The Role of Applied Mathematics in Models and Decision Making

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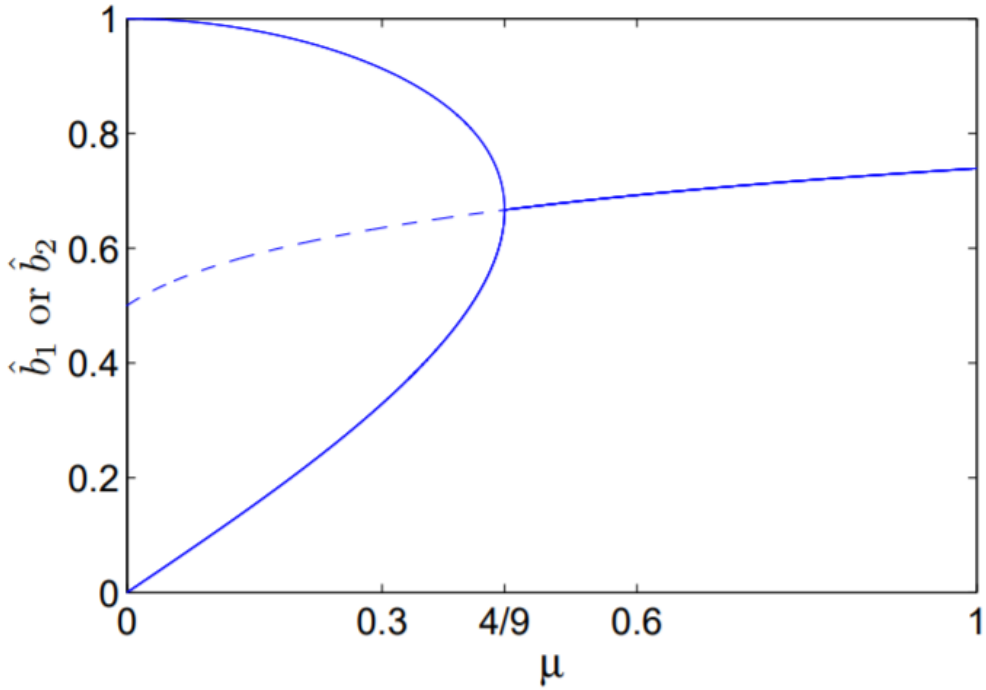
Overview

- Early Lessons
- Bath IMI
- Chicken Welfare
- Catastrophe Risk Modelling
- Cocoa (with an equation or two)

Early Lessons

- You don't need data for a model to be useful!



Early Lessons

- You don’t need data for a model to be useful!
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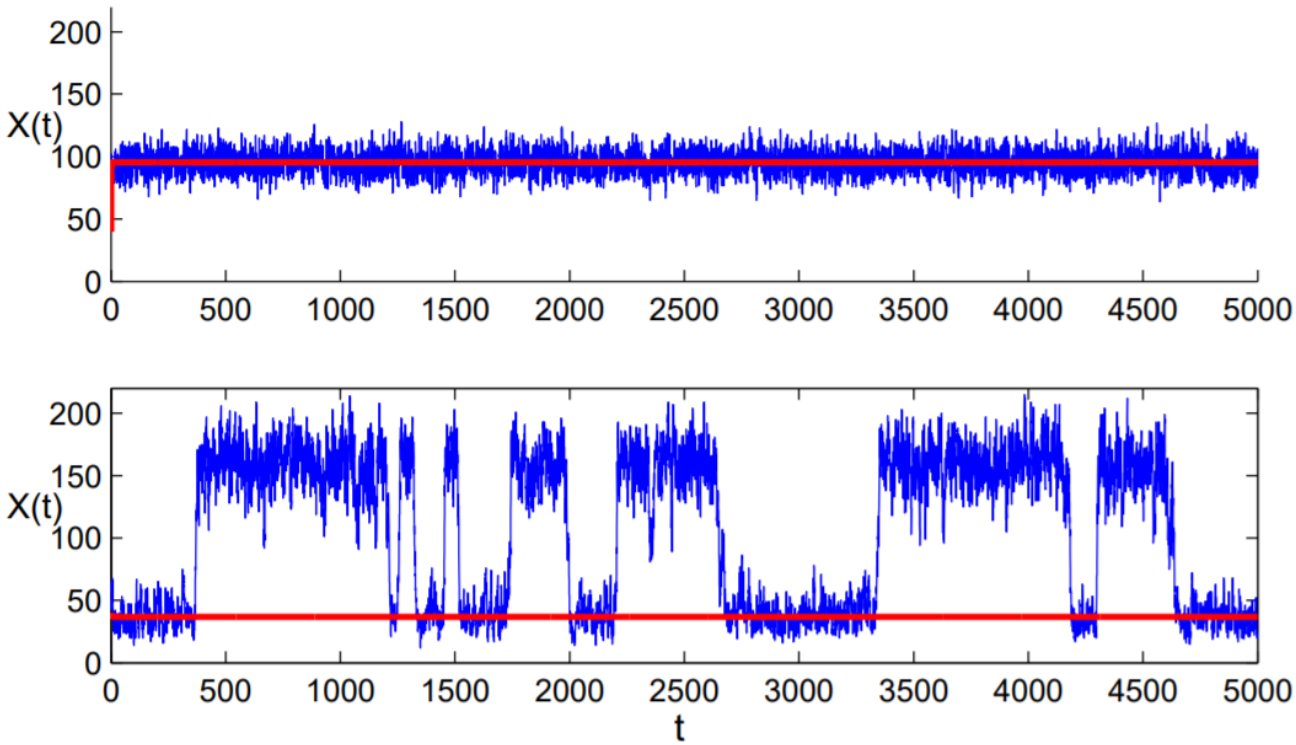


