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## **Climate Change Challenges for Agriculture**

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## Climate Change Challenges for Agriculture

Thank you very much for the kind introduction, and thank you very much for the invitation. It is an honor to introduce this joint SFER/AES workshop on “the challenges for European Agriculture in the context of climate change”; and it is a pleasure to do this at home in AgroParisTech headquarters.

This workshop is particularly timely, because the IPCC is in the process of releasing its newest assessment report. WGI report on the science of climate change was published in the Fall. WGII report on impacts and adaptation has been released last week. And WGIII report on mitigation (the one I contributed to) is being reviewed by Governments in Berlin as we speak, and it will be released next Sunday.

So what I will try to do here is to weave together some key elements from these reports to provide some sense of the climate-related challenges facing agriculture in the 21<sup>st</sup> century. As you will see, I am not a specialist of agriculture per se (I have worked on climate change in general, and on forestry in particular). still I hope to provide relevant insights from a slightly “off” perspective. This is by no means a summary (I have not read the whole 1000 pages of WGI and II!), but rather a subjective pick of what I see as important when we discuss climate change from the perspective of a particular sector.

### What does IPCC WGI tell us?

IPCC WGI report confirms that the climate is already changing:

- Air temperature have increased relative to 18<sup>th</sup> century levels ( $+0.85^{\circ}\text{C} \pm 0.2^{\circ}\text{C}$  from 1880 to 2012 – SPM B.1, Figure SPM.1)
- Greenland and Antarctic ice sheets have been losing mass, and glaciers are retreating almost worldwide – with significant increases in permafrost temperatures [B.3, Figure SPM.3].

*IPCC WGI also confirms that anthropogenic emissions of greenhouse gases are the main driver of this observed change [Figure SPM.6]*

Regarding future changes in the climate, two elements must be distinguished.

- First, given the inertia of the climate system, additional changes in the climate are already “locked-in”—i.e., they will occur anyhow, even if we somehow managed to stop our emissions today.
  - We are talking about  $+0.4^{\circ}\text{C}$  more or less in the coming 2.5 decades.
  - Timeframes differ, of course, from about a couple of decades for temperature increase to a couple of centuries or more for sea-level rise.
- Additional changes, beyond what is already locked-in because of the inertia of the climate system, will depend on the future time path of emissions.

Of course emissions depend on how societies evolve in the future.

In the previous IPCC reports, this uncertainty was explored based on socio-economic scenarios (the IS92 family and then the SRES, 2000, family), that were translated into emissions, then concentrations, and then processed by climate models.

The process is different in AR5, as the IPCC is now starting from the middle of this causal chain, with four “Representative Concentration Pathways” scenarios, or RCPs.

- These scenarios are basically **GHG concentrations scenarios** (technically, they are defined by their approximate total radiative forcing in 2100 relative to 1750—hence their name).
- This allows one to avoid the significant uncertainties on the relationship between emissions and concentrations ;
  - with ranges across carbon cycle models ranging between 1 to 3 (for RCP2.6) and [1 to 1.4, CRP8.5].
  - For example, the cumulative CO<sub>2</sub> emissions compatible with RCP 4.5 are between 595 and 1005 GtC [Table SPM3].
- Still, RCP2.6 can be described as a low emission, stabilization scenario. RCP4.5 and 6.0 are stabilization scenarios at relatively high levels, and RCP8.5 is a high emissions scenario.

**What IPCC tells us is that Global surface temperature change for the end of the 21st century is likely to exceed 1.5°C** relative to 1850 to 1900 for all RCP scenarios except RCP2.6. It is likely to exceed 2°C for RCP6.0 and RCP8.5, and more likely than not to exceed 2°C for RCP4.5 [Figure SPM7a]. In fact, it could reach +4°C by 2080-2100 in the RCP8.5 scenario.

