



# Temperature Indicators for Developing Adaption Strategies for Crop Production: A Case Study in Florida

Anjali Sharma<sup>1,2,\*</sup> and Aavudai Anandhi<sup>2</sup>

<sup>1</sup>Ph.D Candidate, School of Environmental Science, Florida A&M University, Tallahassee, FL, USA, 32307

<sup>2</sup>Biological Systems Engineering, Florida Agricultural and Mechanical University, Tallahassee, FL, USA, 32307

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# Introduction

## Synthesis of 32 studies (Meta-analysis) for temperature change in Florida

- A Scenario is a coherent, internally consistent and plausible description of the future state of the world. It is not a forecast; rather, each scenario is one alternative image of how the future can unfold (IPCC, 2008).
- Temperature change ➡ -3 °C to 6 °C.

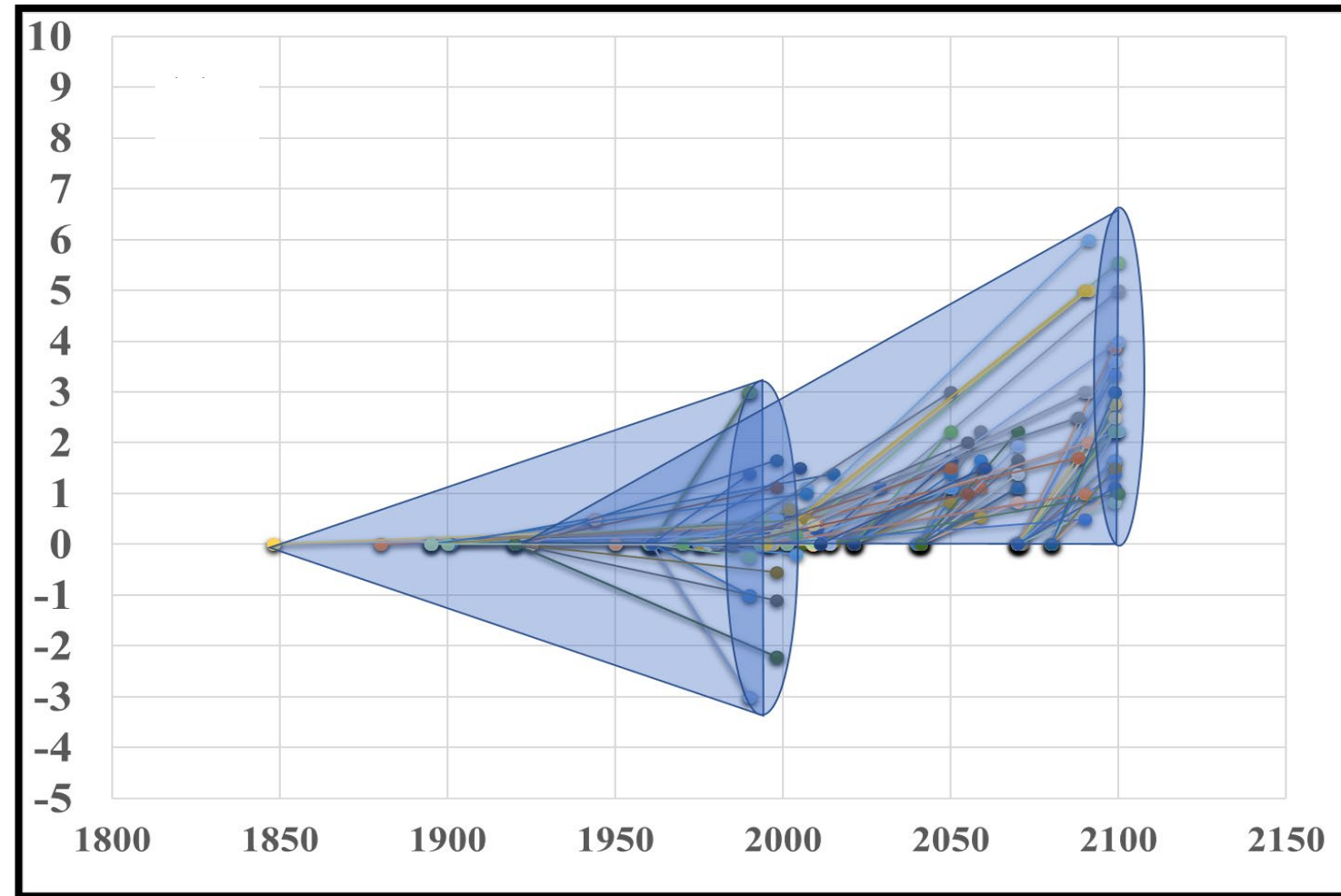


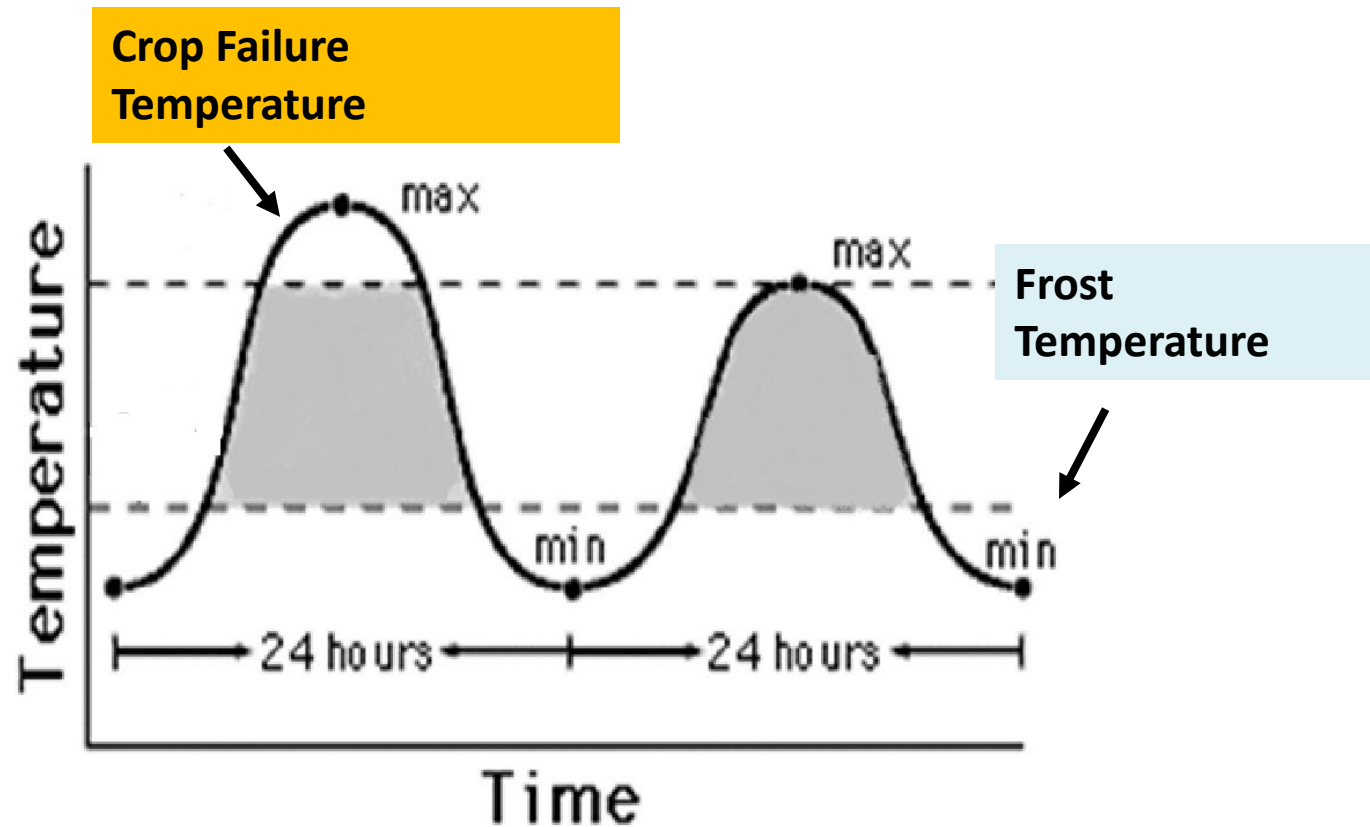
Figure shows the scenario funnel of temperature change in Florida  
(Anandhi, Sharma and Sylvester, 2018)

# Crop Failure Temperature (CFT) and Frost Indices (FIs)

- **Crop Failure Temperature (CFT)** : Maximum temperature above which crop growth stops and which leads to crop failure.

$$T_{max} \geq T_b (\text{Base temperature})$$

- **Base temperature:** temperature at which crop growth and development occurs.



