SCOTTISH EXECUTIVE

**Scottish Executive**
Edinburgh, UK

**Macaulay Institute**
Aberdeen, UK



**British Council**
London, UK; Rome, Italy

**Agricultural Research Council**
ISCI, Bologna, Italy


# Climate Change and Agriculture: are we asking the right questions?

**Mike Rivington, Gianni Bellocchi**

**Keith Matthews, Kevin Buchan, Dave Miller, Marcello Donatelli.**

**23rd November, 2005, Scottish Executive, Edinburgh, UK**

# Welcome – today's timetable

| Start | End | Morning session |
|---|---|---|
| 10:00 | 10:30 | **Arrival, registration, coffee** |
| 10:30 | 10:45 | **Welcome**<br>Organisation of the day<br>Aims / outcomes<br>Exercises |
| 10:45 | 11:30 | **Scope of the study:**<br>Context<br>What really caused change in Scottish upland farming over the past two centuries? – a historical perspective from Dr Graham Russell, Edinburgh University.<br>Drivers of change and multiple objectives<br>Modelling tools<br>Mediated modelling<br>Case study analysis<br>Questions |
| 11.30 | 11.45 | **Tea / Coffee** |
| 11.45 | 12.30 | **Climate impacts modelling**:<br>Sources of uncertainty<br>Analysis of the predicted changes<br>Impacts on soils<br>Questions |
| 12.30 | 13.30 | **Lunch** |

| Start | End | Afternoon session |
|---|---|---|
| 13.30 | 14.45 | **Climate Change and Agriculture:**<br>Crops<br>Land use rotations<br>Crops and livestock<br>Whole farms<br>Farming systems<br>Farming and climate change amelioration<br>Questions |
| 14.45 | 15.00 | **Tea / Coffee** |
| 15.00 | 16.30 | **Issues for Practice and Policy**<br>Break out session**:**<br>Exercises<br>Discussion / debate<br>Plenary session<br>Reporting from groups<br>Final discussion |
| 16.30 | 16.45 | **Closing and thanks** |

# The people involved…

Introductions:

- Drennan Watson – today's Facilitator
- Mike Rivington
- Gianni Bellocchi
- Kevin Buchan
- Dave Miller
- Gerald Schwarz
- Graham Russell, Edinburgh University

- Keith Matthews – LADSS Project manager

  (currently sunning himself in Australia…)

# Aims

- For you to have an enjoyable and rewarding day
- Present the Framework we are using to investigate the impacts of climate change
- Explore the place of climate amongst other drivers of change
- Illustrate potential impacts of climate change on biophysical processes within a farm and their subsequent impacts
- Demonstrate how the modelling tools can be used as a medium to stimulate discussion as part of the deliberative process.
- To elicit feedback from you about the issues
- Establish working relationships with a view to:
  - Developing the Integrated Assessment Framework
  - The planned follow-up seminar / workshop next year

# Outcomes

- Produce a summary report
- Identification of the issues concerning climate change and agriculture
- An indication as to what the role of Scottish Agriculture will be in the future.
- Feedback on the utility of the research approach being taken

# Context

- A historical perspective of changes in the last 200 years
- What are the current and future drivers of change?
- What are the potential impacts?
- What are our future priorities for agriculture in Scotland?
- How do we 'cost' or 'balance' responses to climate change and the multiple objective requirements from land use?
  - Mitigation vs Adaptation vs Impacts
  - How do we define 'costs'.. £, kg/ha, food per person…?

- A multiple-objective problem…..

# Exercise 1

- You have been given a list of issues…
- If you haven't already done so, please assign a priority score to the issues in each table, in the left hand column, where 1 is the most important etc…

- We will look at this exercise again later on…

# Exercise 2

- You have been given some post-its, notebooks, paper etc.
- Around the room are flip-charts with some questions and issues…
- During the morning, please write down comments, further questions, suggestions etc..
- Please attach these to the relevant flip charts
- We can use this exercise again later on for reference purposes…

# Questions for discussion?

- What is the role for agriculture in Scotland in the future?
- What are the priorities for the next 20-30 years?
- How can we develop policies to aid mitigation and adaptation strategies?

During the day we can re-define these questions if required

# Scope of the Study

- Historical perspective
- Drivers of change and multiple land use objectives
- Scales
- Modelling tools

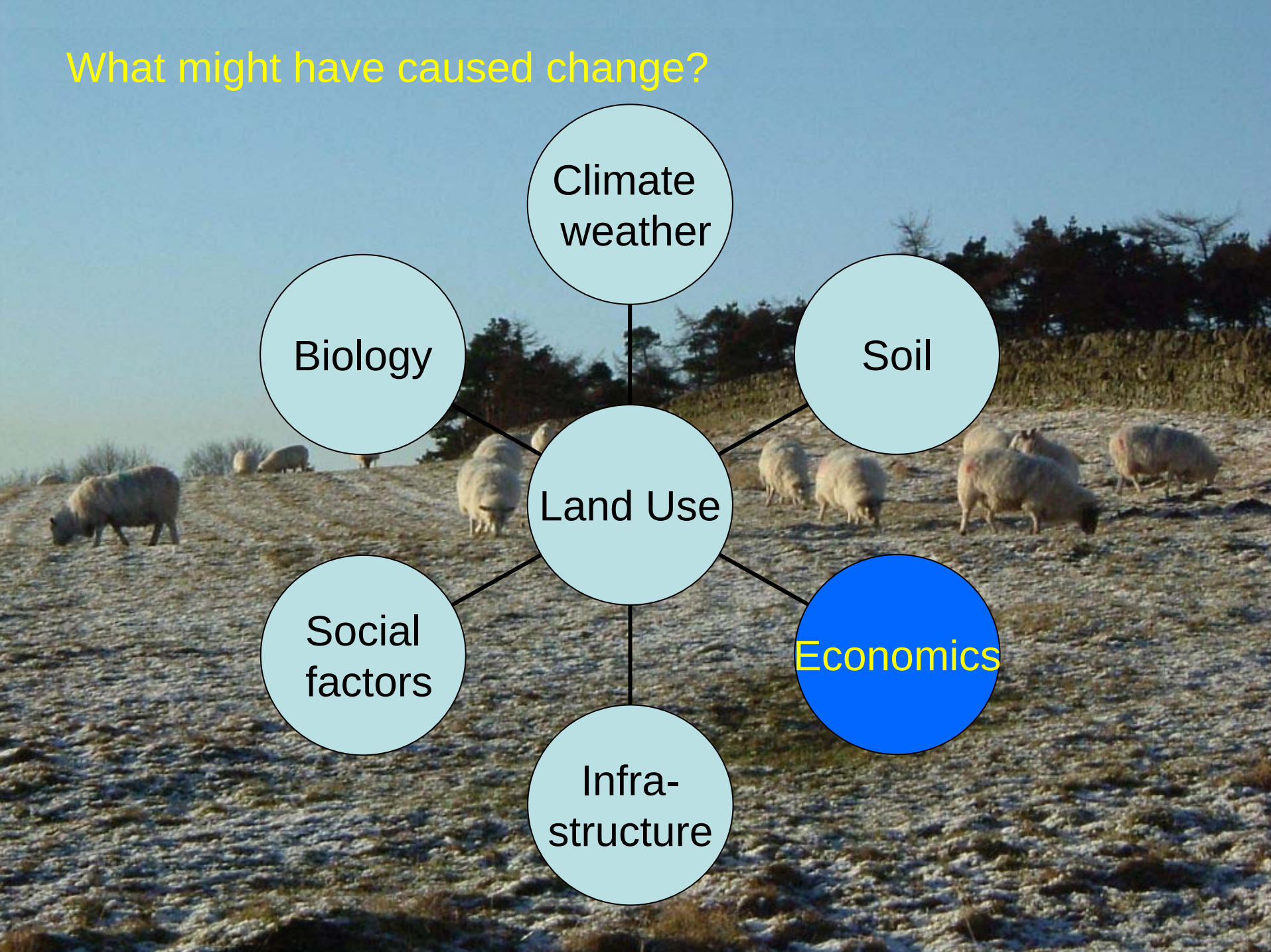
# What really caused change in Scottish upland farming over the past 200 years?

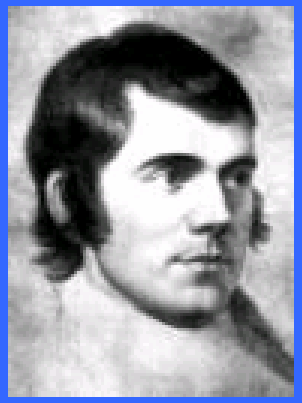
Graham Russell

The University of Edinburgh

How much change has there been?

# What might have caused change?





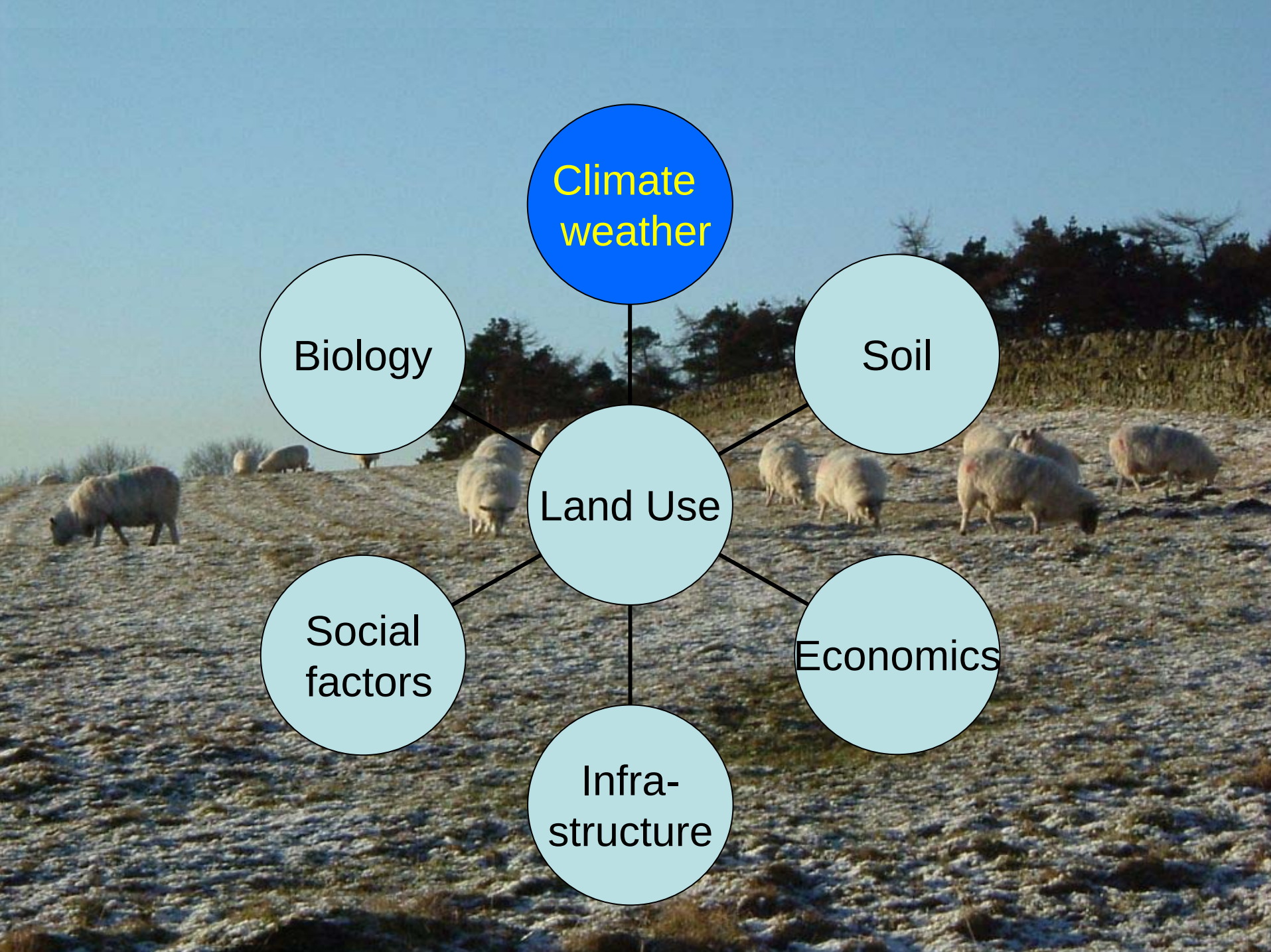
"O, gie me the lass that has acres o' charms,

