TRADEOFFS MODELING FOR CLIMATE ADAPTATION & MITIGATION IMPACT ASSESSEMENTS IN THE CARIBBEAN




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GCF-Readiness Project “Strengthening the foundation for a climate responsive sector in the Caribbean”

The Challenge for the Agricultural Sector

1. Provide healthy food for growing populations
2. Sustainably increase production
3. Adapt to increasing climate extremes and change
4. Mitigate emissions from food system practices
5. Maintain/Improve livelihoods

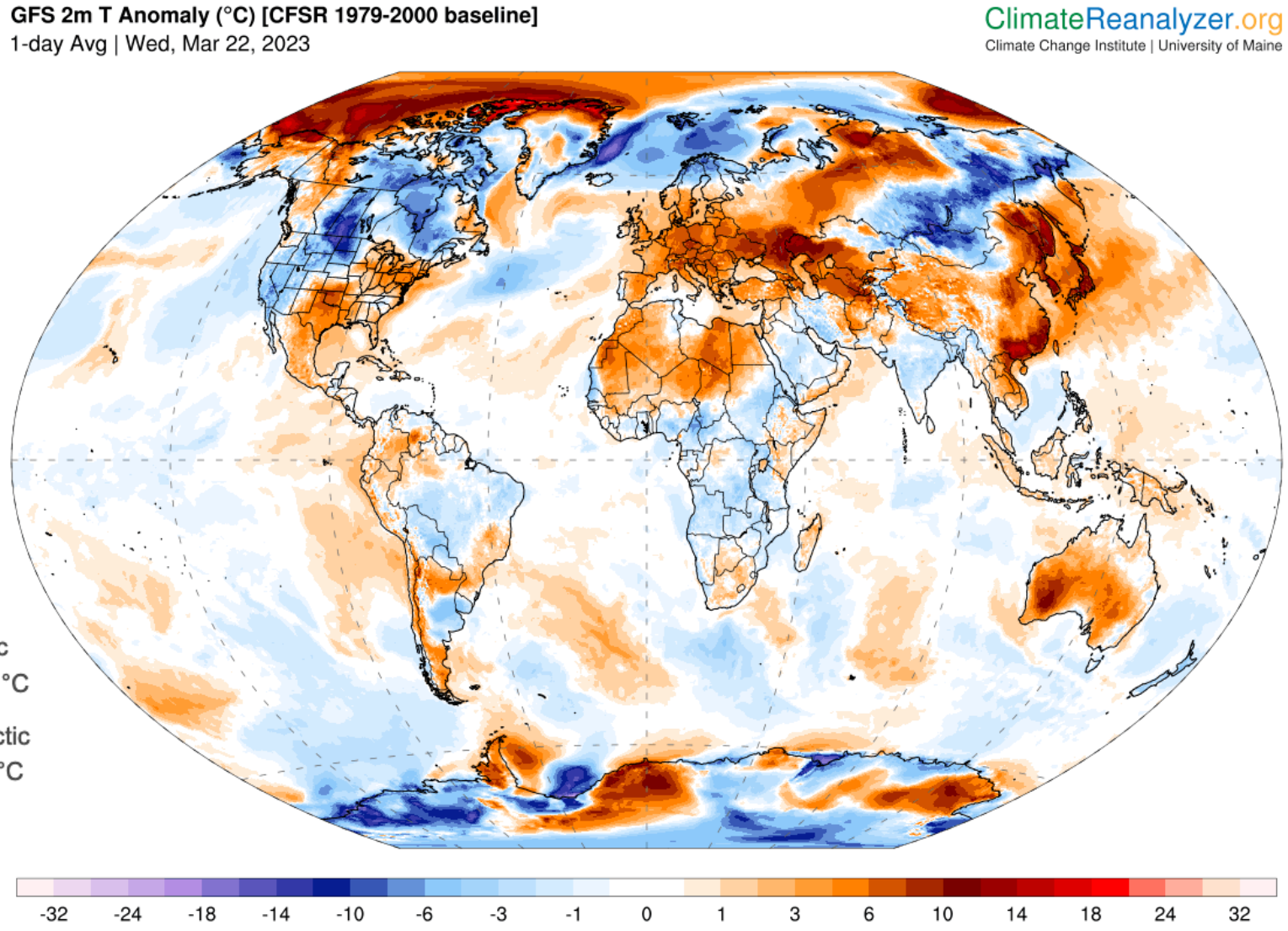
The UNFCCC commissioned an IPCC Special Report on 1.5 ºC Global Warming to better understand the challenges of achieving a 1.5 ºC Warming as well as the differences in outcome against a world where climate stabilized at 2.0 ºC warming.

COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

Climate Change and variability

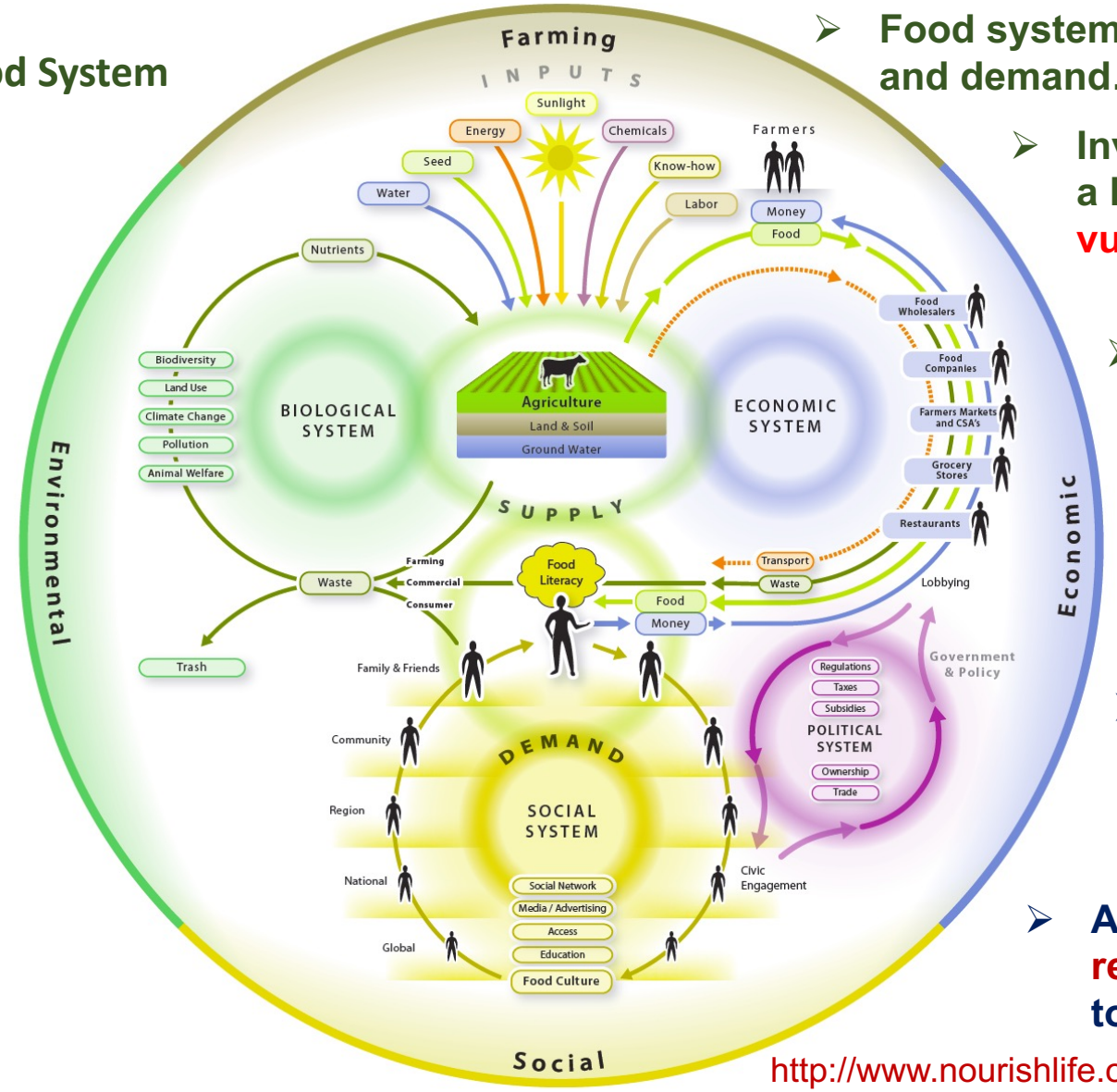
Threat to agriculture and food systems

World	Northern Hemisphere	Arctic
+ 0.58 °C	+ 0.88 °C	+ 3.55 °C
Tropics	**Southern Hemisphere**	**Antarctic**
+ 0.23 °C	+ 0.28 °C	- 0.1 °C



Tradeoffs – Climate Adaptation & Mitigation Impact Assessment

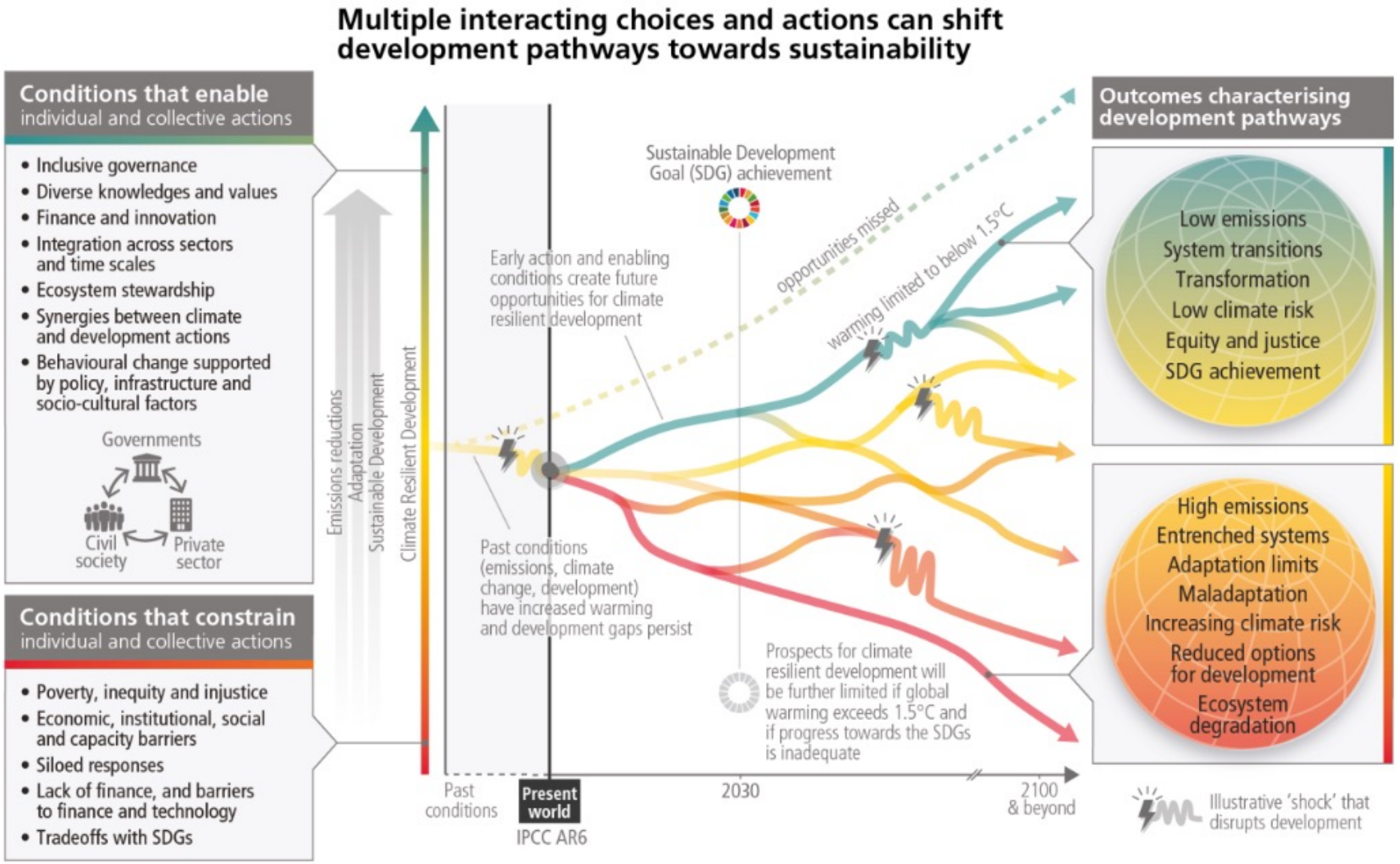
Expanded Food System



- **Food system is much more than supply and demand…it is a complex system!**
- **Involves local to global scales with a lot of potentially volatile & vulnerable points**
- **Very difficult to predict future conditions**
- **Also difficult to assess impacts of shocks and responses (resilience)**
- **Need to represent complexities via models and/or scenarios**
- **Adaptations can build a more resilient system, but need the tools to assess the impacts**