Source: Andrews, 2011

## First fall freeze (FFF)

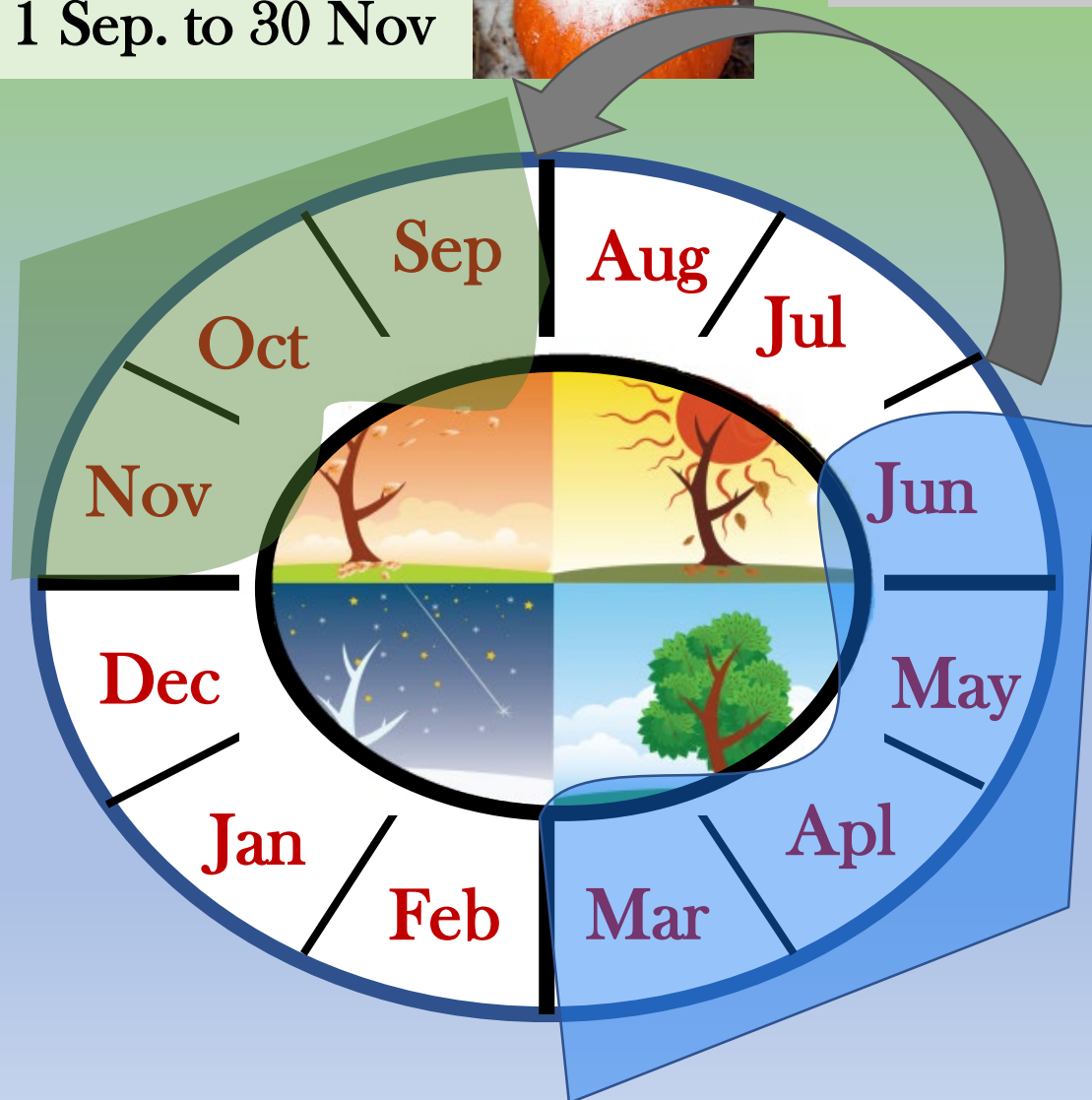
first day when  $T_{\min} < 0\text{ }^{\circ}\text{C}$  in the period

1 Sep. to 30 Nov



## Growing season length (GSL)

The number of days between the LSF and the FFF

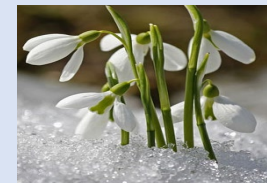


$$T_{\min} \leq T_b (\text{Base temperature})$$

## Last spring freeze (LSF)

last day when  $T_{\min} < 0\text{ }^{\circ}\text{C}$  in the period

1 March to 30 June



**To analyze the effect of indicators such as Crop Failure Temperatures (CFTs) and Frost Indices (FIs) on crops in Florida.**

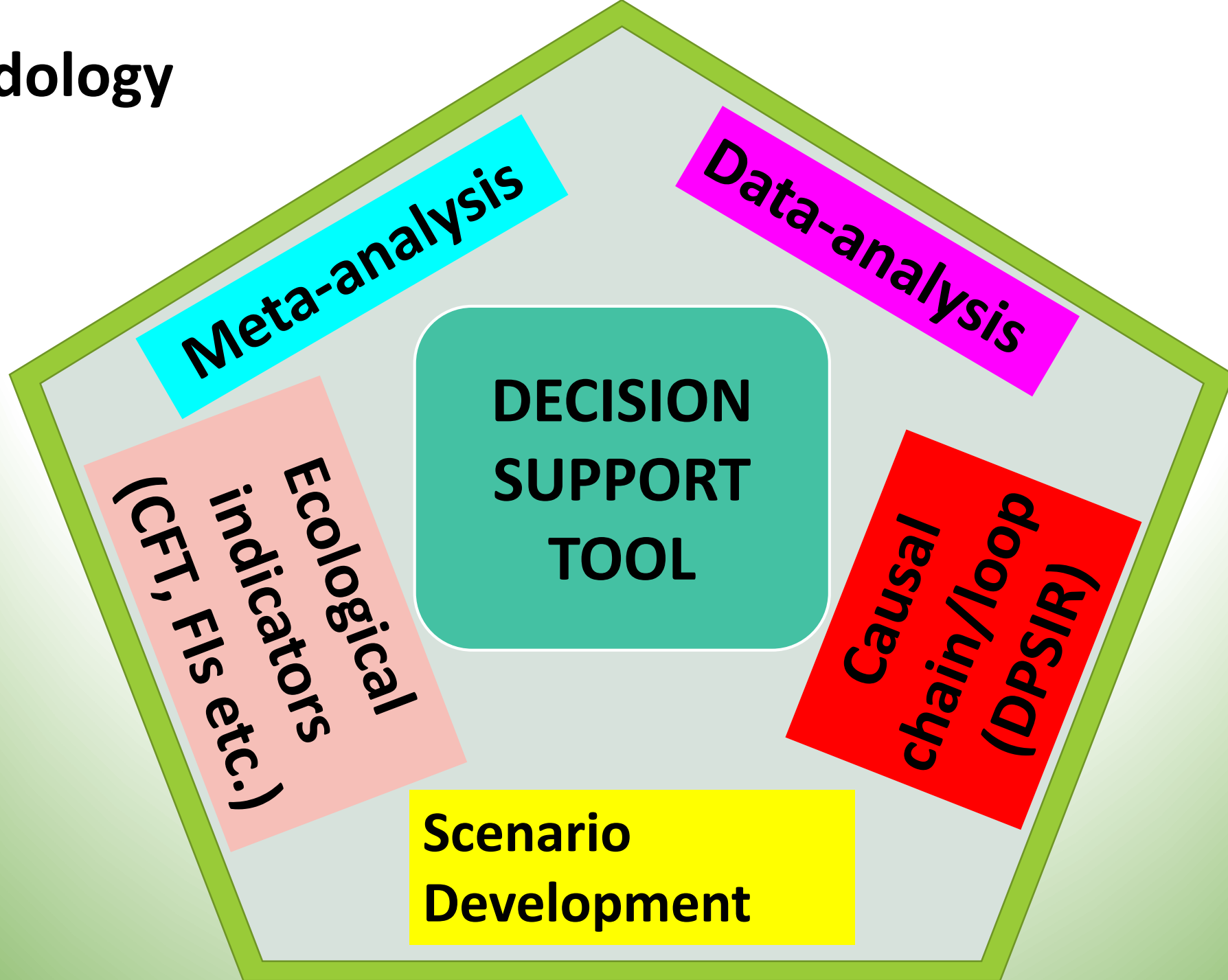
**To develop the adaptation strategies using decision support tool & causal loop: DPSIR (Driver Pressure-Impact-State-responses).**

# Objectives

# Methodology



# Methodology





# Data Collection

Downloaded daily maximum and minimum temperature data at resolution is  $0.125^\circ \times 0.125^\circ$  (Maurer et al, 2014).

Coupled model inter-comparison project phase 5 (CMIP5) models dataset for historical (1950–2005) and Representative concentration pathways RCP8.5 (2006–2100) climate experiments are used.

Florida Grid points  $\rightarrow$  856 in numbers.