O, gie me the lass wi' the weel-stockit farms."

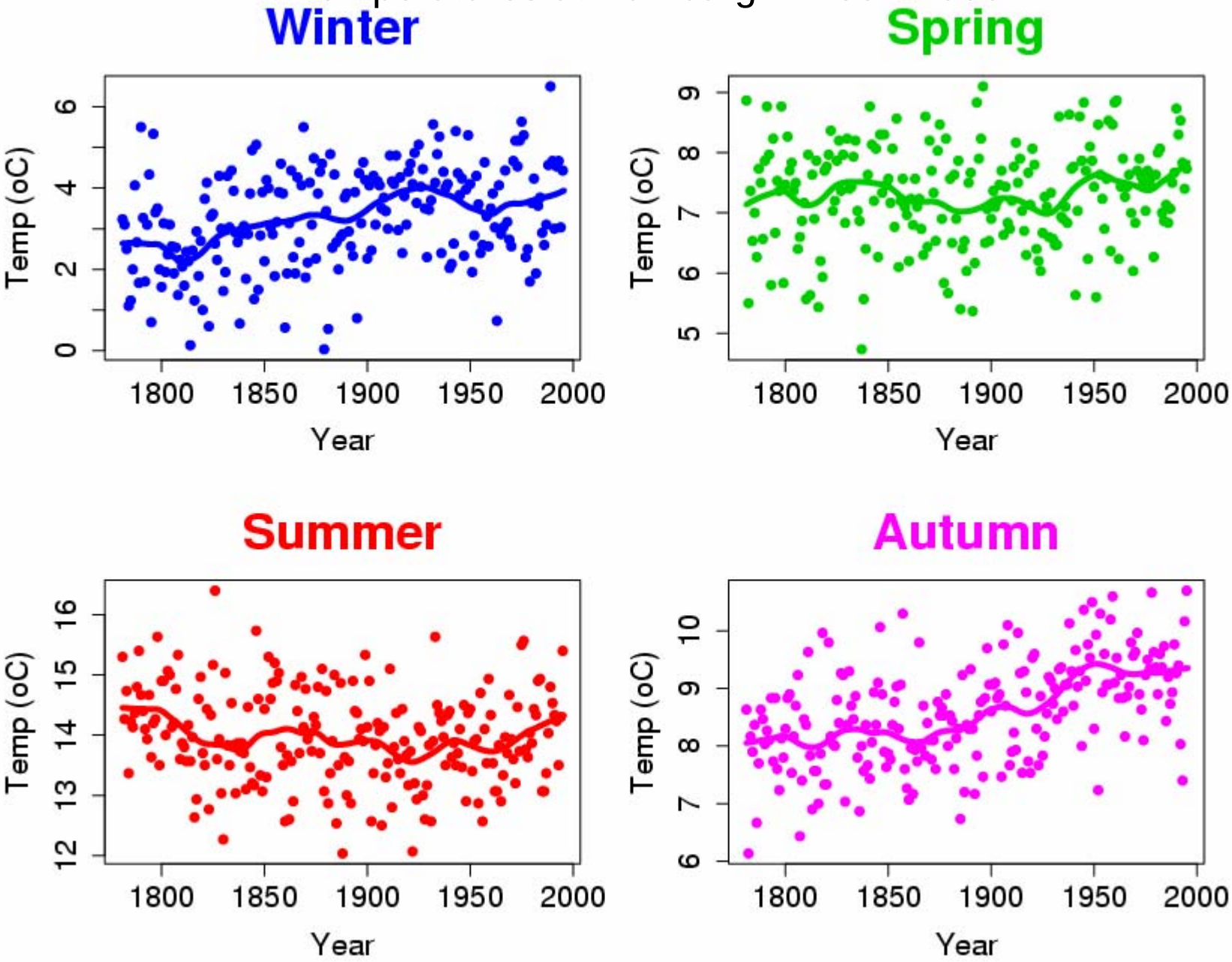
"When Burns took on Ellisland, as in the case of most farms in 18th Century Scotland, the soil was exhausted. It was also stony. Neither crop growing nor dairy farming, to which Burns turned, paid, and Burns was soon thoroughly disillusioned.

'... a lease was granted to the poetical farmer at the annual rent which his own friends declared that the due cultivation of his farm might easily enable him to pay. But these friends, being Ayrshiremen were little acquainted with the soil, with the manures, with the markets, with the dairies, with the modes of improvement in Dumfriesshire; they had estimated his rental at Ayrshire rates…'.

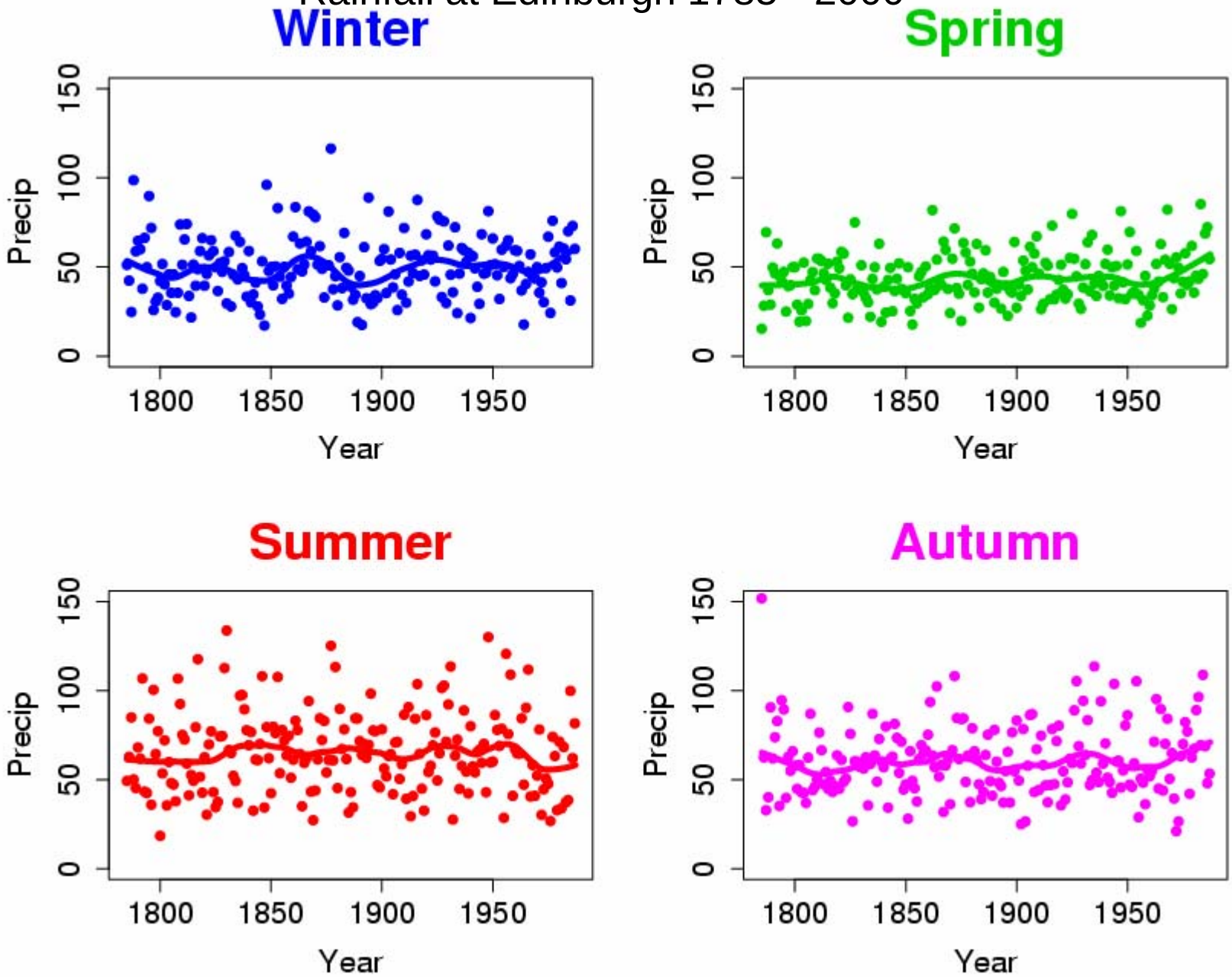
By the end of 1790 Burns had decided that Ellisland was 'altogether a ruinous business'." *The Burns Encyclopaedia*.

