Representing farmers' objectives in integrated models: Trying to hit a moving target for agricultural development

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Structure of the presentation

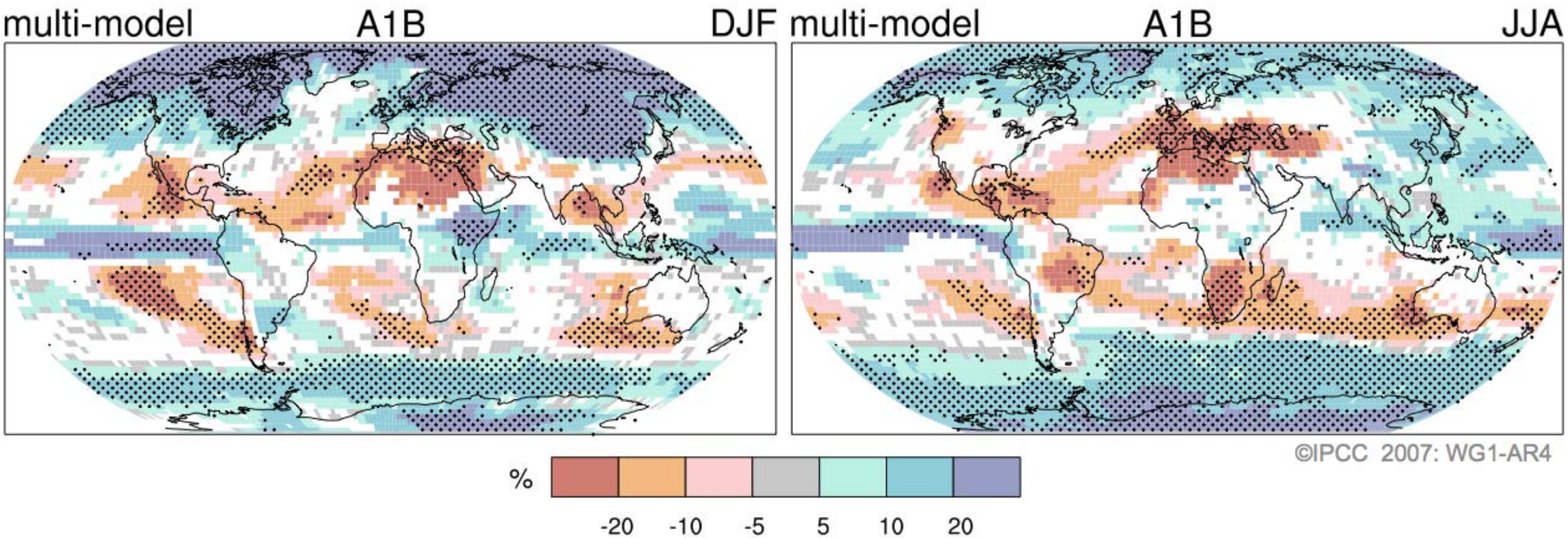
- Changing systems – how can households cope?
- Integrated assessment
- Representing household objectives: two examples
  - European crop-livestock systems
  - Pastoral & agro-pastoral systems in rangelands of southern Kenya
- Challenges for the future

The global context

- World population to grow from 6.5 billion now to 8 billion in 2020
- Income per capita continues to grow in developing countries: around 3% per year in Africa
- In the South, population is moving from rural to urban areas: 30% in 1980 to 49% in 2005
- Huge consequences for volume and composition of global food demand:
  - Current demand: 1.7 billion MT of cereals, 206 MT of meat
  - Demand in 2020: 2.5 billion MT of cereals, 275-310 MT of meat
  - To be produced from essentially the same land and water resources

- **How is this demand to be satisfied in a sustainable way?**
- **How can the poor benefit from this increased demand?**

Projected Patterns of Precipitation Changes



Precipitation increases *very likely* in high latitudes

Decreases *likely* in most (but not all: E Africa?) subtropical land regions

Data shown: 2090-2099 relative to 1980-1999, scenario A1B

White areas: <66% of the models agree on the sign of the change

Black dotted areas: >90% of the models agree on the sign of the change

IPCC FAR (2007)

Understanding how livestock systems may continue to change and evolve …

- For designing a more coherent and dynamic research and policy agenda that benefits the poor and sustains the environment