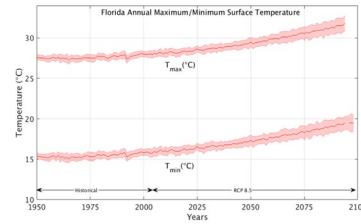
**Crop Failure Temperature**  
(30 °C, 32 °C, 34 °C, 35 °C, 39 °C and 40 °C)

**Frost temperature**  
(5.6°C, 2.2°C, 0°C and -2°C, -1°C and -5°C)

**Step 1**

Analyzed the maximum temperature time series

Analyzed the minimum temperature time series

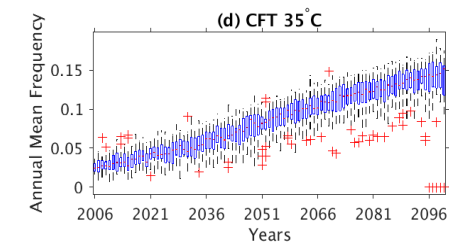


**Step 2**

Estimated the variability in each EIs using boxplot

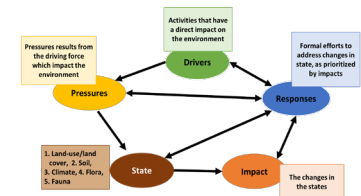
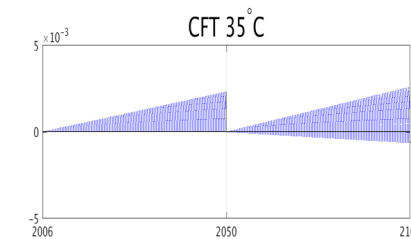
**Step 3**