Early Lessons

- You don’t need data for a model to be useful!
- You need data for a model to be useful!
- Don’t switch off the computer you are using unless you are SURE it’s not running other people’s code…

Bath Institute for Mathematical Innovation

Commercial consulting and research partnerships

We have build a strong external engagement programme that has high impact and is scientifically rewarding.

Cross-campus activities

We support interdisciplinary research, including schemes for academic staff and undergraduates.

Support for mathematical sciences

We enhance mathematical sciences research at the University of Bath and work with high profile academics.

Chicken Welfare

2008: UFAW summer studentship on hen preferences

2016: Statistical analysis of consumer and expert opinions on laying hen welfare

2017: Image analysis of chicken beaks (ongoing)

Next: Mathematical modelling of chicken sleep patterns?

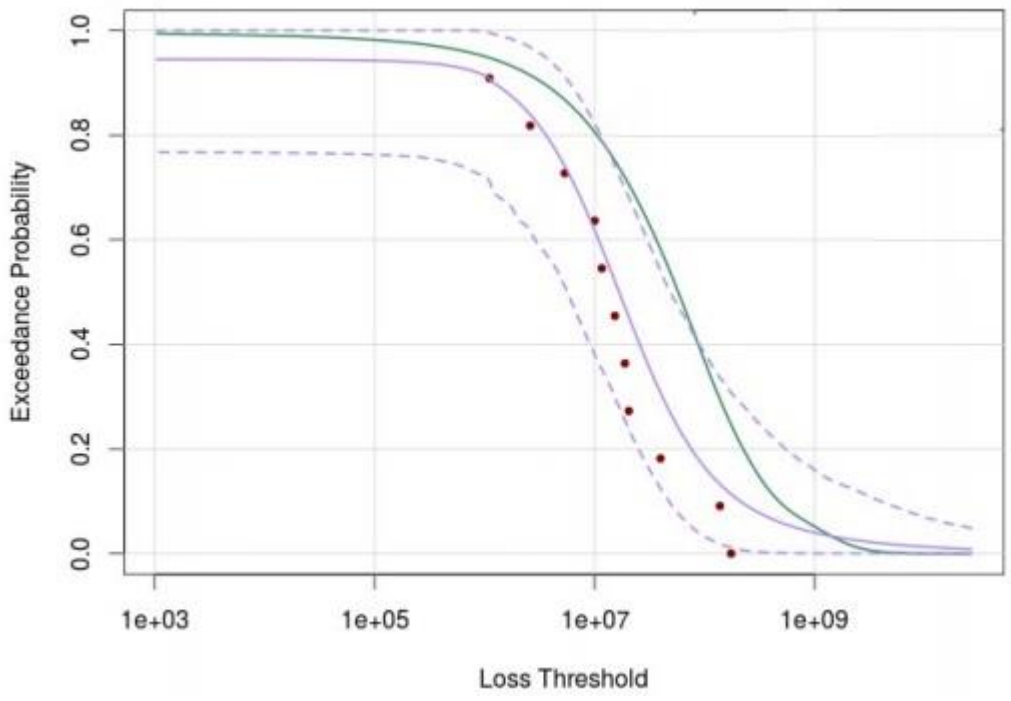
Catastrophe Risk Modelling

- Tokio Millennium Re provide reinsurance, against losses resulting from typhoons in China.
- Risk transfer in this region is particularly challenging due to the poor quality data.

Historical losses from 80 events between 2005-2015 by client.

2016 Project:

Quantify and correct the discrepancy between the current model for losses, and the historical losses data:



2016 Project:

Quantify and correct the discrepancy between the current model for losses, and the historical losses data:

1. Inflate losses from 2005-2014 to for comparison to 2015 losses: Inflation and population were used.
2. Quantify discrepancy: Extreme value distribution fitting.

2017 Project:

Develop a prototype model for losses.