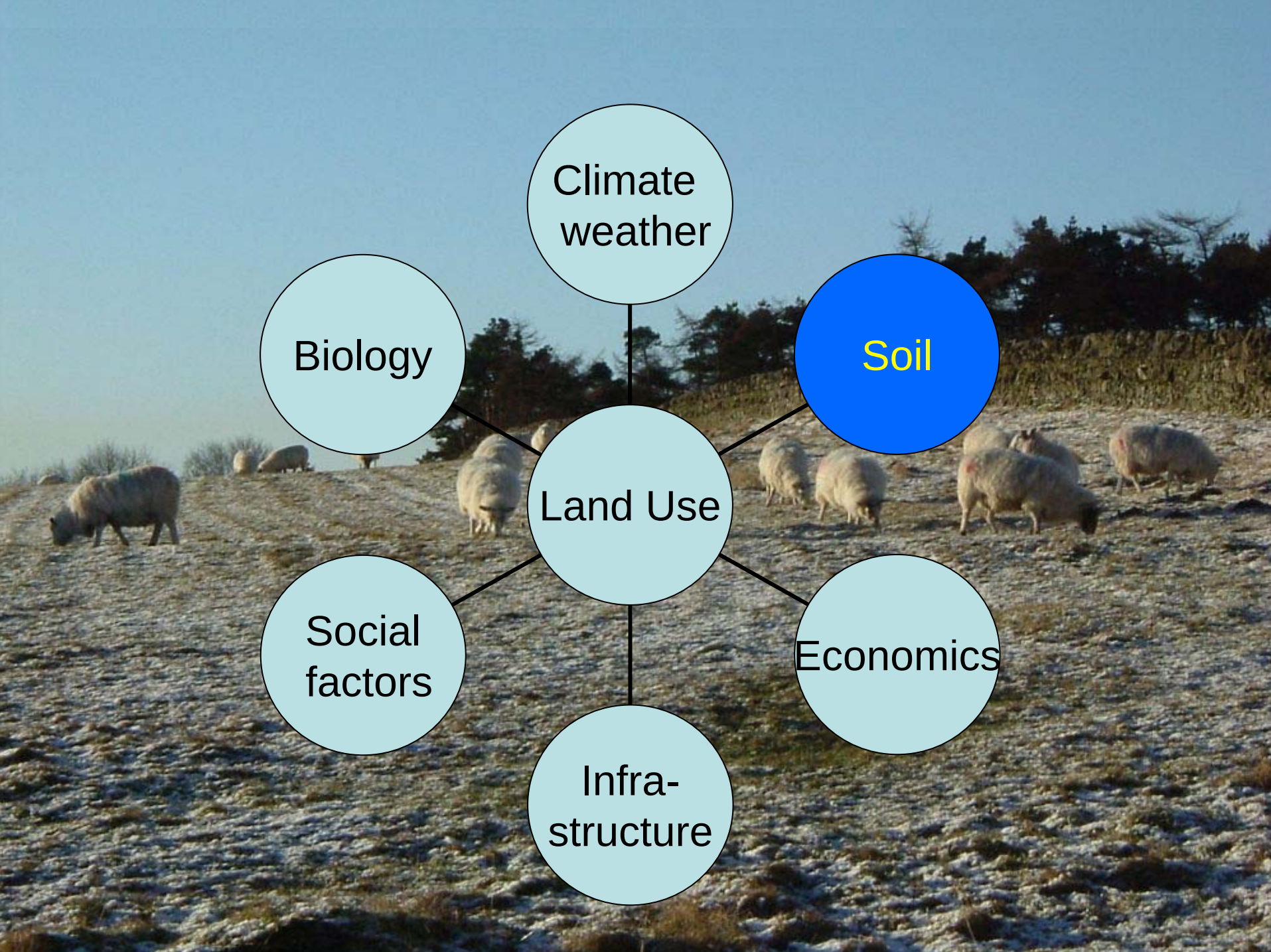

Climate
weather
Biology
Soil
Land Use
Social
factors
Economics
Infra-
structure

# Temperatures at Edinburgh 1785 - 2000



# Rainfall at Edinburgh 1785 - 2000

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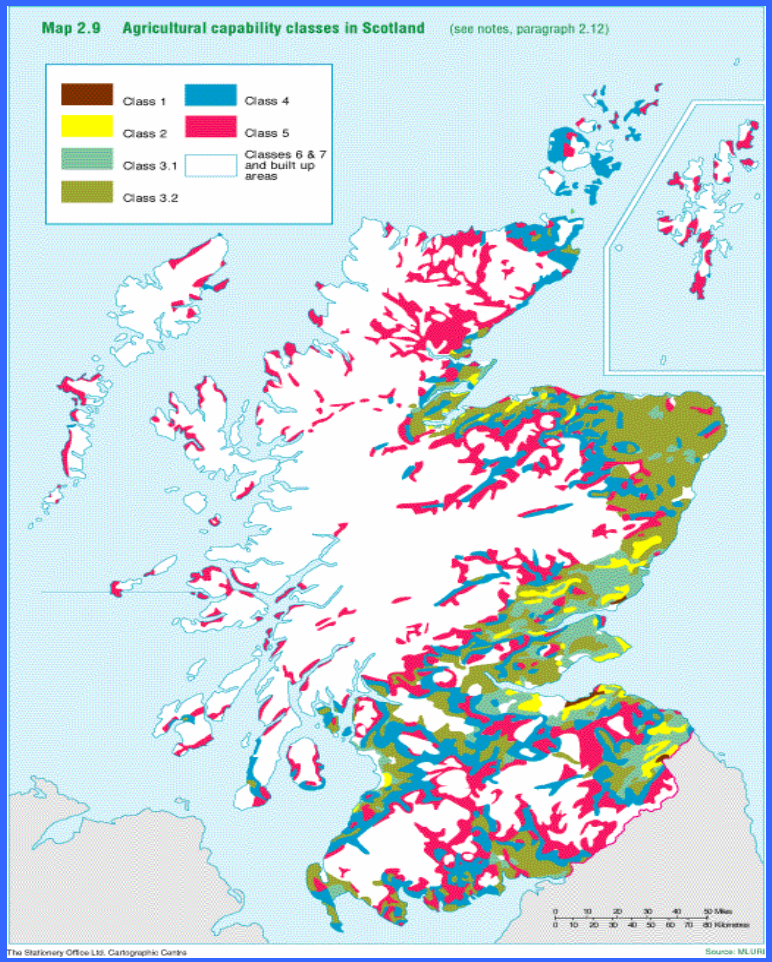
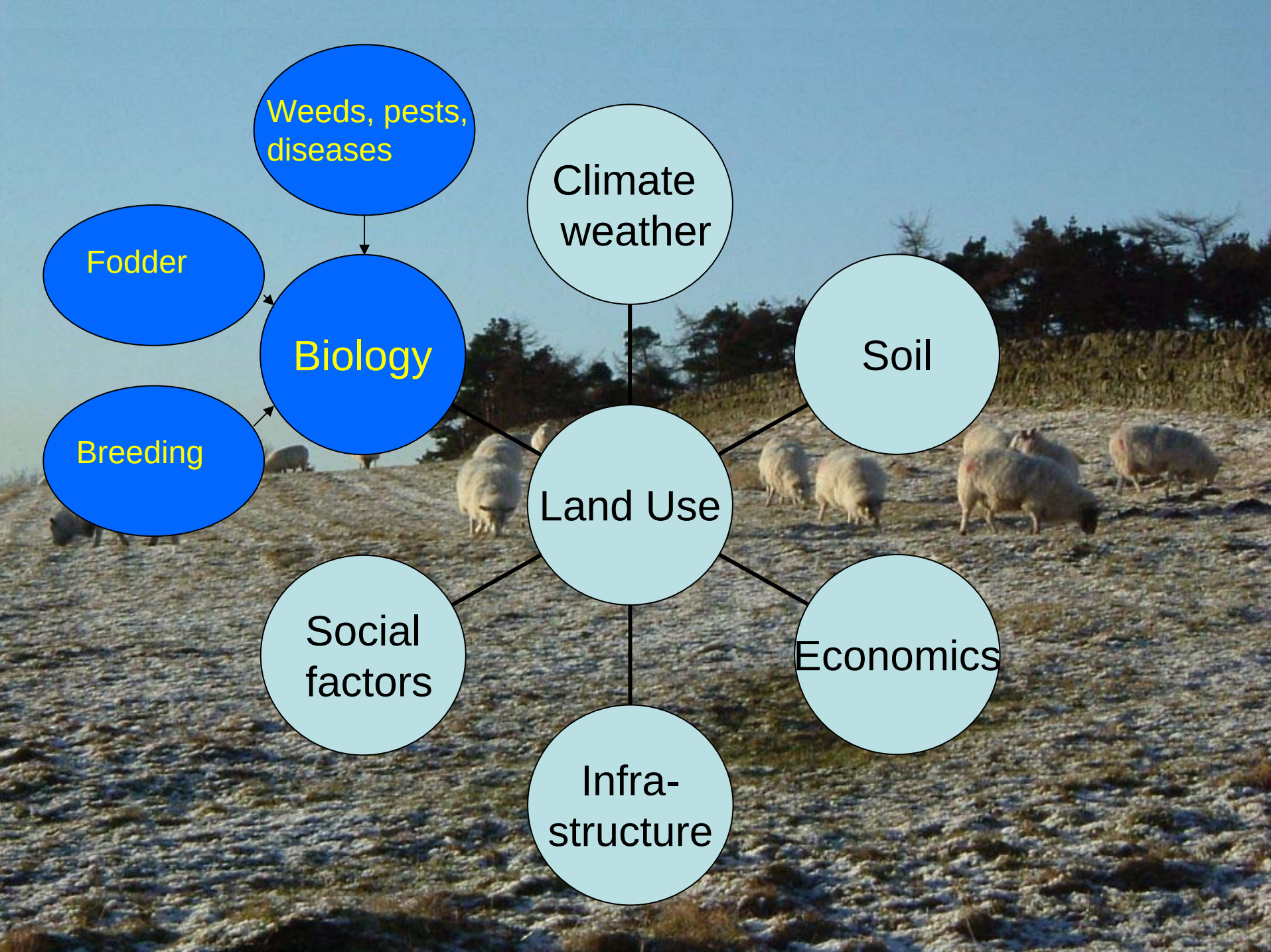
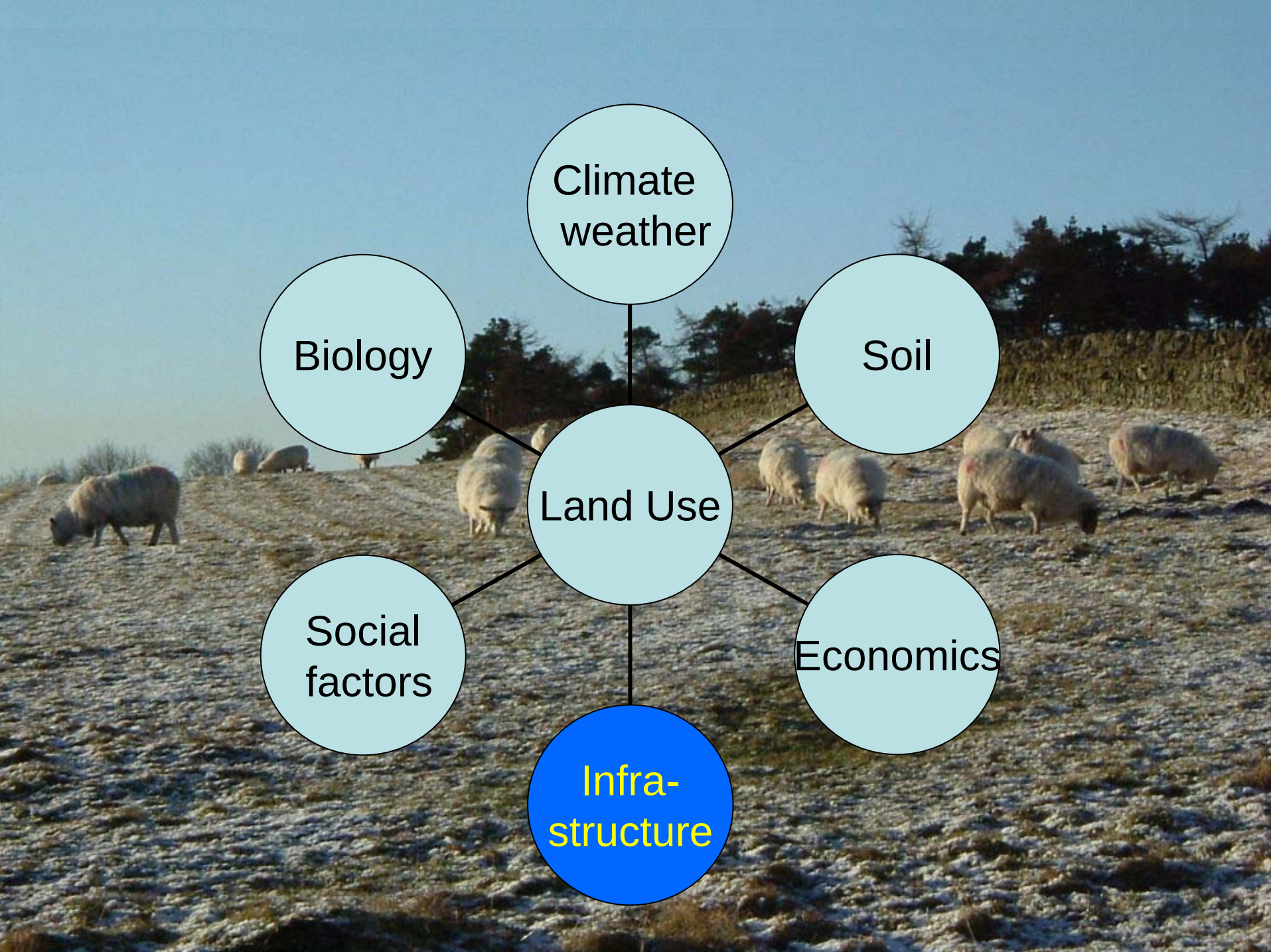
structure