http://www.nourishlife.org/teach/food-system-tools/

Tradeoffs – Climate Adaptation & Mitigation Impact Assessment



IPCC, AR6 Synthesis report, March 2023

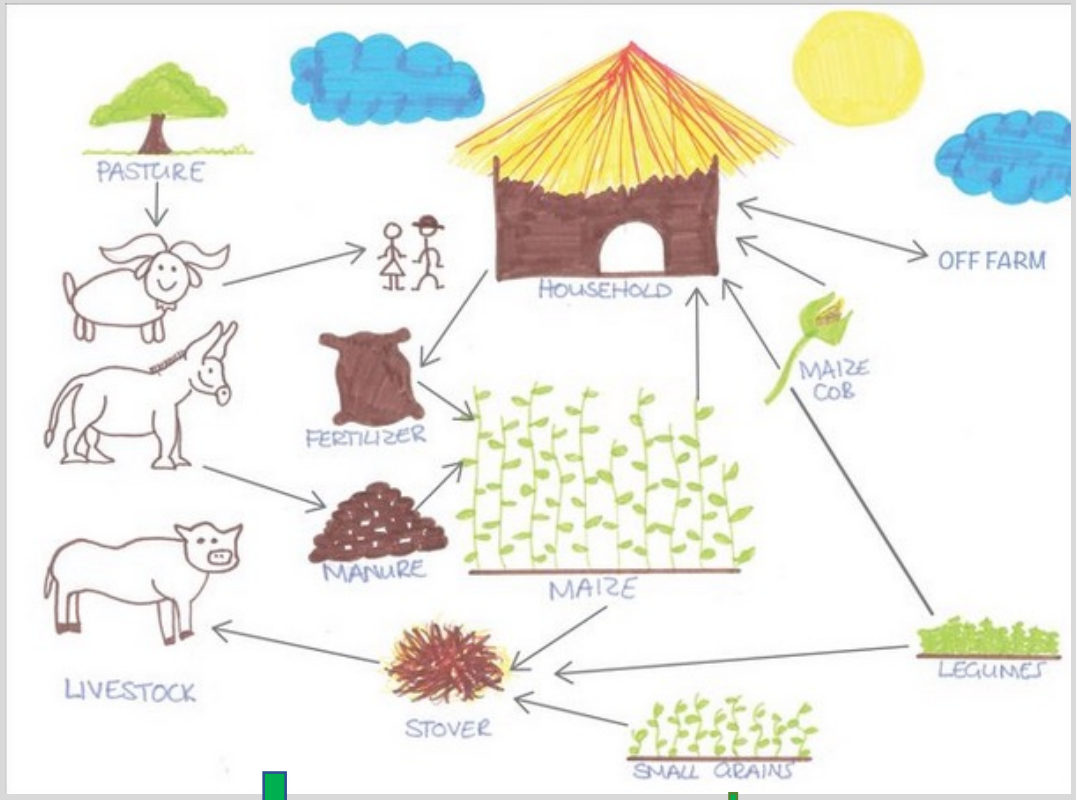
Many studies focusing on impacts of climate change…however:

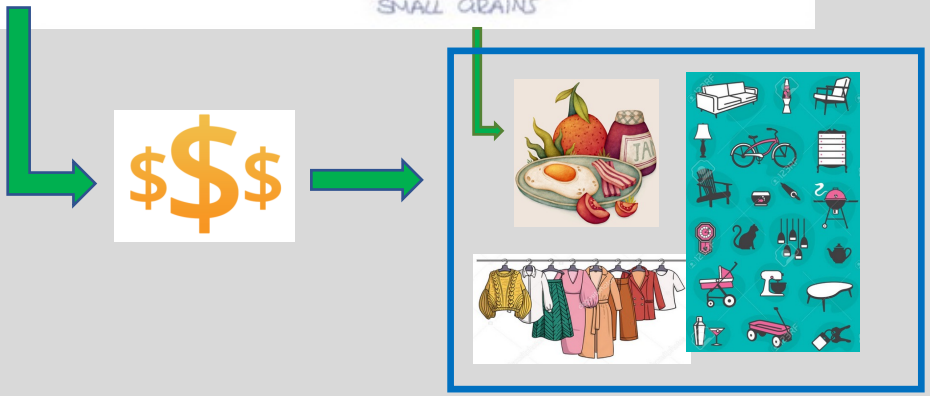
Most methods used to assess CC impact and adaptation to date **have critical limitations** to assess CC impacts and adaptation potential

- Averaged (aggregated) climate, technical and socio-economic data -- and corresponding "representative farm" or aggregate models -- fail to represent heterogeneity and technological detail essential to analysis of adaptation
- Analysis of impacts of future climate done with current socio-economic system and technology
- Limited measures of economic impact (land values, gross returns), lack of distributional impacts.

❖ High degree of bio-physical & socio-economic heterogeneity plays a key role in assessing CC impact, vulnerability & adaptation in ag systems

Let's look at ***a*** farm

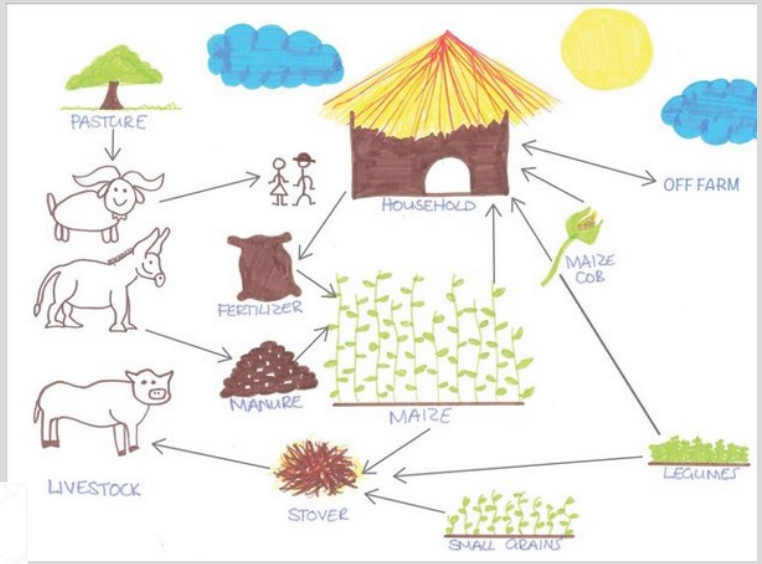




Any change or disruption to the farming system will have an impact (*positive or negative*) on farmers' livelihoods…*and possibly beyond the farm..*

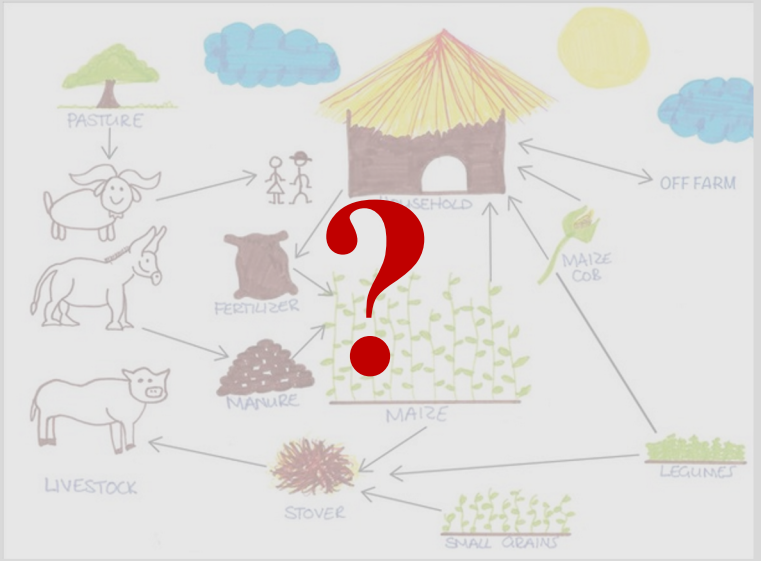
- New Technology (e.g, new crop variety)
- Change in Farming system (e.g., change in components of the system)
- Environmental changes (e.g. climate change)
- Policy interventions (e.g. conservation programs)
- Shocks (e.g. COVID-19)

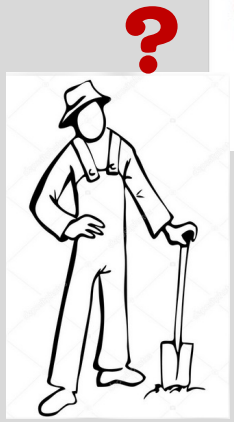
Let's talk about the case of a proposed new technology



CHOICE

To adopt or Not to adopt





Multiple factors could influence the adoption decision (social, cultural, environmental, etc)

$$$

- C/B analysis or other tools
- Could adopt to try it out, if it doesn't work go back to base system

This is not always feasible and could be costly

- What if the proposed new system involves multiple alternatives: options for land use configuration
- Adaptation strategies to climate change

"Expected" $$$

Adoption will have consequences (impacts) on Livelihoods, environment, etc

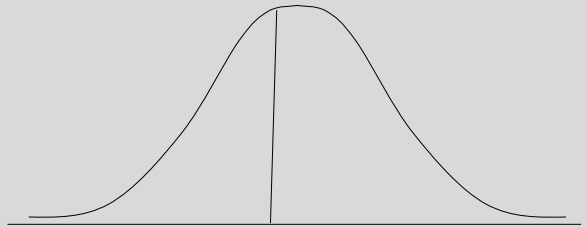
How to deal with multiple scenarios?

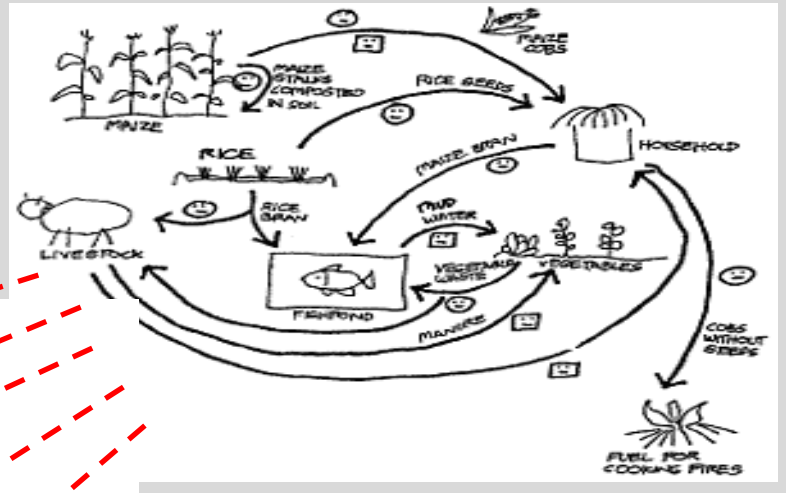
At Regional (landscape) level….