1. Models for event occurrence:

Poisson process

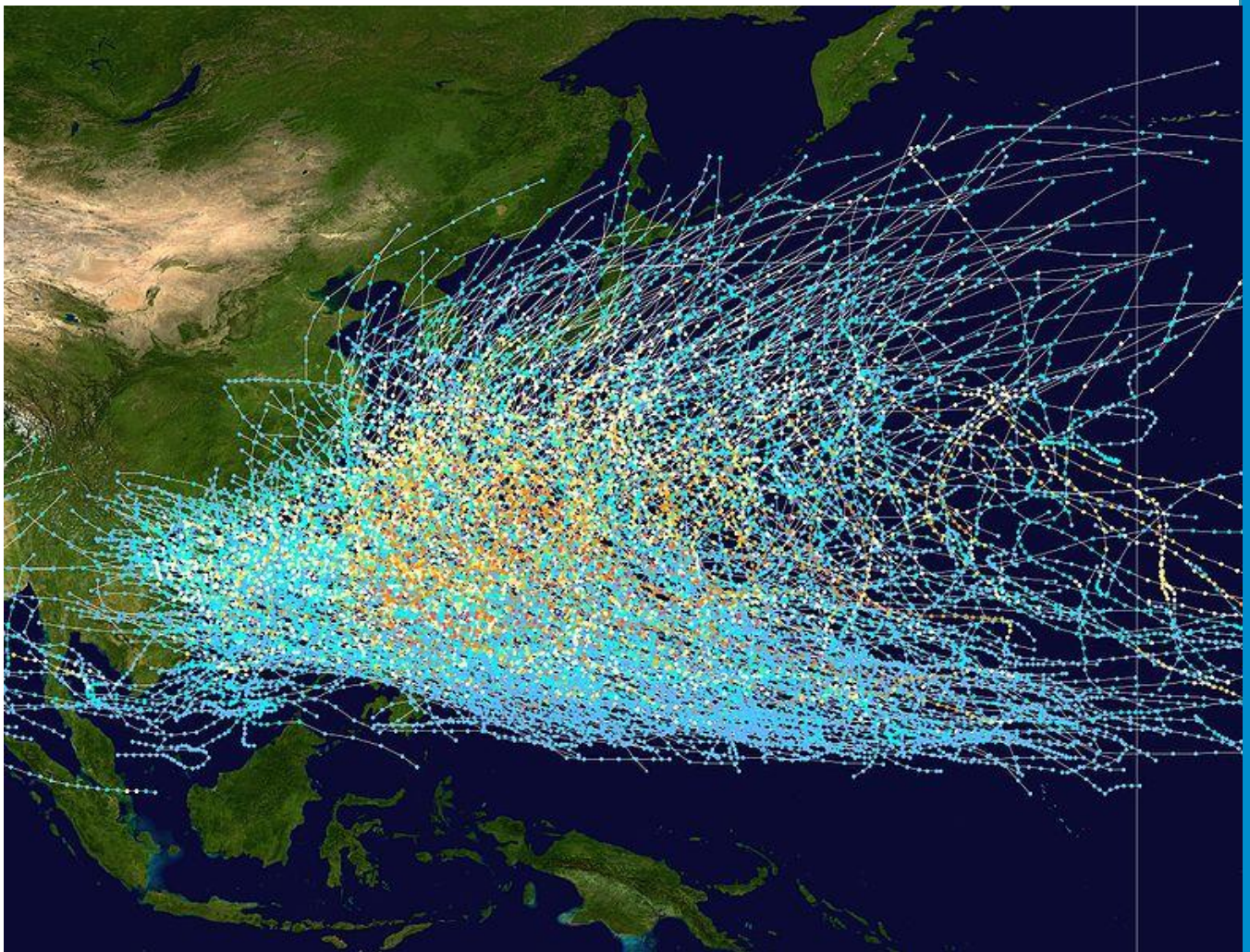
- Seasonality
- Sea-surface temperature

2. Models for losses:

Regression

- Annual investment in property

2018 Project?



UNIVERSITY OF BATH

Agri-Food Study Group

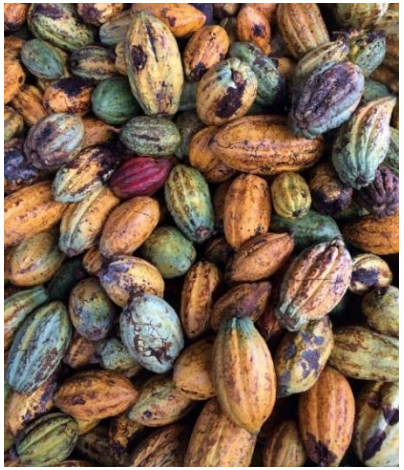
PHYTOPONICS	Design of hydroponic bags for crops (e.g. tomato plants) in glasshouses