# Land Use Capability for Agriculture




- Set by soil, climate and management
- Grade 1 and 2 (black and yellow) rare
- Arable currently not possible if grade > 4 (red and white areas)
- History of drainage, stone removal and fertility enhancement
- Large amount of edge


Weeds, pests, diseases
Fodder
Biology
Breeding
Climate weather
Soil
Land Use
Social factors
Economics
Infra-structure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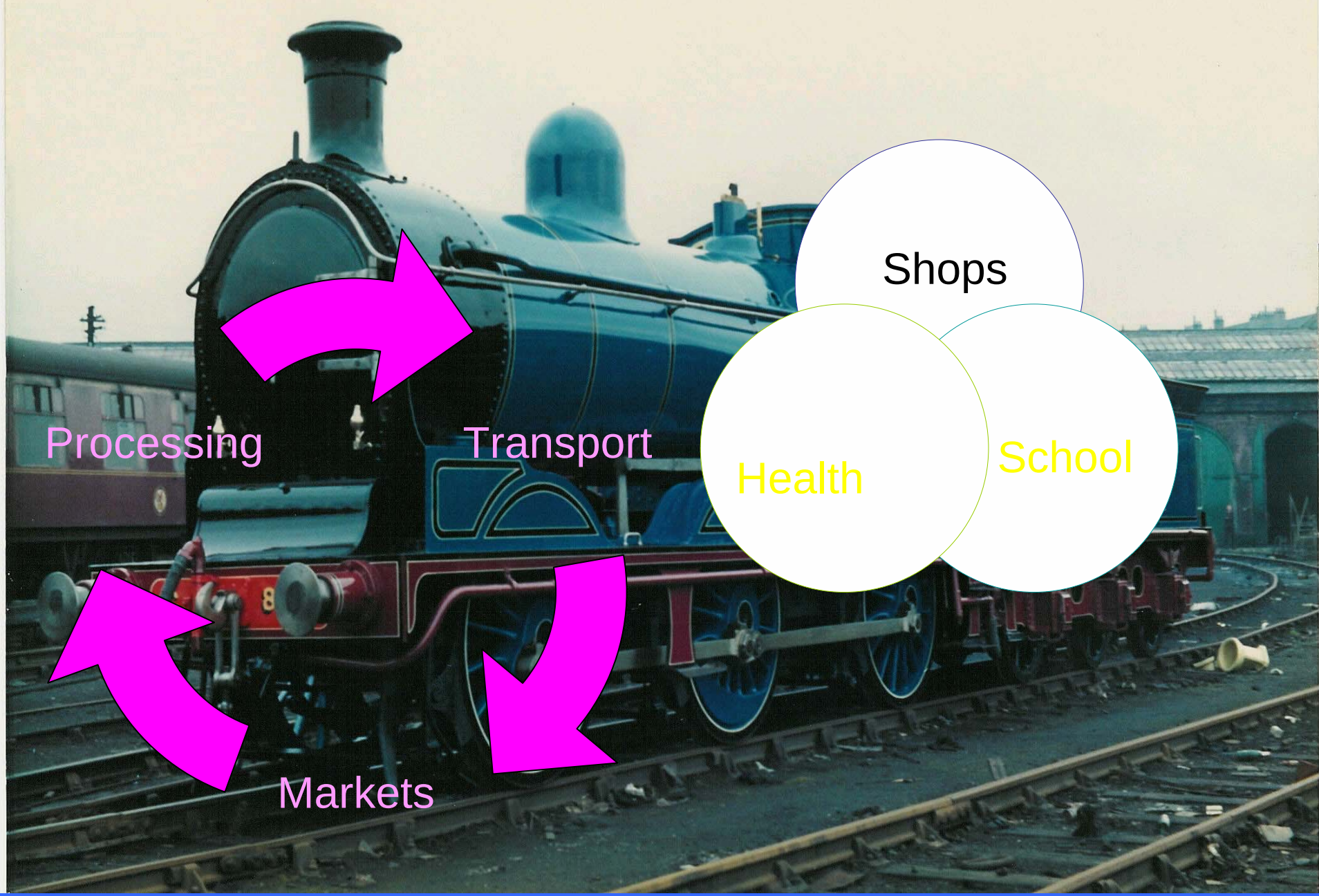
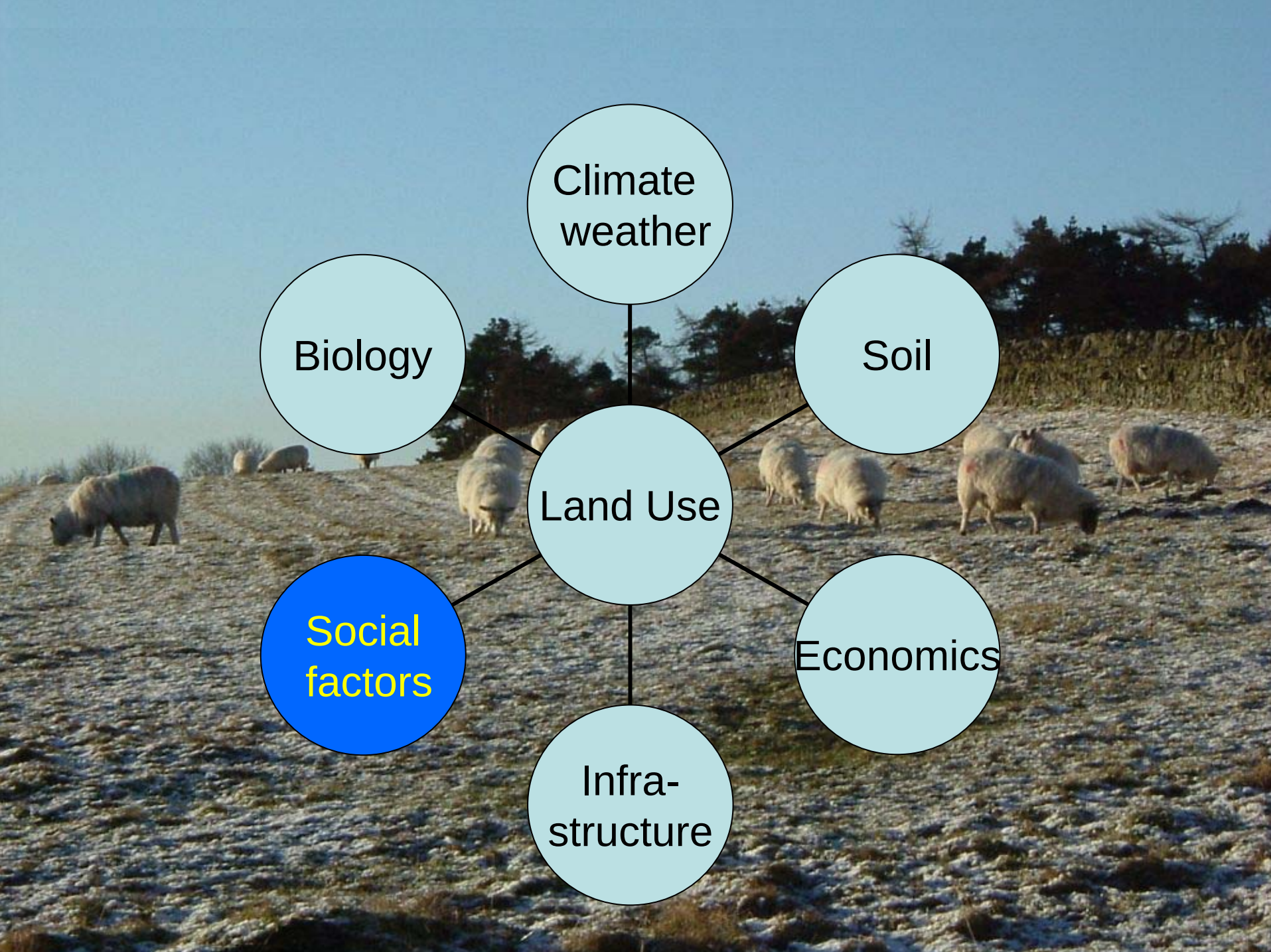
weather
Biology
Soil
Land Use
Social
factors
Economics
Infra-
structure




Caledonian Railway Company McIntosh 812 class Locomotive No. 828 SLPTF


Climate
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View of Beinn Ghlas, Breadalbane mapped as region of cultivation, chiefly oats, below hill and alpine pasture by Robert Smith c 1890.

