD:
Positive 0–5% 5–10% 10–25% 25–50% 50–100%
Negative 0–5% 5–10% 10–25% 25–50% 50–100%