

Sustainability Research Institute

School of Earth and Environment

FACULTY OF ENVIRONMENT



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Methods to anticipate vulnerability in food systems to global environmental change: the challenge of dynamic systems.

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<http://uts.cc.utexas.edu/~marl/images/Tikal.JPG>



UN asks for Malawi hunger relief

Raphael Tenthani
 BBC News, Blantyre

The United Nations has launched an \$88m appeal for Malawi, where one in three people is threatened by hunger.

The country is suffering from its worst food crisis since 1992, due to a drought that sent maize production, the main staple food, plummeting by 24%.

The UN says the appeal aims both to avert hunger and help people recover their livelihoods.

Malawi is one of the poorest countries in the world, where the majority live on less than a dollar a day.

The UN office in Malawi said the funds raised will be used to provide emergency aid for the most vulnerable.

'Deadly mix'



Malawi is one of the world's poorest countries

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Will this increase in the future?

“...climate change [will] lead to pressure on food supplies because of decreased rainfall in many areas and crop failures related to climate...”

Manchester Guardian, 7th March, 2008, referring to John Bebbington's talk on the future of food. See:

<http://www.guardian.co.uk/science/2008/mar/07/scienceofclimatechange.food>



http://www.utexas.edu/depts/grg/hudson/grg360g/EGIS/labs_04/Lab9/sierra_madre_gully.JPG



<http://www.btinternet.com/~grow.communities/images/keithperryweb.jpg>



<http://www.september11news.com/Nov10ABushUN4.jpg>

Therefore, the purpose of this paper is to...

- Propose a method to explore these complex issues.
- Present a case study where we've started to apply this approach.
- Reflect on strengths and weaknesses of this approach.

Methods: “dynamic systems modelling”

- An approach pioneered in the 1960s
- Based on research that suggests the human brain struggles to predict future where feed back loops are involved.
- Uses computers to help develop scenarios and simulate different “futures”.
- Is useful to explore small-medium scale spatially bounded systems where there are complex dynamics.

6 Steps to do dynamic systems modelling...

1. Establish problem and boundaries of system.

2. Interview experts or stakeholders to establish a narrative that explains the system.

4. Stop here, and reflect if you can make recommendations.

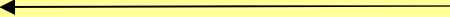
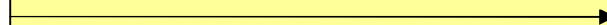
3. Analyse narrative using a flow chart or "mind map".

Conventional social sciences

5. Explore each relationship within the system, and decide whether relationships are linear or non-linear, their slope, etc

Controversial modelling

6. Use computers to run different simulations of the model to explore scenarios.



Exploring how to create a working
dynamic system model using a
trivial example

...getting good marks at school.

Step 1: Establish the problem and boundaries.

- The problem is poor student performance on tests.
- The policy makers want to understand the factors that went into individual student achievement on tests so they can initiate policy that has maximum effect on marks.

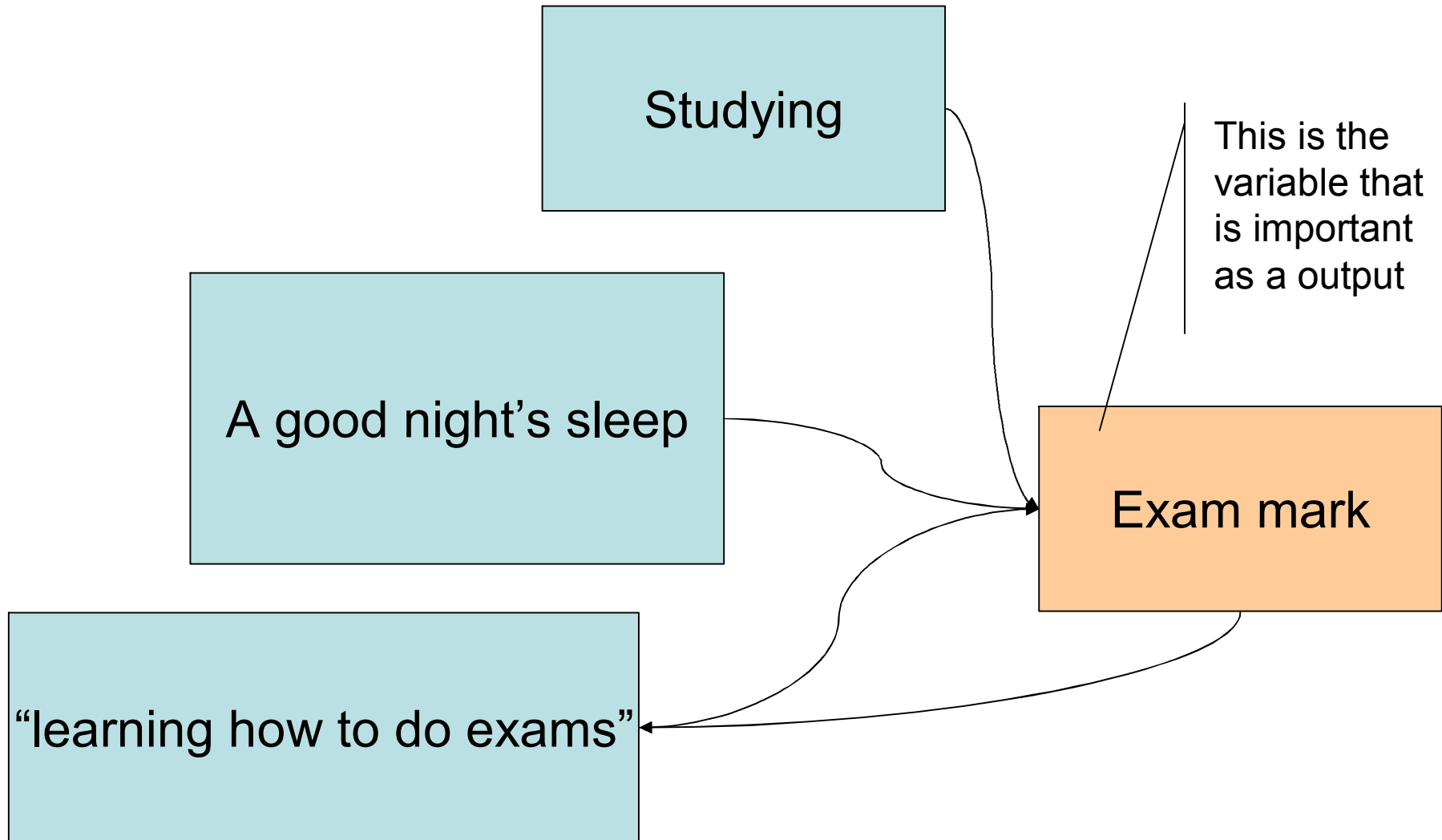
Step 2 work with stakeholders to establish a narrative