# Conclusions

- Not just biophysical factors affect upland farming
- Proximate effect through economics
- The land manager often has multiple objectives
- Resilience and adaptation are very important

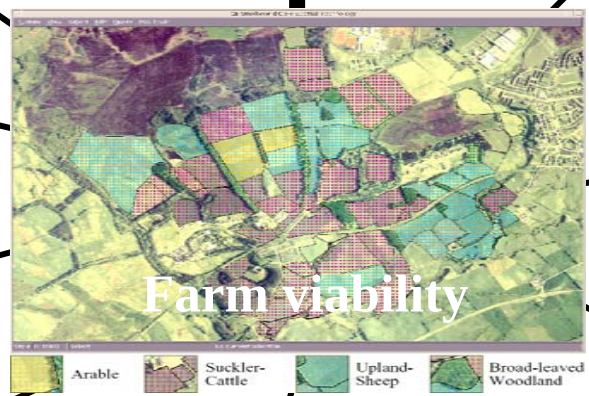
# Drivers of change and multiple-objectives for land use

**Uncertainty in future climatic conditions**

**Global economy:**
- WTO
- G8
- Population

**Local economy:**
- Market prices / Costs
- Transport
- Supply / demand
- Land value

**Energy**
- Where from?




**Food security:**
- Supply
- Quality

**Policies:**
CAP
WFD
etc…

**Mitigation:**
Kyoto
Carbon trading
ECCP
Carbon sequestration
etc....

**Landscapes Functions**
- Water
- Biodiversity
- Visual / aesthetic
- Recreation / access

**Farm resources / constraints:**
- Soils / spatial configuration
- Finance / alternative incomes
- Skills / knowledge
- Farmer preferences / aspirations / social capital
- Labour / Family / Age
- Infrastructure
- Semi-natural vegetation

# Future land use development issues
(for individual farmers…?)

Need to:

- Maintain profitability / competitiveness
- Achieve ‘sustainability’
- Maintain multiple-objective land use:
  - Ecosystem functions: Water / biodiversity / recreation

There will be, over time:

- Shifts in trade-offs between objectives
- Changes in risk
- New demands, obligations and opportunities…

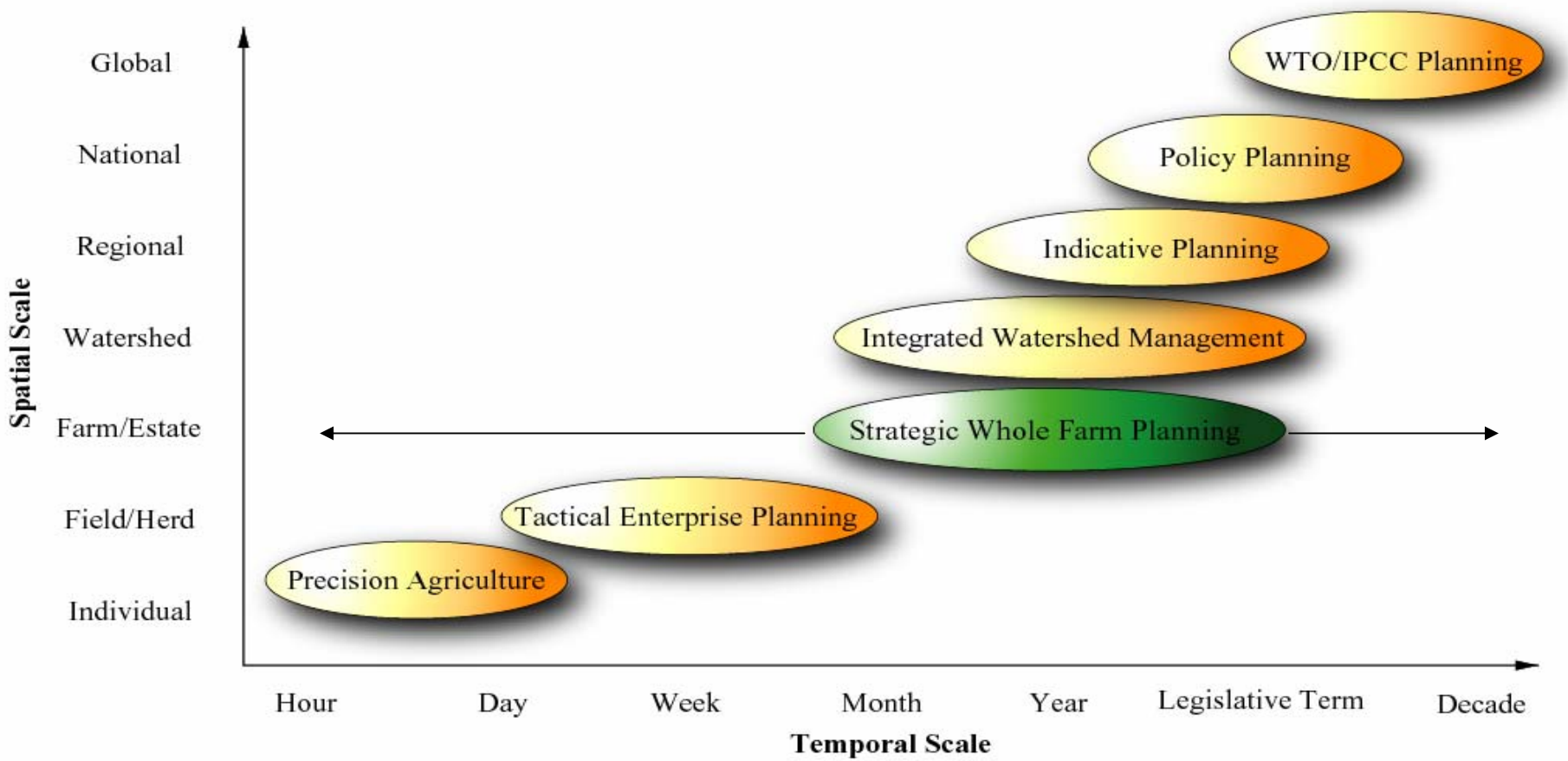
} Learning processes

# Scales – Spatial and Temporal

When considering scales, we're really looking at relationships between them

- Spatial:
  - Micro-site - field – farm – region – national - global
- Temporal:
  - Historical – present – tomorrow – next week, month, year, decade, century…
- The further we look into the future, the less we know about what it will be like….

# Modelling and Planning Scales



# What we know that we don't know….

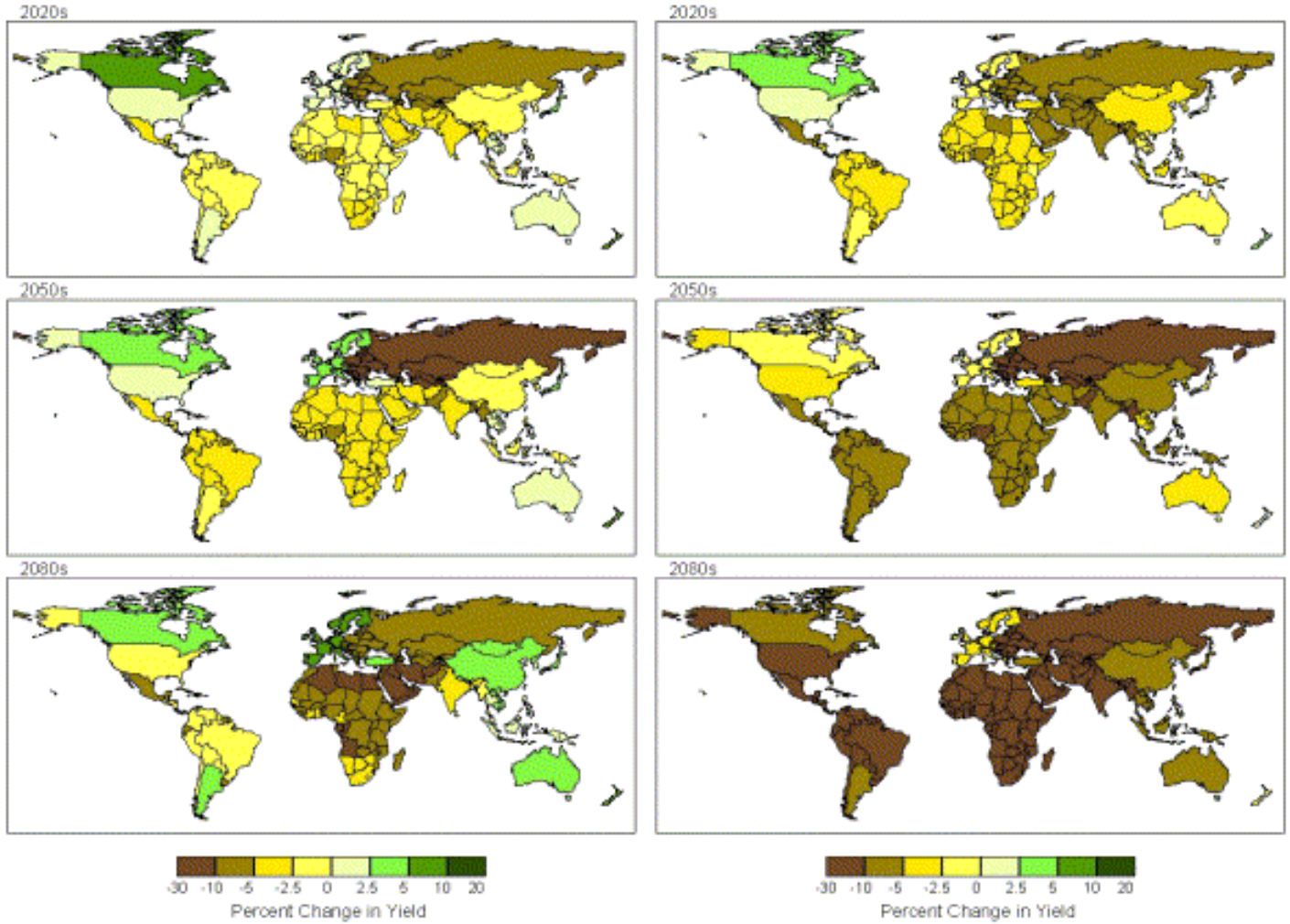
- Many things about the future…
  - Markets, policies, subsidies, trade agreements, attitudes, political climate…
- Future scenarios
  - $CO_2$ emissions, new technologies
  - Are the SRES scenarios becoming redundant?
- Crop and soil responses to elevated $CO_2$, ground level ozone, temperature, precipitation, solar radiation, wind…
  - Biomass / yield production
    - FACE experiments
  - Grass and inter-species competition
  - Soil processes:
    - Plant-microbial interaction
    - Nutrient cycling
- Changes in risk
  - Pests and pathogens (crops and livestock)
  - Weather variability and extreme events
  - Market fluctuations

# Variations at different sites

- Need to consider the impacts of climate change at multiple-sites
  - These effect markets / economy / food supply and demand

- Here we are primarily concerned with agriculture in Scotland, but we need to understand what may happen in other countries in order to better understand how the supply and demand relationships will change.