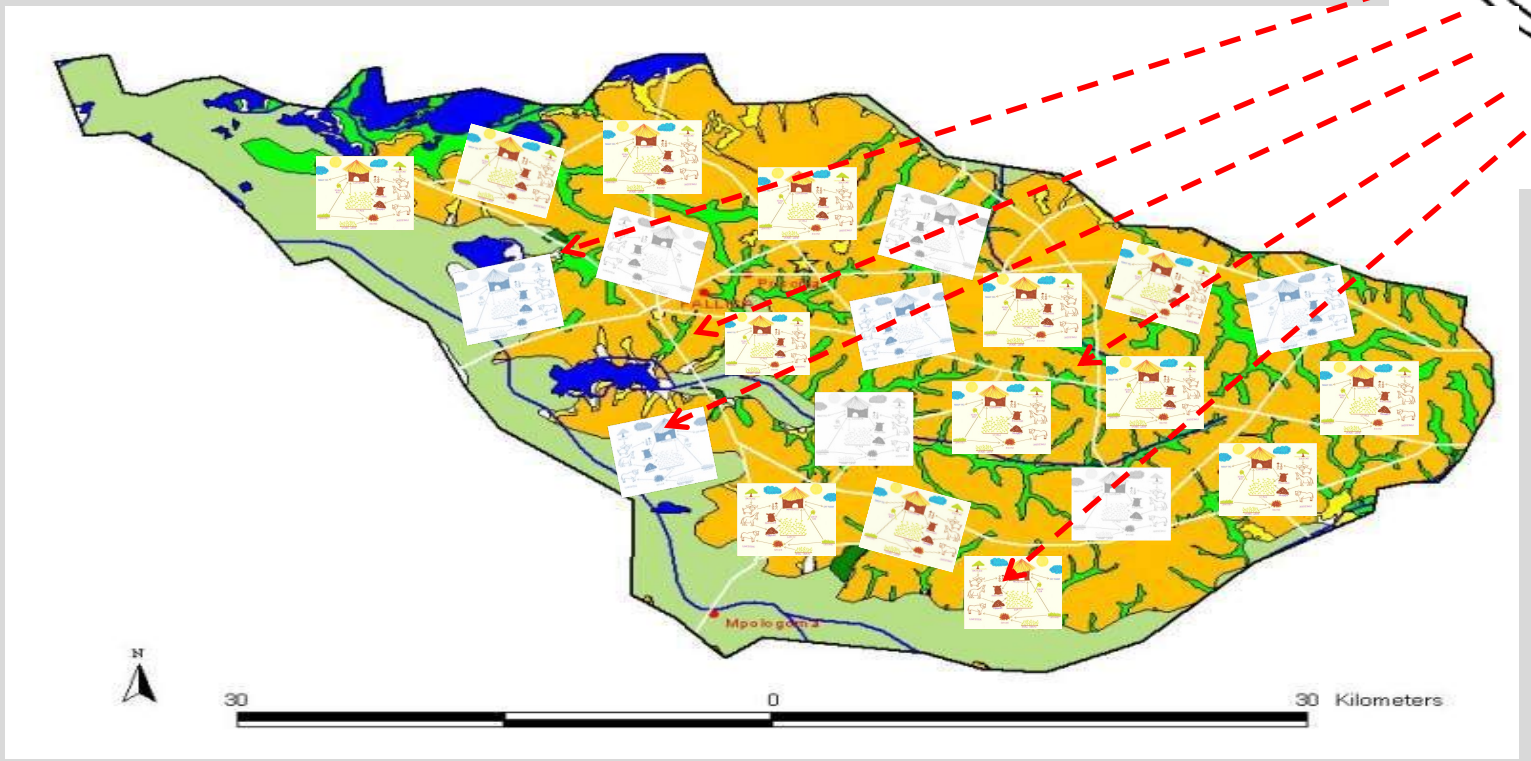
Socio-economic, environmental and bio-physical conditions

- Farm net returns
- Poverty rates
- GHG emissions
- Soil quality
- Etc….

Distribution of outcomes







Systems are being used in heterogeneous populations, resulting in distributions of gains and losses

How to assess impacts of changes in the farming system?

Changes in farm net returns, poverty rates, environmental changes, etc

⇒ Approach to assess Tradeoffs and synergies

⇒ Whole farm system approach – not only one commodity

Antle & Valdivia, 2021

- The **TOA-MD Model** is a unique simulation tool for **multi-dimensional impact assessment** that uses a statistical description of a heterogeneous farm population to simulate the adoption and impacts of a new technology or a change in environmental conditions and of policy interventions such as Payments for Ecosystem Services

- TOA-MD is designed to produce information that is timely and sufficiently accurate to support informed decision making for stakeholders and policy decision makers.

• **TOA-MD** is designed to simulate experiments for a population of farms using a "base" production system (System 1), and an alternative System 2

• **TOA-MD is designed to utilize the available data to attain the best possible approximation**, given the available time and other resources available to conduct the analysis

  – can be used for ex post and ex ante analysis

  – an alternative to econometric models that require large panel datasets

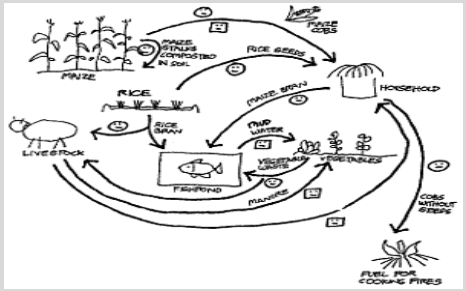
• TOA-MD can be used to assess sensitivity to key parameters and the value of collecting additional data.

TOA-MD 7.0©

Tradeoff Analysis for Multi-Dimensional Impact Assessment

Logical structure of TOA-MD: Adoption analysis

An adoption process leads to selection of the population into two sub-populations of non-adopters and adopters of system 2

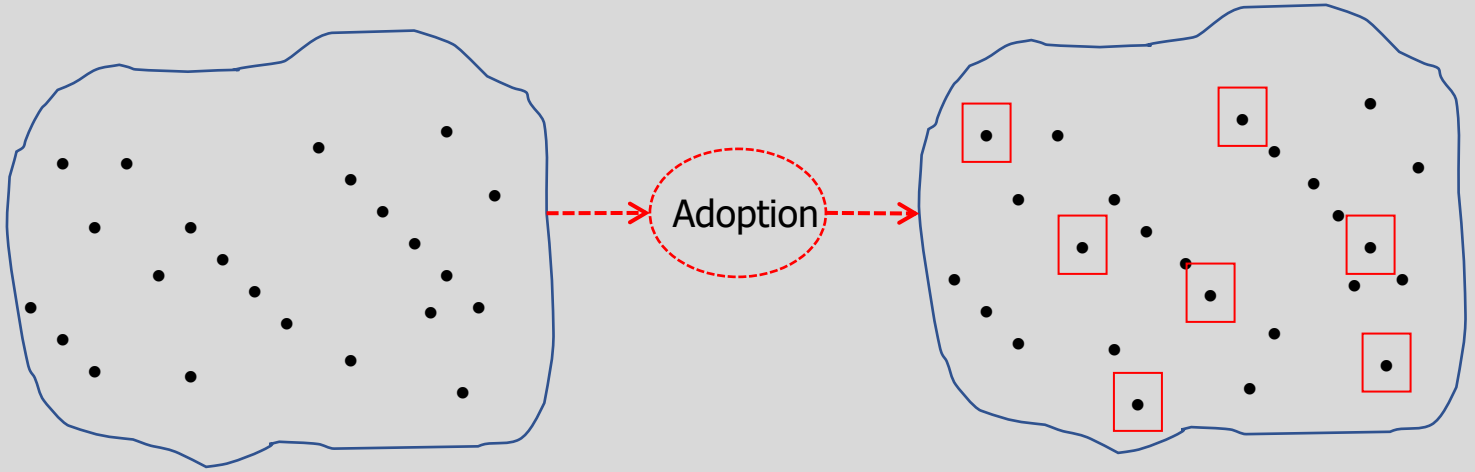


Challenge:

How to characterize the "new system" ?

e.g. What yields would be obtained with a new crop variety?

Observed ***Not always observed***



Farm population w/base tech & base indicators (poverty, sustainability)

Sub-populations:
non-adopters (base tech & indicators)
adopters (improved tech, indicators)

Antle & Valdivia, 2021

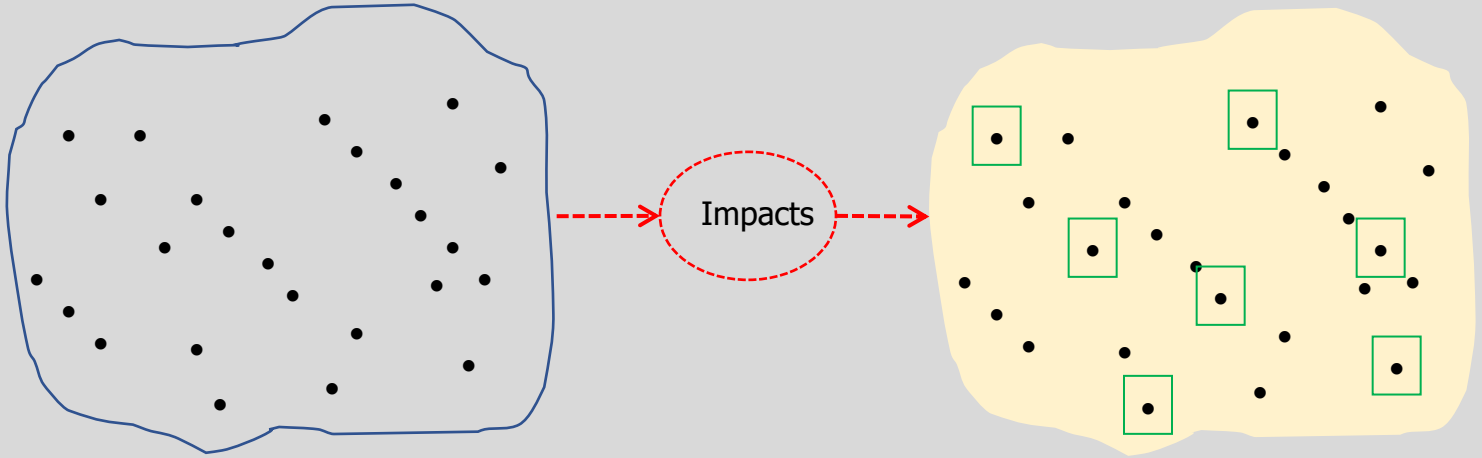
TOA-MD 7.0©

Tradeoff Analysis for Multi-Dimensional Impact Assessment

Understanding the impacts and responses to technology/policy interventions and climate change

Now, lets' assume we have the same population of farms.

But now instead of a technology change, we have climate change. What happens?