- Stakeholder 1 says: Students tend to do really well when they study and get a good nights' sleep before the exam.
- Stakeholder 2 says: Students who have taken many exams in the past, do better because they have learned how to do exams over time.
- Repeat until you hit “theoretical saturation” and are confident you have all the important aspects of the system captured.

The narrative then says,

Obtaining good exam marks is at least partly determined by the length of time studying, whether the student has had a good night's sleep, and extent to which they've "learned how to do exams..."(etc).

Step 3 analyze using flow chart



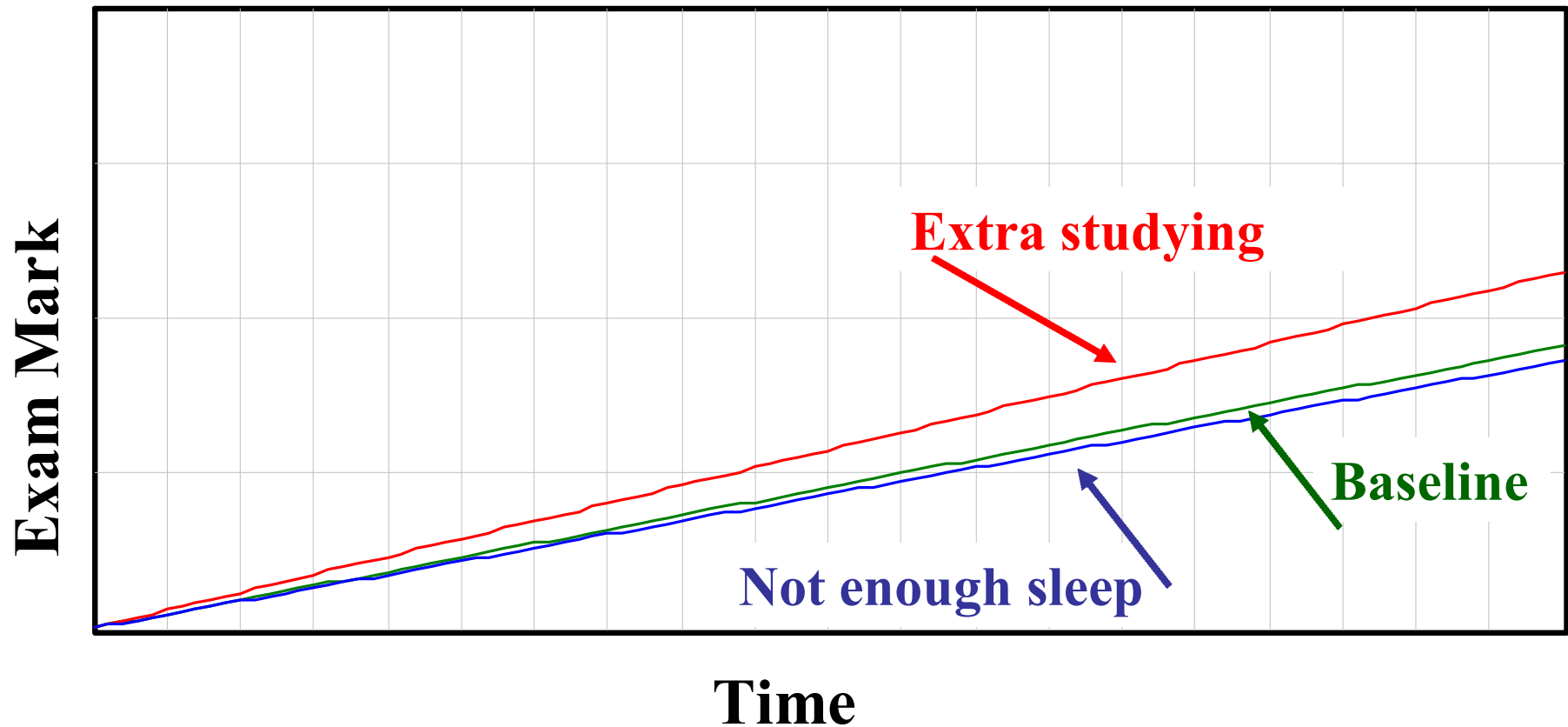
Step 4 Stop here to identify key hypotheses

- Do we know enough about this system to make any judgements or recommendations in terms of policy?
- E.g. what is the relationship between “a good night’s sleep” and “exam mark”?