INNOVENT TECHNOLOGY	Growth of pigs: body weight versus amount of body fat
Mondelēz International	Climate variability and effect on growth of cocoa beans in Ghana

IMI

Innovate UK
Knowledge Transfer Network

Cocoa Sustainability

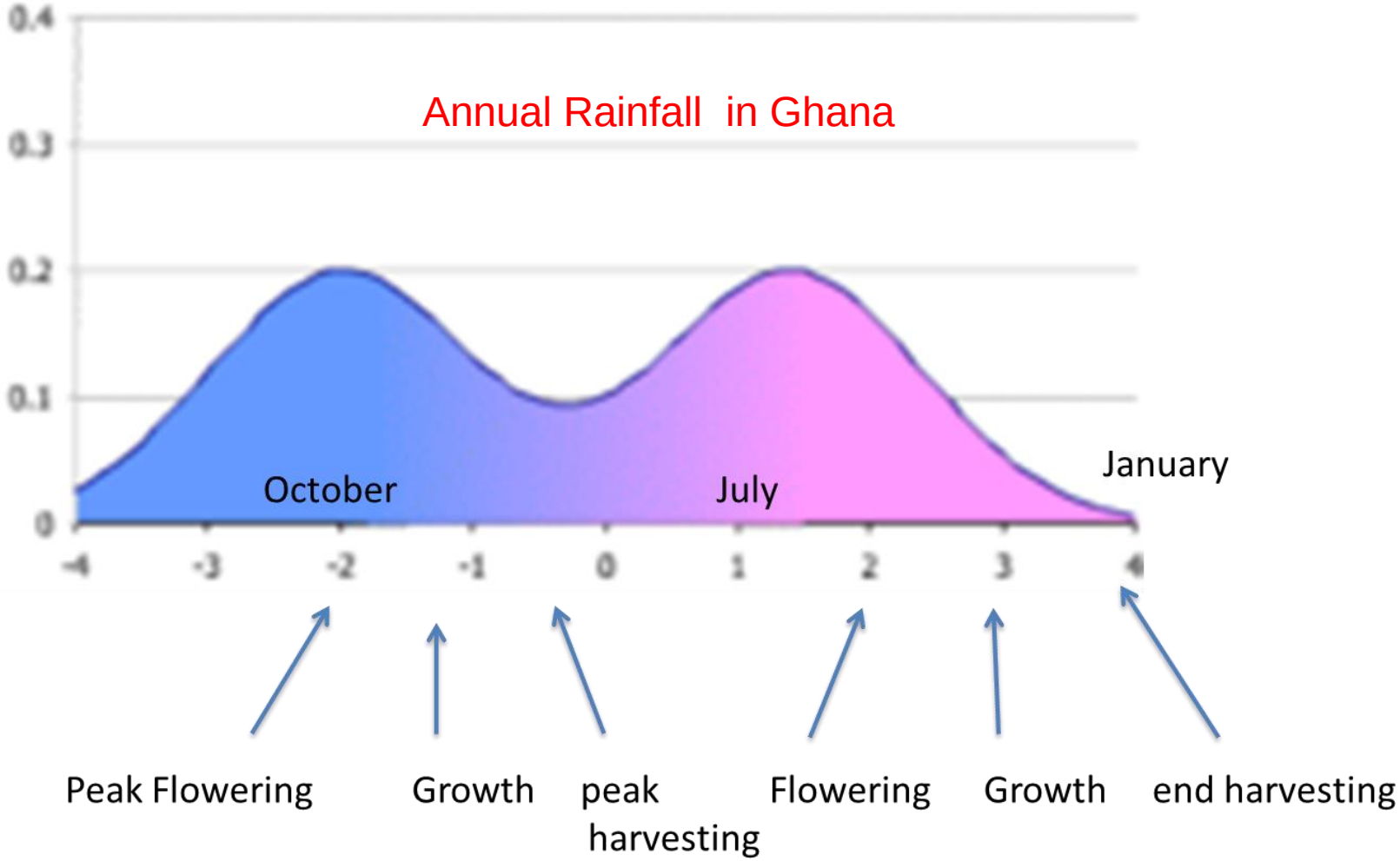
- One major challenge facing cocoa farmers is large variability in crop yield year on year