- For targeting research investments more appropriately

- For trying to bridge the technology adoption gap

- For helping farmers adapt to change

Towards integrated assessment

- **In the search for policy and technology options that help to alleviate poverty and sustain livelihoods, is it possible to balance ecosystem integrity, food security, and human well-being?**

- **Linkage of different types of models together, that have the required sensitivities, to run scenario analyses that look at a wide range of options under different conditions.**

- **Ultimately, requires understanding of why it is that people make the resource management and livelihood decisions that they do.**

Integration

Spatial Integration

- **Plot**
- **Farm**
- **Community**
- **Landscape**

Systems Integration

- **Biophysical (crops, livestock, ...)**
- **Economics and Policy**
- **Socio-cultural**

(Sectoral integration …)

Integrated assessment

Combining models of different types into a coherent tool for assessing effects of change

- **Biophysical simulation models (crops, livestock, ecosystems, …)**
- **Socio-economic household models (resource allocation decisions)**
- **Agricultural sector models (costs and prices)**
- **General circulation models (climate and weather)**
- **…**

Household-level resource allocation decisions

Related to objectives and attitudes

- Understanding the nature and the drivers of household decision-making
- Affected by risk
- Affected by flows of information
  - How can new or different knowledge help decisions
  - How can indigenous knowledge be built on that has been accumulated over many years
  - Some decisions are taken at the community level, others at the household level

The integrated assessment "ladder"

Aggregate to regional response

Response to changes

Baseline runs & testing

Set up appropriate household and biophysical models

Elucidate household objectives

Characterise representative households (crops, land, livestock, labour, …)

Typology of households for the study region seamless

Sixth Framework Programme

System for Environmental and Agricultural Modelling: Linking European Science and Society

Towards a computerized integrated assessment framework for the EU (SEAMLESS-IF)

Consortium led by Martin van Ittersum, Wageningen University, The Netherlands

Consortium

- UNEW
- UEDIN
- UNIABD

- FLD

- UMB

- LU
- LUEAB

- TEAGASC
- NUI Galway

- UBER
- ZALF
- UBonn

- WU
- Alterra
- LEI
- PRI

- SGGW

- ILE ASCR
- VUZE

- UEvora

- INRA
- CIRAD
- IAMM
- Cemagref

- CRA
- JRC

- IDSIA -SUPSI
- AntOptima

Mali: IER

USA: UVM

SEAMLESS Integrated Framework

A generic, flexible and modular integrated assessment tool

To carry out ex-ante assessment of agricultural, environmental and rural development policies and agricultural innovations

- Analysis at a full range of scales
- Analysis of the environmental, economic and social contributions of a multifunctional agriculture
- Analysis of a broad range of issues

To generate information that can assist in the formulation of appropriate agricultural, environmental and rural development policies

SEAMLESS typology of farms in the EU-25

189 combinations

Economic size (€)

- Small scale
- Medium scale
- Large scale

+

- Low intensity
- Medium intensity
- High intensity

+

- Arable/Cereal
- Arable/Fallow
- Arable/Others
- Arable/Specialised crops
- Beef and mixed cattle/Land independent
- Beef and mixed cattle/Others
- Beef and mixed cattle/Permanent grass
- Beef and mixed cattle/Temporary grass
- Dairy cattle/Land independent
- Dairy cattle/Others
- Dairy cattle/Permanent grass
- Dairy cattle/Temporary grass
- Horticulture
- Mixed farms
- Mixed livestock
- Permanent crops
- Pigs/Land independent
- Pigs/Others
- Poultry and mixed pigs/poultry
- Sheep and goats/Land independent
- Sheep and goats/Others

Intensity (€ per ha)

Household decision making in SEAMLESS

For representative farms, maximise

$$\text{Utility } (€) = E - r^{*}\sigma$$

standard deviation of income (yields, prices)

Expected income: sum of crop & livestock revenues – variable costs

Risk aversion coefficient

Decision variables (ha per crop, number of animals, quantity of purchased feeds, etc)

Exogenous variables (prices of inputs and outputs, yields as a function of states-of-nature, EU farm payments, etc)

Policy instruments being implemented in FSSIM-MP

Instrument	Modelling
Milk and sugar beet quotas	Constraints in the system (upper bounds on sales)
Compulsory set-aside	Constraints in the system, restrict set-aside to minimum 10% of COP (cereals, oilseeds and protein) crops
Voluntary set-aside	Constraints in the system, restrict total set-aside to 33% of COP crops
Environmental conditions, cross-compliance	Restrictions in the system (controlled by binary variables)
Agri-environmental measures	Restrictions in the system (controlled by binary variables)