The controversial step 5, using math to express relations

- Look at each box, arrow and feedback and express relations mathematically.
- E.g. for the relationship between “a good night’s sleep” and “exam mark” you might say that a good night sleep is 8 hours and for every hour missed the exam mark drops by 20%.
- The problem of doing this is that it may not be accurate.
- The benefit is that by quantifying relations we explore limits of our understanding.

The controversial step six: creating simulations



Controversial step 6 con't

- These sort of results look concrete but they aren't.
- By taking this step, do we open the door for the analysis to be mis-used in terms of policy?
- By not taking this step are missing key lessons from our understanding of how these systems work?

Some key references...

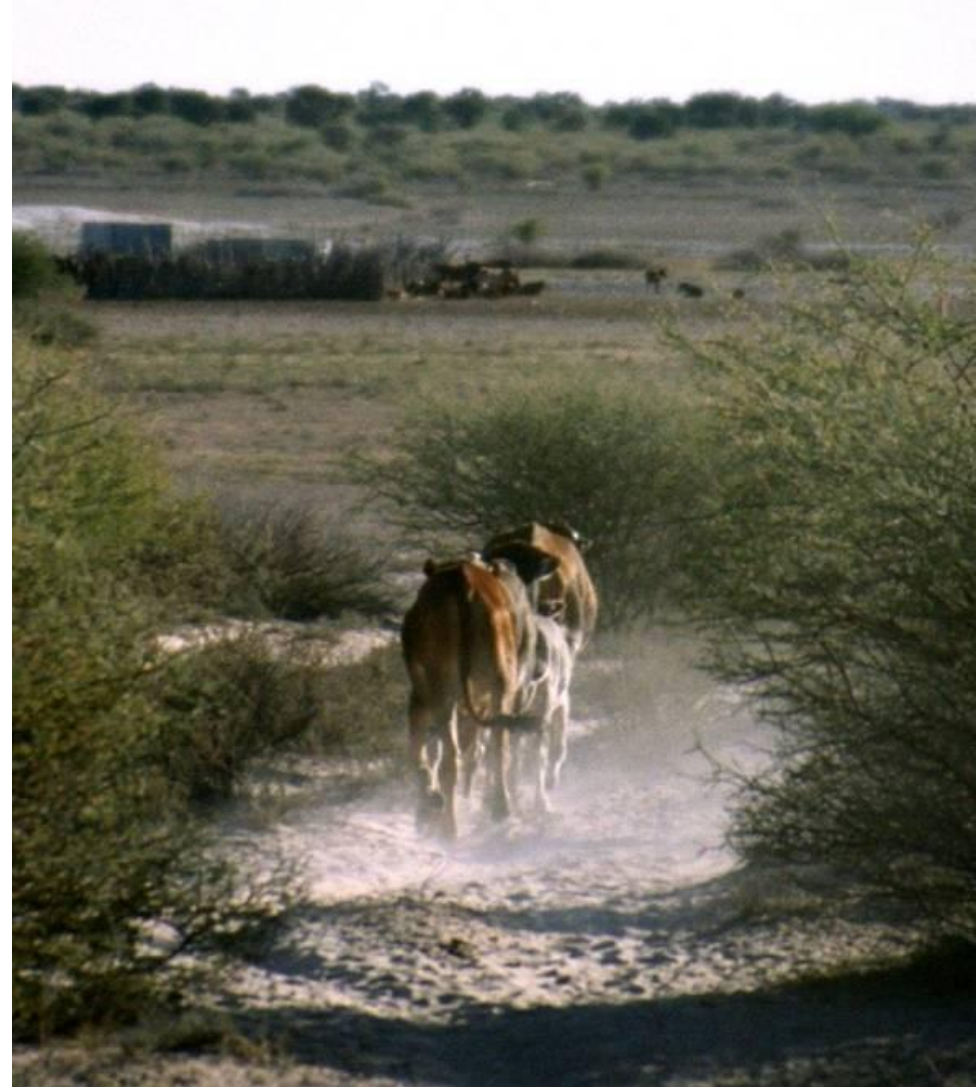
- A guided reading programme by Jay Forrester's group at MIT: <http://sysdyn.clexchange.org/road-maps/home.html>
 - This work strongly endorses the computer simulation aspect.
- The soft systems approach by Peter Checkland (U. Lancaster).
http://www.open2.net/systems/practice/files/pet_chec.pdf
 - Much more critical of the use of computer simulations.
 - See also: 2006, *Learning For Action: A Short Definitive Account of Soft Systems Methodology, and its use Practitioners, Teachers and Students*, Wiley