Farm population w/base tech & base indicators (poverty, sustainability)

Sub-populations:
Gainers (base tech, CC, indicators)
Losers (Base tech, CC, indicators)

Antle & Valdivia, 2021

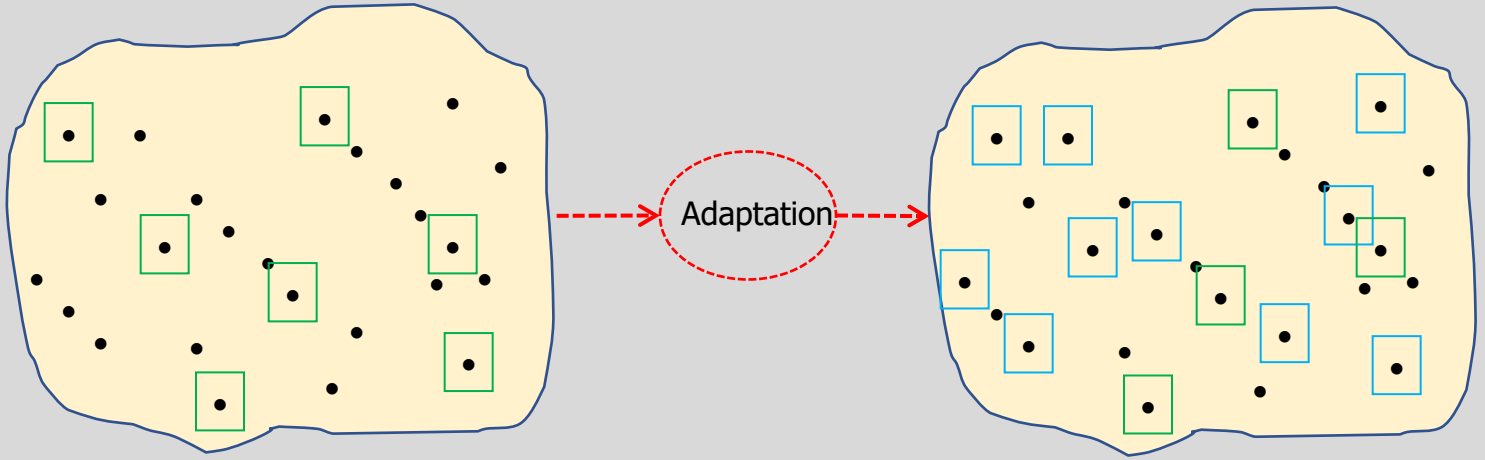
TOA-MD 7.0©

Tradeoff Analysis for Multi-Dimensional Impact Assessment

Understanding the impacts and responses to technology/policy interventions and climate change

Now, lets' assume we are under Climate change (there are some gainers and some losers)

Now an adaptation strategy proposes a new technology change. What happens?



Sub-populations:
gainers (base tech, CC & indicators)
Losers (base tech, CC, indicators)

Sub-populations:
non-adopters (adapted tech, CC, indicators)
adopters (adapted tech, CC, indicators)

Antle & Valdivia, 2021

AgMIP The Agricultural Model Intercomparison and Improvement Project

AgMIP7, IICA, Costa Rica, 2018

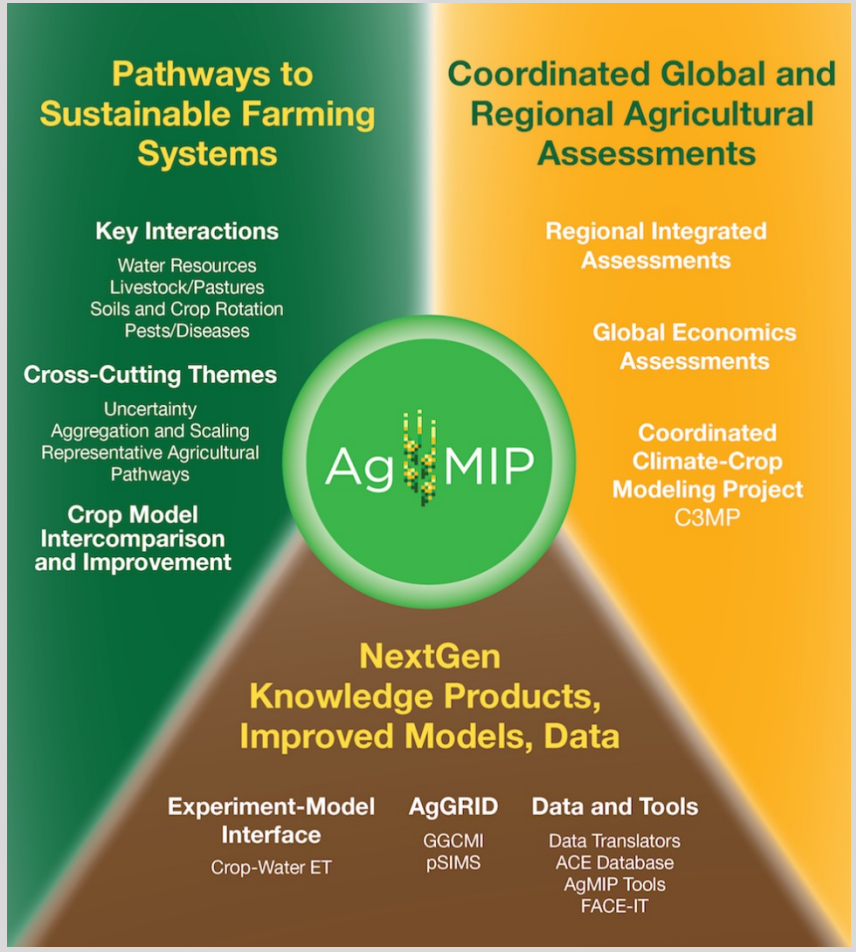
The Agricultural Model Intercomparison and Improvement Project

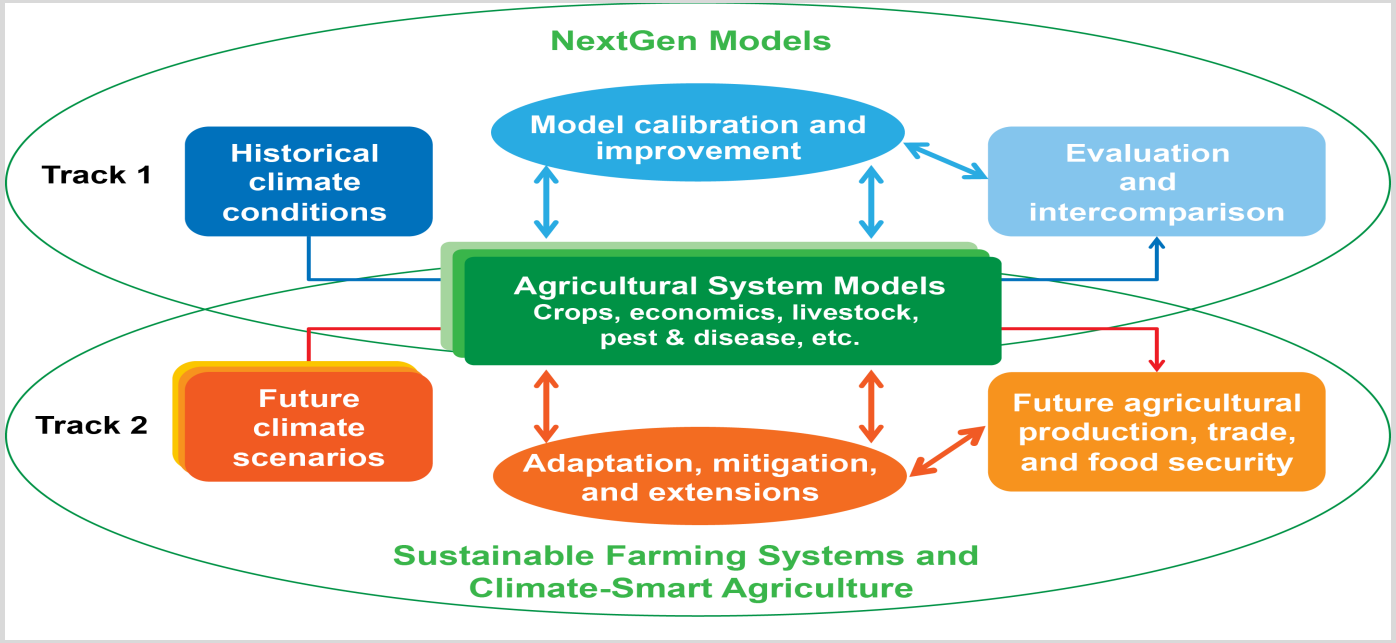
AgMIP has been working to address critical limitations of climate impact assessment methods

AgMIP The Agricultural Model Intercomparison and Improvement Project

Mission

Provide effective science-based agricultural decision-making models and assessments of climate variability and change and sustainable farming systems to achieve local-to-global food security.





Track 1: Develop/Test NextGen Agricultural Systems Models

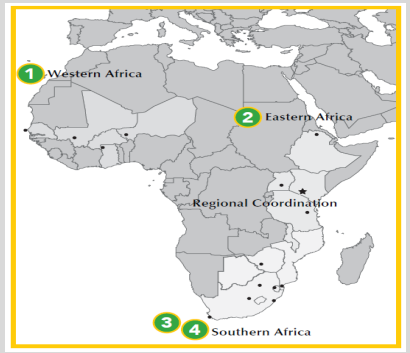
Track 2: Conduct Multi-Model Assessments for Sustainable Farming Systems and Climate-Smart Agriculture

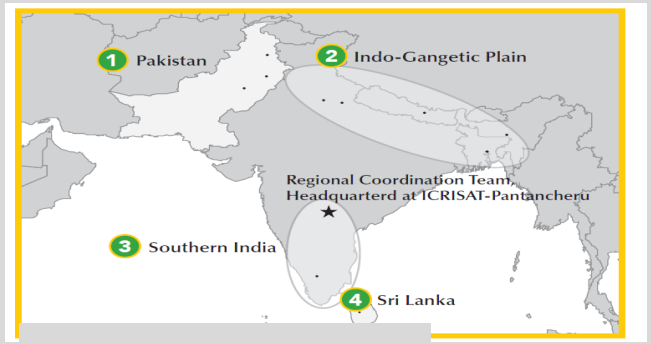
Modeling for Sustainable Farming Systems: Regional Integrated Assessments