Global food production




Potential changes (%) in national cereal yields for the 2020s, 2050s and 2080s (compared with 1990) under the HadCM3 SRES B2a scenario with and without CO2 effects. "Effects of climate change on global food production under SRES emissions and socio-economic scenarios". Parry et al, 2004. Global Environmental Change

# Climate change threatens crop losses, more hungry people - UN

Climate change

*26 May 2005* – Climate change threatens to increase crop losses, increase the number of people facing malnutrition, or worse, and may change the development patterns of animal diseases and plant pests, the United Nations agricultural agency says in a new report.

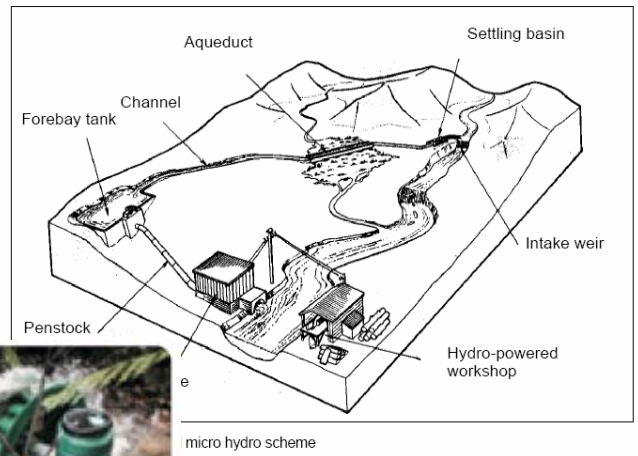
The UN Food and Agriculture Organization (FAO), in collaboration with the International Institute of Applied Systems Analysis (IIASA), has developed the Agro-Ecological Zones (AEZ) methodology, a worldwide spatial soil and climate suitability database for use in quantifying regional impacts and geographical shifts in agricultural land and productivity potentials.

Using this data, FAO says in the report, presented during the 31st session of the Committee on World Food Security, that the northern industrialized countries could increase their crop production potential as a result of climate change.

On the other hand, "in some 40 poor, developing countries, with a combined population of 2 billion, including 450 million undernourished people, production losses due to climate change may drastically increase the number of undernourished people, severely hindering progress in combating poverty and food insecurity," the report says.

# Future energy sources

- UK commitment to reduce $CO_2$ by 60% by 2050
- New technologies
- Scales
- Renewables – as relevant to agriculture
  - Biofuels
    - Crops
    - Trees
  - Wind
  - Hydro
- Consumption
  - Higher levels of efficiency ?

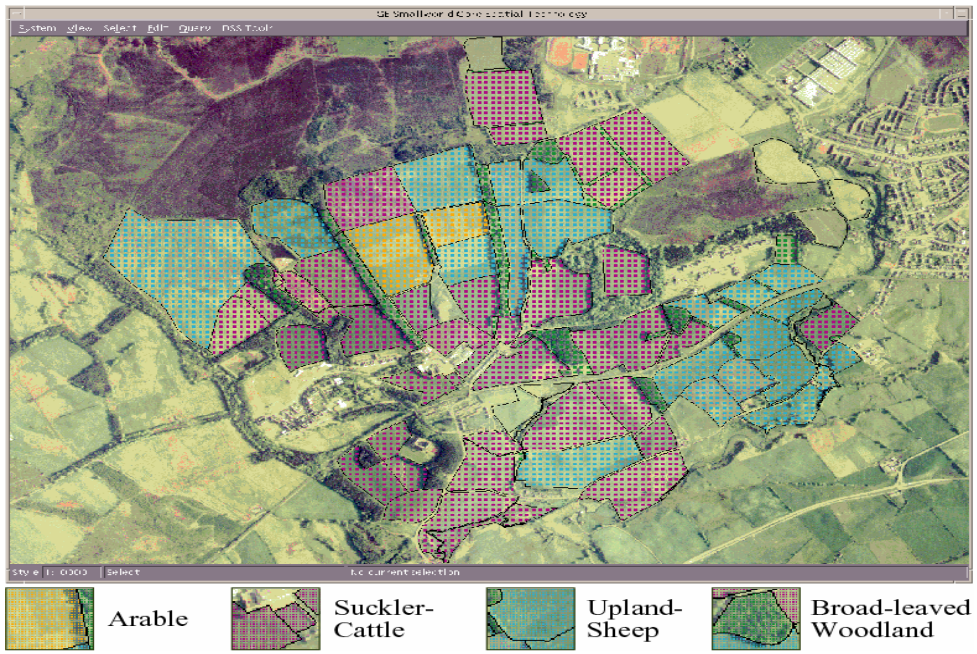



# Farm-scale Modelling: Tools for the study

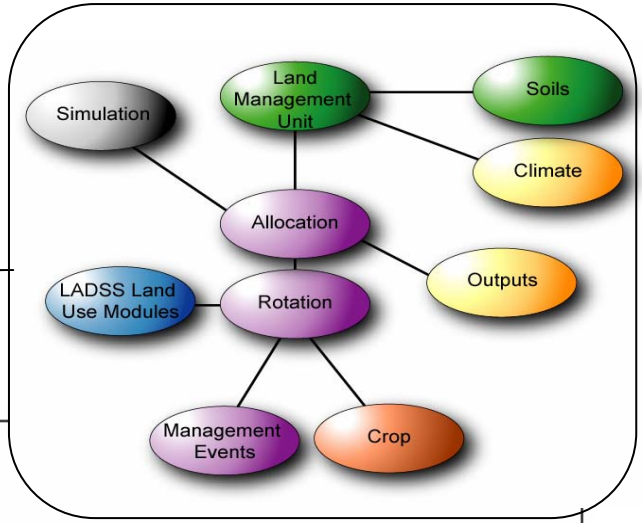
- Modelling tools – Integrated Modelling Framework
  - Farm-scale analysis
  - LADSS and CropSyst
  - Outputs
- Mediated modelling
  - Simulation modelling and the deliberative process
- Climate change impacts
  - what we can model?
- Case study analysis
  - The pros and cons of this approach

# Core modelling tool – Land Allocation Decision Support System (LADSS)

- Multiple-objective: evaluating the structure of trade-off(s) between objectives
- Strategic: determine the best mix of enterprise and management regimen, “what to do?”
- Management-unit: operating at the level where decisions are implemented
- Spatial: accounting for the juxtaposition of the management unit's resources



# LADSS system components




Spatial Data Capture

Geographic Information System (GE Smallworld)

SW-Oracle Interface

Relational Database (Oracle)

Global & Management Parameters

G2-SW Bridge

G2-Oracle Interface

Land Use Planning Tools (Gensym G2)

Integrated Impact Assessments (Gensym G2)

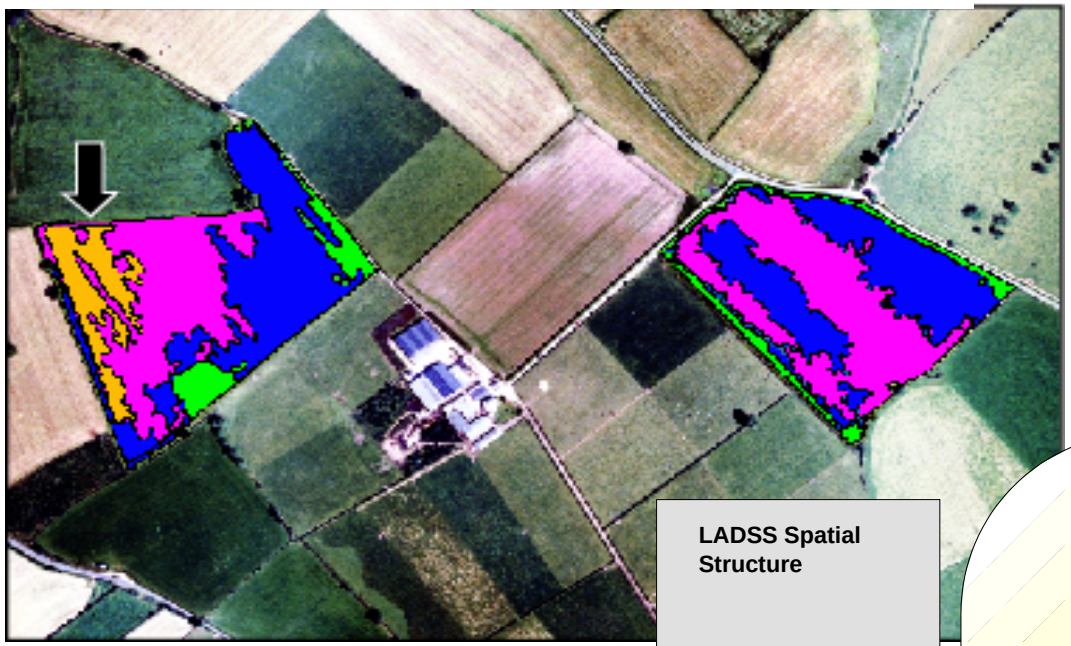
Land-Use Systems Models (Gensym G2)

CropSyst (Bespoke C++)