Applying this framework to Botswana

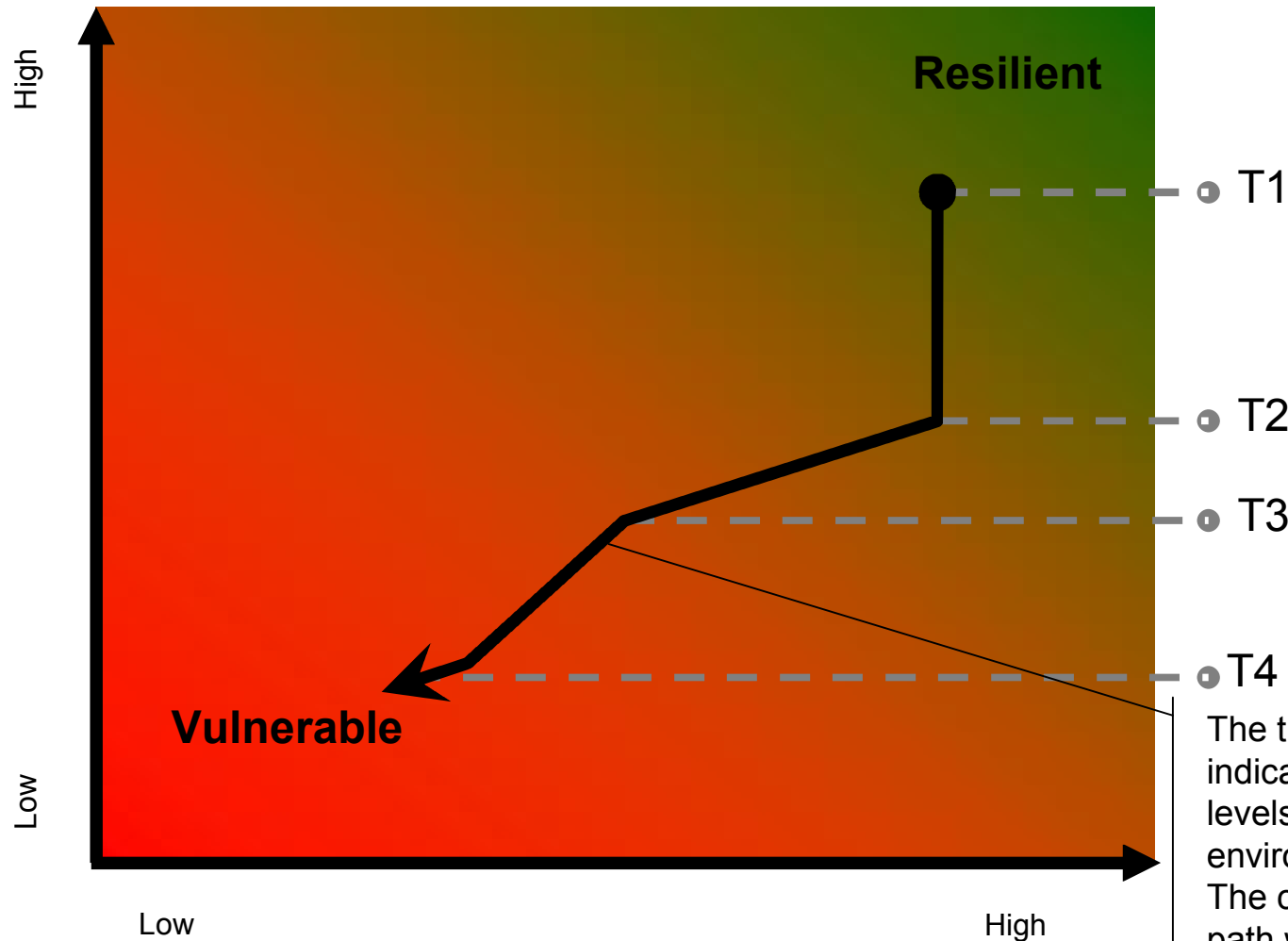


Step 1 (The Problem): vulnerability to drought in pastoral food systems

- Socio-economic changes are making this region's food system more vulnerable to drought:
 - Affect ecosystems' ability to remain productive during drought
 - Undermine people's ability to find alternative sources of food should drought cause agro-ecosystem to lose productivity.
 - Climate change may increase size/frequency of drought.



Ability of people to find alternatives if main food/livelihoods supply stops



The trajectory indicates changing levels of resilience to environmental change. The causes for this path way will be a reflection of the socio-economic system.

Ability of the agro-ecosystem to remain productive during a drought

Step 2 use the stakeholder to establish a narrative.

- Concern that land privatization has:
 - Taken land out of communal production and this reduces ability to move cows around in search of fodder during a drought.
 - Caused livelihoods to depend on good market conditions.
 - Led to over grazing that reduces long-term fodder production.