Plotted the scenario (funnel) plots



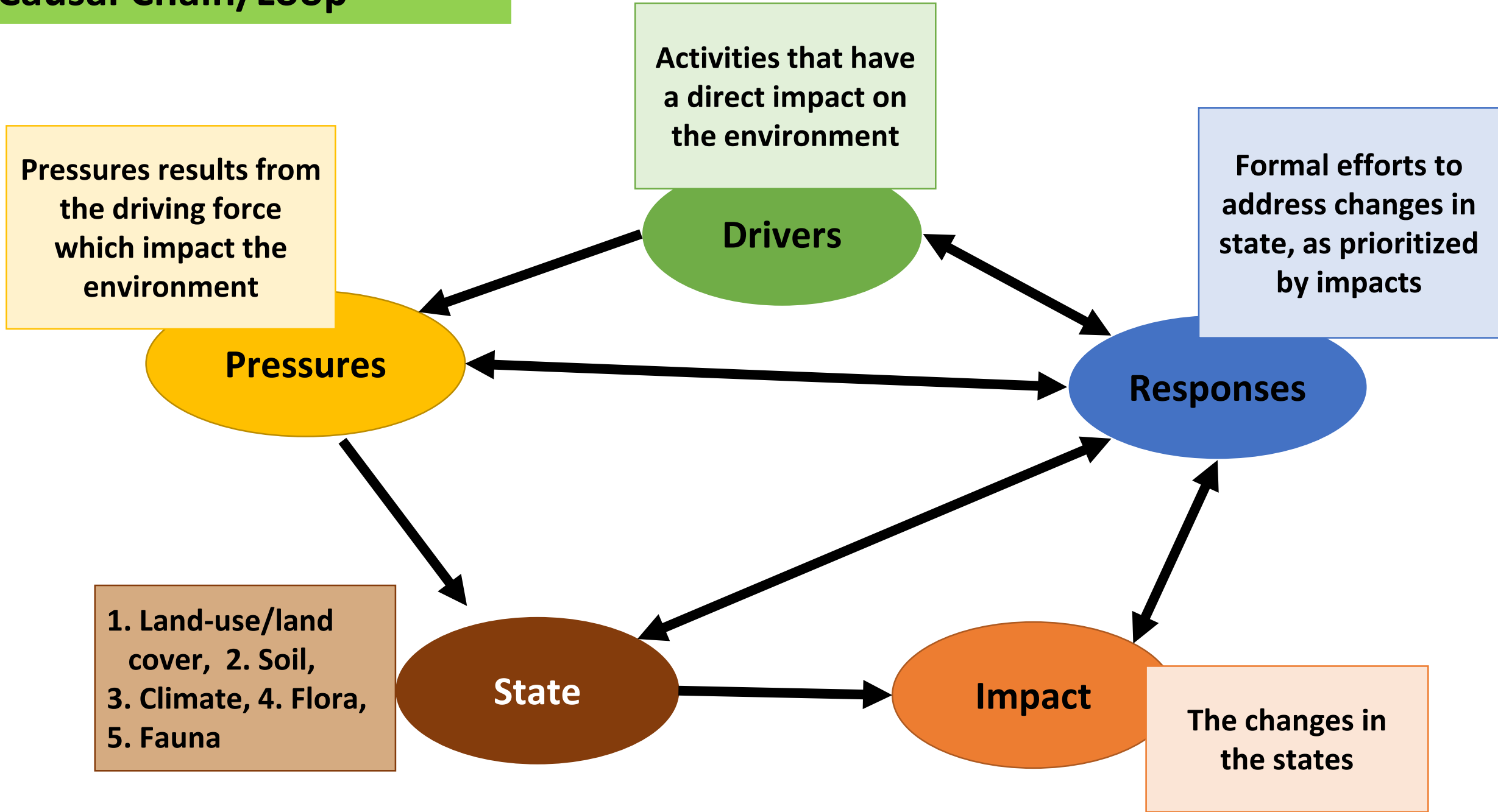
**Step 4**

Developed DPSIR framework



# Causal chain/loop: DPSIR framework

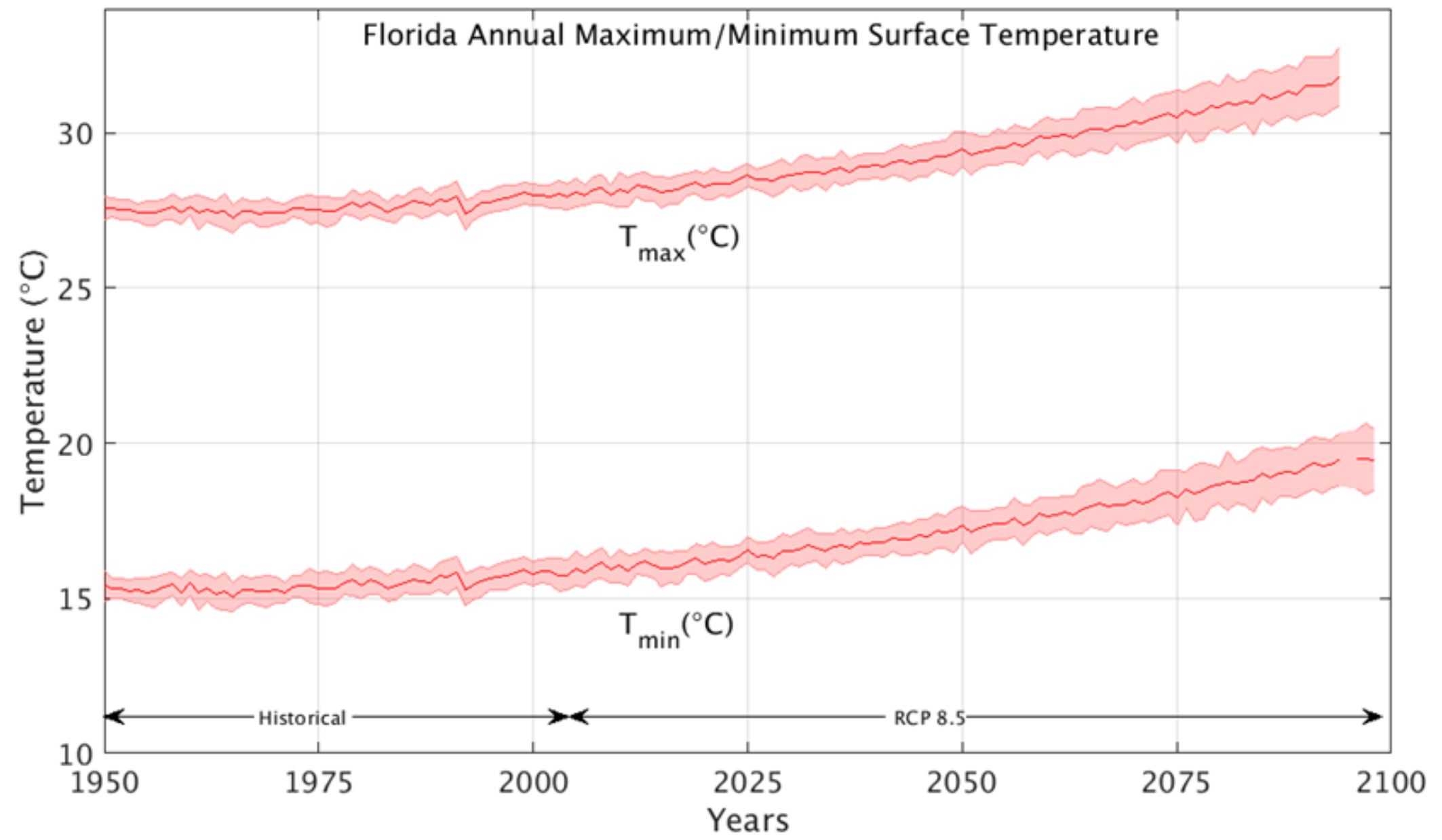
# Causal Chain/Loop





# Results

# Maximum and minimum Temperature trends in Florida(1950-2100)

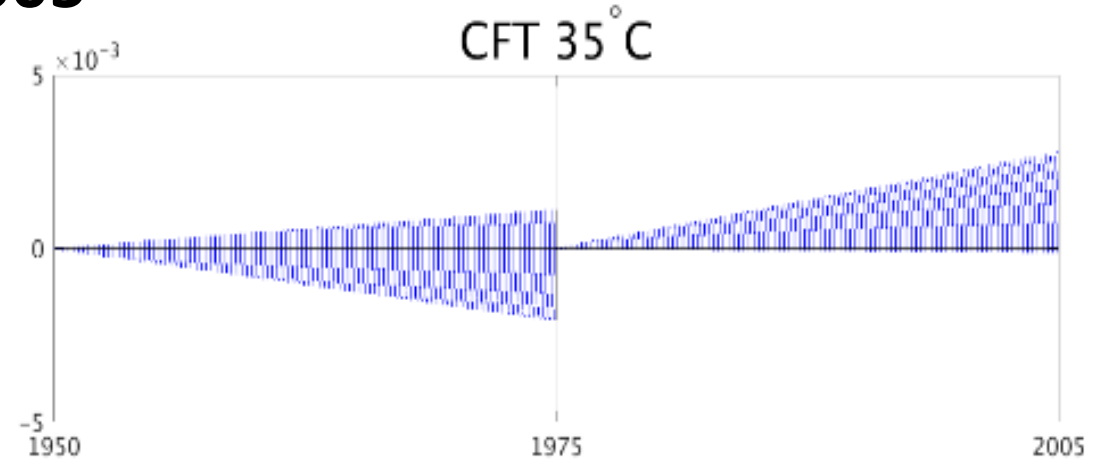
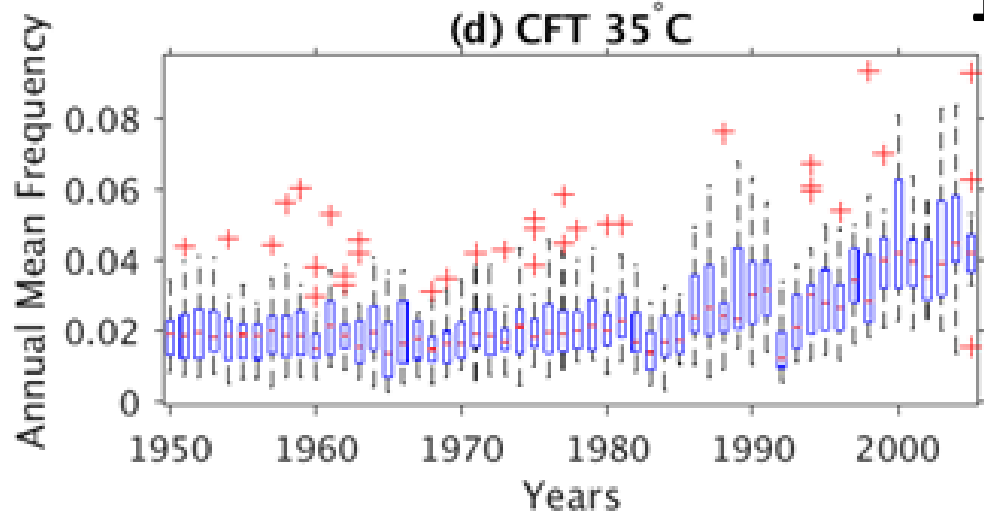


# Frequency boxplot

# Scenario (Funnel) Plot

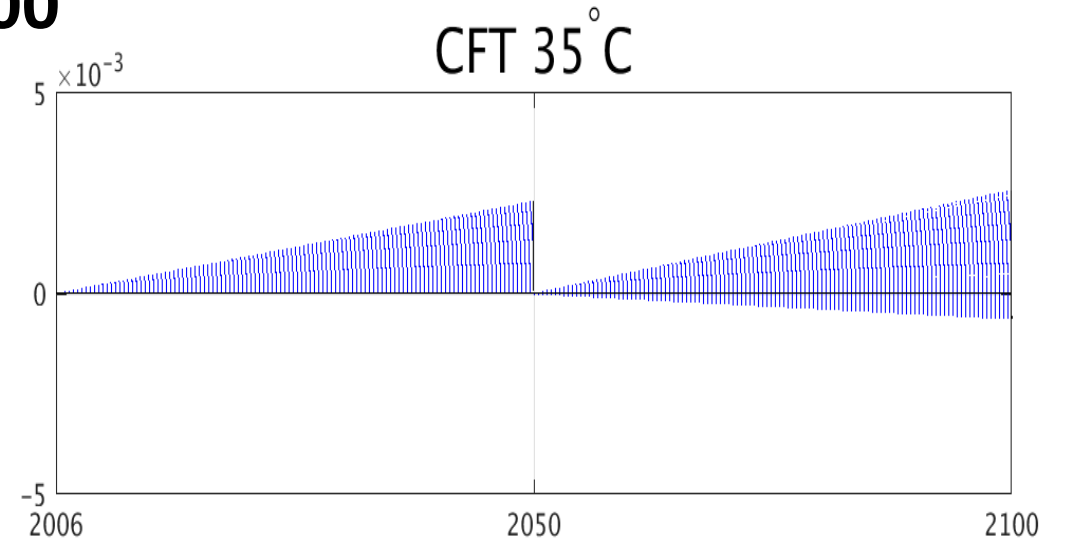
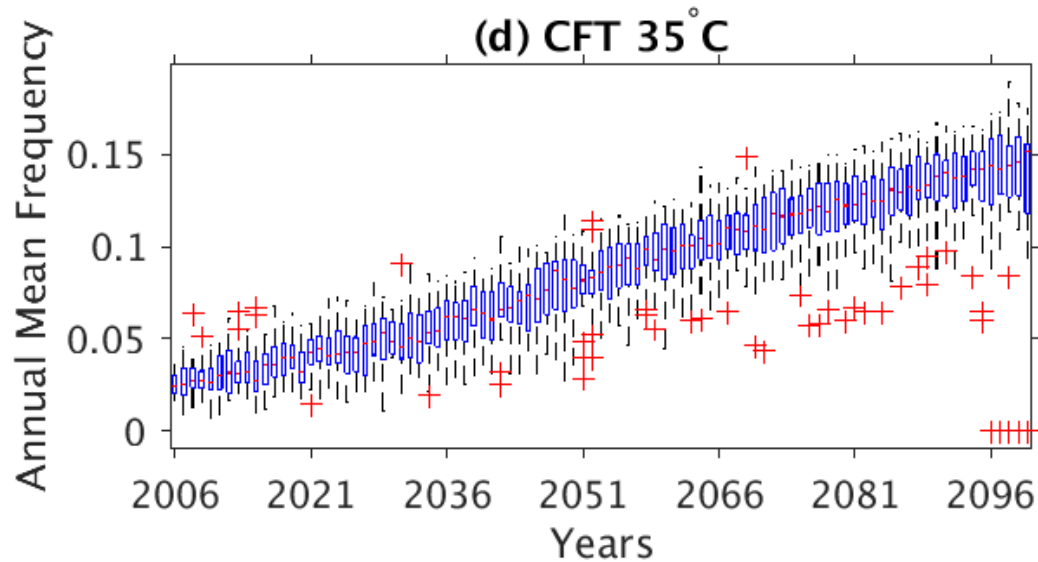
1950-2005

Historical (1950-2005)