Models and links in Prototype 1

Translate policy questions & scenarios into indicators

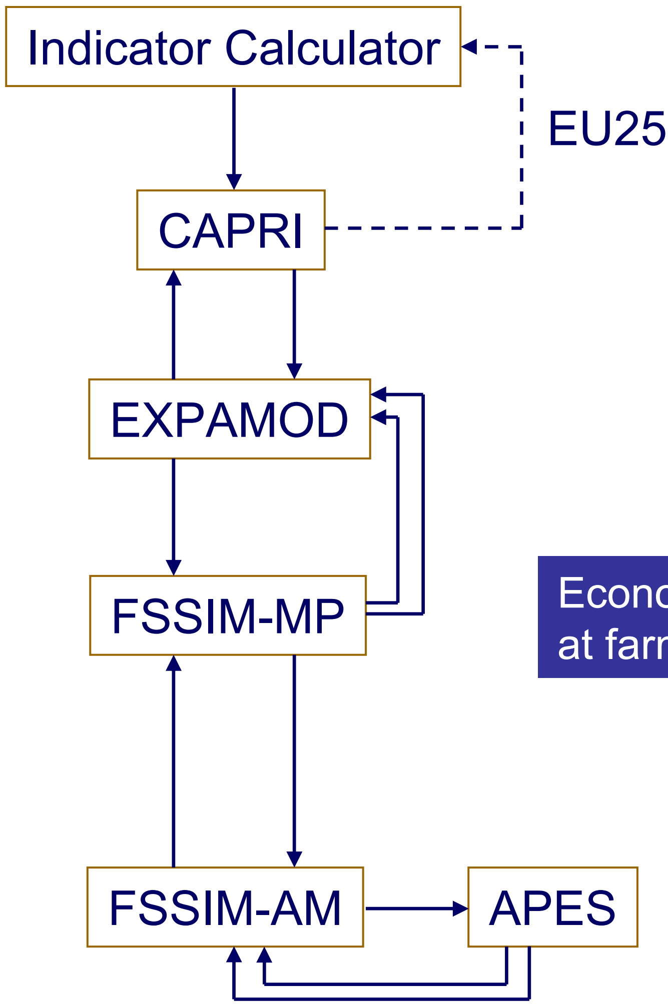
Market model for agricultural products

Linking sample of farms to market model

Economic decision at farm level