AgMIP The Agricultural Model Intercomparison and Improvement Project

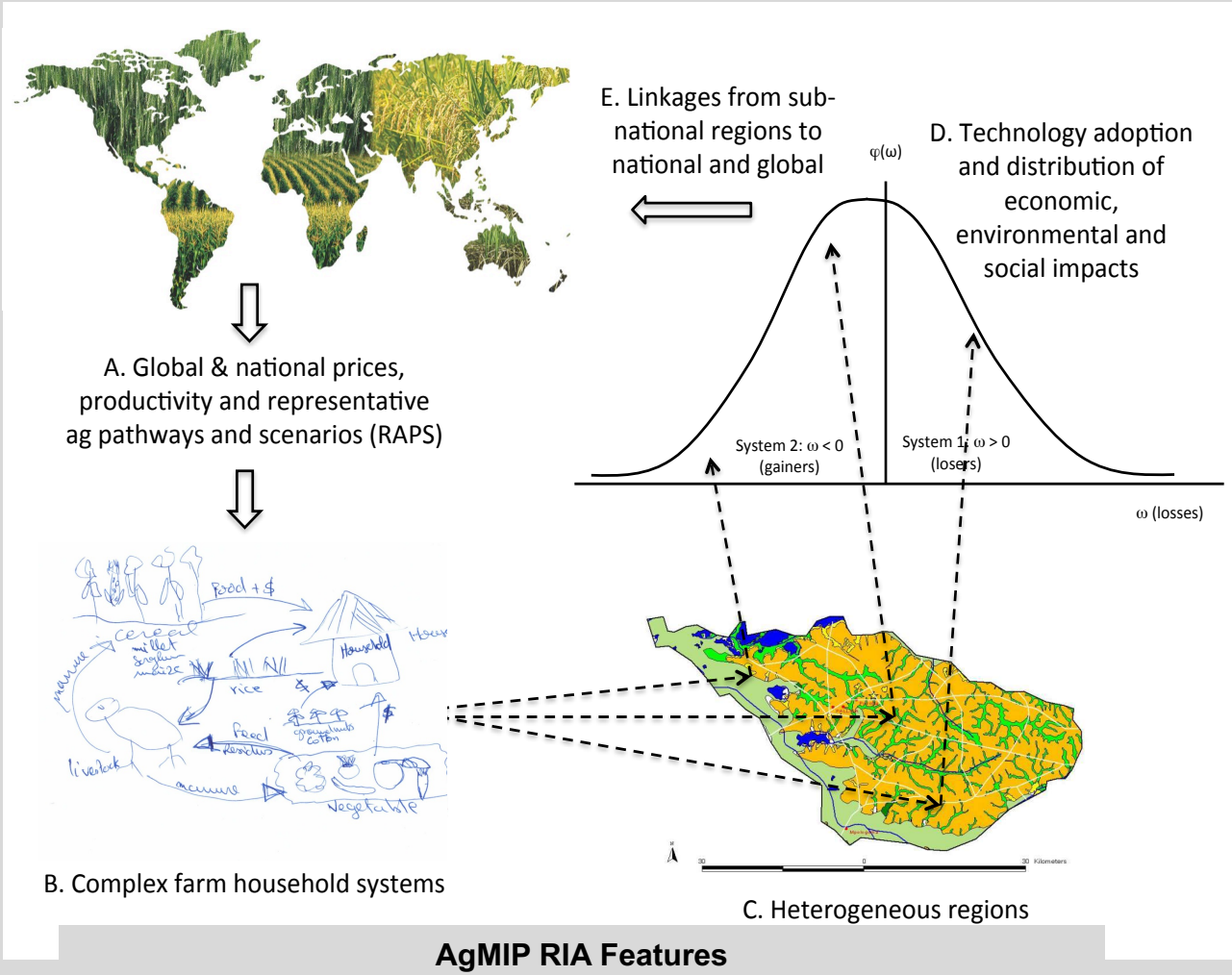
Protocol-based approach

- Integrated modeling framework (crops, livestock, whole farm economics, nutrition)
- Evaluate pathway/scenario uncertainties under future climate, bio-physical, socio-economic conditions
- Scaling down, up scenarios, interventions through stakeholder engagement (disaggregation, aggregation)





5-year project, UK DFID funded
8 regional teams, 18 countries,
~200 scientists



AgMIP RIA Features

- Farming systems
- Transdisciplinary: biophysical/socio-economic
- Multi-scale: field, farm, region, global data and models
- Multiple climate and crop models
- Distributional results, e.g. impacts on poverty rates

CARICOM AgREADY TRADEOFFS ANALYSIS

CASE STUDIES

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GCF-Readiness Project “Strengthening the foundation for a climate responsive sector in the Caribbean”

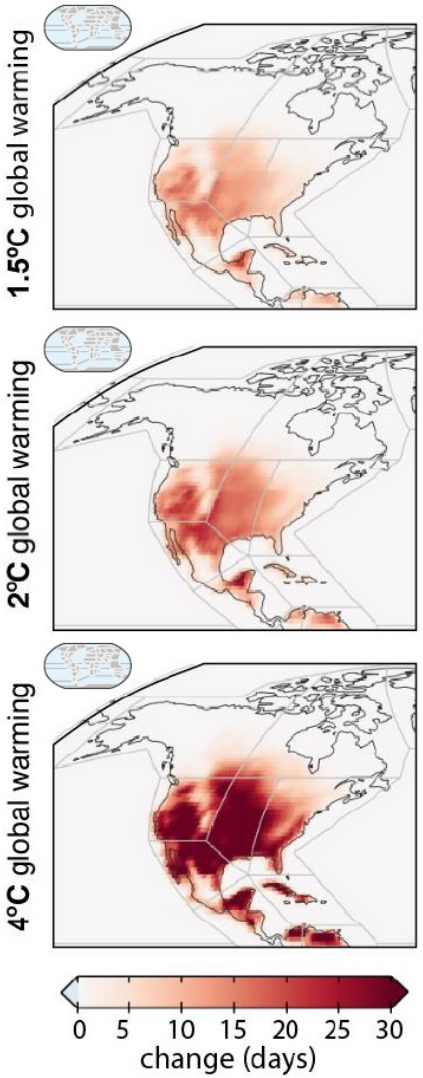
OBJECTIVE:

Demonstrate a stakeholder-driven, multi-disciplinary methodology to assess climate change impacts on multiple-dimensions in at least one representative farming system in the region, based on data availability.

This is a pilot study aimed at presenting the kinds of information that could be produced by using the AgMIP's Regional Integrated Assessment Approach and the modeling tools developed by AgMIP.

The results in the following slides are an approximation using available data and expert knowledge.

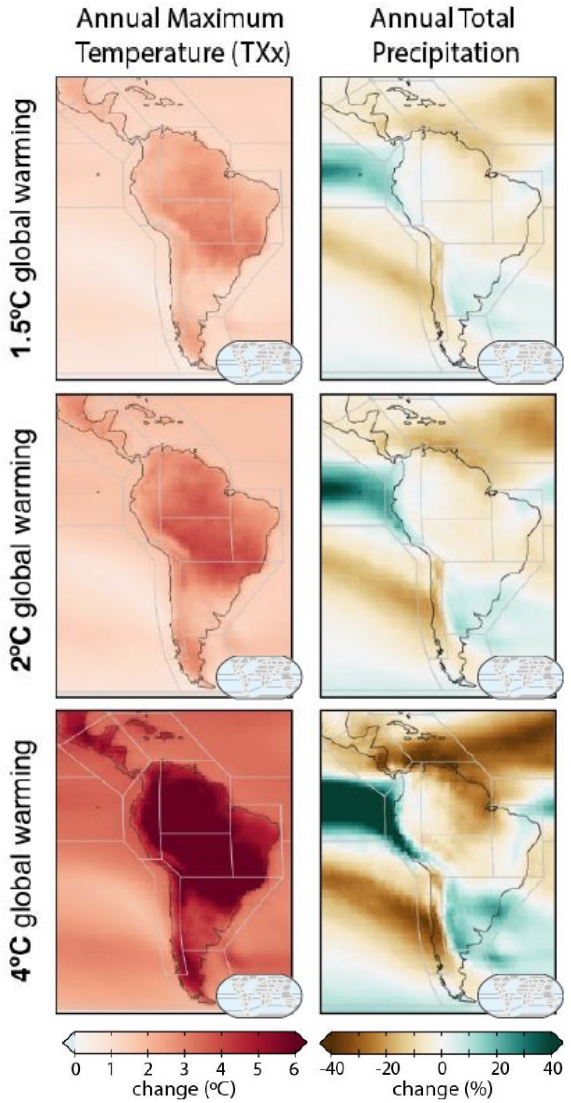
Tradeoffs – Climate Adaptation & Mitigation Impact Assessment



Projected changes in number of days with daily maximum temperatures over 35°C in summer at 1.5°C, 2°C, and 4°C (in rows) global warming relative to 1850-1900.

Based on CMIP6 using the SSP5 8.5 scenario to compute the warming levels.

Results expanded in the Interactive Atlas (active links)



Projected changes in annual mean temperature and annual total precipitation, at 1.5°C, 2°C, and 4°C (in rows) global warming relative to 1850–1900.

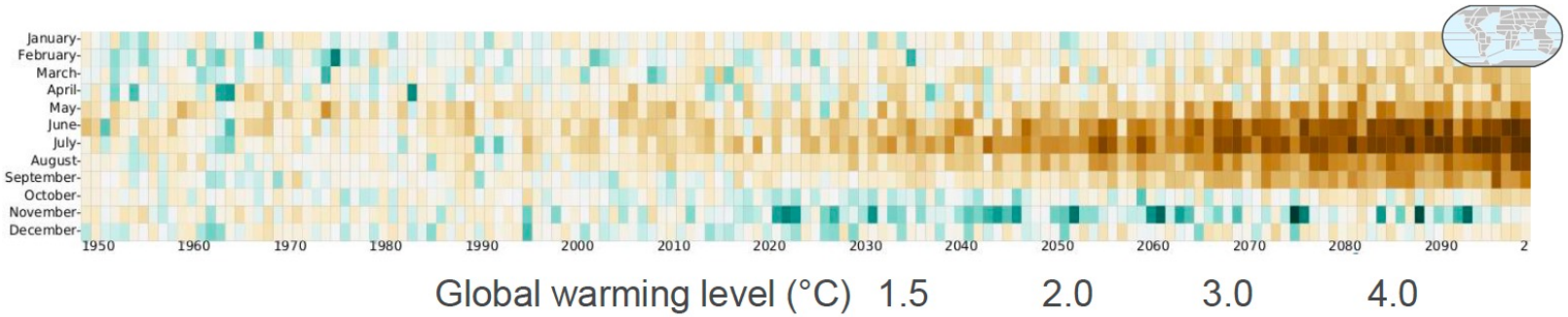
Results are based on simulations from the CMIP6 multi-model ensemble (32 global climate models) using the SSP5-8.5 scenario to compute the warming levels.

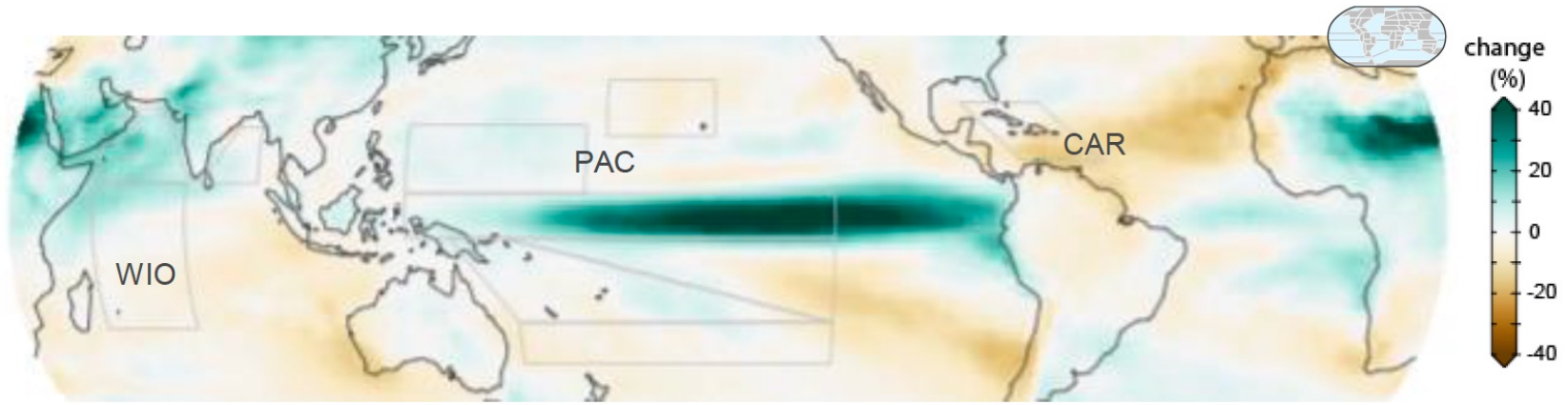
IPCC Interactive Atlas

Caribbean (CAR)

- Declining trend in rainfall during June–July–August in CAR will continue in coming decades (*high confidence* at 2°C global warming and above).
- Higher evapotranspiration under a warming climate will result in increased aridity and more severe agricultural and ecological droughts in CAR (*medium confidence* at global warming level of 2°C and above).