- This causes large fluctuations in income for farmers, and makes investment less attractive

- In what way does changing climate affect yield variability?

Cocoa Sustainability



Harvesting depends on the age of the pods and the distribution of the pods on the tree

Cocoa Growth Model

$$\frac{dC}{dt} = \underbrace{\alpha(t)\,(1 - C)\,C}_{\text{Logistic growth rate}} - \underbrace{\lambda(t)C}_{\text{Harvesting rate}}$$

$0 \leq t \leq 1$

Time scale = 1 year

$C(t)$: Cocoa Mass on Trees

$\vartheta(t)$: Rainfall (proxy weather variable)

$\alpha(t)$: Growth factor

$\lambda(t)$: Harvesting factor

$$\vartheta(t) = \vartheta_1 e^{-\tau_1 (t-t_1)^2} + \vartheta_2 e^{-\tau_2 (t-t_2)^2}$$

$$\alpha(t) = \alpha_0 e^{-k(\vartheta(t)-\theta^*)^2}$$

$$\lambda(t) = \lambda_0 \frac{\int_0^t \vartheta(\tau)\, d\tau}{\int_0^1 \vartheta(\tau)\, d\tau}$$

Cocoa Sustainability

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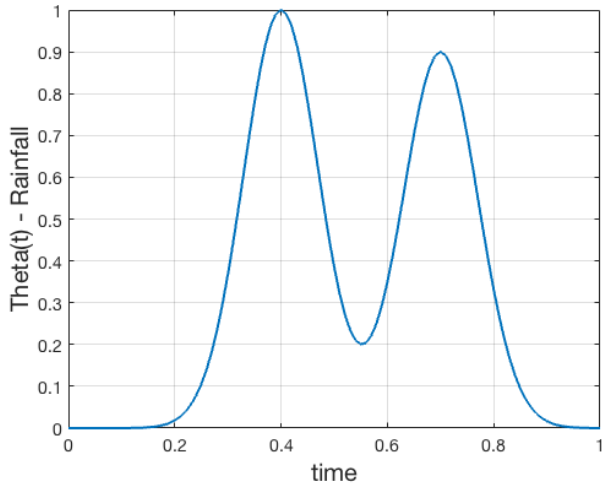
Time scale = 1 year