2006-2100

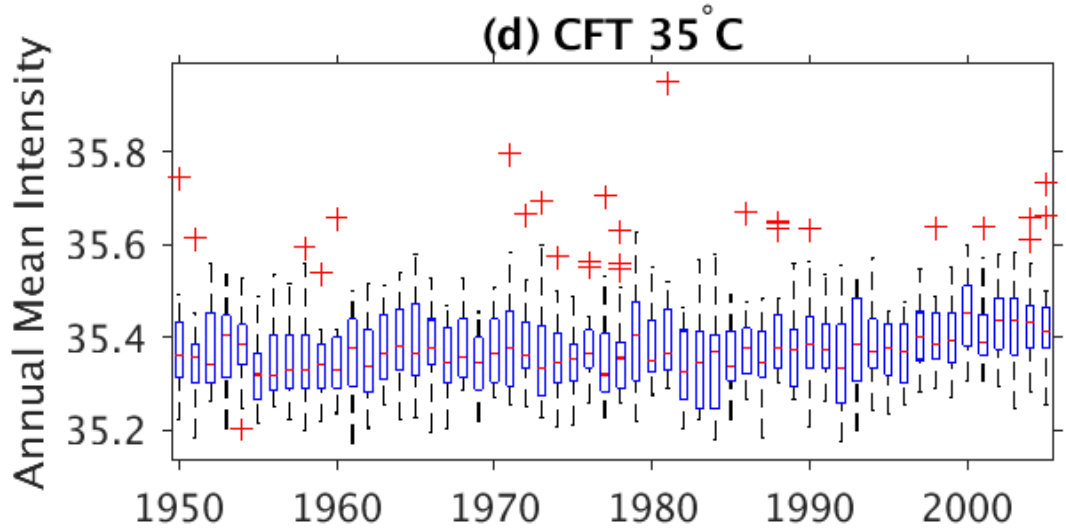
RCP 8.5 (2006-2100)



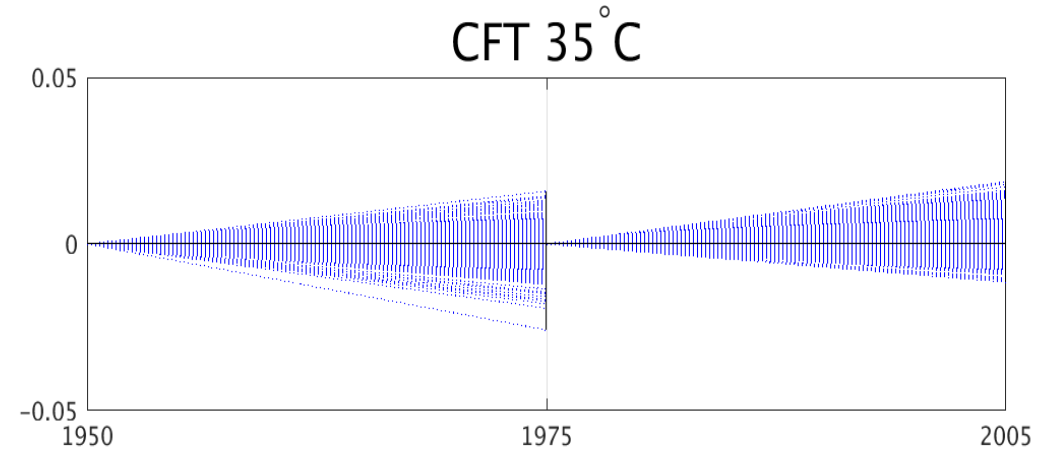
# Intensity boxplot

# Scenario (Funnel) Plot

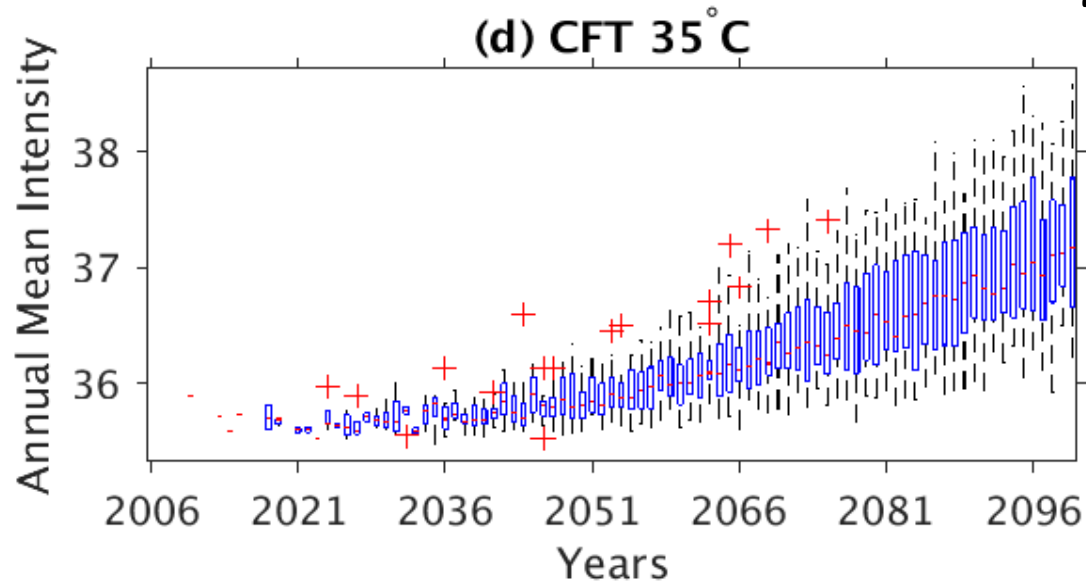
Historical (1950-2005)



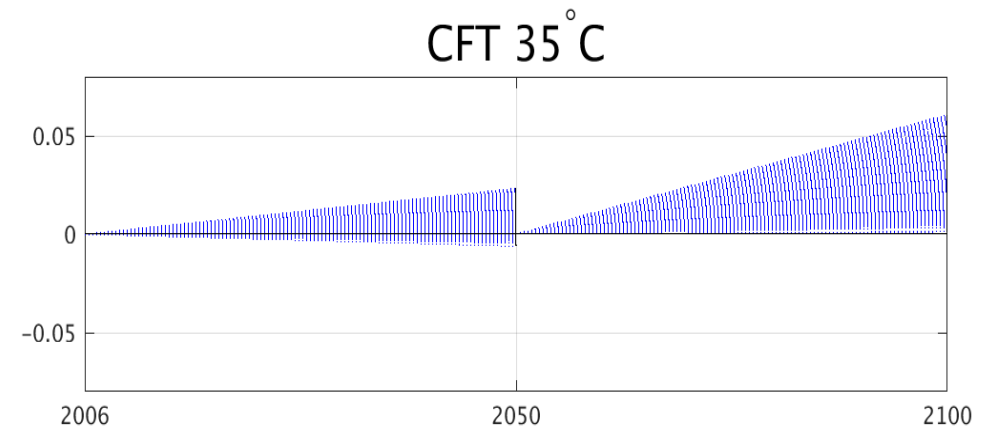
1950-2005



RCP 8.5 (2006-2100)