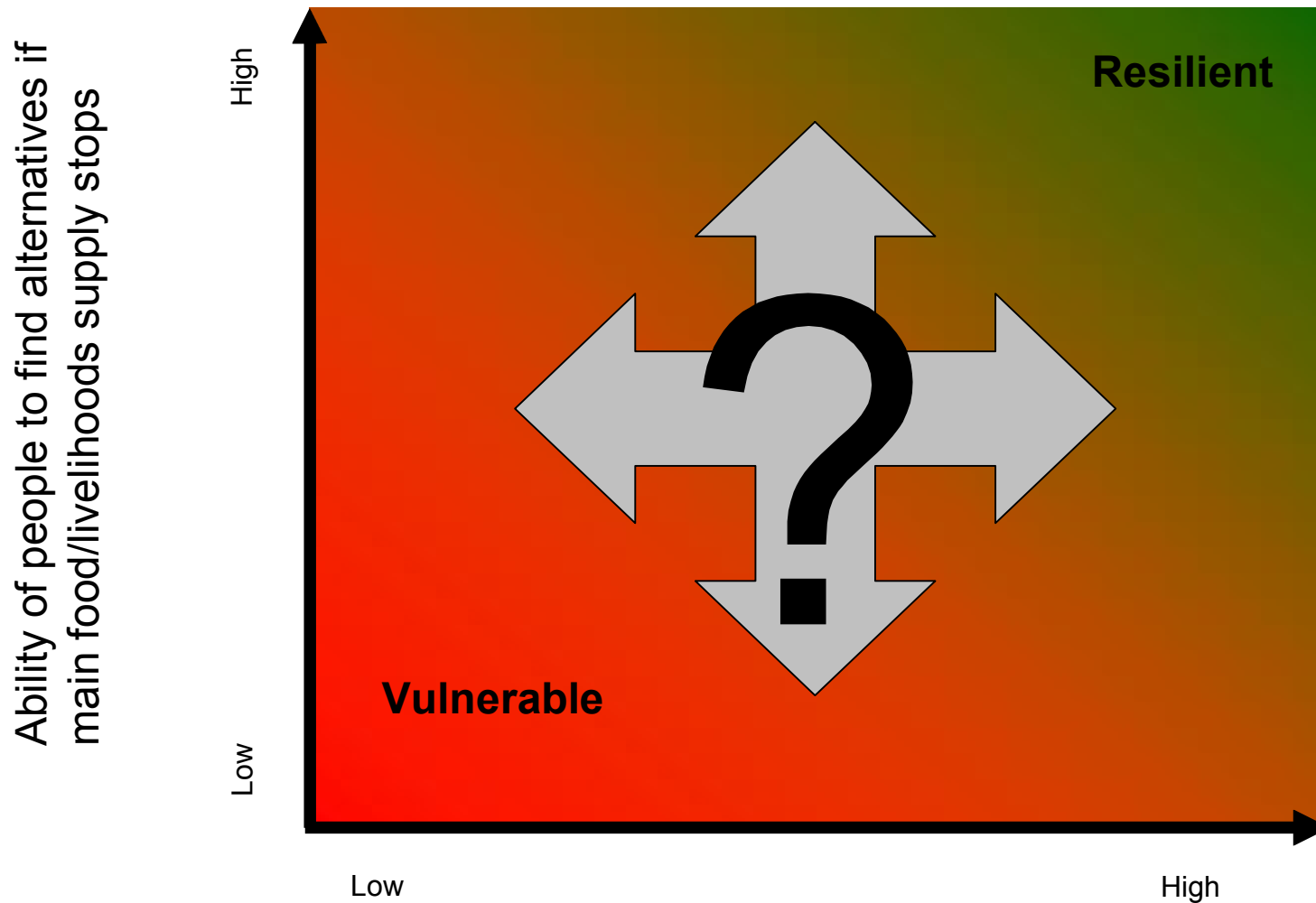
Bush Encroached System



Ranch (L) versus Communal (R) land



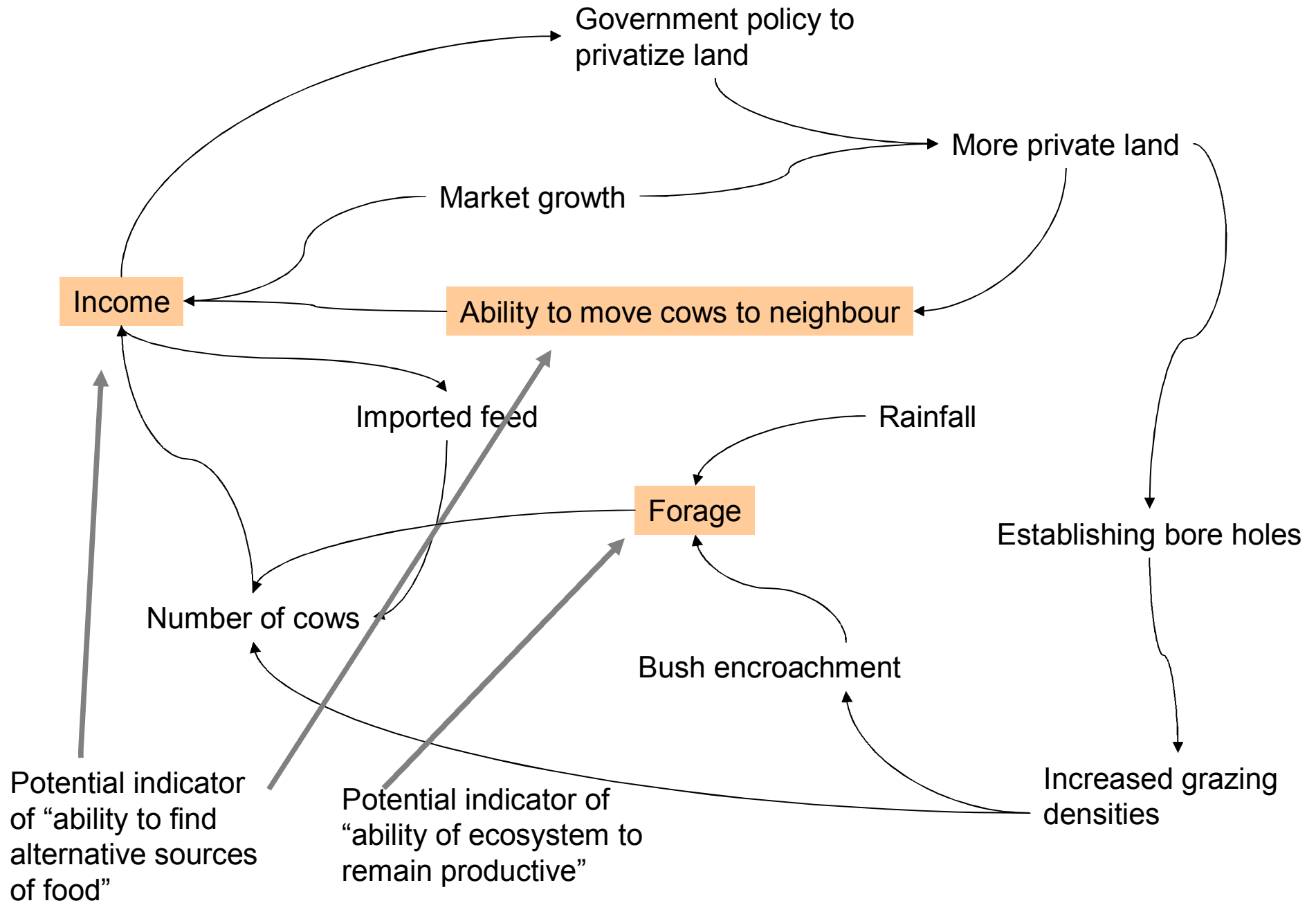
How do the changes to land ownership affect movement through this space?