Change in monthly average precipitation relative to 1995–2014 for the Caribbean under increasing warming levels

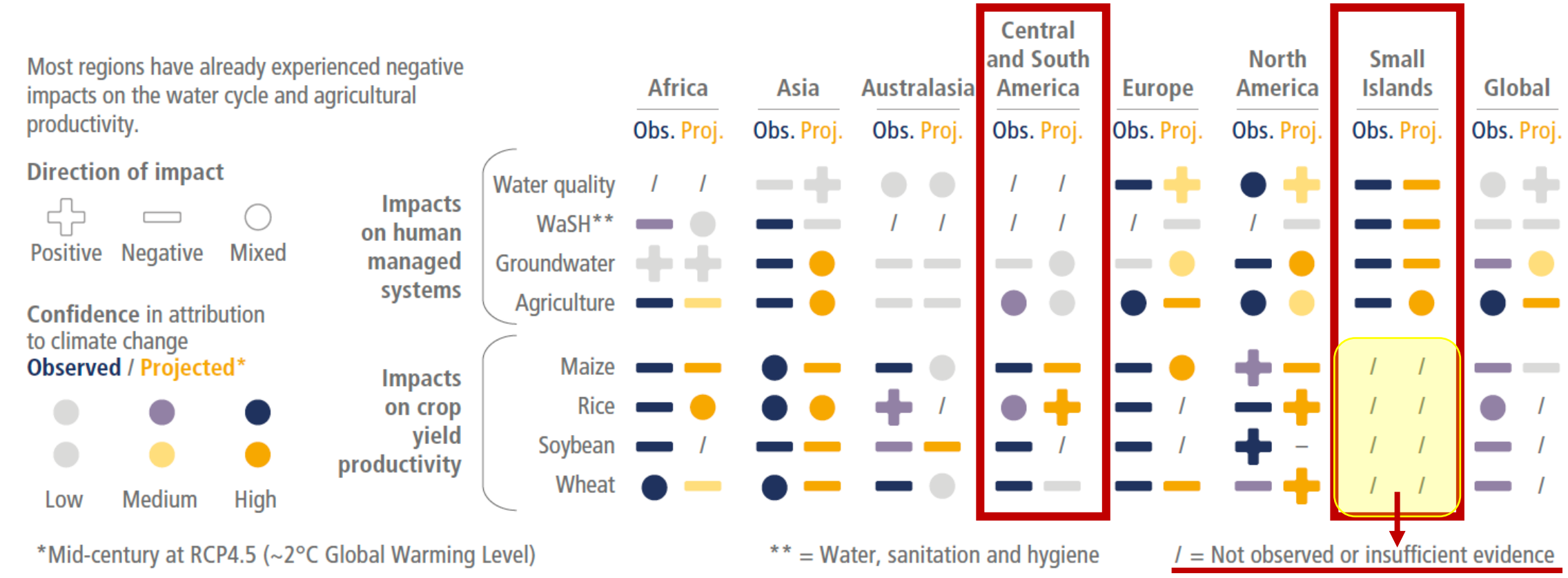




Annual average precipitation change, mid-21st century relative to 1995–2014 (SSP3-7.0)

IPCC AR6-WG1 Report

Tradeoffs – Climate Adaptation & Mitigation Impact Assessment



IPCC AR6-WG1 Report

1. Training:

❖ 12 researchers from the Caribbean region trained on the basics of the TOA-MD model. They have learned to:

- ✓ Understand the logic and basics of the TOA-MD
- ✓ Understand the kinds of data needed to conduct assessments of agricultural systems
- ✓ Prepare data, estimate parameters and implement the TOA-MD model for a technology adoption assessment
- ✓ Understand the basic concepts of the AgMIP Regional Integrated Assessment of climate change and adaptation
- ✓ Prepare the data, estimate parameters and implement the TOA-MD for a climate change and adaptation assessment

2. Proof-of-concept Case study

The goal of the proof-of-concept case Study is to implement the TOA-MD and the AGMIP RIA method to demonstrate the kinds of science-based information that can support policy decision making, inform the process of development NAPs and NDCs and countries strategies to achieve the Sustainable Development Goals

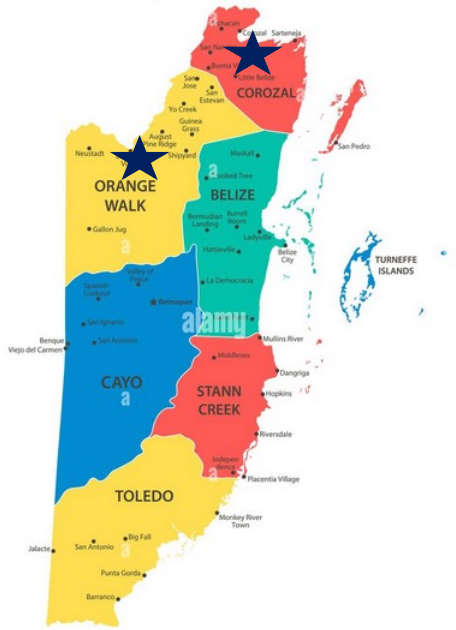
Minimum Data Approach:

- Use existing data to obtain the basic model parameters
- Use secondary data (other studies, expert knowledge, etc) to complement the basic data
- Use data from existing literature on average changes in crop yields due to climate change (not possible to run climate-crop models in this proof-of-concept analysis

CASE STUDIES

Tradeoffs – Climate Adaptation & Mitigation Impact Assessment

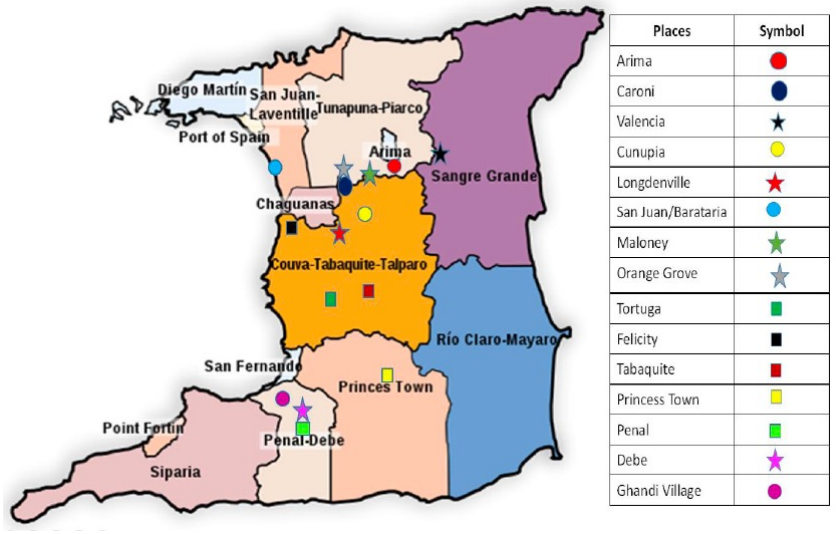
Belize: Sugarcane production system



We analyzed the potential impacts of CC and adaptation farm income, per-capita income, and poverty rates for 2 sugarcane producing regions in Belize. We used data available for a 7 year-cycle of sugarcane production (year 1 as establishment of the crop and years 2-6 ratoon years). We focused on farms categorized as micro, small and medium size, based on the production levels. The adaption strategy is based on implementing climate smart practices and a combination of policy to decrease initial investment cost.

Source of data: SIRDI. (Luciano Chi)

Trinidad and Tobago
Tomato and pepper production system

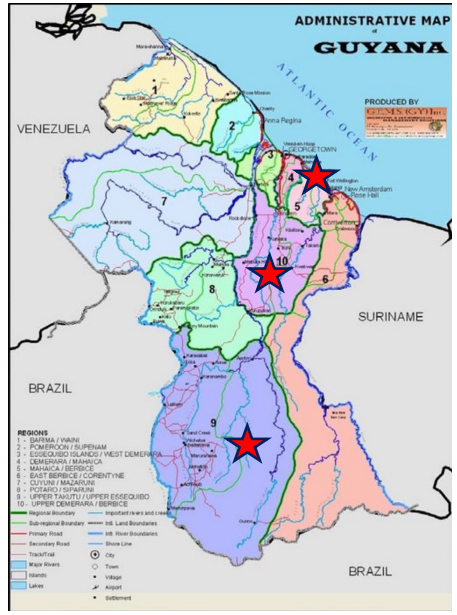


Places	Symbol
Arima	
Caroni	
Valencia	
Cunupia	
Longdenville	
San Juan/Barataria	
Maloney	
Orange Grove	
Tortuga	
Felicity	
Tabaquite	
Princess Town	
Penal	
Debe	
Ghandi Village	

We focus on tomato and chili peppers smallholder farms to assess the impacts of climate change and adaptation. This analysis includes the use of data collected for a master thesis and secondary information from different sources to obtain a closer characterization of the tomato-peppers farming system. The adaptation strategy is based on improved crop varieties and management.

Source of data: Brandon Murphy and NAMDEVCO

Guyana: Cassava production system



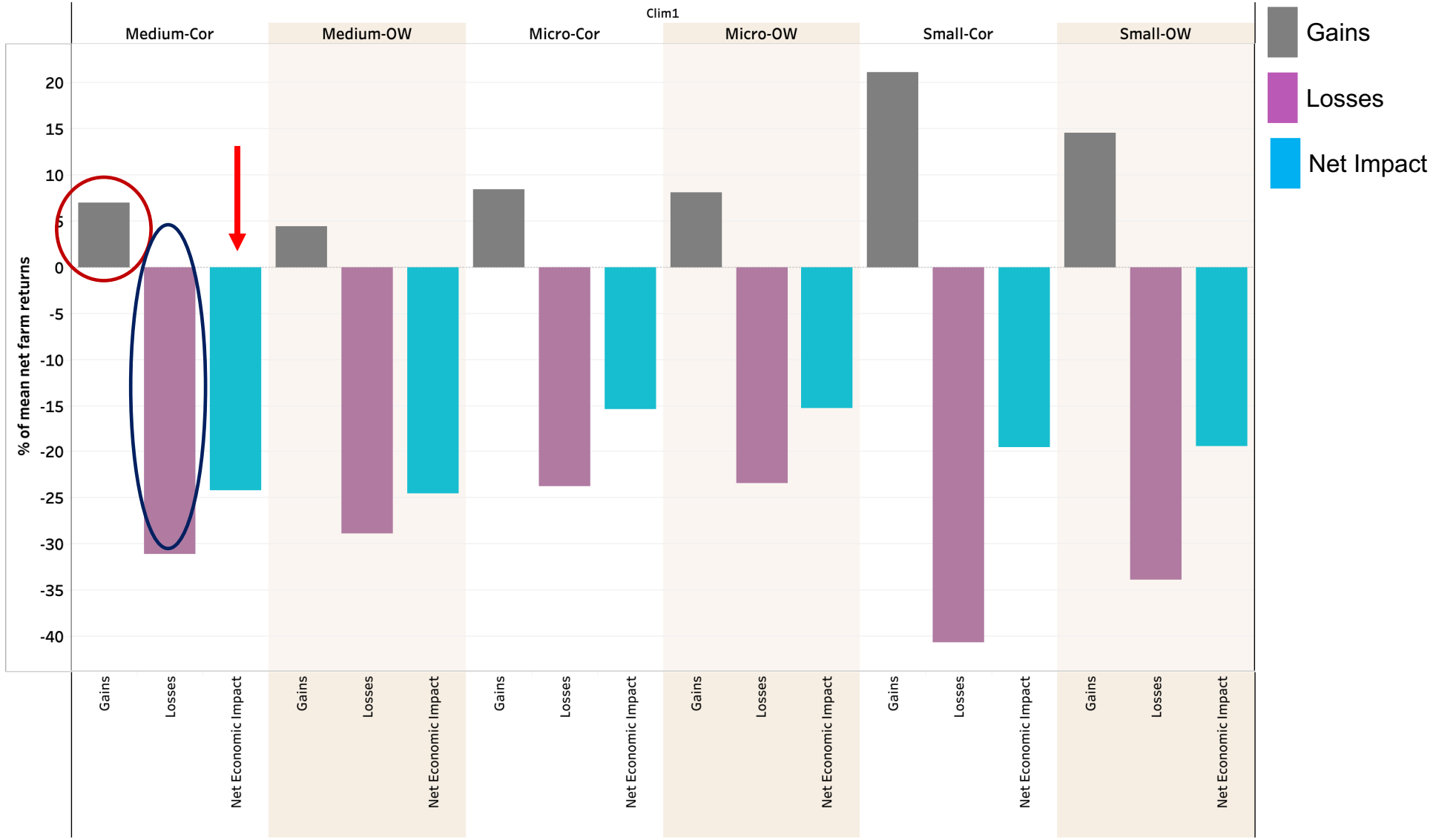
This case study focuses only on cassava as a commodity, because of lack of data to represent the farming system, the results can't produce outcomes such as poverty rates. The adaptation strategy is based on implementation of integrated pest management and improved cultivars.