$\vartheta(t)$: Rainfall



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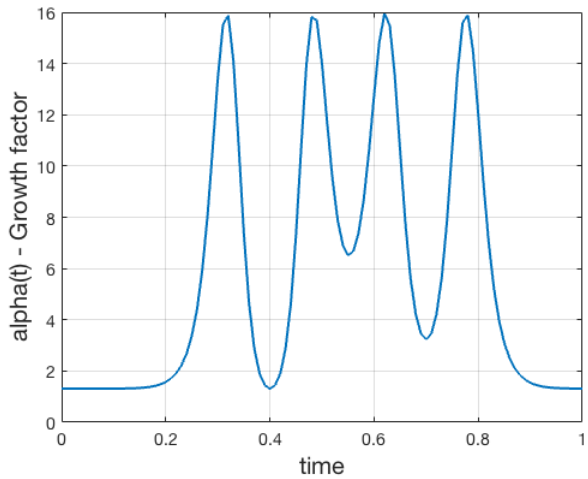

Cocoa Sustainability

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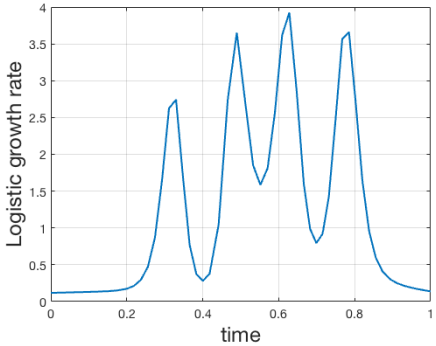

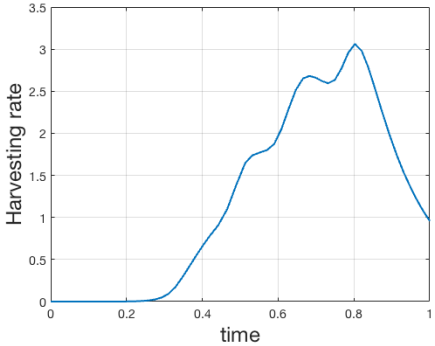

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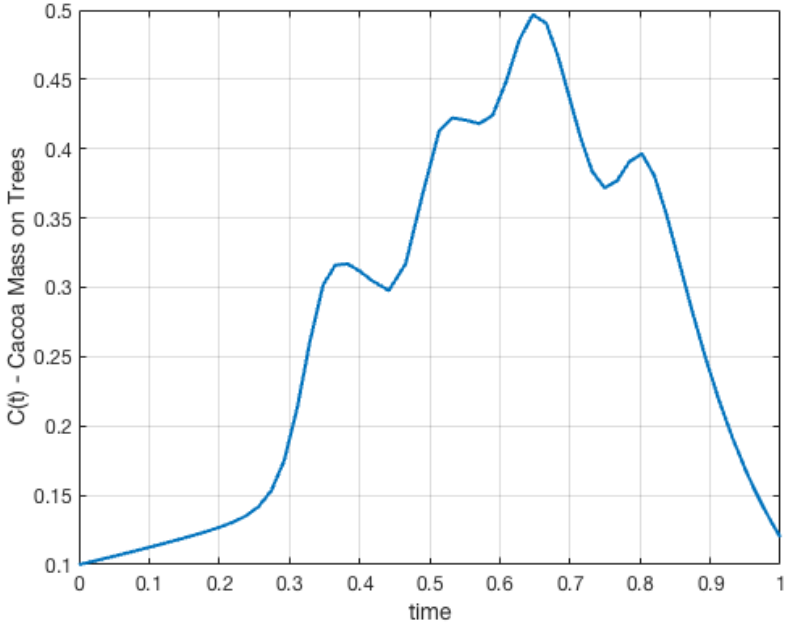
$C(t)$: Cocoa Mass on Trees



Cocoa Sustainability

Aims:

1. Develop farm level ODE and age-structured PDE models for cocoa yield in Ghana, incorporating plant-based factors such as age of tree, as well as weather and climate factors.

2. Use data and results from plant based studies to parametrise the model and carry out sensitivity analysis to determine the relative importance of model parameters.

3. Extend the model to include yields from crops sown in the plantations under the coca trees; this common farming practice is known as ‘multi-cropping’.

Innovation Pipeline / Readiness Scale

Decisions

Model

Decisions

Decisions

Decisions

Fundamental Mathematics Research

Model

Model

Model

Idea

Development

Implementation

Applied Mathematics Research

Proof of Concept

Testing and Validation

Model

Decisions

Model

Decisions

Model

Decisions

Thank You