Production technology and externalities at farm and field level

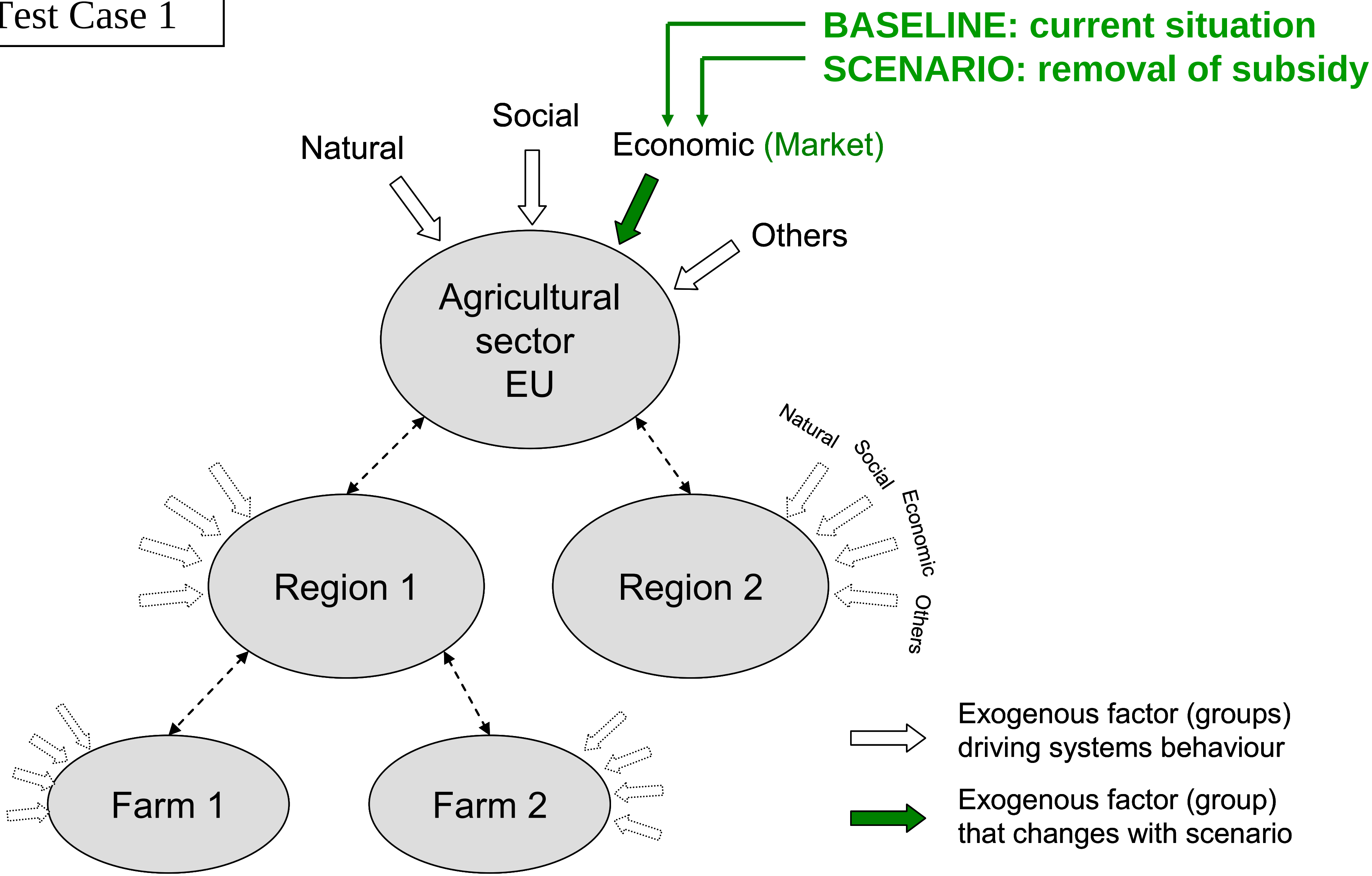
Crop & livestock models



Scenario analysis

Example for Test Case 1

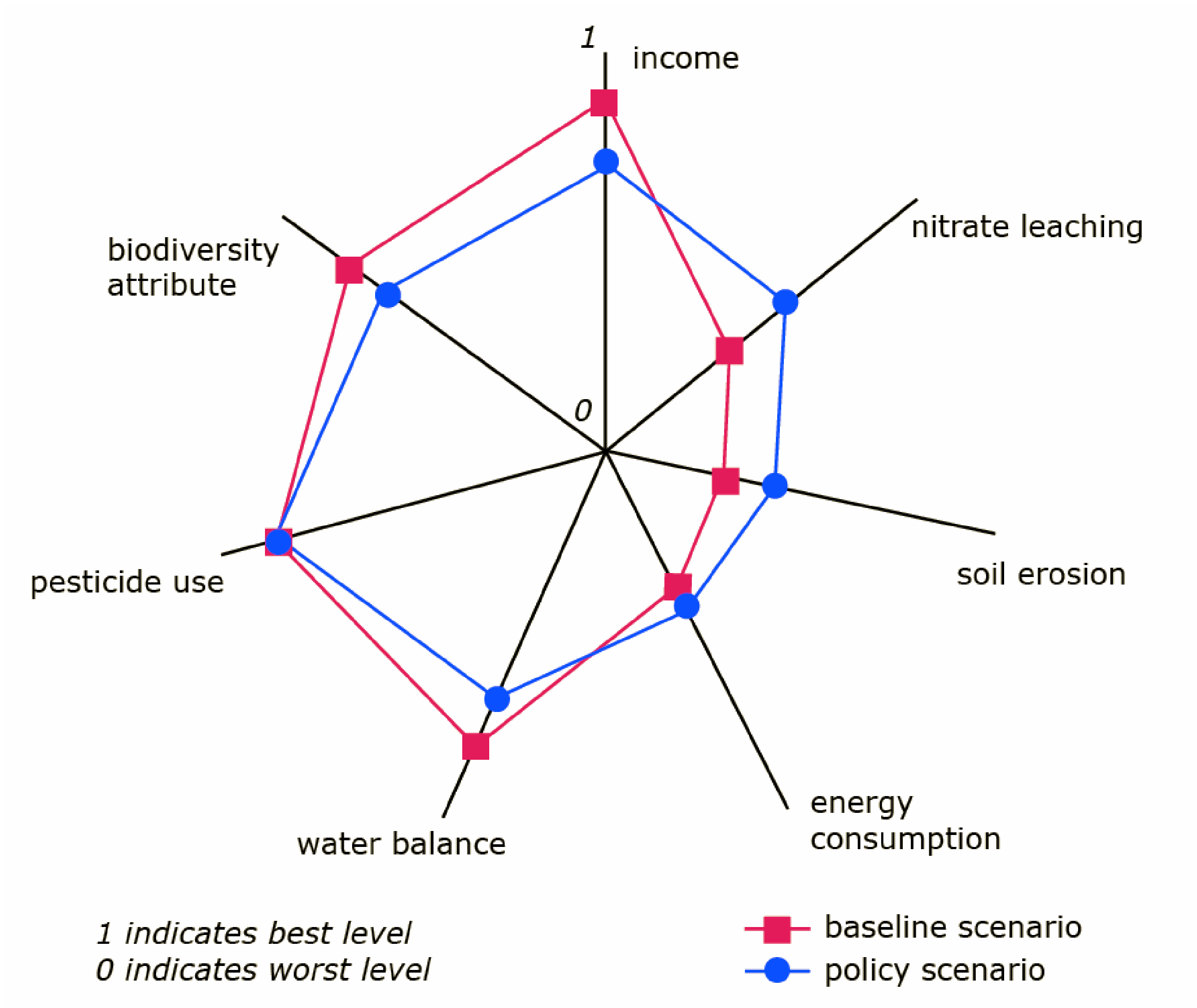
Policy option: Removal of a livestock subsidy