Source of data: Interamerican Development Bank, Sustainable Agricultural Development Program

RESULTS:
Net Economic Impact

Tradeoffs – Climate Adaptation & Mitigation Impact Assessment

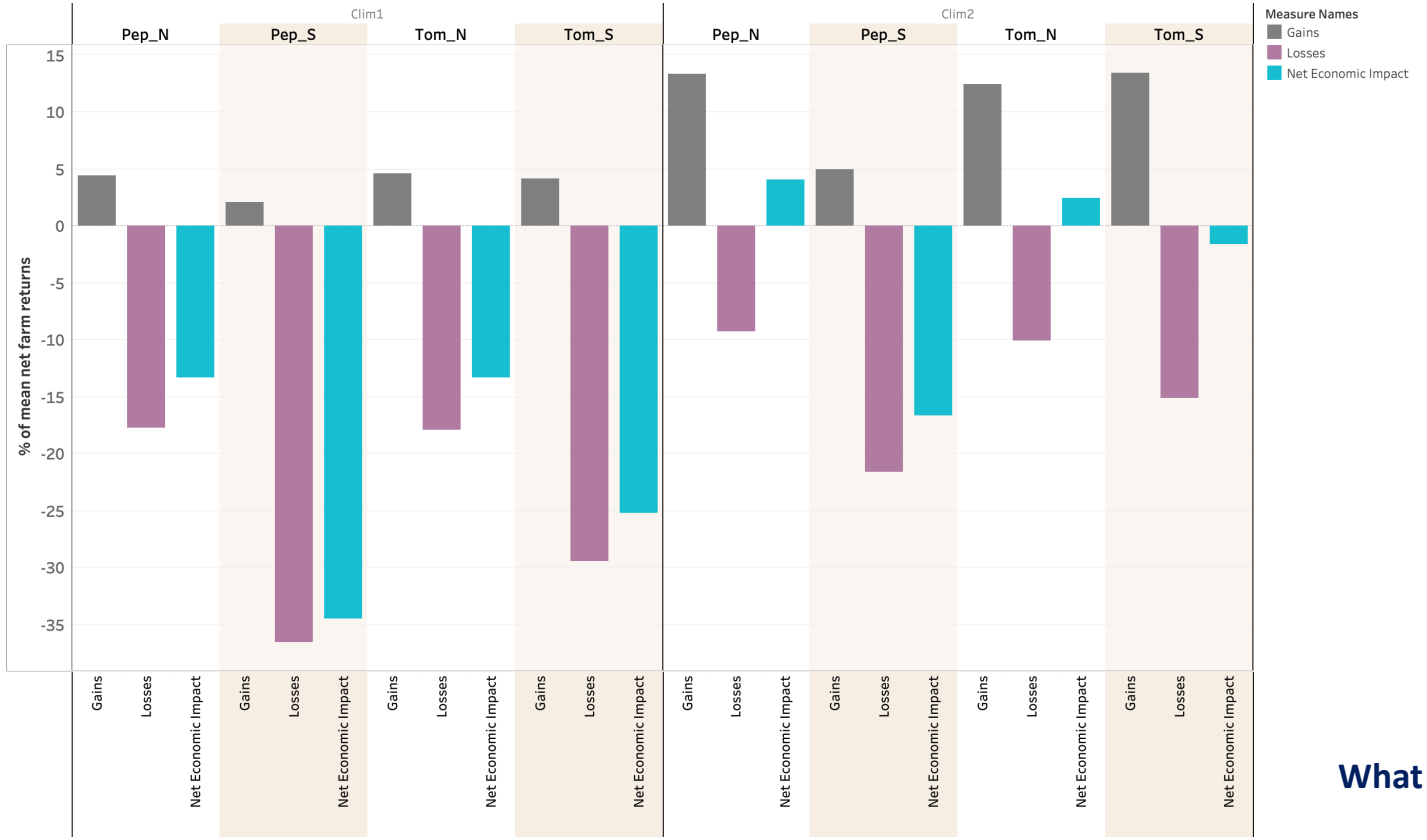
Belize: Sugarcane



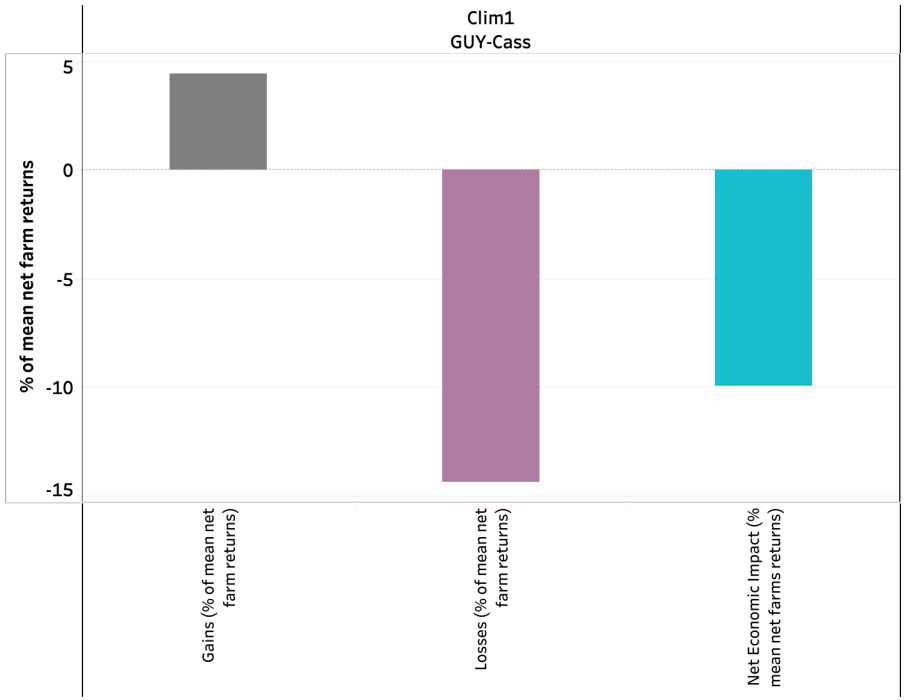
RESULTS: Gains, Losses, NEI

Tradeoffs – Climate Adaptation & Mitigation Impact Assessment

Trinidad and Tobago: Tomato & Pepper

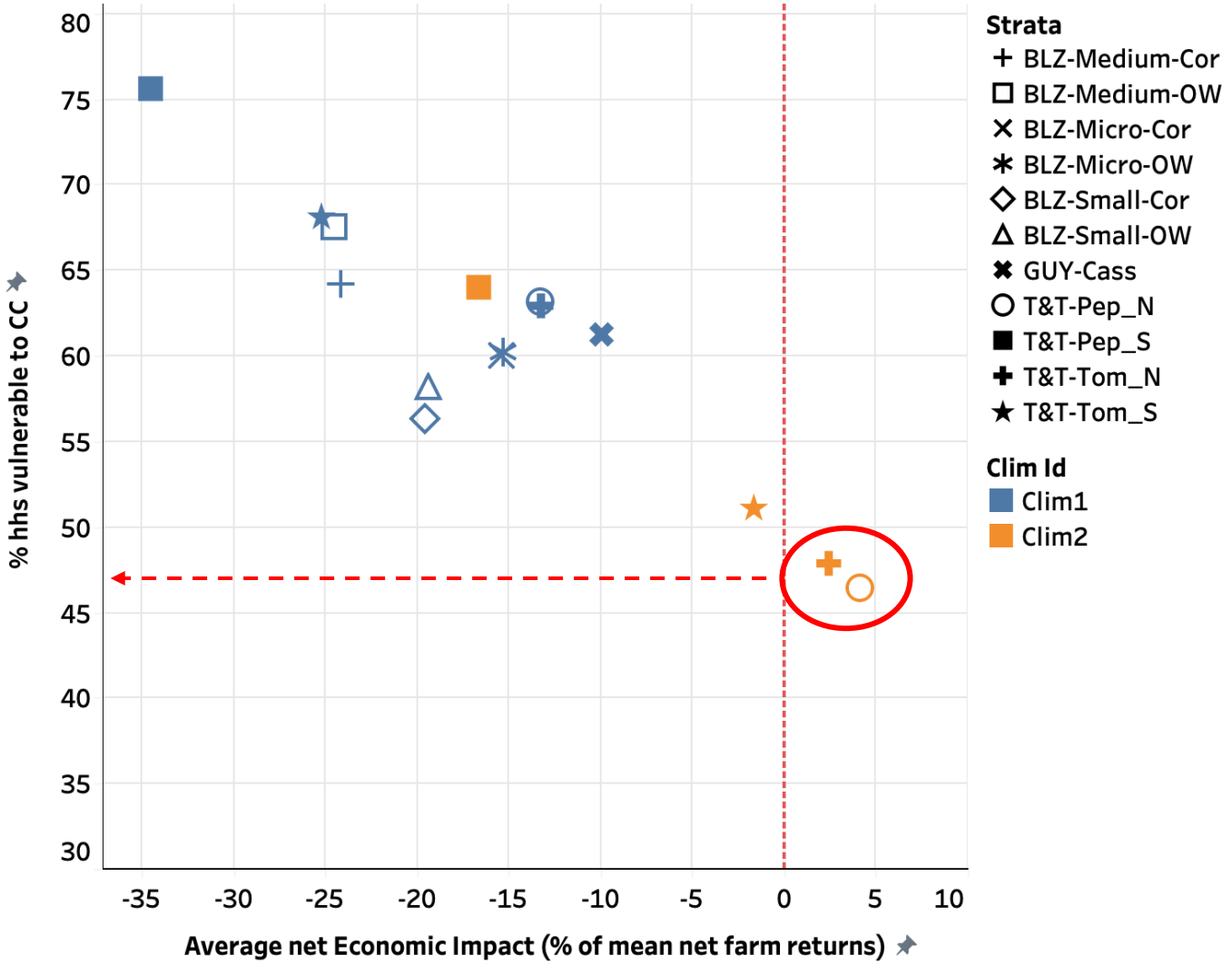


Guyana: Cassava



What does this mean?