Ability of the agro-ecosystems to remain productive during drought

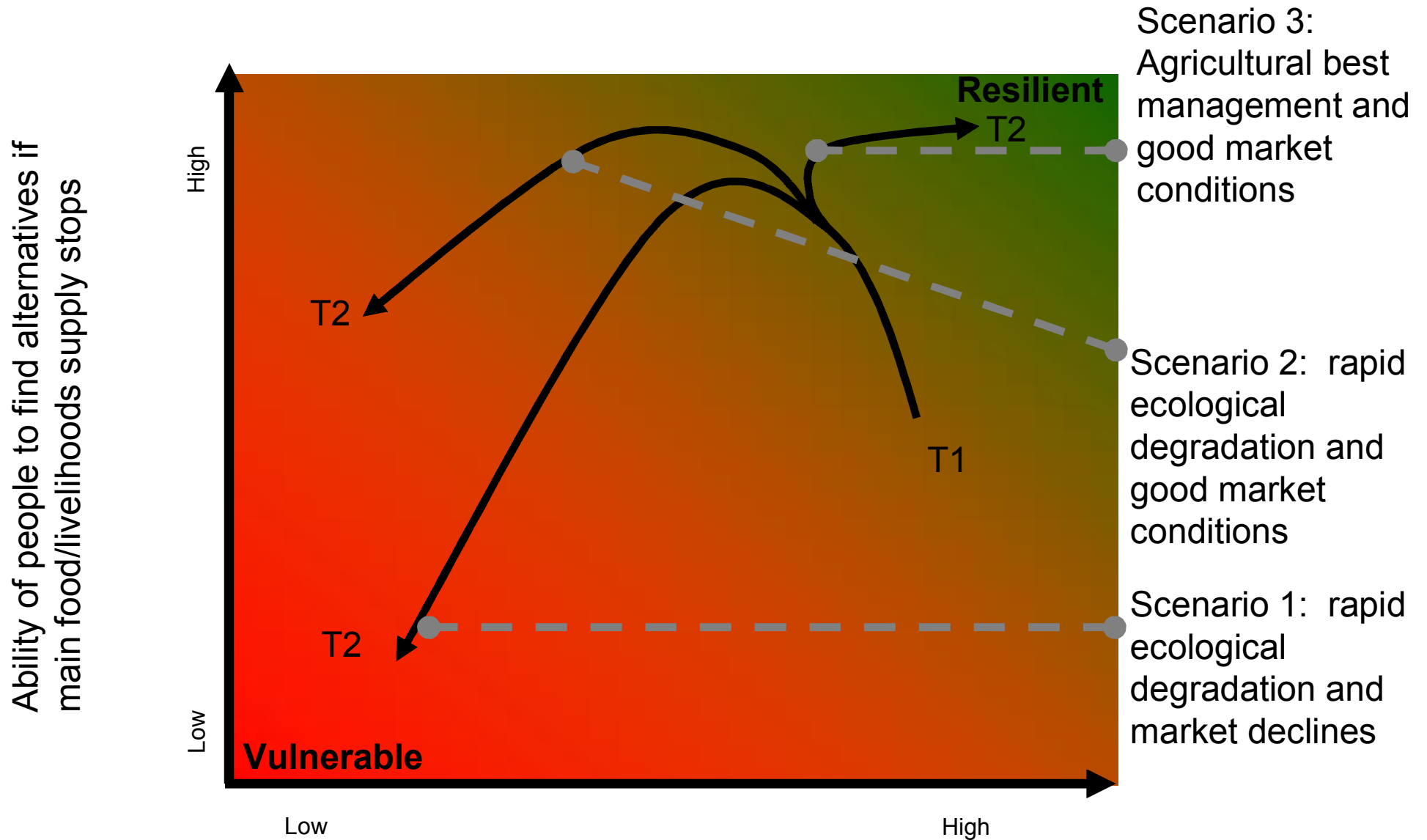
Step 3 analyze using flow chart

- Flow charts simplify the complex.
- The flow chart we developed had dozens of boxes and arrows.
- The following flow chart is a further simplification for presentation purposes.



Step 4 Stop here to identify key hypotheses and make recommendations

- Yes, recommendations are possible, but future research needs be done on rate of land conversion, or extent to which private land stands in the way of moving cows around.
- Most published work stops here.



Ability of the agro-ecosystems to remain productive during drought

The controversial step 5, using math to express relations

- We used a combination of data, expert opinion and secondary literature to explore relations and express them using very simple math.
- While we don't believe our model is correct, it has helped sharpen up our understanding on what is clear versus what is conjecture.