2006-2100

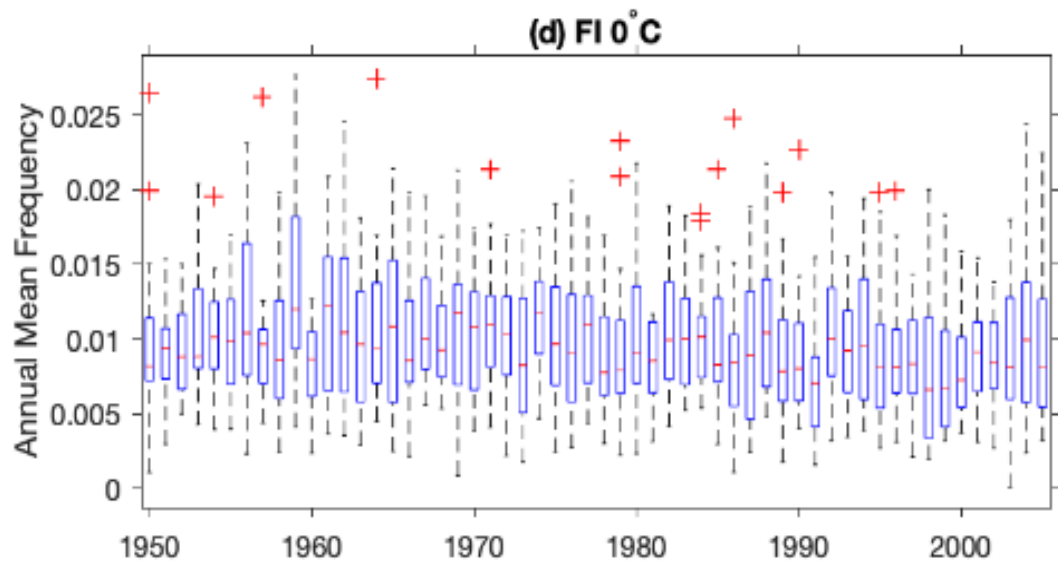




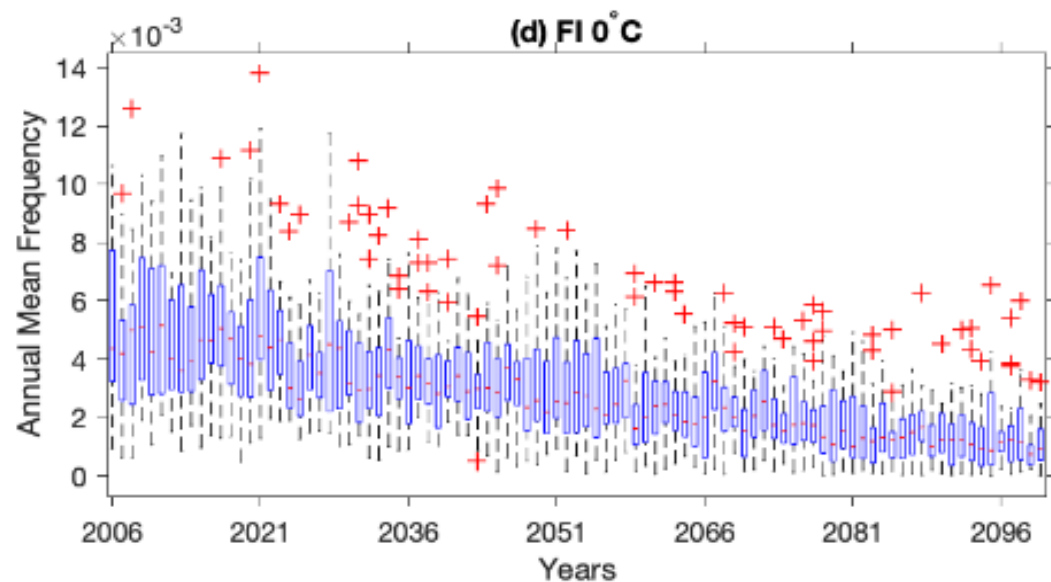
Frost  
temperature

# Frequency boxplot

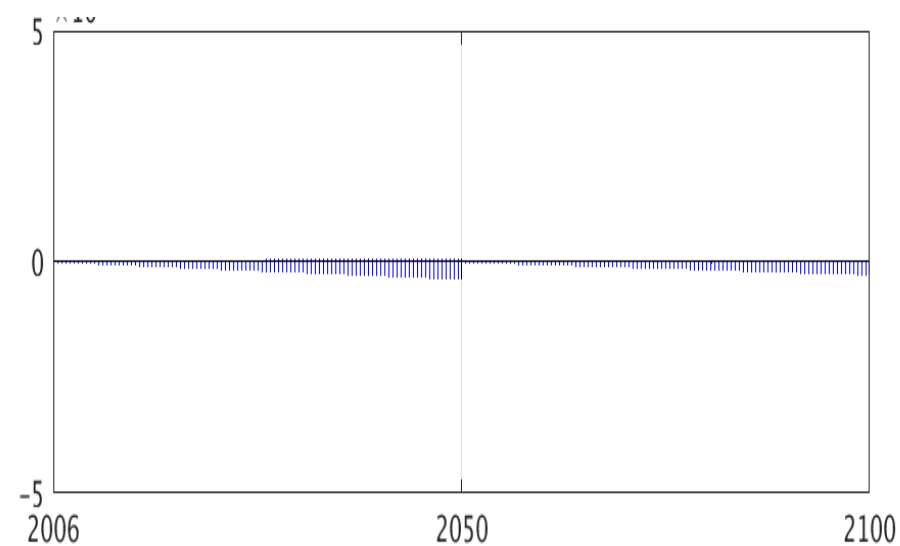
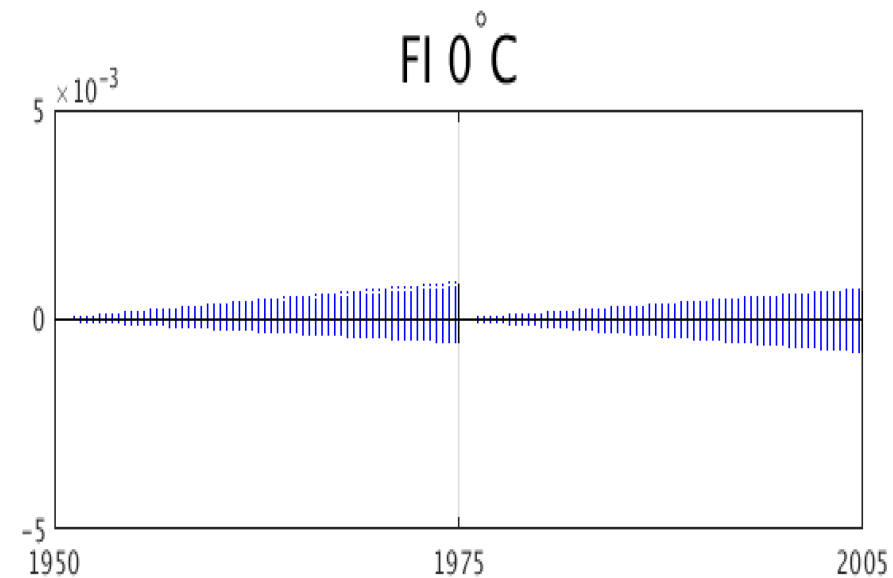
Historical (1950-2005)



RCP 8.5 (2006-2100)



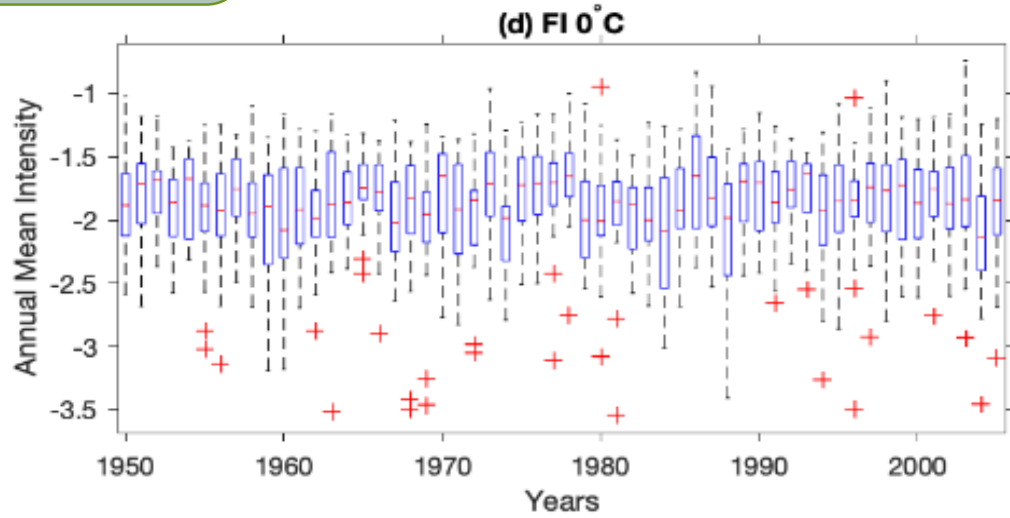
# Scenario (Funnel) Plot



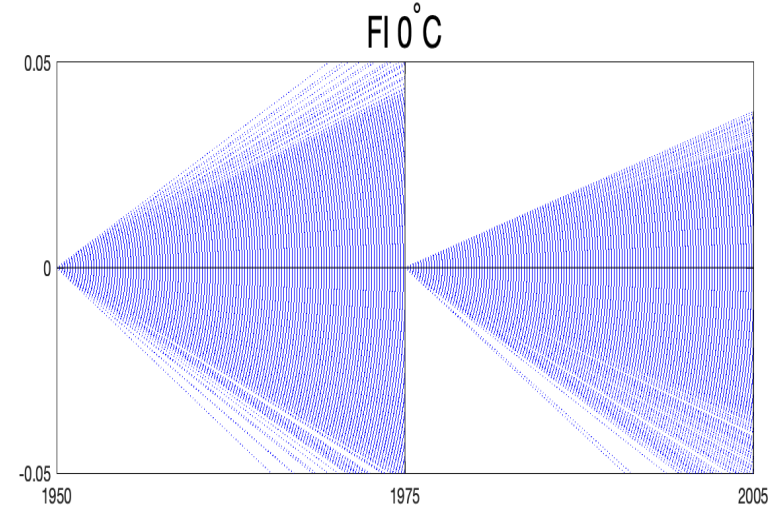
Historical (1950-2005)