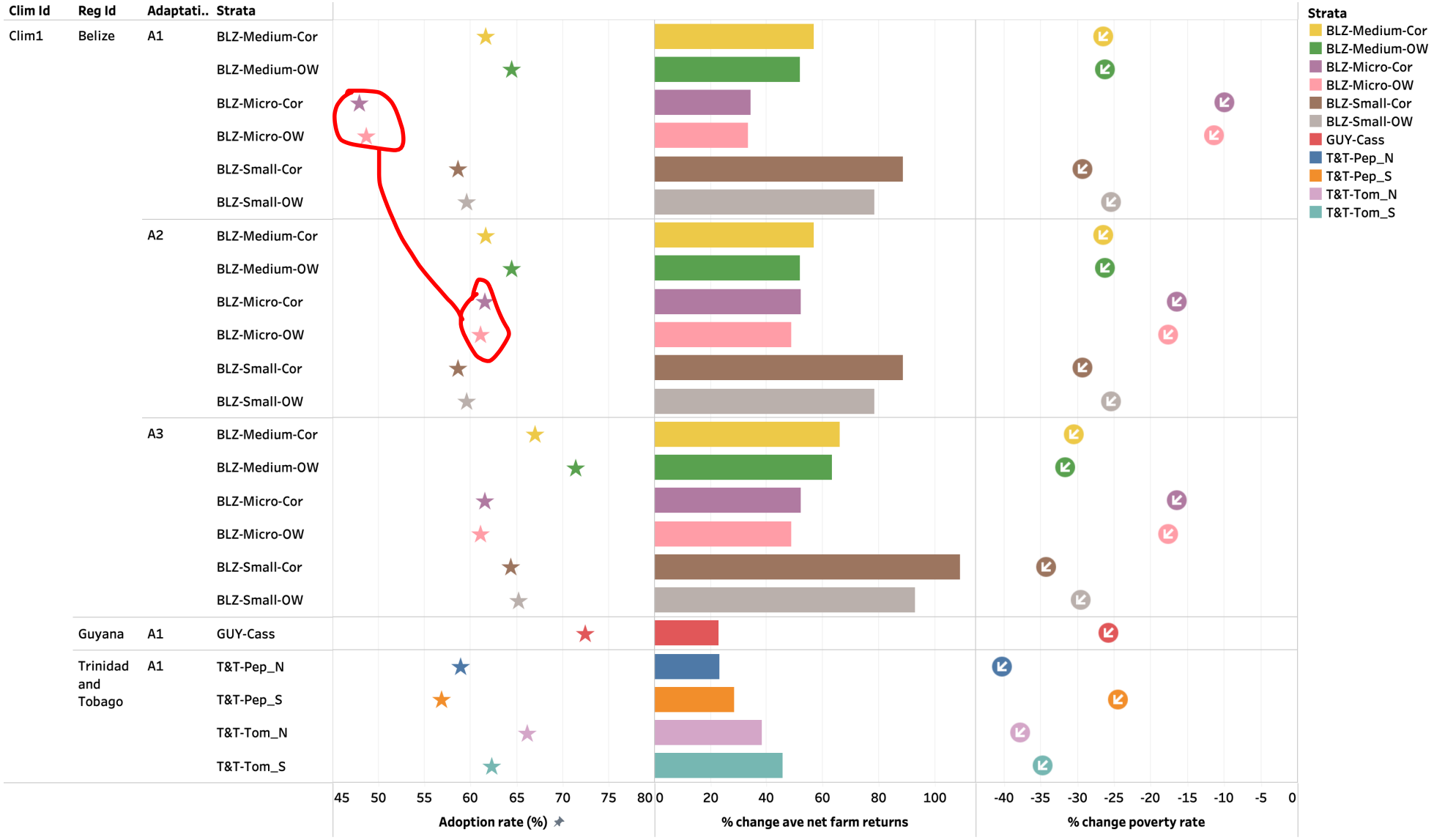
- There are gainers and losers. Why?
  - Heterogeneity
- ***Implications for***
  - Policy-Decision making
  - Adaptation/Mitigation planning
  - Investment



RESULTS: Tradeoffs: Vulnerability & NEI

Farming system	Adaptation package
 *Tomato*	Drought resistant varieties and improved irirgation systems
 *Pepper*	Drought resistant varieties and improved irirgation systems
Sugarcane 	Soil conservation practices, improving soil nutrients, organic matter and bio-fertilizer (CSA, CA)
	Improved crop varieties and diversification
	Microdosing and irrigation and drainage management
	Support on initial investments
 *Cassava*	Integrated Pest management and improved crop varieties (CSA)

Adaption of adapted strategies – all sites (adoption rate, change in NRs and poverty)



Conclusions

❖ **Based on this pilot study:**

- ➢ CC is likely to have net negative effects on some farming systems in the Caribbean region
- ➢ There are likely to be both gainers and losers from climate change due to heterogeneity (variations) in bio-physical and socio-economic conditions
  - Even in cases where there are net average gains due to climate change, many households will be vulnerable to large losses
  - An important policy challenge is to identify the most vulnerable and develop adaptation strategies to reduce vulnerability
  - Climate resilient crops in the region can be used with CSA and IPM management practices to adapt to climate change
- ➢ There is the need to assess impacts of climate change, adaptation & mitigation under future socio-economic conditions (e.g. RAPs)

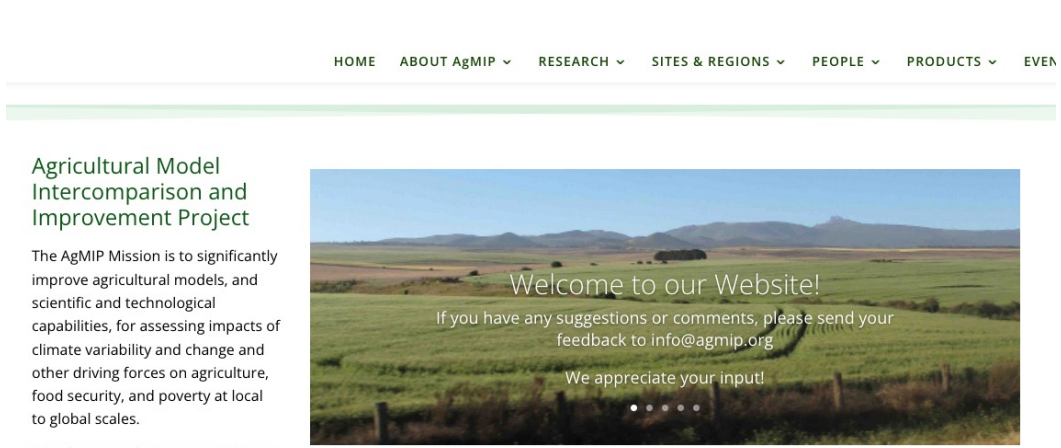
❖ Based on this pilot study:

- The AgMIP protocol-based approach to climate impact and adaptation assessment facilitates collaborative analysis, research synergies and learning across regions and countries
  - Methods and models are available to be learned and used by research teams across the LAC region
  - Investment on improving capacity of both, scientists (on the use and implementation of the RIA methods and tools) and stakeholders (on the understanding and use of the results)
  - Investment in bio-physical and socio-economic data is needed to identify vulnerable populations and develop science-based adaptation strategies

Abstracts and sessions requests by March 24, 2023

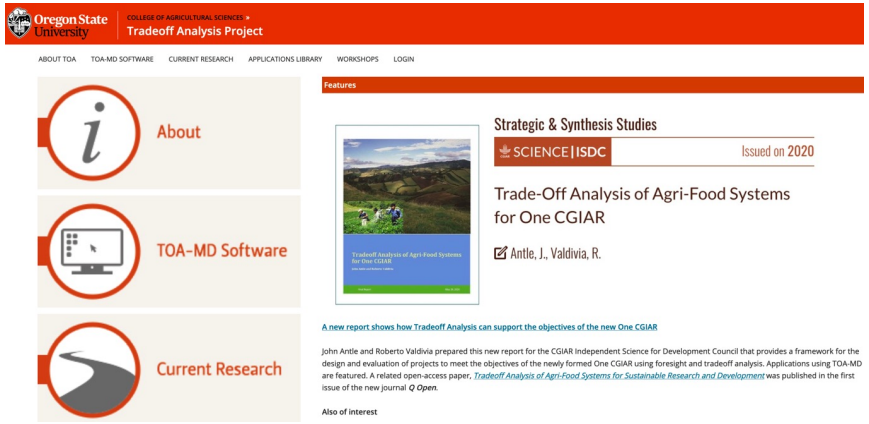
Thanks!

AgMIP The Agricultural Model Intercomparison and Improvement Project

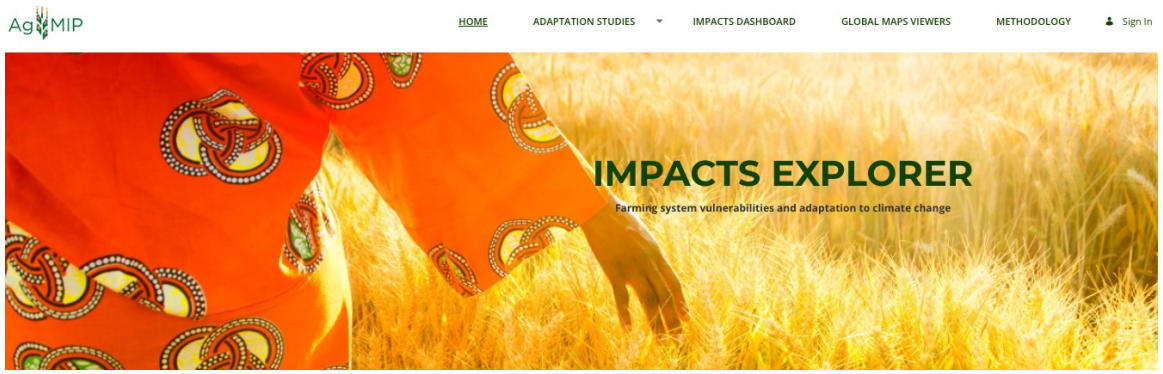


https://agmip.org/

TOA-MD MODEL



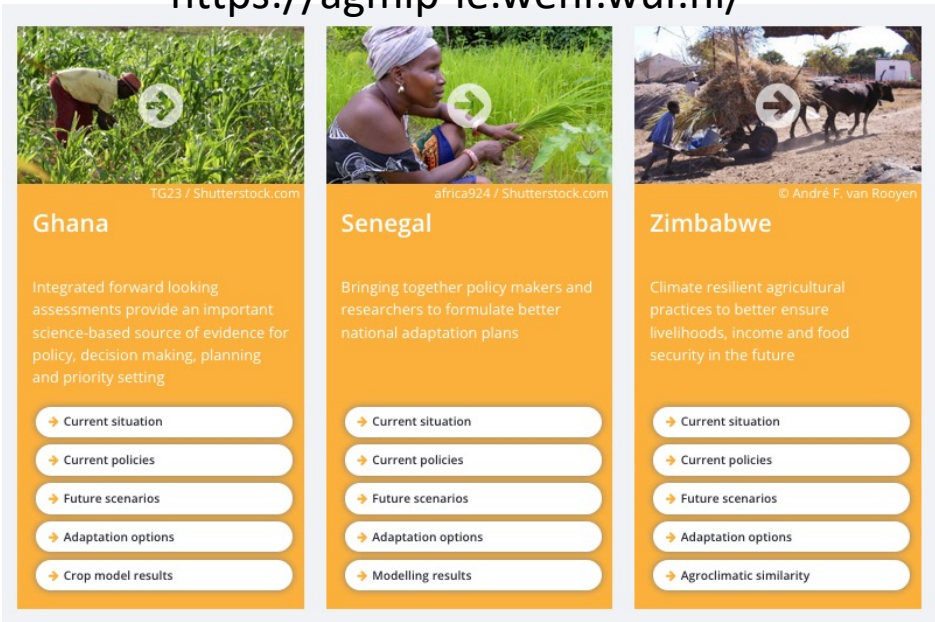
https://tradeoffs.oregonstate.edu/



National and regional assessments: studies of climate change impacts and adaptation

The national - regional assessments show how knowledge of the impacts of climate change on regional farming systems informs national policy making. They illustrate plausible narratives of national drivers, agricultural, food security and climate policies, by which the countries aim at achieving their national goals, visions and climate change committments.

https://agmip-ie.wenr.wur.nl/



Papers- Global Trainings – Courses - Consultancies