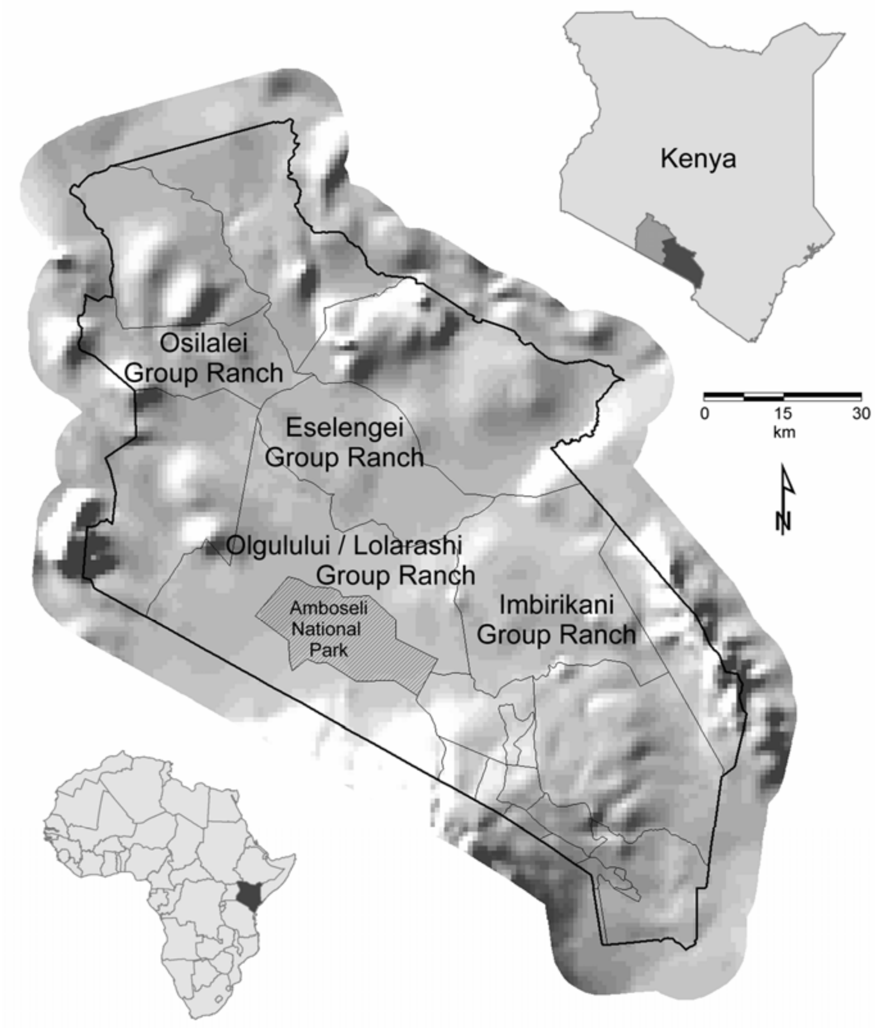
Ewert et al.., 2006

Example simulation of a specific farm type with FSSIM

Baseline versus a scenario with new agro-environmental policies



Integrated assessment in Kajiado District, Kenya: Trade-offs between agro-pastoralists, livestock and wildlife



Natural Resource Ecology Laboratory