Frost temperature

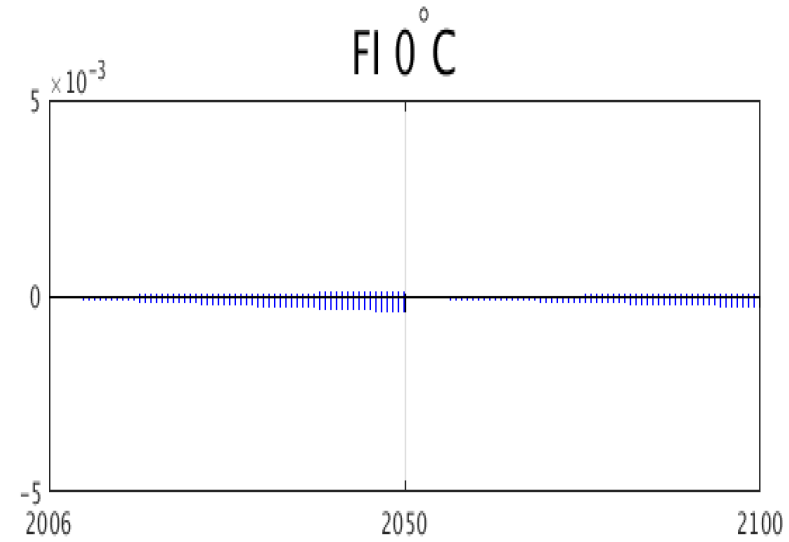
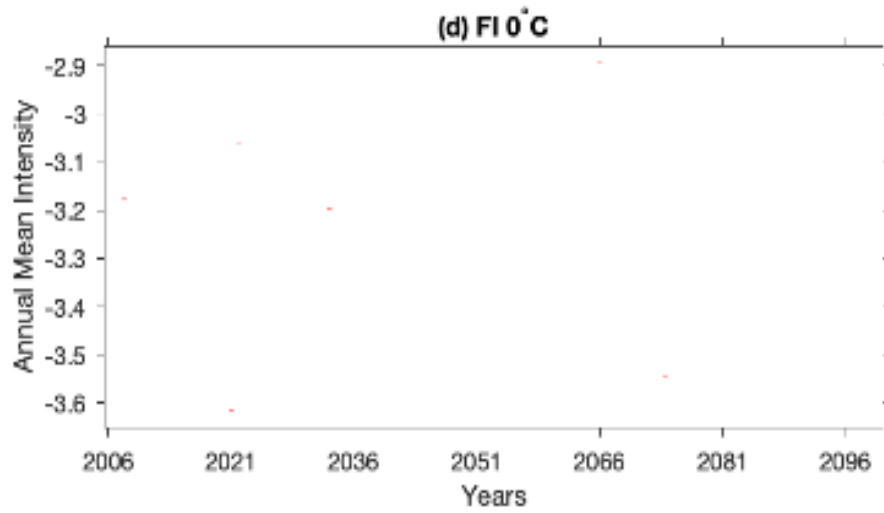
# Intensity boxplot



# Scenario (Funnel) Plot



RCP 8.5 (2006-2100)



# Impact of crop failure temperature

## Regional



### Above-ground

### Below-ground

Crop yield and production

Reproductive and vegetative develop.

Inc. drought condition and dry spells

Crop failure

Reduce pod

Pollen viability

pH scale

Soil microbial diversity

Harvest indices

Global Food production

Evaporation rate in soil and water

Seed production

## Plant



Dec. pollen production

Inc. soil respiration

Orientation of root growth

Dec. photosynthesis

No pollination

Soil water content loss

Effect primary and sec. metabolites

Floral development

Low fruit set

Damage cell division

Dec. plant height

Filed anthers

Inc. biomass accumulation.

## Microscale



Infest of pest and insects

Growth and soil microbial diversity

Seed germination

Meiosis in pollen

Fungi effect plant photosynthesis.

Inc. soil biological process

# Impact of frost temperature

## Regional



Crop yield and production

Effect biodiversity

Harvest indices

Global Food production

Reproductive and vegetative develop.

Seed production

## Below-ground

Soil drainage

Soil microbial diversity

Nutrient leaching

## Plant



Dec. pollen production

Dec. photosynthesis

Floral development

Dec. plant height

No pollination

Low fruit set

Soil micro biodata

Soil water content loss

Damage cell division

Carbon and nutrient budgets

Free amino acids and sugar in soil

Respiration activity of soil

Kills root

## Microscale



Inc. in black mold

Seed germination

Pest infestation

Pest problem by attracting aphids(transmits viruses)

Severe water loss and kill plants

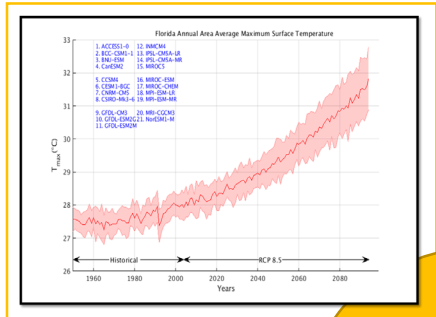
Soil biological process

# Causal chain/ Loop

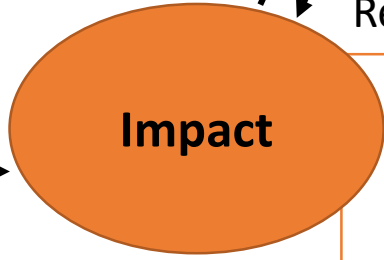
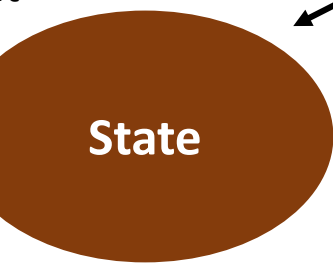
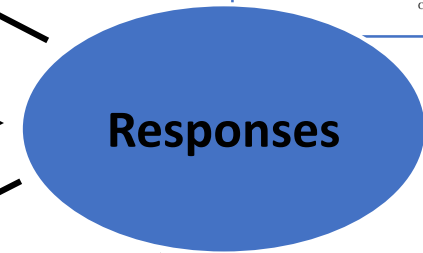
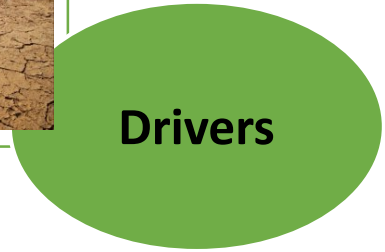
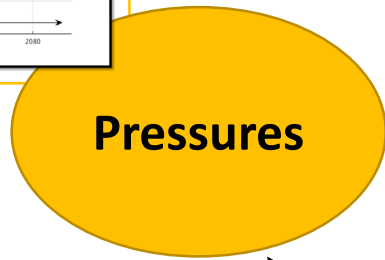
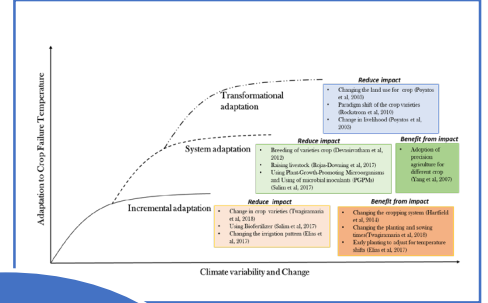
Climate variability



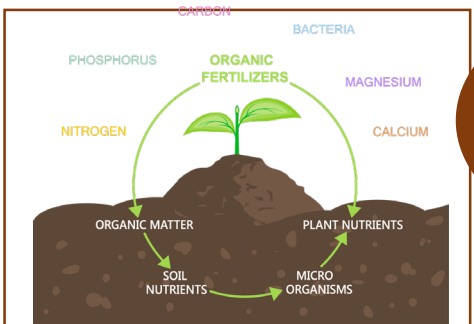
Temperature change



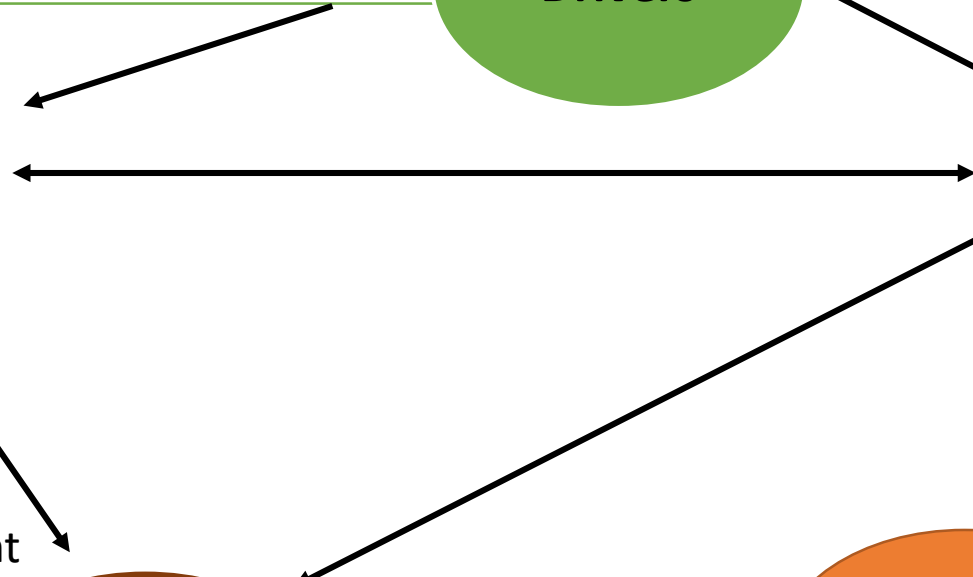
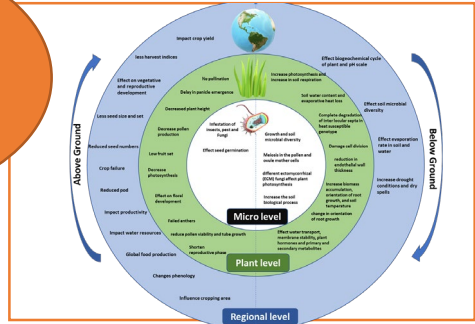
Adaptation Strategies