- The +2°C target is important because it is the globally agreed target for mitigation, as per the Copenhagen accord (2009).
- Let me make a digression here about timing.
  - 2100 might be considered very long term. But it is not. Consider that I was born in the early 70s, which gives me only anecdotal chances of seeing the 2080 – 2100 period. My kids were born between 2002 and 2012, and they are more likely than not to see that period. And my grandchildren, if I am lucky enough to have some, will be born somewhere between 2025 and 2050... And they are very likely to witness the 2080 – 2100 period. Said differently, the 2080 -2100 period is when my children will get old, and when my grandchildren will live. This is not science fiction. This is tomorrow.
  - In addition, a focus on 2100 also misses the point that the climate will not evolve brutally in 2099. Changes are already perceivable today. And increased climate change is likely to be perceived in the coming decades.
  - Symmetrically, warming does not stop in 2100 under all RCP scenarios except RCP2.6.
  - **Reminds us that the issue is NOT to adapt to a new state of the world (warmer), but to adapt to a continuously changing climate.**

**Of course, this average surface temperature increase is not evenly distributed at the surface of the globe.** Temperature increase more over land than other water, and it increases more at high

latitudes relative to low ones [Figure SPM 8]—with a large standard deviation of the distribution [several degrees].

**Changes in precipitation are also significant**, though more contrasted, with decrease over Mediterranean, western Africa, Southern Africa or Middle East, and increases over higher latitudes (though with d [Figure SPM.8]).

Intense precipitation events are likely to become more frequent, and so are extreme events.

**Regional to global-scale projected decreases in soil moisture and increased risk of agricultural drought are likely in presently dry regions** and are projected with medium confidence by the end of this century under the RCP8.5 scenario [TS.5.5.4]

## On this basis, what does IPCC WGII tells us about the impacts of climate change on agriculture?

### Commercial for Working Group II

**First of all, negative impacts of climate change are already measured.**

**Negative impacts on crop yields SO FAR have been more common than positive impacts** (high confidence).

- The smaller number of studies showing positive impacts relate mainly to high latitude regions, though it is not yet clear whether the balance of impacts has been negative or positive in these regions (high confidence).
- Crops differ:
  - Climate change has negatively affected **wheat** and **maize** yields for many regions and in the global aggregate (medium confidence).
  - Effects on **rice** and **soybean** yield have been smaller in major production regions and globally, with a median change of zero across all available data, which are fewer for soy compared to the other crops.
- *Observed impacts relate mainly to production aspects of food security rather than access or other components of food security. See Figure SPM.2C.*
  - *Since AR4, several periods of rapid food and cereal price increases following climate extremes in key producing regions indicate a sensitivity of current markets to climate extremes among other factors (medium confidence).*

Impacts from recent climate-related extremes, such as heat waves, droughts, floods, cyclones, and wildfires, reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate variability (very high confidence).

- *Impacts of such climate-related extremes include alteration of ecosystems, disruption of food production and water supply, damage to infrastructure and settlements, morbidity and mortality, and consequences for mental health and human well-being.*
- For countries at all levels of development, these impacts are **consistent with a significant lack of preparedness for current climate variability in some sectors**

Looking ahead, IPCC WGII sees

- More constraints on agricultural production
  - Increased in temperature (déjà dit) and impact on precipitation (already said)
  - Climate change over the 21st century is projected to reduce renewable surface water and groundwater resources significantly in most dry subtropical regions (robust evidence, high agreement), **intensifying competition for water among sectors** (limited evidence, medium agreement).
- Resulting in decreasing production
  - For the major crops (wheat, rice, and maize) in tropical and temperate regions, climate change without adaptation is projected to negatively impact production for local temperature increases of 2°C or more above late-20th-century levels, although individual locations may benefit (medium confidence).
    - Of course, after 2050 the risk of more severe yield impacts increases and depends on the level of warming. See Figure SPM.7.
    - Projected impacts vary across crops and regions and adaptation scenarios, with about 10% of projections for the period 2030-2049 showing yield gains of more than 10%, and about 10% of projections showing yield losses of more than 25%, compared to the late 20th century.
- **Climate change is also projected to progressively increase inter-annual variability** of crop yields in many regions. These projected impacts will occur in the context of rapidly rising crop demand.
- Overall resulting in
  - **Risk of food insecurity and the breakdown of food systems** linked to warming, drought, flooding, and precipitation variability and extremes, particularly for poorer populations in urban and rural settings
    - All aspects of food security are potentially affected by climate change, including food access, utilization, and price stability (high confidence).
    - Global temperature increases of ~4°C or more above late-20th-century levels, combined with increasing food demand, would pose large risks to food security globally and regionally (high confidence). Risks to food security are generally greater in low-latitude areas.
  - **Risk of loss of rural livelihoods and income** due to insufficient access to drinking and irrigation water and reduced agricultural productivity, particularly for farmers and pastoralists with minimal capital in semi-arid regions.
    - Major future rural impacts are expected in the near-term and beyond through impacts on water availability and supply, food security, and agricultural incomes, including shifts in production areas of food and non-food crops across the world (high confidence).