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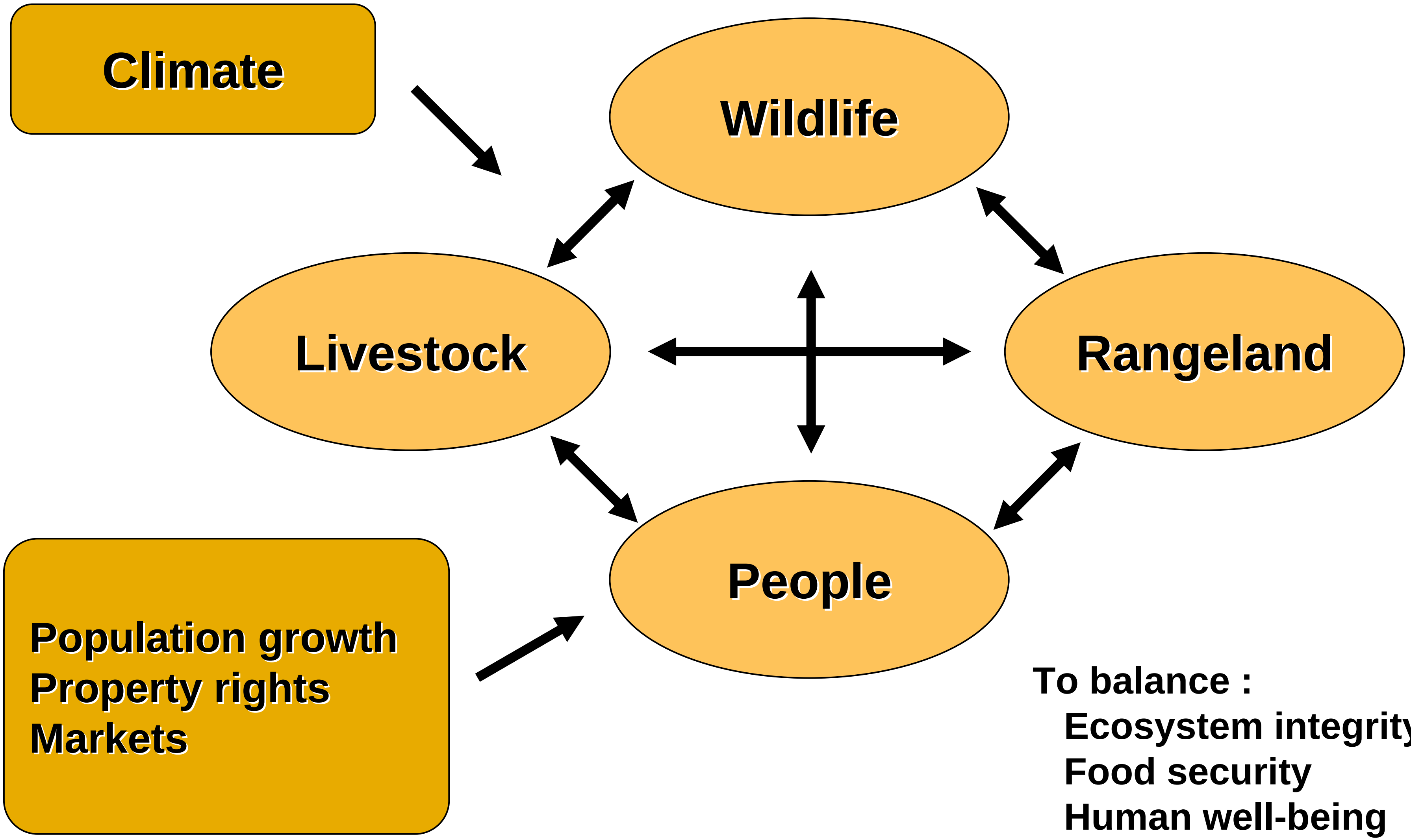
Kajiado District, Kenya

- Population increase, social change, rising economic expectations, group ranch subdivision

- Wildlife numbers declining

- Can competing objectives of wildlife conservation for tourism, agro-pastoralists’ well-being, and livestock production be balanced?