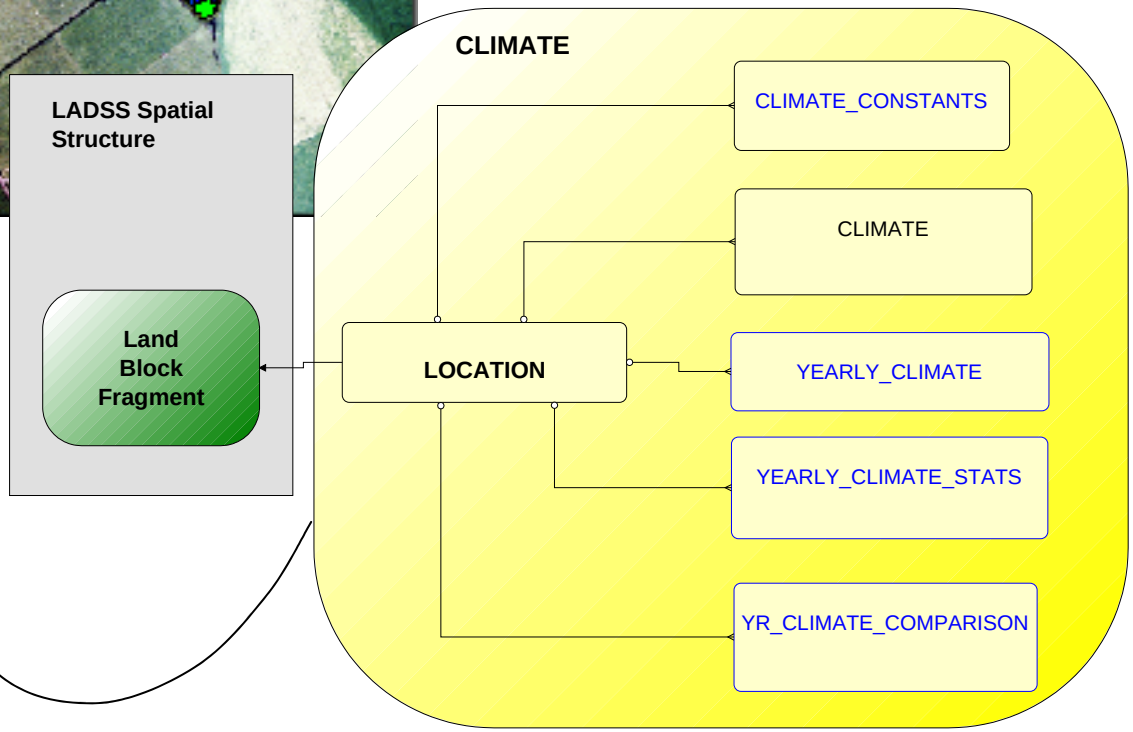
Graphical Communication Interface (Gensym G2)

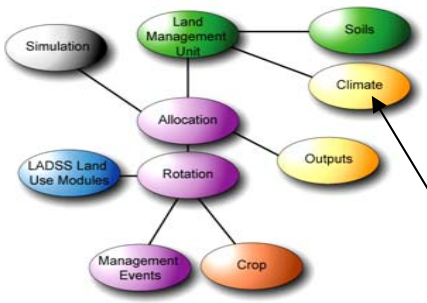
*Decision makers, consultants, or policy analysts*

# Spatial variability in soils

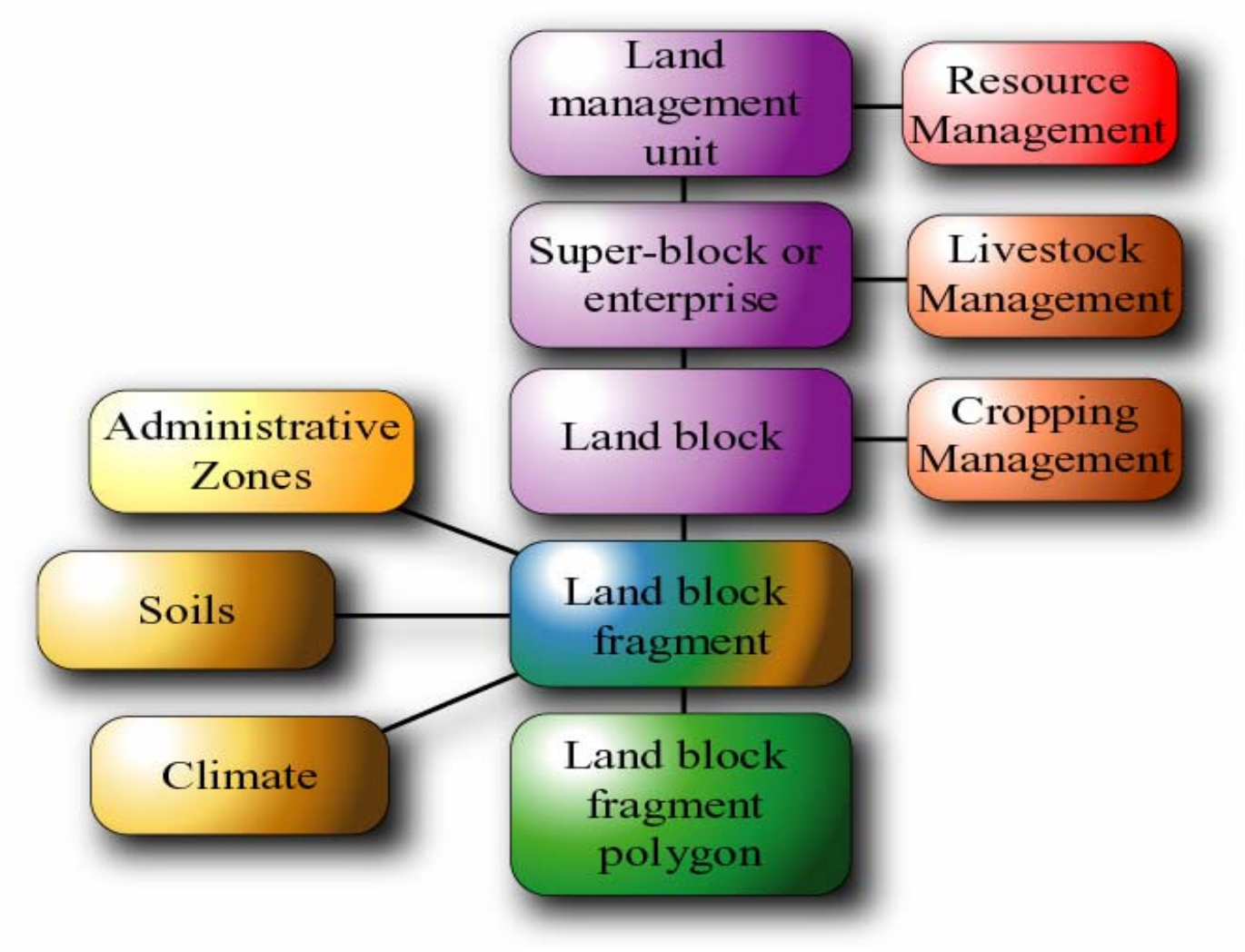


## Database: Location and Climate



# Hierarchy of geo-spatial classes and management regimen

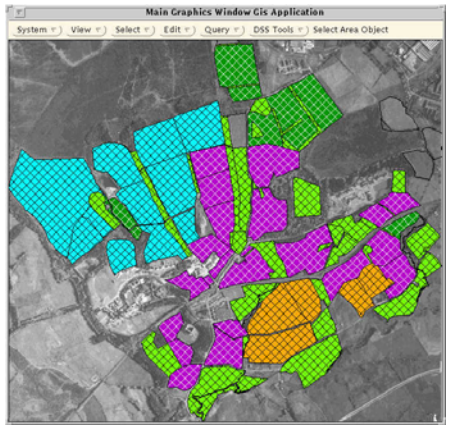


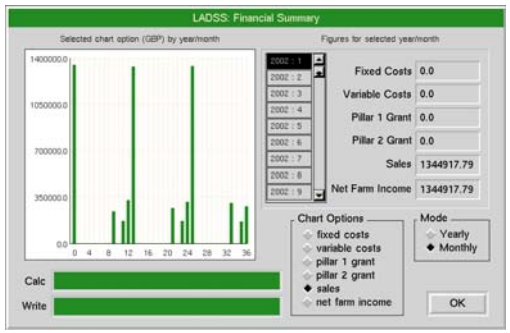
# Modelled outputs

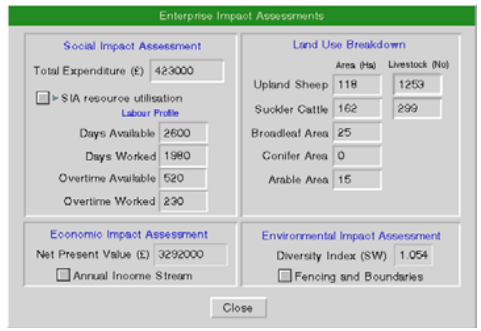
- Land use allocations
- Biophysical
  - Crop / soil / water

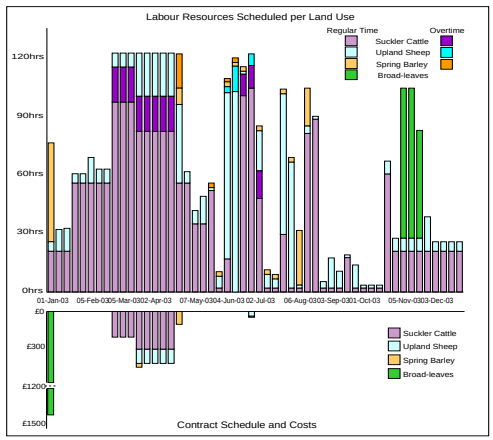
Accounting

- Financial
  - Income streams
  - Costs
- Social
  - Labour / resource scheduling
- Environmental
  - GHG
  - Spatial configuration