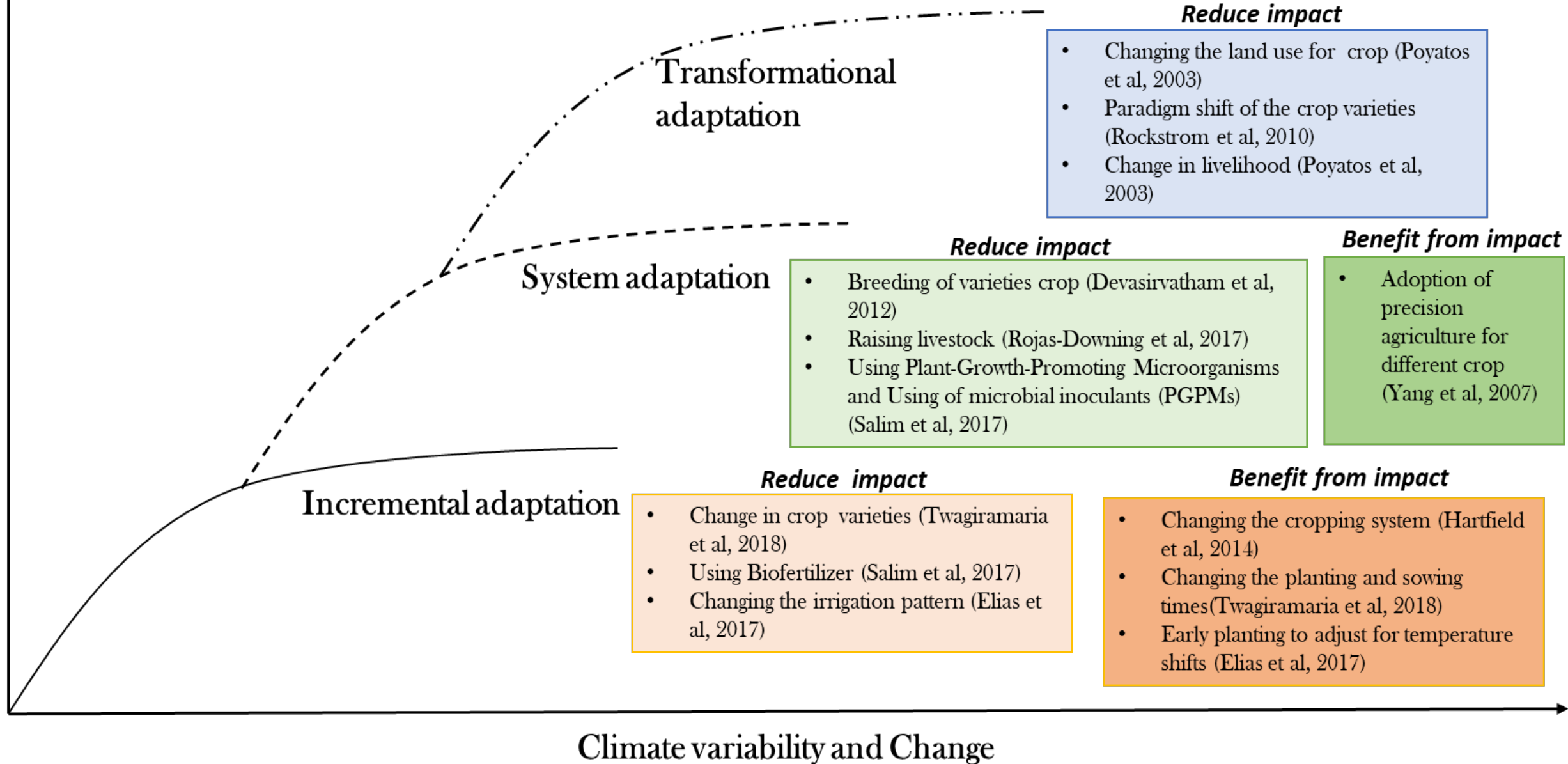
Plant growth and development



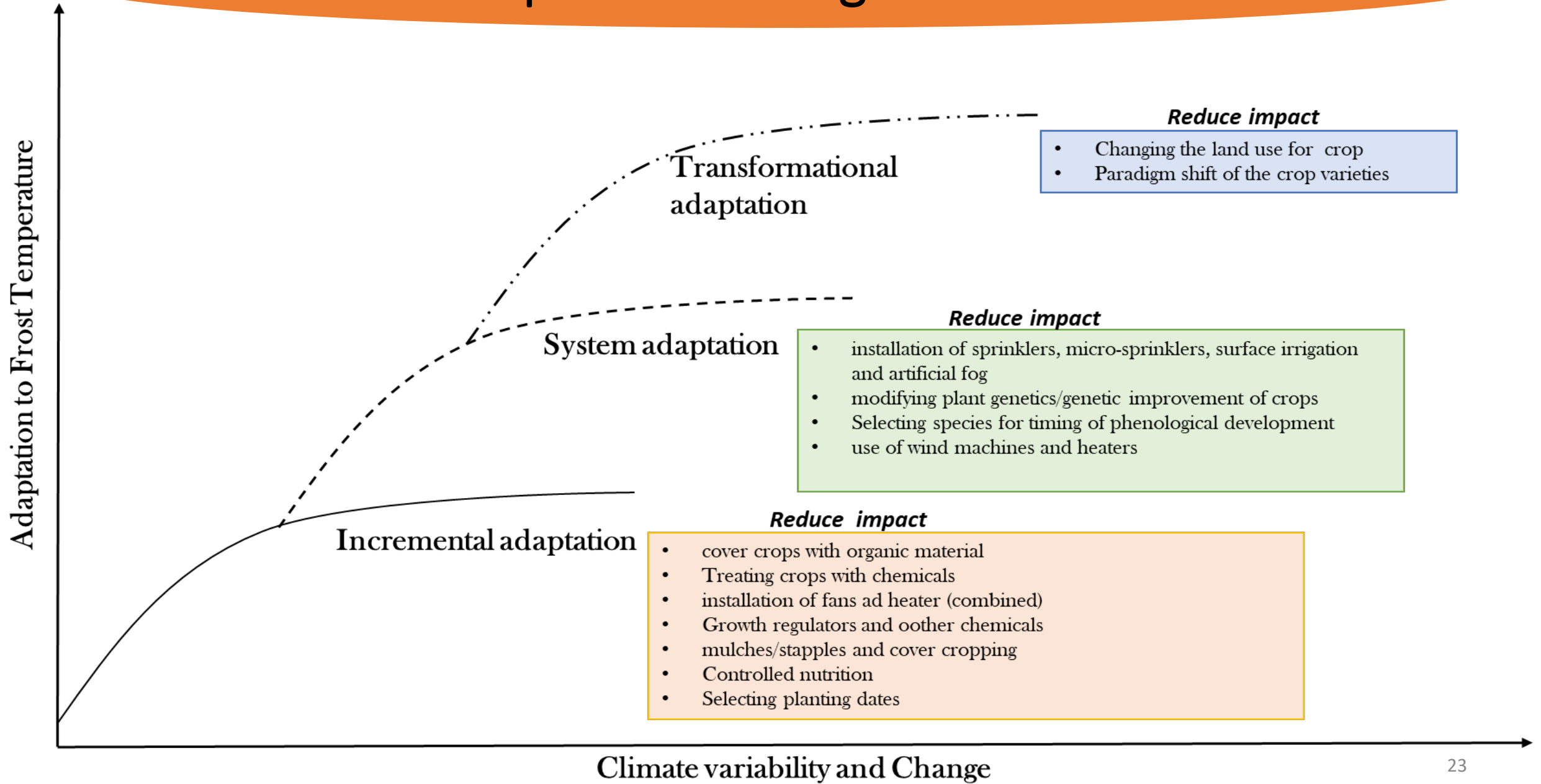
Regional/ Plant/ micro level



# Adaptation strategies for CFTs



# Adaptation strategies for Frost



# Conclusions

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This study is innovative because:

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- 1) DPSIR framework is used to develop decision support tool using ecological indicators (CFTs & FIs).
  - 2) As a basis of adaptive management strategies and insights for updating management decisions.
  - 3) To improve the linkage between the climate impacts and adaptation research.
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This study helps us in explaining the trends for the crop at different thresholds from the historical (1950 – 2005) and future projection RCP 8.5 (2006 – 2100) by using 21 GCMs.

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Temperature change affects different crops at different threshold in terms of intensity and frequency for CFTs and FIs.

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National Institute of Food and Agriculture





**Contact:**

Anjali Sharma

Email: [anjali1.sharma@famu.edu](mailto:anjali1.sharma@famu.edu)

Address: 1409 Wahnish way, Florida A&M University, FL, Tallahassee