Integrated assessment to look at resource conflicts on rangelands: linking the Savanna ecosystem model and a household model



To balance :

- **Ecosystem integrity**
- **Food security**
- **Human well-being**

Household typology in the group ranches

- **All households have livestock (L)**
- **Some have access to**
  - **Rainfed agricultural plots - maize, beans for home consumption (R)**
  - **Irrigated agricultural plots - mostly vegetables for sale (I)**
  - **Rainfed plots on the slopes of Kilimanjaro - maize, beans (K)**
- **Some have a small business, often livestock trading (B)**

Household typology in the group ranches

24 combinations

Size of cattle, sheep and goat herds

Poor
Medium
Rich

x

L	livestock	
LB	+ business	
LI	+ irrigated ag	
LR	+ rainfed ag	
LK	+ hillslope ag	
LBI	+ business	+ irrigated ag
LBR		+ rainfed ag
LBK		+ hillslope ag

Data from S Burnsilver (2003)

Household objectives, Kajiado

1 Maintain cattle as a capital and cultural asset

2 Maintain a high proportion of household-produced calories – meat and milk, maize and vegetables (if grown)

3 Generate cash as needed, mostly through livestock sales
  - To meet a limited cash need, sell a sheep/goat
  - To meet a larger cash need, sell a cow and buy a sheep/goat

Pastoral Household Economic and Welfare Simulation Model (PHEWS)

A simple rule-based approach

For different household types, PHEWS accounts for:

- **Dietary energy flows (meat, milk, maize, etc)**
- **Cash flow, household expenditure decisions**
- **Livestock sale and purchase decisions**
- **Cropping decisions**

Cattle, sheep, goat herd dynamics and production are handled in SAVANNA

Baseline results (current conditions)

- **Most households need some “external” calories sometimes, but not many and not frequently**
- **30 - 46% of calories are home-produced -- only rich households can be purely pastoral (9 TLU per Adult Equivalent). Most households (> 80%) have to crop or be in business**
- **In general, the more diversified the household, the better, in terms of food security and income**