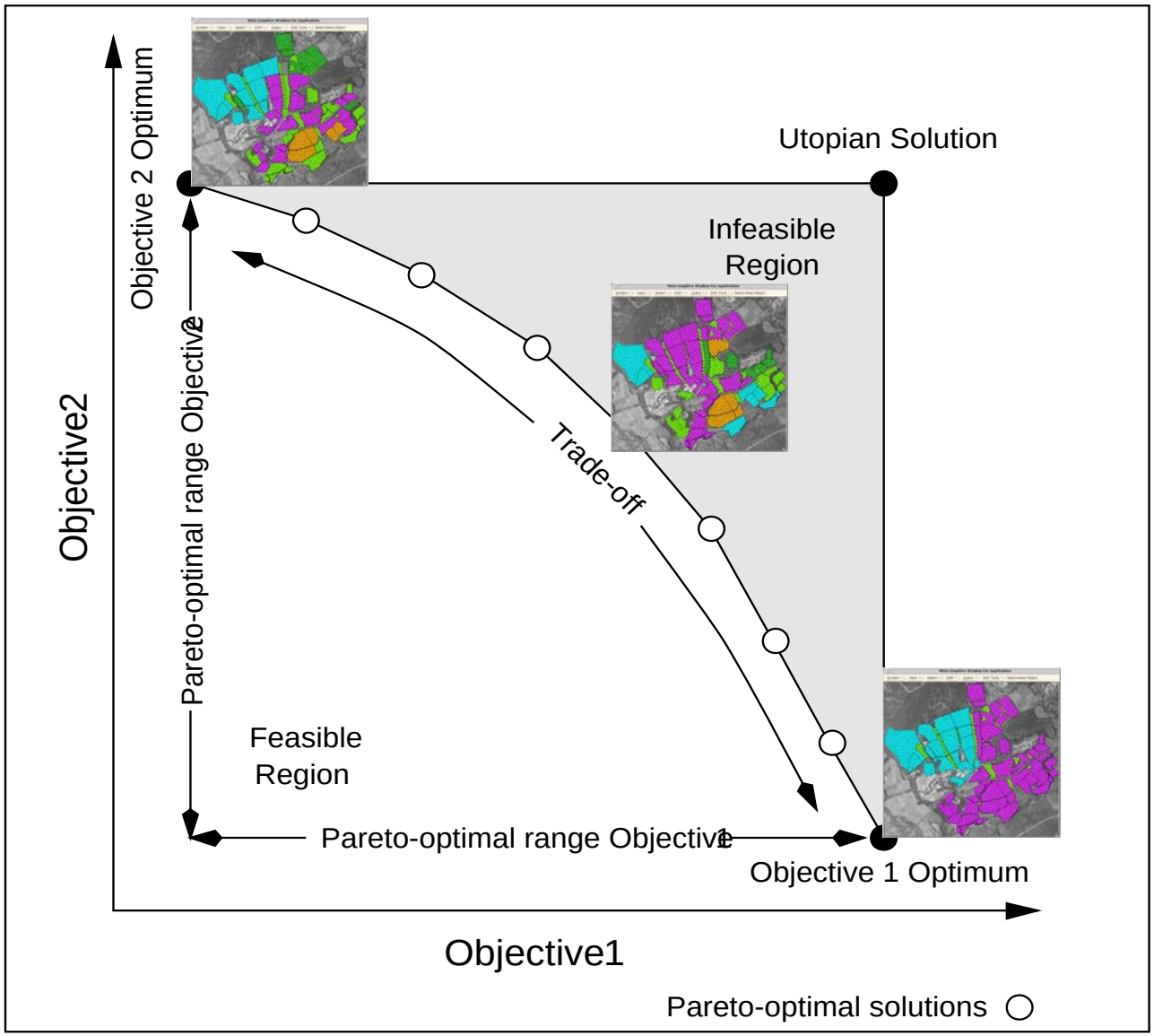


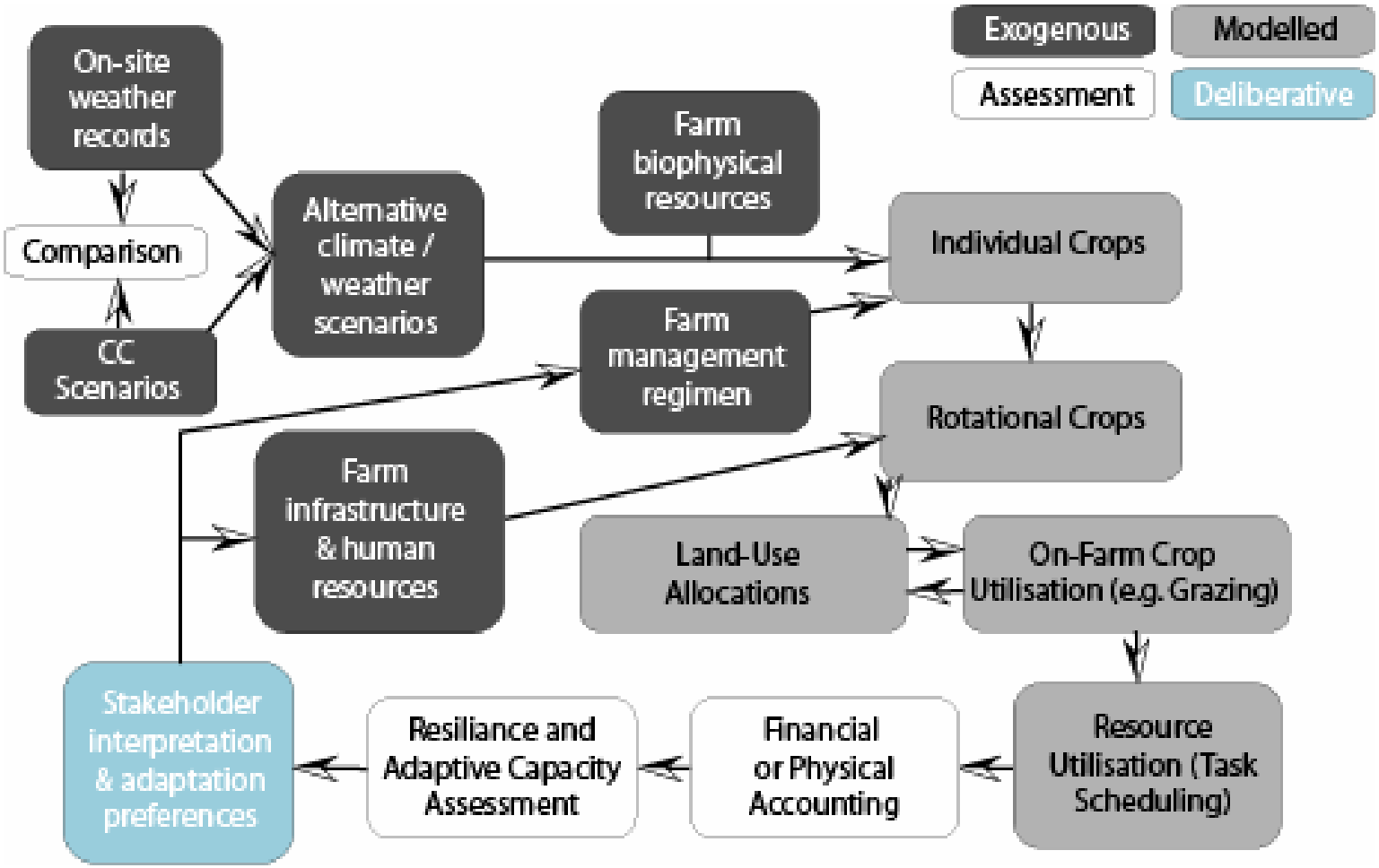



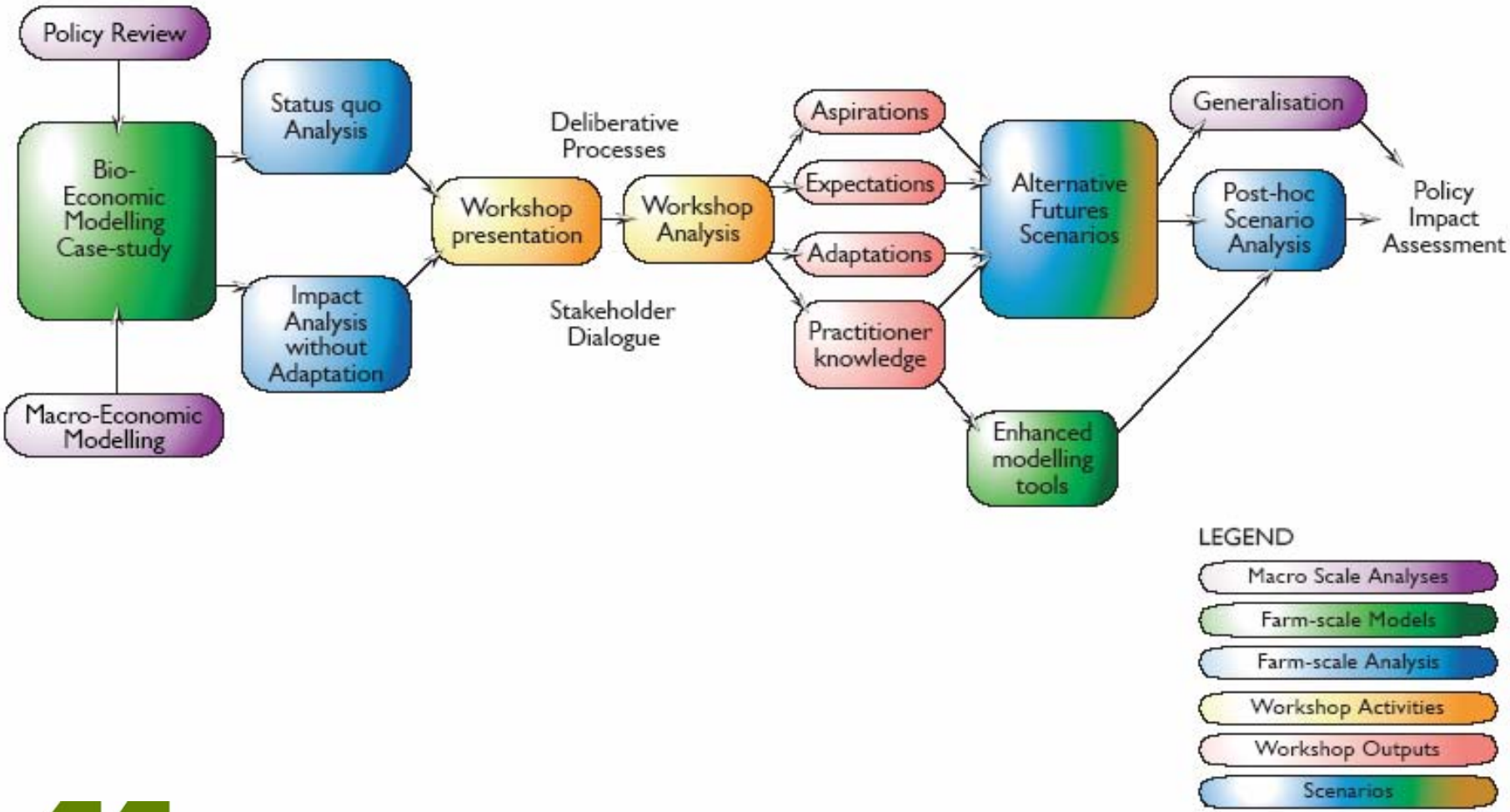
# Nature of multi-objective optimality



# Modelling and deliberative process



# Integrating Policy Review, Macro-Economic Modelling, Simulation Modelling and Deliberative Methods



# Case study analysis

- Advantages:
  - Farm-scale: using real management and physical resources
  - Allows detailed investigations into internal relationships
  - Easier to understand the boundaries of what is possible

- Disadvantages
  - How to up-scale to regional / national level?
  - How ‘representative’ is the case study site?