- QUESTION: do the benefits of taking this step out weigh the problems?

Vensim:botswana efv2 JS PM.mdl Var:% of open access land reduced to bush/unpalatable grass

File Edit View Layout Model Tools Windows Help

gap between size

test

baseline with climate change+high fee

gap between size of private herd and

Size of herd on private land

Number of cows supported on private

Time (Month)

Editing equation for - gap between size of private herd and number of cows supported on pri...

gap between size of private herd and number of cows supported on privately owned land

Add Eq

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Size of herd on private land-Number of cows supported on private land

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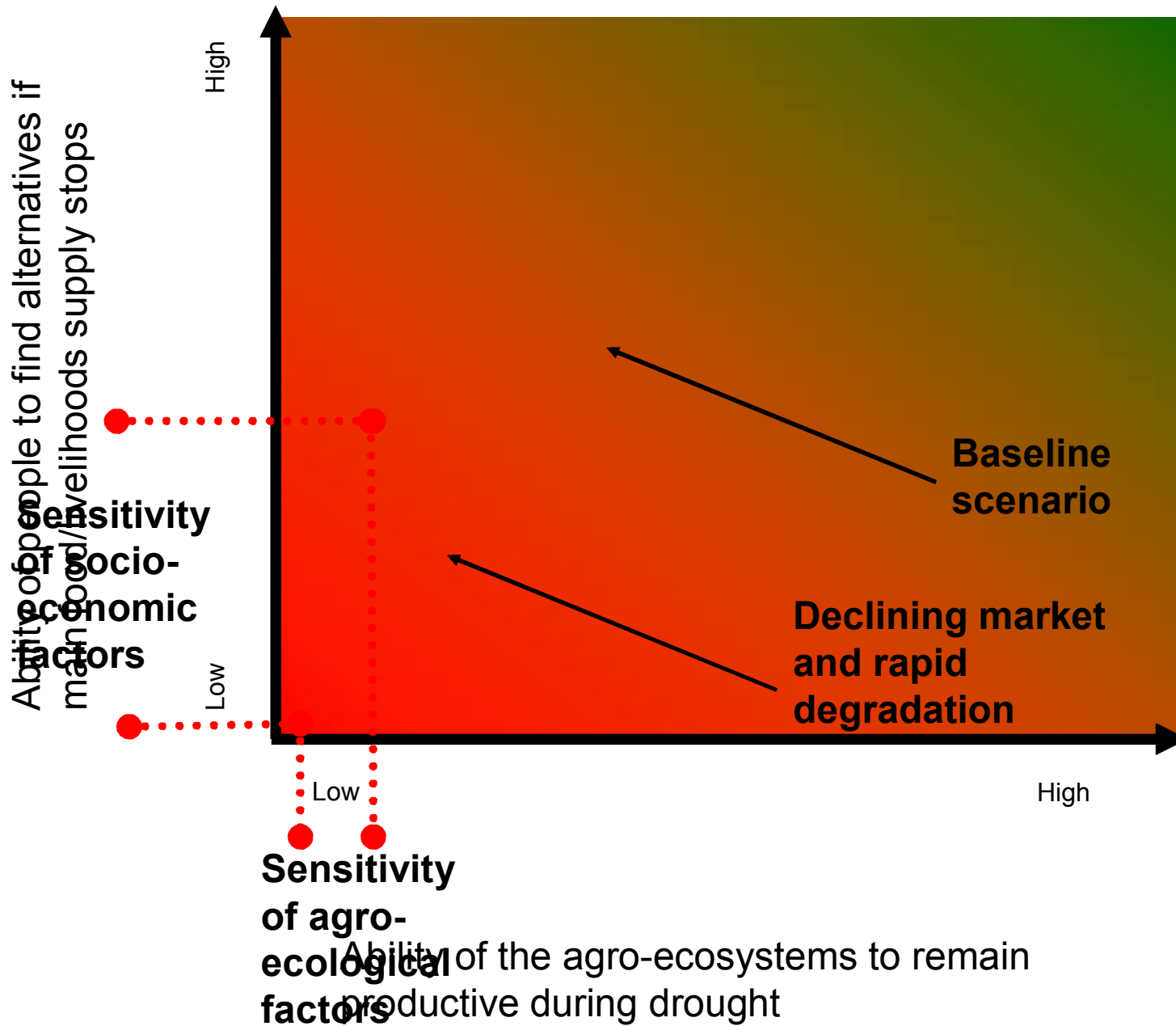
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Ability of people to find alternatives if
main food/livelihoods supply stops