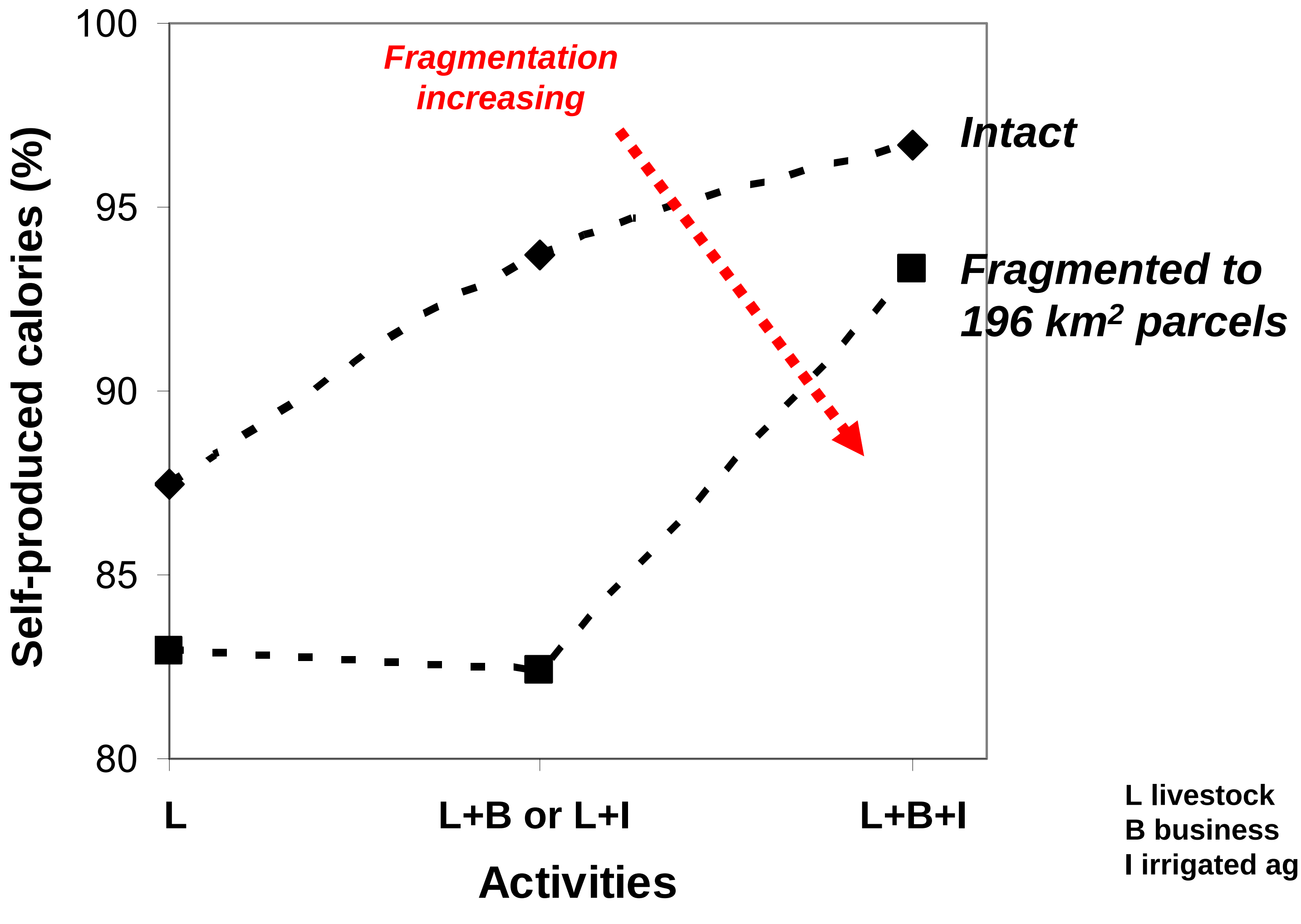
Results of one scenario analysis

Subdivision scenarios (cattle, wildlife movement restricted)

- **For all Group Ranches, resulted in substantially fewer livestock that could be maintained**
- **To maintain current food security and income levels, livelihood strategies would have to change, or household numbers be reduced to keep herd sizes stable**
- **Wildlife numbers also decrease in the scenarios where subdivision is carried out**

Proportion of self-produced food calories for poor households engaged in different activities in Imbirikani Group Ranch, Kajiado

Savanna-PHEWS simulations



L livestock
B business
I irrigated agriculture

Comparison of the two examples

	EU25	Kajiado
Household objectives	Utility maximization (expected returns minus a risk premium)	1 Maintain cattle as a capital and cultural asset 2 Maintain a high proportion of household-produced calories 3 Use livestock to generate cash
Market orientation	High	Low but increasing
Drivers of change	Environmental policy Multi-functionality	Population growth Drought frequency Social networks changing Economics
Main options	Diversification Intensification Increase off-farm income Exit from farming	Diversification Increase off-farm income Communal management of grazing resources
Integrated assessment tools	SEAMLESS-IF (biophysical + farm + sector models)	Savanna-PHEWS (ecosystem + household models)
Major trade-offs at household level	Income & income variability, environmental impacts	Food security, income, wildlife numbers

Future challenges

1 Elucidating and representing objectives and attitudes

- **Do we have adequate understanding to formulate appropriate decision rules for integrated assessment?**
  - **diversity in household objectives**
  - **diversity in coping strategies in response to change**
- **Do we need to consider household network interactions to deal with flows that occur between activities that are far-flung in space and time?**

Future challenges

2 Understanding how decisions may be modified through time

- by far-reaching events such as drought
- at different stages in the life cycle of the household
- as a result of changing systems, changing economics, changing socio-cultural circumstances

Future challenges

3 Understanding how best to represent decision-making in integrated models

- Most appropriate units of analysis – representative households, agents, etc
- How much detail at the household level is required, when results are aggregated through space and time?

Integrated assessment

To identify not only what is desirable but also what is feasible

- Identify situations where households are unlikely to be able to sustain current livelihood options based on exploitation of natural resources
- Well-being may then depend on radical shifts in production technology or exit from farming
- Implications for policy making may be far-reaching

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