- **These impacts are expected to disproportionately affect the welfare of the poor** in rural areas, such as female-headed households and those with limited access to land, modern agricultural inputs, infrastructure, and education.
- **In both cases (food security and rural livelihoods), it is important to note that climate change is not the only driver.** I do not know if there are study of the importance of multiple drivers in these particular cases, but...
  - The general idea of WGII report is that for increases in T less than 2°C, non-climate drivers of change remain more important than climate change. It is for higher temperature increase that climate change becomes main driver.
  - As you well know, food insecurity has multiple causes, which are the focus of multiple research at the moment.
  - Similarly, rural livelihoods are affected by non climate drivers. For example, Dorin et al. at Cired look at the development paths of agriculture over the past 40 years, and point out that – should countries like India follow the same Lewis Path as OECD countries have (ie increased prod of labor and increased mechanization, increased area per worker) – they might hit a wall as there are no places for the ag. people to go.

*There are still under-researched areas.*

- *Less data on pasture and livestock, however, there is suspicion that increased productivity will lead to less heat tolerance (because of increased metabolic activity, WGII Ch.7 p.18)*
- *Anecdotal evidence so far on pest, weed and disease response to cc (ibid p.23)*

There is considerable scope for adaptation, notably changes in cropping patterns, crop choices, and crop adaptation. Further adaptations for agriculture, water, forestry, and biodiversity can occur through policies taking account of rural decision-making contexts. Trade reform and investment can improve market access for small-scale farms (medium confidence)

The IPCC report notes, however, that focus on adaptation at the margin might distract from more “transformational” adaptation (including relocation, etc.)

- This to me is a major point. the growing recognition that climate change is not ‘just’ an marginal problem. Given the magnitude of the problem, adapting to climate change to limit large risks requires more than changes at the margin. Often, adaptation and/or mitigation will require changes in development trajectories of whole territories.
- For example, a key development goal for a small, very poor country with a high share of GDP in agriculture might be to improve smallholders’ agricultural productivity and their integration into agroprocessing. To meet this goal, the high vulnerability of smallholders to the currently observed range of weather-related shocks must be reduced through irrigation projects, improved management of key watersheds, and other agriculture development programs that include weather-risk mitigation. It would seem at first glance that many

countries' current development strategies already target vulnerable rural communities with the objective of reducing the impacts of weather-related risks. However, these projects and programs may not be sufficient to cope with increased variability in climate, or with sustained climate patterns for which there is no precedent—such as 100-year floods or multiyear droughts occurring much more frequently. And they might even be a waste of resources if climate variability increases so much in the future that outmigration of the local population, shifting the domestic economy towards other, less climate-sensitive sectors, or both, become the only viable solution (Shalizi and Lecocq, 2009).

- To this extent, the challenges are not only to agriculture, but to the organization of territories as a whole.
- We know that transformations are difficult.... Hence an interest in looking at mitigation.

## What does WGIII say?

**I can't say anything, this paper is under embargo.** Still, let me put a few figures without jeopardizing the entire IPCC process.

**Emissions from the Agriculture, Forestry and Other Land Use (AFOLU) are around 10 GtCO<sub>2</sub> / year** (over 40 total) in the past decade [2000-2009], or 25% of the World total emissions.