Ability of the agro-ecosystems to remain
productive during drought



Controversial step 6 con't

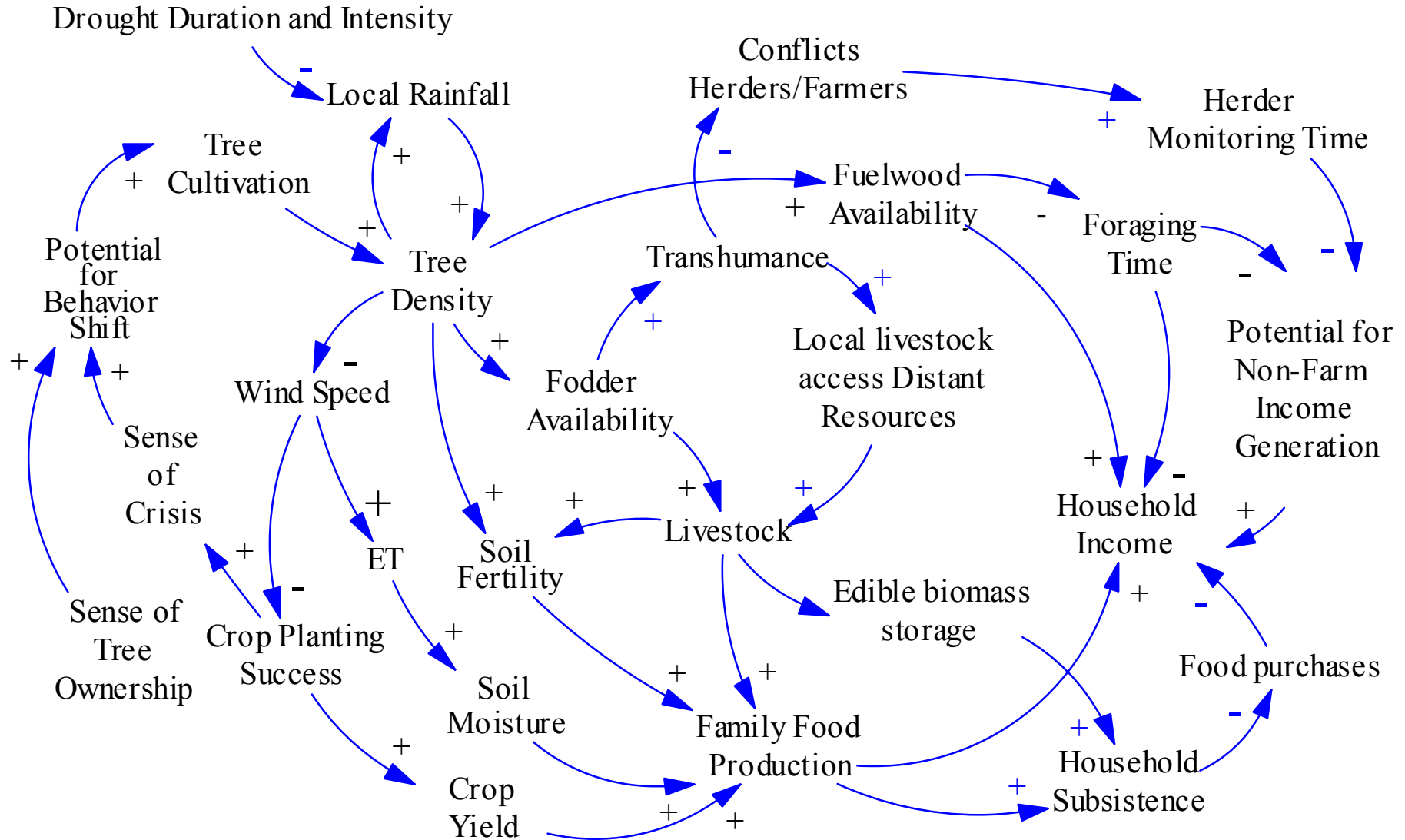
- These sort of results look concrete and give illusion of authority, but they aren't.
- By taking this step, do we open the door for the analysis to be mis-used?
- By not taking this step are we moving forward in terms of our understanding of this system?

Next steps

- We hope this is the start of a number of case studies on the vulnerability of arid or semi-arid food systems to a range of possible environmental threats.
- We hope that by working through a number of studies we will:
 - sharpen our understanding of vulnerable food systems.
 - refine and test a method to deal with the complexity of this field of study.

Sahel Reforestation Success

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Copies of papers are available at:

<http://homepages.see.leeds.ac.uk/~earedgf/Personal/index.html>

(or just google: evan fraser leeds)