- Of this total, emissions from land-use change and forestry (aka deforestation) represent about 40%. They constitute one key issue per se, which I will not dwell on here.
- Of the rest,
  - enteric fermentation (CH<sub>4</sub>) from livestock is about 2.1 GtCO<sub>2</sub> (IPCC WGIII Ch.11 p.14).
  - Manure. 1
  - SYnthetic fertilizer. 0.7
  - Rice paddies. 0.5

**This is significant, and cannot but be reduced if we are to get to a low-emissions world.** However, if there has been considerable efforts on reducing emissions from forest degradation and deforestation [REDD], the agriculture sector is rarely present in climate mitigation policies so far [notably not in the EU ETS].

**There is a variety of mitigation options,** such as – on the supply side -- reduction in CH<sub>4</sub> or N<sub>2</sub>O emissions from croplands, grazing lands and livestock, reduction of carbon losses from biomass and soils (eg switching to no till cropping), etc.

**as in most sectors Supply probably insufficient ( )---hence the need to look at demand-side mitigation options.**

- Big issue is reducing diets. And the Agrimonde prospective, conducted notably at Cired, has shown how important food diet were for the sector. In fact, when plugging Agrimonde scenarios into our Nexus model of land use, we find that a BAU model leads to increased food prices (Brunelle et al.).



- Terra incognita are options in the food processing chain, both in terms of waste management, but also in terms of transformation. We know it takes roughly two calories out of the field to produce one calorie eaten by the consumer. But what combination of research requires more research.

This is not the only link between ag and mitigation. In fact, **there is considerable interest in developing bioenergy as a substitute for other energy sources, and in coupling bioenergy and carbon capture and storage to obtain negative emissions.** In fact, negative emissions are required along many baselines to reach +2°C target.

- However, one cannot avoid the link to land use and potential tensions over it. Scenarios of high biomass deployment can lead to heightened tensions on food prices.

Agriculture is also very sensitive to mitigation efforts in other sectors, notably via costs of energy and of fertilizers. Impact on energy prices on the agricultural sector and on food processing (notably transportation). Poorly known, but potentially significant as well.

We are back to the issue of large scale transformations at the level of territories, that need to be managed in relation with mitigation.

## Concluding remarks

To conclude, I would like to take an image that we used in the 4<sup>th</sup> assessment report of the IPCC. We tried to differentiate ourselves from the rest of the report by saying that the report was looking at development from a climate lens, and that we were looking at climate from a development lens. I am not sure how successful in the program, but I think that this is the necessary change of focal lens that one has to make when looking at climate change from the perspective of a particular sector, as you are doing today with agriculture.

The key point from the talk is that cc should be considered as a whole, without separating mitigation and adaptation ; neither separating cc from other challenges and issues already facing the sector. The question then becomes to revisit the development strategies of the sector given the constraints imposed by cc (impacts, adaptation, mitigation).

A second point is that comprehensive action on climate change will require efforts in terms of mitigation, including in the ag sector so far more or less preserved (-40% by 2030). Not clear what global process will be in 2015, for the moment bottom-up approach with limited “teeth”. How does one reconcile what we call subscription equilibrium with global mitigation ambition is unclear. What we know also is that one will not trigger investment required w/o financing ; and w/o a set of instruments, including but certainly not limited to a price of carbon. Opens up possibility for sectoral deals, within which ag; could take place.

Summit in September. Not clear what will get out of it. Proposals for financing transition key.

Issue of timing probably more relaxed on adaptation front. Not that easy, but annual crops easier to manage than oaks or beech trees planted for 8 to 12 decades ahead..... Requires identifying key

preparadness issues for adaptation in the ag sector (that are long lived) such as technology development, infrastructure development (including reservoirs if required), etc.

And all conditions to allow for systemic change, notably INSTITUTIONS.

The workshop is also timely because the negotiation process is heading up to COP21 in Paris in 2015, a conference during which a comprehensive agreement on climate change for the years 2020 and beyond should be agreed upon... At least this is the plan. The recent history of Copenhagen reminds us that we have already seen bubbles of expectation on climate change burst. But at least this provides some perspectives in terms of policy, and I will try and come back to that at the end of my talk.

Sources: