



Pro-Poor
Livestock
Policy
Initiative



A Discussion-Decision Support Tool for Assessing Impacts of Policy Changes on the Poor

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EXTRAPOLATE
version 1.0



◆ Reference Manual

TABLE OF CONTENTS

Preface	iii
1. Background	1
2. Framework for the EXTRAPOLATE tool	3
3. Using EXTRAPOLATE	11
3.1 Models	11
3.2 Model Data	13
3.3 Model Summaries	16
3.4 Analysis Tools	17
4. Other aspects of EXTRAPOLATE	21
4.1 Pairwise comparisons	21
4.2 Calculation scheme in EXTRAPOLATE	24
4.3 SLATE	28
4.4 PRIMAS	32
5. An Example: The Use of Lactoperoxidase in Kenya	37
6. Future developments	47
7. Glossary	49
References	51

Figures

Figure 1: A model for pro-poor policy analysis	1
Figure 2: The framework of EXTRAPOLATE, part 1: stakeholders, constraints and outcomes.	4
Figure 3: The framework of EXTRAPOLATE, part 2: impact of policies on constraints and outcomes, and thence on stakeholders' status.	7
Figure 4: Kenya and district boundaries, shaded areas showing a domain for Pennisetum purpureum (Napier grass)	34

Tables

Table 1: Relationship matrices in EXTRAPOLATE and allowable indices.	9
Table 2: The pairwise comparison scale (Saaty, 1990, p 78).	22
Table 3: Elements in PRIMAS and EXTRAPOLATE, with examples of entries with spatial and non-spatial characteristics.	36
Table 4: Model elements for the LPS example.	38
Table 5: LPS example: relevance of the constraints to the stakeholder groups.	40
Table 6: LPS example: impact of outcomes on the stakeholder groups	41
Table 7: LPS example: impact of constraints on the outcomes.	42
Table 8: LPS example: impact of policies on the constraints.	42

Screenshots

Screen 1:	Opening screen of EXTRAPOLATE.....	12
Screen 2:	The “Model Diagram” option - the basic EXTRAPOLATE model.....	12
Screen 3:	Direct data entry - stakeholder groups with associated livelihood status.	14
Screen 4:	Viewing model elements.....	15
Screen 5:	Viewing input data in the “Model Summaries” submenu.	16
Screen 6:	Summary of policy impacts on stakeholder groups (Kenya coastal dairy).	17
Screen 7:	Relative change in livelihood status as a result of implementing policies (Kenya coastal dairy).....	18
Screen 8:	Data entry screen for estimating the ex ante livelihood status of stakeholder groups by pairwise comparisons.....	24
Screen 9:	SLATE: Project description page.	29
Screen 10:	SLATE: Project livelihoods page, showing project indicators, weights and ranks.	30
Screen 11:	Sample assets pentagon in SLATE.	31
Screen 12:	Filtering the library of asset indicators in SLATE: human assets.	32
Screen 13:	Data summary charts in EXTRAPOLATE: showing the potential mean impacts of outcomes on stakeholder groups for the LPS example.....	43
Screen 14:	Data summary charts in EXTRAPOLATE: showing the potential mean impacts of the policies on the constraints for the LPS example.	43
Screen 15:	Analysis results: showing the relative change in livelihood status before and after application of the two policies promoting use of LPS.....	44
Screen 16:	Recommendation domain for LPS technology, based on stringent criteria relating to dairy animal numbers, milk surplus and distance to road (see text for details).....	45
Screen 17:	Districts related to the recommendation domain for LPS technology in Screen 16.	45
Screen 18:	Recommendation domain for LPS technology, based on less stringent criteria relating to the top 50% of Divisions in terms of dairy animal numbers and milk surplus, and distance to road (see text for details).....	46

PREFACE

This is the 1st of a series of User Guides prepared for the Pro-Poor Livestock Policy Initiative (PPLPI). The purpose of these guides is to assist policy analysts to use decision support tools that have been developed or adapted by the PPLPI. They provide explanatory notes with worked examples related to livestock development in the context of poverty alleviation.

Livestock is vital to the economies of many developing countries. Animals are a source of food, more specifically protein for human diets, income, employment and possibly foreign exchange. For low-income producers, livestock can serve as a store of wealth, provide draught power and organic fertilizer for crop production and a means of transport. Consumption of livestock and livestock products in developing countries, though starting from a low base, is growing rapidly.

EXTRAPOLATE is a decision support tool that assess the impact of different policy measures. By disaggregating the effects of policy interventions the tool facilitates discussion of the relevant issues and enables users to visualize the predicted impacts of policy interventions, based on a simple numerical analysis. The tool helps decision makers to sift through a range of policy measures to identify those that could be applied in a specific situation to achieve particular outcomes that further specific policy objectives.

The programme is entirely independent and can be freely downloaded from the PPLPI website. It has been developed in close collaboration with policy makers in the livestock sectors of developing countries, and thus adapted to meet their specific requirements. There is an on-line library of models that have been already developed, enabling users from different regions and disciplines to share knowledge and experiences. Some of these have been written up more fully as PPLPI Working Papers.

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Acknowledgments

Jeroen Dijkman and Tim Robinson conceived the original model for pro-poor policy analysis, depicted in Figure 1, from which EXTRAPOLATE has been developed. Jeroen has continued to provide conceptual input. Without implicating any of them in any way, we are very grateful to the following colleagues for inputs at various stages in this work: Isabelle Baltenweck, Cheikh Ly, Achilles Costales, Katinka DeBalogh, Luc D'Haese, Thomas Emwanu, Ernesto Gonzalez-Estrada, Ade Freeman, Mario Herrero, Florence Kasirye, Nicholas Kauta, Russ Kruska, Nelson Mango, Pamela Ochungo, Joachim Otte, Robert Ouma, Ugo PicaCiamarra, Carlos Quiros, Maren Radeny, Jimmy Saamanya, Stijn Speelman, Steve Staal and Francis Wanyoike. Financial support for the development of EXTRAPOLATE has come from the UK's Department for International Development (DFID), through the Rural Livelihoods Department and the Livestock Production Programme.

Keywords

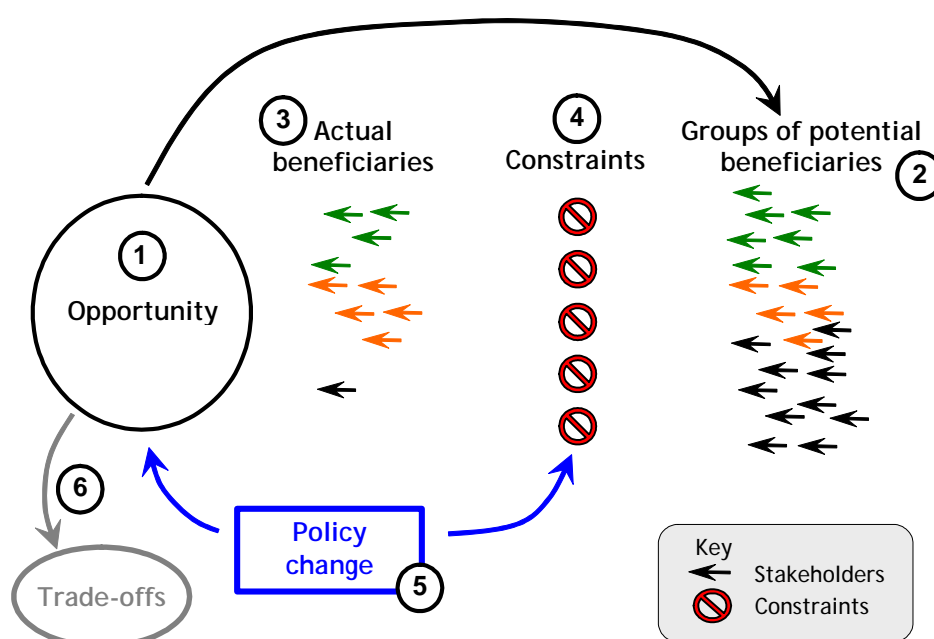
Livestock policy, decision support, livelihoods, stakeholders, constraints, livestock, pairwise comparison, EXTRAPOLATE, PRIMAS, SLATE.

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1. BACKGROUND

EXTRAPOLATE (EX-ante Tool for RANKing POLicy AITernatives) arose out of the need for a decision support tool to assess the impact of different policy measures. By disaggregating the effects of policy interventions the tool facilitates discussion of the relevant issues and enables users to visualize the predicted impacts of policy interventions, based on a simple numerical analysis. The idea is for the tool to serve as a “filter” that allows the user to sift through, in an *ex-ante* fashion, a range of policy measures to identify those that could be applied in a specific situation to achieve particular outcomes that further particular policy objectives. This would be the first step in assessing potential impact before looking at identified policy options in more detail.

Figure 1: A model for pro-poor policy analysis.



The original idea was formulated as in Figure 1. The framework is circular, and an analytical “start” could reasonably be made at almost any point in the cycle, but assume that we start with identifying the opportunity (number 1 in Figure 1) – this might be the existence of a rapidly-expanding market for eggs around a large town. Who are the potential beneficiaries of this expansion (number 2)? Potentially, the peri-urban and rural farmers in the vicinity. Who is currently benefiting from this expansion (number 3)? Only a limited number of these peri-urban and rural farmers. Why? What are the constraints that prevent some farmers benefiting from this expanding market (number 4)? There may be several: for example, many farmers have limited physical access to feeds and markets; commercial producers have a competitive edge; many of the farmers lack the required husbandry skills; and there are poultry diseases that are constraining smallholder producers. Several policies can be envisaged that may have an impact both on the constraints that currently prevent smallholders from taking more advantage of the expanding egg market, and on other opportunities for increasing incomes (number 5): for example, policies that influence rural infrastructure (roads for access, etc); policies that favour commercial producers at the expense of smallholder producers; and existing sanitation rules. If any of these policies are changed, what are the possible impacts on the constraints, and what are

the trade-offs involved (number 6)? For example, commercial producers may suffer; it may result in lower food standards; it may increase peri-urban pollution. So if access to markets is improved, if sanitation laws are relaxed somewhat, and if animal health services are improved, what are the impacts likely to be, and who will gain and who may lose out?

Mainstream economics has a wide array of tools to assess these sorts of policy changes in a rigorous and quantitative fashion (such as policy analysis matrices, computable general equilibrium models, etc). The purpose of EXTRAPOLATE is to be a rapid screening device, to allow the user to carry out quick assessments of likely candidate policy changes that may have particularly beneficial impacts on the poor in particular situations, the most promising of which can then be analysed further using much more rigorous (and time- and data-intensive) methods. The tool has the further characteristic that it is participatory in nature, encouraging stakeholder involvement and discussion around the likely impact of policy change. The next section of this guide describes the basic framework of EXTRAPOLATE, and this is followed by sections on data handling and on the use of the tool.

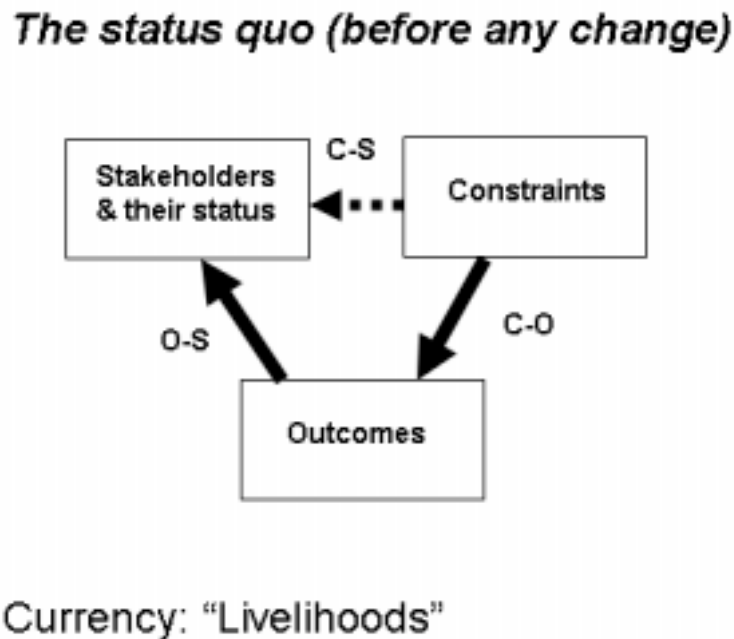
2. FRAMEWORK FOR THE EXTRAPOLATE TOOL

The current framework of EXTRAPOLATE was arrived at after a certain amount of trial and error. There are at least two issues that have caused some problems. One is terminology - what is really meant by words such as "stakeholders", "constraints", and "opportunities". A second is that EXTRAPOLATE has to be formulated to look at what is essentially a dynamic system (i.e., the situation before change, then after change). This means that the framework as programmed is somewhat different to that outlined in Figure 1. The underlying notion of both is similar, in that specific constraints hinder the poor from taking advantage of all sorts of opportunities, and that policy change that is well-directed can relax some of these so that potential beneficiaries become actual beneficiaries of these opportunities.

In what follows below, the framework is presented in a linear fashion. The reality of using EXTRAPOLATE will be anything but linear, however, and a satisfactory delineation of the various elements of the problem may require several iterations back and forth between the various steps. EXTRAPOLATE basically attempts to show what may happen as a result of a policy change. For any application, the user has to define the situation as it is now, before any policy intervention has been made. Figure 2 shows the components needed to define the status quo.

First, there are a number of stakeholder groups: these are the various groups of people who are involved directly in the system being analysed, and may be affected (both positively and negatively) by prospective policy changes. How these groups are chosen really sets the level of detail of the analysis. Enough discrimination is needed so that different stakeholder groups can be distinguished, but too many groups will make it difficult to specify all the input data needed and to make them coherent. A stakeholder group needs to be a reasonably homogenous group of people (i) of similar welfare status so that the average "livelihood status" (or whatever other currency of welfare is being used) is a meaningful statistic, and (ii) who face similar constraints in terms of the opportunity under review. Examples of stakeholder groups are "landless labourers", "smallholder producers of a particular livestock species or commodity", and "poor urban consumers". The need for iteration soon becomes clear: if an EXTRAPOLATE example is set up concerning a policy change that may have differential impacts on smallholders depending on whether they have large ruminant livestock or not (veterinary service provision, for example), then a "smallholder" stakeholder group may need to be split up into two: "smallholders with large ruminants" and "smallholders with no large ruminants". It will generally be easier to be discriminating from the start in setting up stakeholder groups for each example; groups can always be amalgamated later in the process, if significant differences do not become apparent.

Figure 2: The framework of EXTRAPOLATE, part 1: stakeholders, constraints and outcomes.



At the same time as the stakeholder groups are being identified, some thought has to be given to the "currency" or the "units" of the analysis. In our experience to date, this has always been expressed in terms of "sustainable livelihoods" - things such as household income, food security, increased production, and potentially many other things that can affect the wellbeing of groups of stakeholders. EXTRAPOLATE is flexible enough to handle different currencies of analysis, as long as these relate to the stakeholder groups in a way that can be quantified.

Once the stakeholder groups have been identified, and the currency of the analysis decided upon, each stakeholder group has to be assigned a **status** in relation to the currency to be used. Normally, this will be in terms of the relative livelihood status of each group. This might be assigned on the basis of a simple "low" to "high" scale ("poorly endowed" to "well endowed"). Such an assessment could be based on a synthesis of the physical, financial, social, human and natural capital assets of each group, or it might be based on the proportion of the stakeholder group that is below a particular poverty line, for example. It should be remembered that this is describing the current situation, and so is an estimate of the *ex ante* (before the change) status of each stakeholder group. EXTRAPOLATE has the facility to use pairwise comparison to ensure consistency in selection of livelihood status of stakeholder groups. For example, if group A is much better off than group B but only marginally better off than group C, it follows that group C is better off than group B - and this type of consistency can be checked for. This feature is discussed in more detail in section 4.1 of this guide.

Once the stakeholders and their status have been defined, the next things to identify (Figure 2) are the various **constraints** that are faced by these various groups. One way to define these is to go through each of the stakeholder groups identified and list appropriate constraints - these are really constraints to improving their livelihood status (in relation to the opportunity under review). Choosing the appropriate level of detail for describing these constraints is not easy, but in our experience to date of applying EXTRAPOLATE to real situations, there are often many different stakeholder

groups and many different constraints. Two examples of possible constraints, and the type of stakeholder groups that they may affect, would be (1) poor market access caused by poor roads locally, making it difficult for smallholders to get inputs and sell outputs; and (2) livestock disease prevalence, constraining the use of more productive livestock breeds by smallholders.

Having identified stakeholder groups, and a number of constraints, the next stage of the process is to estimate the relative strength of each constraint as it currently affects the various stakeholder groups (the dotted arrow C-S in Figure 2). The question that has to be answered is, how does constraint X affect stakeholder group Y - is it a very strong effect, or a very weak or non-existent effect? It may be easiest to think of this in terms of relevance: some constraints are simply not relevant for some stakeholder groups, while others may be. Consider a simple example with four stakeholder groups and four constraints. A matrix can be set up, and a number entered in each cell that describes the relevance of the constraint to each stakeholder group, as below.

Constraints	Stakeholder Groups			
	Hired labour	Large commercial producers	Smallholders	Poor urban consumers
Access to household cash				
Access to milk markets				
Livestock diseases				
Livestock feed supply				

Depending on the constraints and stakeholder groups identified, it will usually be possible to put zeros in some cells; for example, the constraint "access to household cash" will not be very relevant for commercial producers.

There are some simple (and obvious) rules involved in filling out such a matrix. First, if no constraint is relevant to any stakeholder group, the constraint can be deleted. Second, if no constraints have been identified that are relevant to any particular stakeholder group, it may be worth reconsidering the constraints identified, rather than deleting the relevant stakeholder group. Third, the matrix should be checked for consistency (this can be done using pair-wise comparisons, described later on in this guide). Numbers in any one column should be logically consistent: for example, for smallholders, if constraint 1 is more important than constraint 2, and constraint 2 is more important than constraint 3, then constraint 1 is more important than constraint 3.

The next step in defining the status quo (Figure 2) is to identify **outcomes**. Outcomes are things that can be quantified that contribute to the status of the stakeholders, in terms of the currency being used for the analysis. The question to be asked at this stage is, what is it that contributes towards a particular level of livelihood status (say) for any particular stakeholder group? Taking smallholder livelihood status as an example, appropriate outcomes may include cash income, milk production and level of food security; for commercial producers, profit margins and cash flow; for poor urban consumers, the price of food staples; and so on. In the model, these outcomes can be taken to explain the differences in stakeholder livelihood status. In our experience of applying EXTRAPOLATE to date, there tend to be relatively few outcomes, compared with the number of stakeholder groups and constraints.

Next, the user has to define the type of relationship between the outcomes defined above and the livelihood status, i.e., how important is any particular outcome on livelihood status (the relationship O-S in Figure 2). Examples would be as follows:

- “For smallholders, cash income has an enormous effect on their livelihood status” (i.e., small increases in cash income can have a substantial impact on livelihood status).
- “For the rural landless, an employment opportunity can have a substantial impact on their livelihood status”.

A similar matrix as before can be set up, and values entered in each cell to represent the degree to which the outcome shapes the livelihood status of each stakeholder group. As before, some cells can be filled in easily; “increased smallholder milk sales” is an outcome that will affect only smallholders directly. The same matrix rules apply as for the constraints - stakeholders matrix outlined above.

Outcomes	Stakeholder Groups			
	Hired labour	Large commercial producers	Smallholders	Poor urban consumers
Increased household milk consumption				
Increased smallholder milk sales				
Increased off-farm employment opportunities				

The next step is to identify the relative strength of the interaction between each of the constraints as they affect each of the outcomes (relationship C-O in Figure 3). Here, it is necessary to think in terms of the impact of each constraint as it affects potential changes in each outcome. The question to be answered is, for a small change in relaxing the constraint, what relative impact will this have on each outcome? An example would be: animal diseases are a serious and direct constraint on farmer income (either farmers cannot own cattle, or if they can, the vet and drug bills are very large), so even a small relaxation of this constraint will have a marked impact on production and hence farmer income. These relative strengths then have to be balanced for each stakeholder group. So, for example, for smallholders, lack of animal feed in the dry season may affect household income to a greater degree than the presence of the disease East Coast Fever (ECF). On the other hand, for commercial producers, ECF may affect profits more than lack of animal feed.

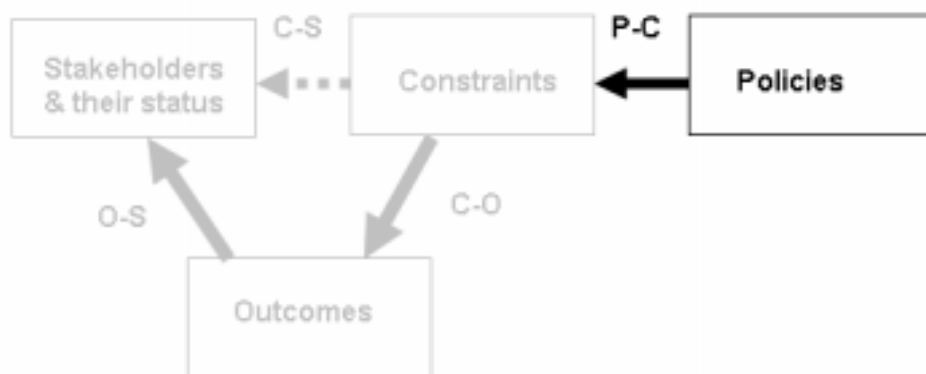
The matrix below carries on the (incomplete) example above, with the four constraints and three outcomes, here represented as outcome changes, i.e., increases or decreases in household milk consumption, smallholder milk sales, and smallholder productivity. The increases would be represented as positive indices, and decreases as negative values.

Change in Constraints (as a result of policy implementation)	Outcome Changes (as a result of changes in the constraints)		
	Increased household milk consumption	Increased smallholder milk sales	Increased off-farm employment opportunities
Access by smallholders to household cash			
Access to milk markets			
Livestock diseases			
Livestock feed supply			

These steps complete a description of the current situation (Figure 2). At this stage, stakeholder groups have been defined, their status estimated in terms of the currency being used in the analysis (livelihoods, generally); the major constraints facing each group have been identified and ranked; the outcomes that affect each stakeholder group's livelihood status have been identified and ranked; and the impacts of changes in the constraints on the various outcomes have been defined. With this basic information, which is assumed not to change within in any one analysis, we can then start to explore the impacts of policy changes that affect the various constraints, in an attempt to see which stakeholder groups will be most affected in terms of their livelihood status.

Figure 3: The framework of EXTRAPOLATE, part 2: impact of policies on constraints and outcomes, and thence on stakeholders' status.

After a policy change



Currency: "Livelihoods"

The situation after a policy change is shown in Figure 3. The elements that describe the status quo, already identified above, are shown in grey: stakeholders, constraints, outcomes, and the relationship between constraints and stakeholders (C-S) and outcomes and stakeholders (O-S), in both cases represented by two-dimensional matrices. To complete the model, the policy or policies to be examined have to be identified, and the impact of these policies on the constraints (P-C) need to be estimate. With this information, EXTRAPOLATE can then calculate and display the resultant changes in livelihood statuses of each stakeholder group as a consequence of applying the policy or policies, through the action of the policies on some or all of the constraints, the impacts of relaxing some or all of the constraints on the various outcomes, and the effects of these changes in outcomes on stakeholder livelihood status.

To get to this stage, the first thing to do is to identify one or more policies that are the subject of study. While the focus of EXTRAPOLATE is on policy change, it seems likely that the impacts of any sort of change could be examined within the same framework - technology, knowledge, management skill, etc. - that has some impact on one or more of the constraints identified. An example of a policy that could be looked at is the provision of veterinary services and health care by the government in a country.

For each policy measure identified, the strength of the impact of the policy has to be assessed on each of the constraints, assuming that it is implemented fully and successfully (the relationship P-C in Figure 3). Using the same four constraints as were identified above, another matrix can be constructed, and similarly a value placed in each cell that describes the relative strength of the impact of the policy (or policies) on each constraint, i.e., how much is this policy going to modify this constraint. An example in words would be, "Vet service subsidies will have a moderate impact on the animal disease constraint, and no impact at all on the output market access constraint". A sample matrix appears below. This step may involve just one policy, or a range of different policies: the advantage of setting up the "status quo" parts of the model first is that a wide range of changes can be investigated (once the user is happy with the basic mode), without having to change the basic structure of stakeholders, constraints and outcomes.

Constraints	Policy to be examined
	Vet service provision
Access to household cash	
Access to milk markets	
Livestock diseases	
Livestock feed supply	

With all this information, EXTRAPOLATE calculates the relative impact of the changes in outcomes on the relative livelihood status of each of the stakeholder groups, by simple multiplication of the relevant indices and rescaling of these among all stakeholder groups for each policy. An example of how this is calculated in the programme is discussed in section 4.2 of this guide.

As noted above, EXTRAPOLATE is looking at a combination of a particular set of constraints in particular places on a particular set of stakeholders whose livelihoods are defined in terms of certain outcomes, and the constraints may be relaxed in some way because of the introduction of specified policies. Specifying the model is an iterative rather than a linear process, and the associations between the various elements in Figures 2 and 3 may require several attempts to get them to be

reasonably consistent. Once the stakeholders, constraints and outcomes are defined to the satisfaction of the users, then the basic model does not have to be changed, and various different policy changes can be assessed by changing only the policies (P) and the matrix P-C (Figure 3).

From the above, it is clear that to fully specify a model in EXTRAPOLATE, there are four matrices to be filled in, three to define the status quo and one the impacts of a policy change. There are some important differences between the nature of these matrices, in terms of the indices or numbers that may be used in the software. These are summarised in Table 1.

Table 1: Relationship matrices in EXTRAPOLATE and allowable indices.

Relation	Type of Relationship	Allowable Indices
C-S	Relevance (of constraints to stakeholder groups)	0 (no relevance) to 9 (extremely relevant)
C-O	Impact (of constraint on outcomes)	-5 (highly negative impact) to 0 (no impact) to +5 (highly positive impact)
O-S	Impact (of outcomes on livelihood status of stakeholders)	-5 (highly negative impact) to 0 (no impact) to +5 (highly positive impact)
P-C	Impact (of policies on constraints)	-5 (highly negative impact) to 0 (no impact) to +5 (highly positive impact)

In summary, it should be noted that the EXTRAPOLATE tool is still under development, and that we are still experimenting with different ways to identify stakeholders, outcomes and constraints. This is being done through field testing with partners in different parts of the world; looking at a diverse range of livestock commodities. There can be problems in deciding upon an appropriate scale of analysis, i.e., are constraints and outcomes very general or very specific? The framework of EXTRAPOLATE is flexible enough to be able to handle both general and specific examples, and the key requirement is that of consistency within any one specific model - so if the outcomes are highly specific, then the constraints (and stakeholders) should also be highly specific. There are clearly trade-offs involved, however, as increasing specificity will generally result in larger numbers of stakeholders and constraints (and possibly outcomes too). With larger numbers of model elements come potential problems of data requirements and issues of internal consistency of the resulting model.

The guidelines above recommend identifying stakeholders, then constraints, and then outcomes. We are currently experimenting with identifying stakeholders, then outcomes, and then constraints, as it may be easier to identify outcomes and constraints at the same level of detail in this way. The various case studies in which EXTRAPOLATE is being applied should help considerably in leading to a replicable method that can be recommended for other situations, and a revision to this user guide may well be required before long.

3. USING EXTRAPOLATE

In using the software and setting up a model, there are various steps required, as explained in section 2 above. There are as follows, distinguishing model elements from linkages by showing the linkages in bold, underlined text:

- Definition of stakeholder groups (livelihood status)
- Definition of constraints faced by different groups
- **Relevance of constraints to different groups**
- Definition of outcomes (measurable effects of relaxing constraints)
- **Impacts of constraints on outcomes**
- **Impacts of outcomes on stakeholder groups**
- Proposed policy changes
- **Impact of policy changes on constraints**

In using the software, these steps can be followed in this order, although as pointed out above, setting up a model will always be an iterative process.

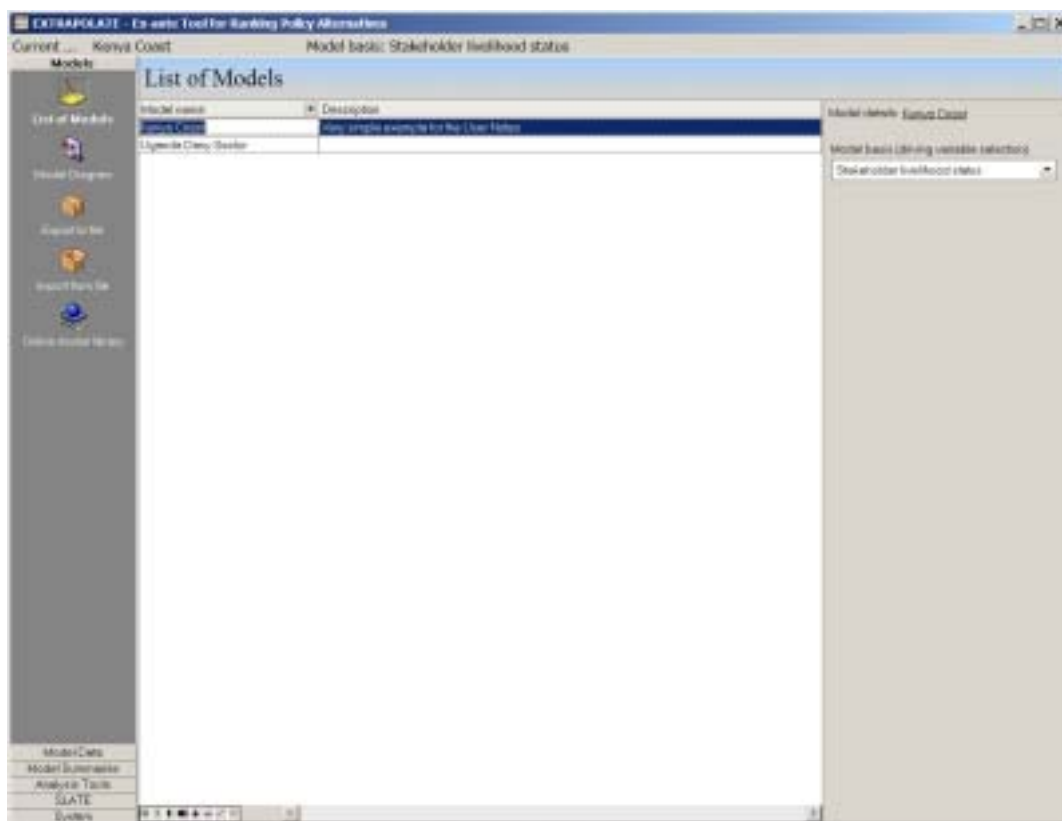
3.1 Models

The various menus available in EXTRAPOLATE are listed in a panel to the left of the screen. Under each menu is a series of buttons that implement the options available under that menu. Pushing these buttons activates the relevant interactive or graphic window.

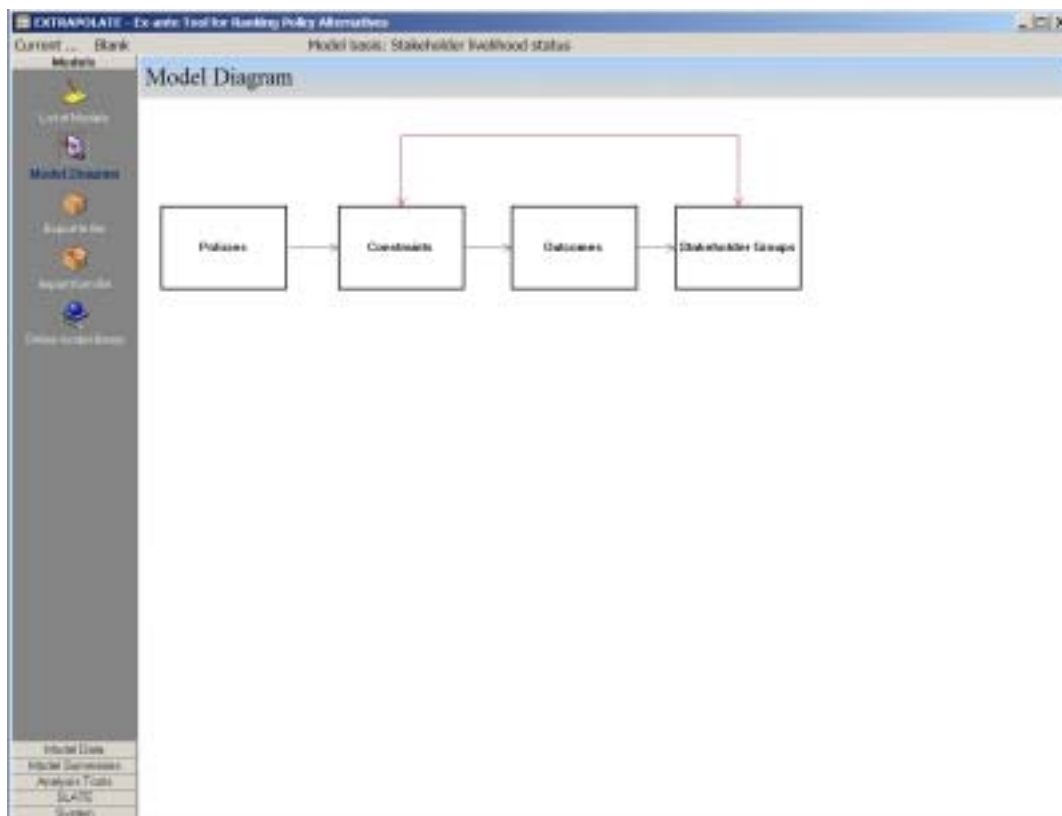
Screen 1 shows the opening screen of EXTRAPOLATE, which starts up in the “Models” menu. This shows the list of available models that can be accessed by the user, or a new model may be entered, or an existing model may be imported. Three types of analysis are possible. The first is an analysis based on the stakeholder livelihood status, such as was described in section 2. The second is an analysis that is linked to a sustainable livelihoods capital asset framework, and may (but does not have to) involve the use of the tool SLATE (described briefly in section 4.3 below). In this case, it is possible to use a range of “currencies” for the analysis, by focussing on one or more of the five capital asset types (human capital, natural capital, physical capital, social capital, and financial capital). The third type of analysis allows the user to define his or her own driving variable for the analysis.

The second option under the “Models” menu, “Model Diagram”, brings up the basic model diagram of EXTRAPOLATE (Screen 2).

Screen 1: Opening screen of EXTRAPOLATE.



Screen 2: The "Model Diagram" option - the basic EXTRAPOLATE model.



The third and fourth menu items under “Models”, allow the user to import and export models to a file; a simple interchange format that enables users to: a) keep a record of sequential changes in the development of a model; b) backup completed models; and c) transfer models among each other, for example by email. The last menu item enables models to be up-loaded or down-loaded from an on-line model library. The on-line model library contains models that are reasonably complete and well-documented and this facility enables users from different regions and disciplines to share knowledge and experiences.

3.2 Model Data

The “Model Data” menu option, allows the user to enter data directly. The first four buttons relate to the model elements (i.e., stakeholder groups, constraints, outcomes and policies) and the second four, to the linkages between model elements (i.e., impacts of policies on constraints, impacts of constraints on outcomes, impacts of outcomes on stakeholder groups, and relevance of constraints to stakeholder groups). Box 1 provides some guidelines for specifying model elements.

Box 1: This box contains simple guidelines to help the user to define stakeholders, outcomes and constraints.

Stakeholders need essentially to be fairly homogeneous groups of individuals, households or communities, of similar welfare levels and who face similar constraints. For each stakeholder group in the model, think about a characteristic example and specify a “typical household”. Are the stakeholders in the model all sufficiently different? If not, you may need to reduce the number of stakeholders. Are all the major system types accounted for? Are all stages of the marketing chain accounted for? If not, you may need more stakeholder groups. You might think about aiming for 10-20 stakeholder groups in total.

Outcomes are the measurable effects of relaxing constraints, and act directly on the welfare of a group of stakeholders. If an outcome reads as the reverse of a constraint, it needs to be reformulated. If you have more than 6-8 outcomes in the model, consider if the things you have as outcomes really are things that directly affect welfare. The outcomes need to be highly specific, cover only one outcome each, and should be as independent of each other (and of particular constraints and stakeholder groups) as possible.

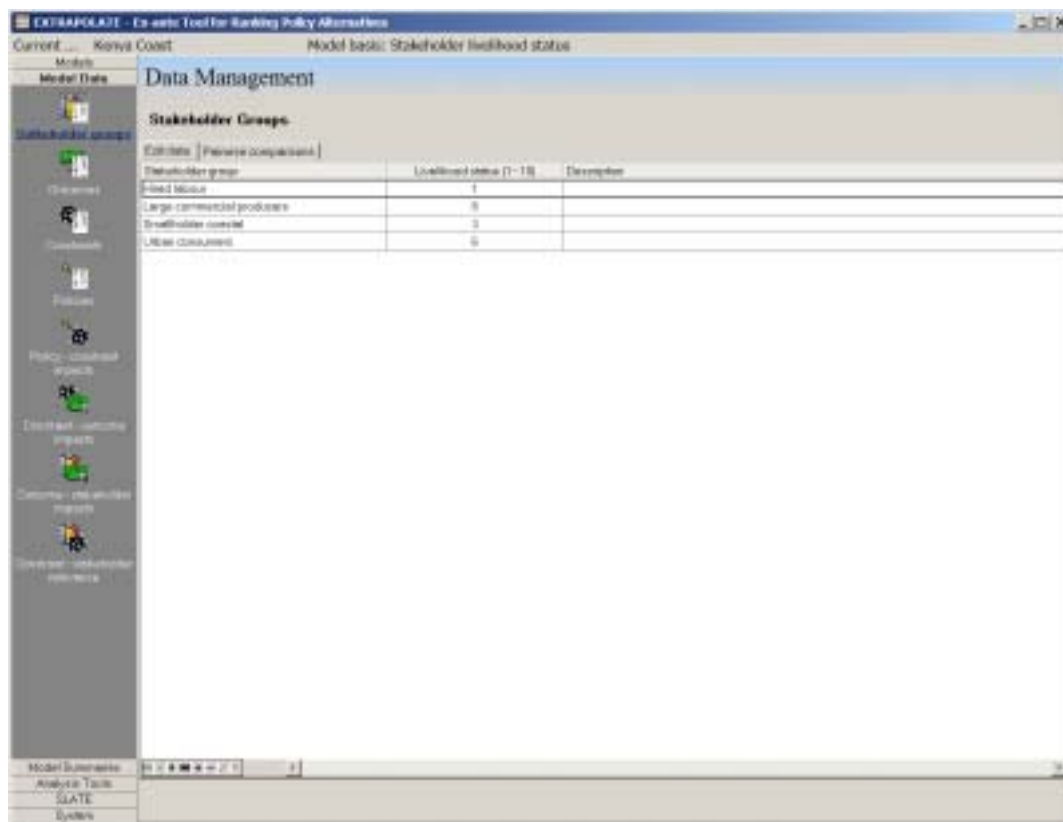
Constraints should be specific and deal with one thing only each. They should not overlap, in fact they should be independent, as far as possible. If two constraints are very similar it is likely that either they can be reformulated as a single constraint or that one is a direct result of the other, more fundamental constraint. Each constraint should be of some relevance to at least one stakeholder group, otherwise throw it out. You might think about aiming for 10-20 constraints in total.

For direct data entry, screen 3 shows the stakeholder groups for one of the sample models in the database. This example looks at smallholders in coastal Kenya and the adoption of dairy technology. It is extremely simple, based very loosely on information in Nicholson *et al.* (1999), and is included here merely for illustrative purposes. A more comprehensive and realistic example is gone through in section 5 below.

In this example, the beneficiary groups and their *ex ante* livelihood statuses are (Screen 3):

- Hired labourers working on smallholder dairy farms; they are landless, with a low livelihood status.
- Large commercial producers, who are a market outlet for smallholders' milk production, and also a source of credit and inputs, with a high livelihood status.
- Smallholder coastal producers, often on 12 ha lots, who are involved in milk production, with a relatively low livelihood status.
- Urban consumers, living in a milk deficit area (the Kenya coast), with a moderate livelihood status.

Screen 3: Direct data entry - stakeholder groups with associated livelihood status.



The example lists various current constraints:

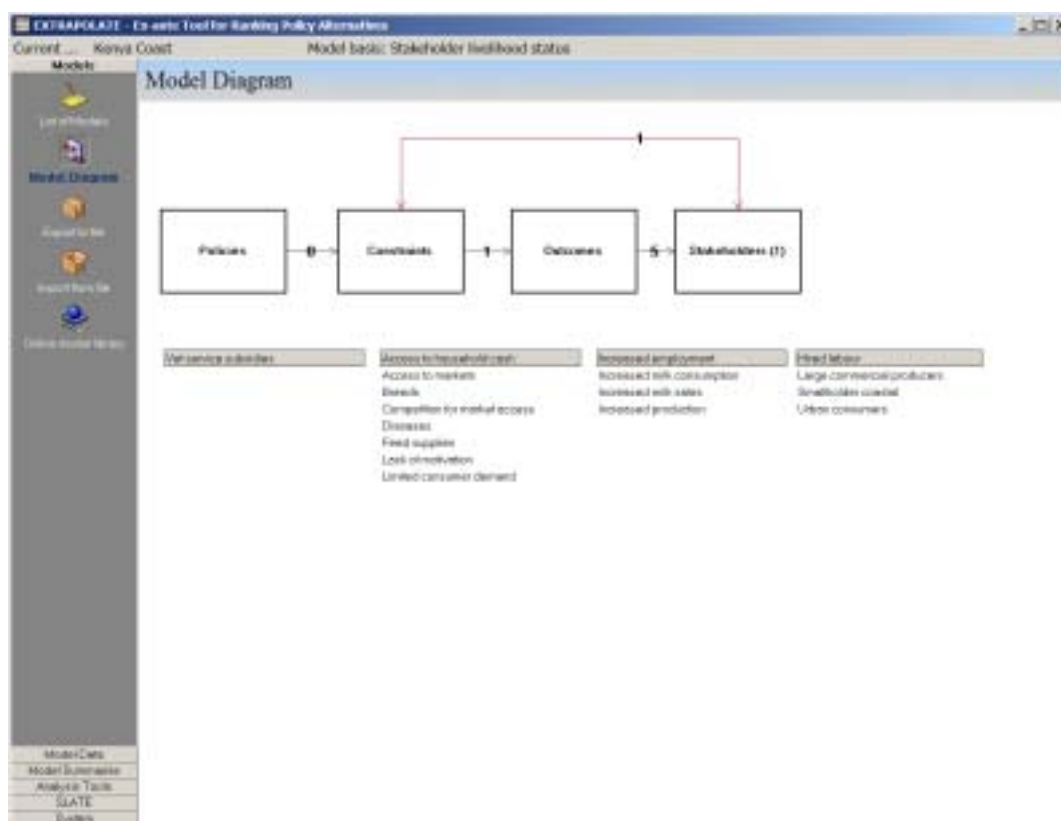
- Access to household cash, making it difficult to get access to animals and other inputs.
- Access to markets is difficult, particularly in areas south of Mombasa.
- There is a widespread shortage of cross-bred and grade animals, and these are relatively expensive to buy.
- There is some competition for market access between smallholders and the large commercial farms in the area, but this is generally a minor constraint.
- Animal disease is a considerable constraint (trypanosomiasis and East Coast Fever); these are difficult and/or relatively expensive to control.
- Access to feed resources is a considerable constraint in the area.

- Lack of motivation to keep animals: the indigenous peoples of the coast have no tradition in cattle keeping, and there are other livelihood options in the region.
- There is relatively limited local consumer demand for milk, although this is balanced by the tourism and hotel industries, however.

Sample impacts of these constraints on the four beneficiary groups are shown in the example, together with the impacts of four outcomes on the livelihood statuses of stakeholders, and the impacts of relaxing the eight constraints on these outcomes. The outcomes are increased employment; increased milk consumption, with associated health and nutrition benefits within the smallholder household and for local consumers; increased milk sales, with associated income effects; and increased production, with associated consumer price effects. The policy investigated in this example is the provision of subsidised veterinary services in the area by the government of Kenya. Of the eight constraints, vet service provision will have an impact only on the disease constraint, and to a lesser extent, on smallholders' access to grade or cross-bred animals.

During the model-building process, or at the completion of it, all the elements can be viewed by bringing up the model diagram (Screen 2). Once a model has been defined, the mouse can be moved and clicked over any combination of elements in the model, and the data associated with the elements and the links will be displayed. Screen 4 shows the completed model diagram for the Kenya coastal dairy example.

Screen 4: Viewing model elements.



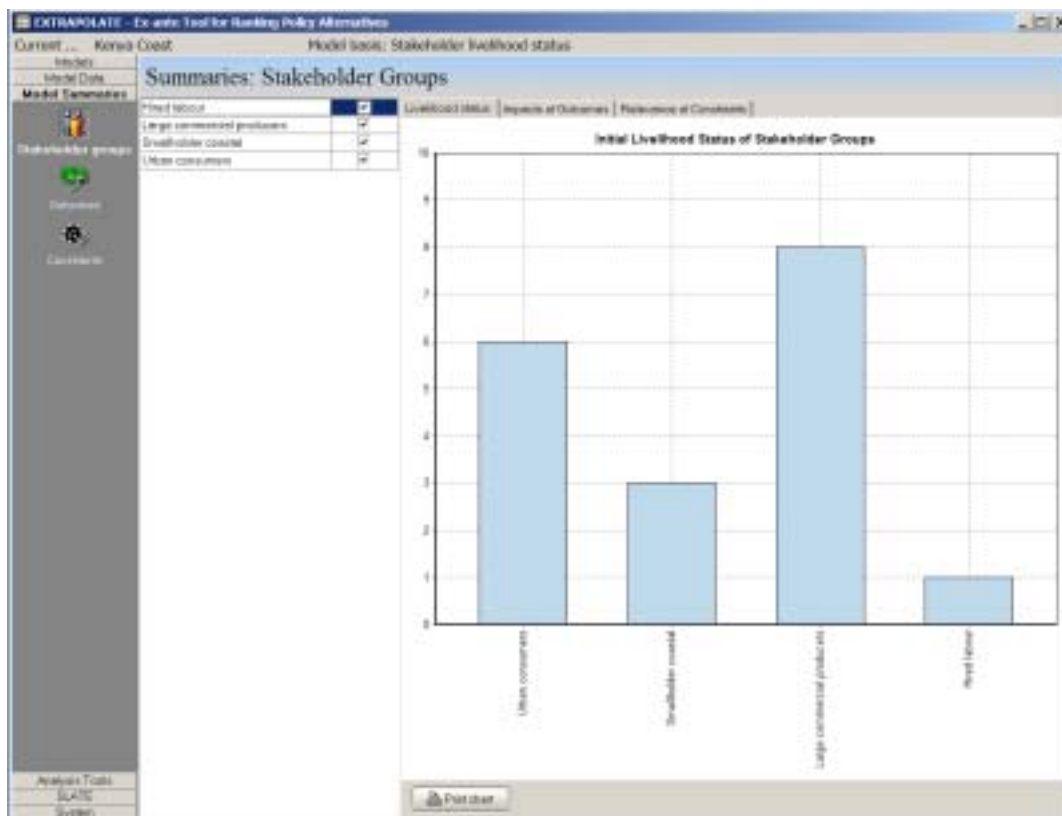
From the model diagram in Screen 4, it is also possible to go directly to the data management screens. To do this, select an element in the diagram (policies, constraints, outcomes or stakeholders) with a left-button click, and then right-clicking and selecting the “data management” option that appears. This will also work for the element linkages in the diagram (policies-constraints, constraints-outcomes, constraints-stakeholders, and outcomes-stakeholders).

Another feature of the software is that model datasheets can be generated in rich text format (RTF) for any of the elements or element linkages. This is particularly useful if, for example, a group is attempting to quantify the various model impacts and relevance; datasheets can be printed that show the elements listed and the matrix that needs to be filled in (if model element linkages have been selected), and these can be distributed to the group for completion. Note that current values in the model are not included in these datasheets - these are for data entry purposes only.

3.3 Model Summaries

Under the “Model Summaries” menu (available on the left-hand side of the screen), the data that have been entered for the currently-selected model can be viewed with simple bar charts. As can be seen from Screen 5, stakeholder groups can be compared in terms of livelihood status (if there are very many, groups can be selected/deselected using the tick boxes). By clicking on the appropriate tab, it is also possible to graph the cumulative potential impact of all outcomes on stakeholder groups (the indices assigned are averaged), and the relevance of each constraint to all stakeholder groups.

Screen 5: Viewing input data in the “Model Summaries” submenu.

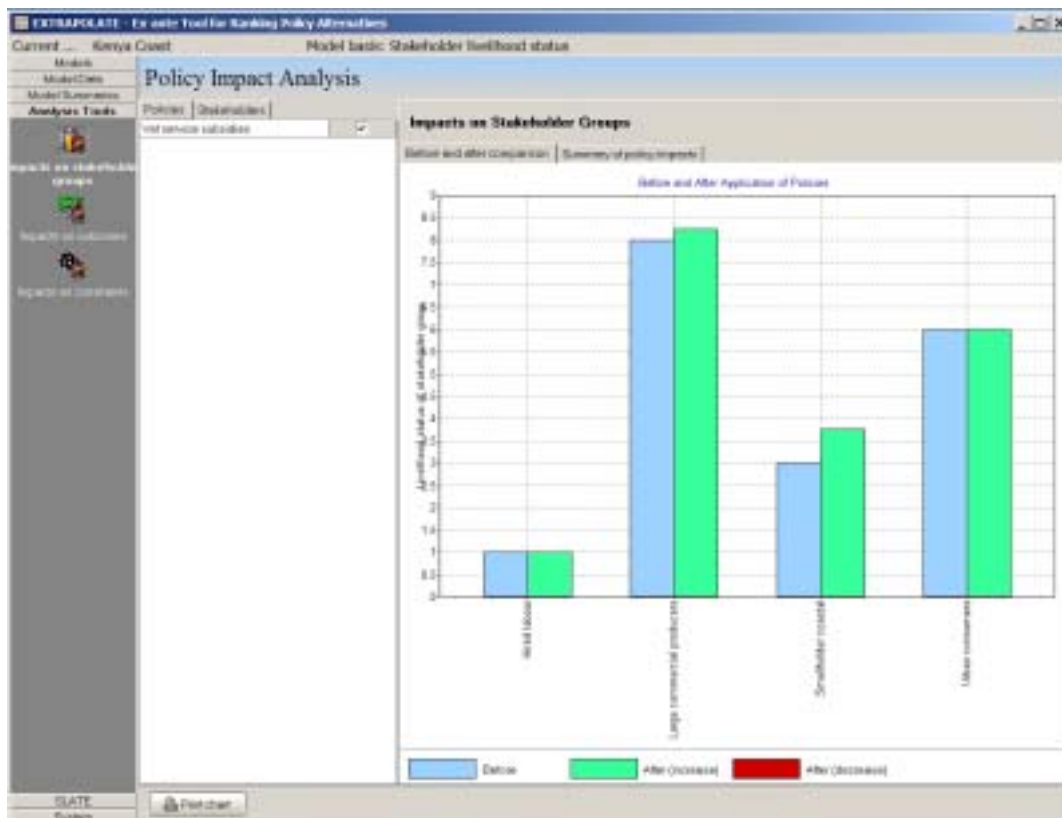


Under the left-hand “Outcomes” button, the user can see the impacts of outcomes on stakeholder groups (as before), and the aggregated susceptibility of the outcomes to each of the model constraints; again, these are averaged over all constraints. Similarly, the “Constraints” button will show the aggregated relevance of the constraints to each stakeholder group, and the aggregated impacts of the constraints on each of the outcomes. The “Policies” button shows the aggregated impacts of the policies (if there is more than one) on the various constraints. All of these bar charts can be printed. Again, it should be remembered that these charts reflect simply the data that were entered - no analysis has been done on them as yet.

3.4 Analysis Tools

Under this menu, the model that has been set up is actually run to produce results. The way in which this is done is explained in section 4.2 below. The major analysis that is done here is to show the impacts of one or more policies on stakeholders’ livelihood status. Outputs of the run can be looked at in two ways. First, the software can display the relative changes in the livelihood status of the various stakeholders, “before” and “after” implementation of the policy. Screen 6 shows the results for the Kenya coastal dairy example. As indicated in the key, the blue bars show the situation before, and the green bars the situation after - if there is a decrease in livelihood status, the shading is red rather than green.

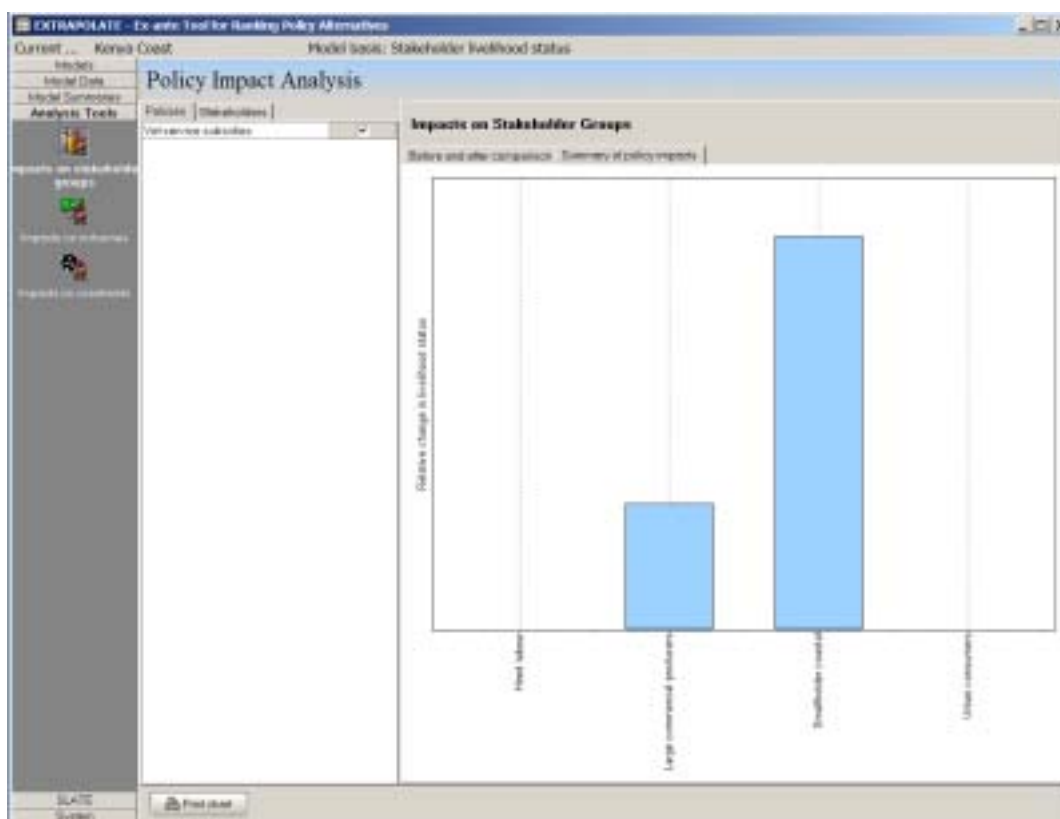
Screen 6: Summary of policy impacts on stakeholder groups (Kenya coastal dairy).



The second way to view the results is to click on the second tab “Summary of policy impacts” (see Screen 6, under the heading “Impacts on Stakeholder Groups”), which

shows the relative change in livelihood status for all stakeholder groups arising because of implementation of the policy or policies. Screen 7 shows this graph for the Kenya coastal dairy example. Again, nothing should be read into these results, other than to see how the software operates, although in this case it can be seen that the one policy looked at (vet service provision) will have most impact on smallholder dairy farmers, and some positive impact on the commercial dairy producers.

Screen 7: *Relative change in livelihood status as a result of implementing policies (Kenya coastal dairy).*



EXTRAPOLATE provides other ways to view aspects of the selected model under this menu. By selecting the “Impacts on outcomes” button (the second button down in the “Analysis Tools” menu), the user can summarise the impacts of the policy or policies on the outcomes, in the same way that policy impacts on livelihood status can be viewed, with a “before and after” bar chart, and with a bar chart that shows the relative changes in values associated with a selected combination of policies. For the Kenya coast example, the only outcome that is affected by the policy is increased production. Similarly, impacts of the policies on the constraints can be viewed using the third button, “Impacts on constraints”. It is important to remember that these screens summarise the impacts of changes on the constraint-outcome and the policy-constraints linkages, rather than the constraints and outcomes themselves. These relative effects are apportioned among the various constraint and outcome linkages in the model, and in a complicated model, these screens will allow the user to isolate the causes of specific changes in livelihood status that may be of particular interest. As noted above, a more detailed (and realistic) example is gone through in section 5

of this guide, after a brief discussion of some additional features of the software in section 4.

4. OTHER ASPECTS OF EXTRAPOLATE

4.1 Pairwise comparisons

The technique of “pairwise comparisons” (PWC) was developed by Saaty (1977) in relation to the Analytic Hierarchy Process, a method for priority setting that is based on hierarchies of objectives. A simple exposition can be found in Saaty (1990), for example. An advantage of the technique is that it allows a consistency index to be calculated, so that consistency in subjective judgments in a matrix can be attained. PWC is implemented in various decision support software programmes. It is best illustrated with an example.

Assume that we have three constraints for a smallholder, and we want to rank their importance to a smallholder household, one of several stakeholder groups in our example. Set out a matrix thus:

Relevance (of ↓ compared with →)	Cash constraint for a smallholder	Milk market constraint for a smallholder	Livestock disease constraint for a smallholder
Cash constraint for a smallholder household	1	a	b
Milk market constraint for a smallholder	1/a	1	c
Livestock disease constraint for a smallholder	1/b	1/c	1

Of the nine cells to fill in, the three diagonal elements are set to 1s. The three elements in the top right-hand triangular matrix (a, b and c) are reciprocals of the three elements in the bottom left-hand triangular matrix (1/a, 1/b and 1/c). So, in this example, only three judgments need to be made. In general, if there are n elements in the matrix, the number of judgments needed is given by $(n^2 - n)/2$. As we are dealing with a constraint-stakeholder relationship (C-S, Table 1), the question to be asked in the three cases in the top right-hand triangular matrix is: what is the relevance of the y-element compared with the relevance of the x element in the matrix? So to estimate a in the matrix above, we would ask: What is the strength of the relevance of the cash constraint for a smallholder household compared with the milk market constraint for a smallholder household? Table 2 shows the pairwise comparison scale to use, taken from Saaty (1990). It should be remembered that if element i is assigned a value of n when compared with element j , $e_{ij} = n$, then by definition $e_{ji} = 1/n$.

Table 2: The pairwise comparison scale (Saaty, 1990, p 78).

Intensity of importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the property
3	Moderate importance of one over another	One element is slightly favoured over another
5	Essential or strong importance	One element is strongly favoured over another
7	Very strong importance	An element is strongly favoured and its dominances is demonstrated in practice
9	Extreme importance	The evidence favouring one element over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	Compromise is needed between two judgments

Assume we make a choice to assign a value of 5 to element a above (i.e., the relevance of the cash constraint for a smallholder household is strongly more important than the milk market constraint for a smallholder household), and to element b, and that the marketing constraint is moderately more relevant than the disease constraint (so element c receives a 3). The complete matrix can now be filled in:

Relevance (of ↓ compared with →)	Cash constraint for a smallholder	Milk market constraint for a smallholder	Livestock disease constraint for a smallholder
Cash constraint for a smallholder household	1	5	5
Milk market constraint for a smallholder	1/5	1	3
Livestock disease constraint for a smallholder	1/5	1/3	1

The benefit of doing this lies in the fact that we can now calculate a consistency value for this matrix, and adjust our judgments if necessary, to make it more consistent. This is done in EXTRAPOLATE by a process very similar to that used in the GIS software Idrisi (Eastman, 2001), and described in the help notes for the Idrisi module WEIGHT as in Box 2.

Box 2: *Description of weights and consistency estimates, taken from the Idrisi manual (Eastman, 2001).*

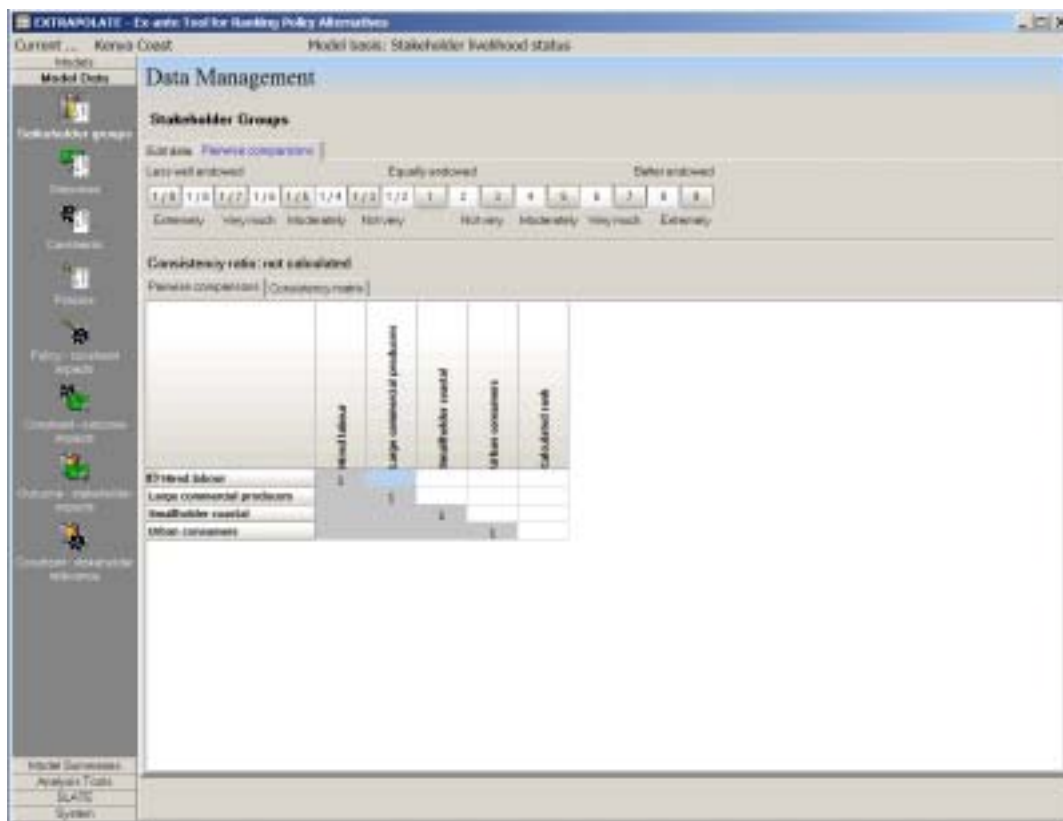
"The weights are produced by means of the principal eigenvector of the pairwise comparison matrix. A good approximation can also be generated by hand as follows: First, fill out the entire matrix by making each entry in the upper-right triangular half equal to the reciprocal of the corresponding entries in the lower-left. Sum each column to get a column marginal total, then generate a matrix by dividing each entry by the marginal total in its column. Each column of this matrix will be an estimated set of weights. Average the weights across the rows. The result will be very similar to that achieved using the principal eigenvector.

The consistency index is generated by producing a new set of ratings based on the computed weights. A rating is calculated by simply dividing one weight in the comparison by the other. The difference between this rating and the original is then reported.

The consistency matrix shows how the individual ratings would have to be changed if they were to be perfectly consistent with the best fit weightings achieved. If the overall Consistency Ratio is greater than 0.1, examine this matrix to see the pairwise comparison with the largest deviation. This is the most inconsistent rating. (Remember that the matrix contains a variety of ways in which any pair can be compared. In addition to a direct rating of variable A to variable B, there are ratings such as A to C and C to B that allow the same kind of comparison. Thus the consistency of ratings can be evaluated.) The deviation noted for this more inconsistent rating indicates how it would need to be changed to be consistent with the best fit weightings. If, for example, it indicated a -2, this would mean that it would need to move 2 points down the scale. This would be equivalent, for example, to decreasing the rating from a 5 to a 3, or equally, from a $1/3$ to a $1/5$. Thus the deviations noted are in positions along the scale. Fractional positions are possible (thus, if the deviation was +1.8, and the original weighting was $1/5$, this indicates that the new rating would need to be $1/(3.2)$, or 1.8 positions higher on the scale).

Perhaps the best way to re-evaluate any comparison is to generate a new rating without regard for the amount of deviation suggested by the consistency index. Then compare that new rating with the amount of deviation suggested by the index. Then re-rate again. If you do not accept the extent of deviation suggested for a particular comparison, this would indicate that all of the other comparisons with those variables will need to be re-evaluated. Once a new rating has been established, simply return to the pairwise comparison matrix, alter the cell rating, and press Calculate Weights again. The complete weighting scheme will now be modified and a new set of consistency index values generated. Continue in this fashion, re-evaluating the most deviant rating, one rating at a time, until the consistency ratio drops below 0.10. Although it is possible to continue this re-evaluation process until perfect consistency is achieved, there is little appreciable change in the weights once the consistency ratio drops below 0.10. Thus it is usual to stop at this point."

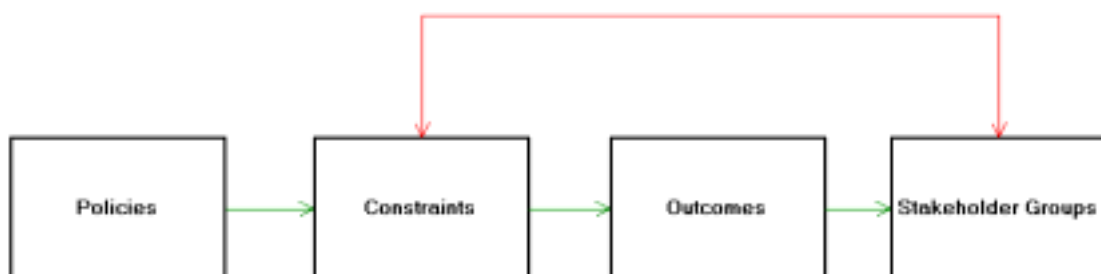
Screen 8: Data entry screen for estimating the ex ante livelihood status of stakeholder groups by pairwise comparisons.



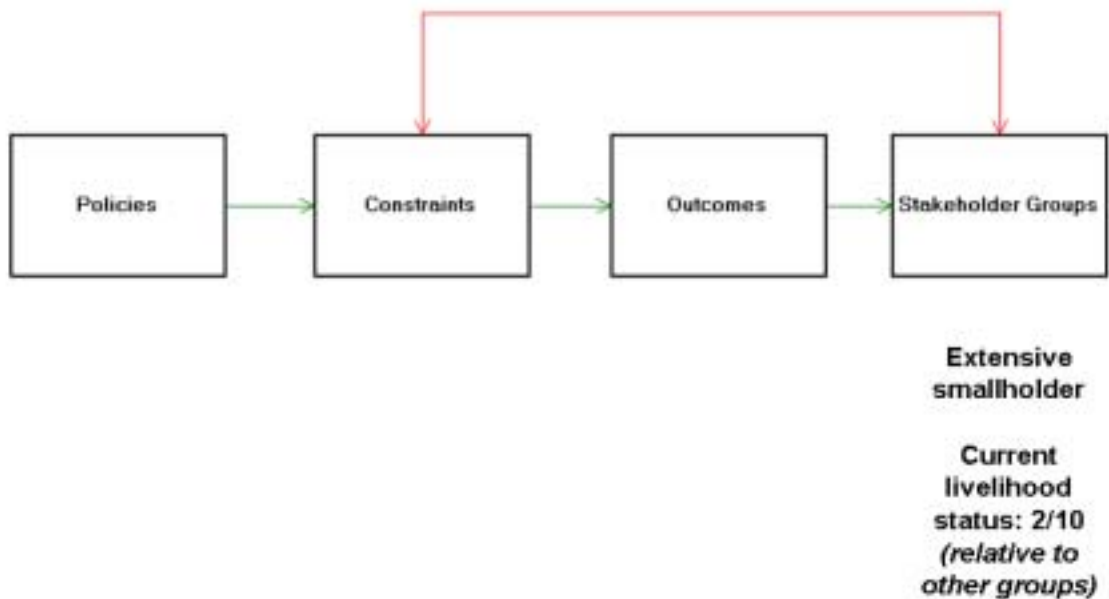
Access to the pairwise ranking tool in EXTRAPOLATE is through choosing “Models”, then “Model Data”, then “Stakeholder groups” in the menu system, and clicking on the right-hand tab (see Screen 3). The screen in EXTRAPOLATE for doing the analysis is shown in Screen 8.

4.2 Calculation scheme in EXTRAPOLATE

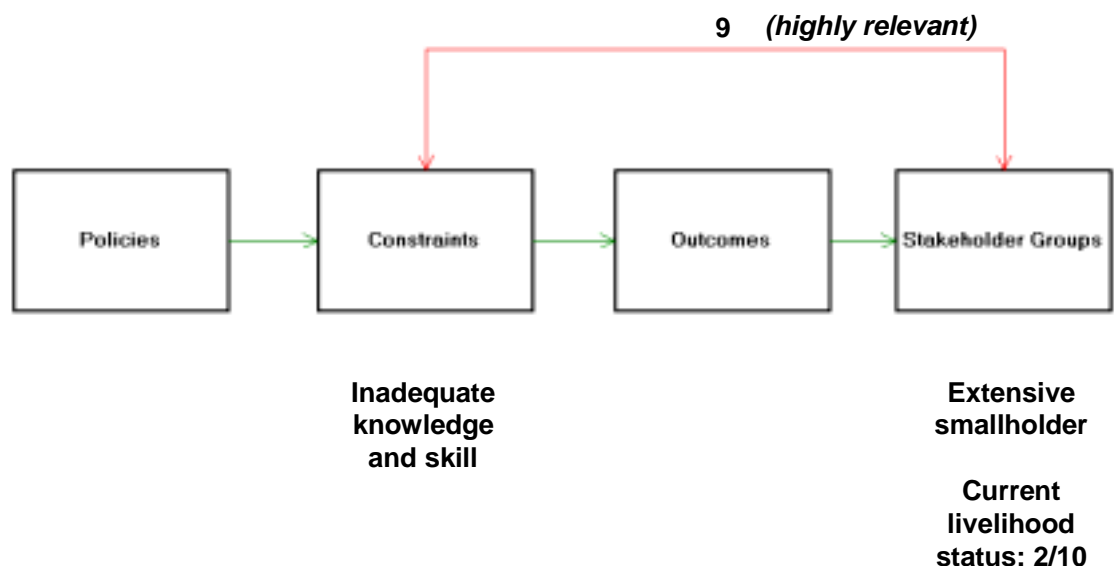
The basic calculation scheme in EXTRAPOLATE is illustrated below, in relation to just one “strand”: one policy acting on one constraint that acts on one outcome that modifies the livelihood status of one stakeholder group. Here is the model diagram as in the software:



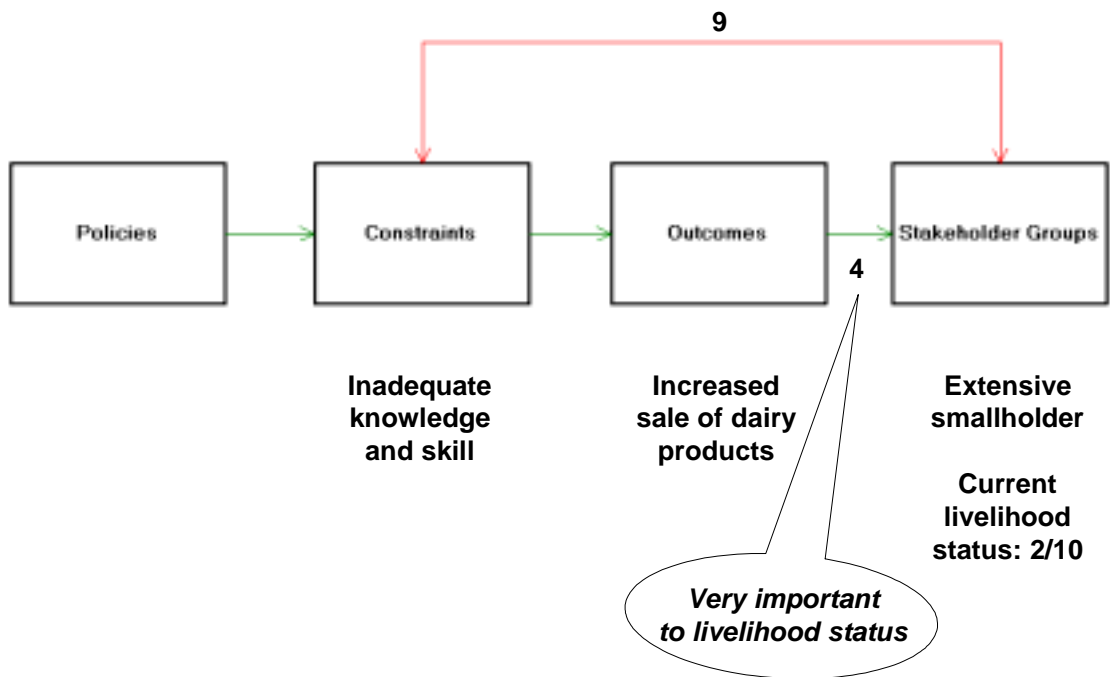
Assume that we define one stakeholder group as “extensive smallholder”, and relative to the other stakeholder groups in the model, we assign a current livelihood status of 2 to this group (1 being the lowest and 10 the highest status).



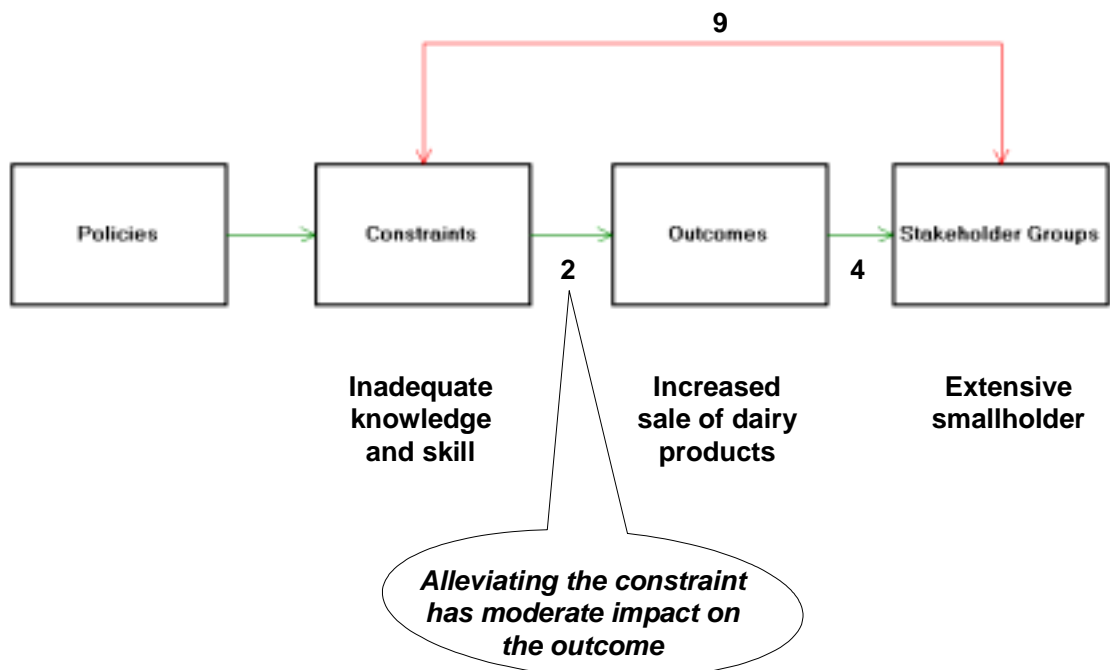
Next, we define one constraint; assume that it is “inadequate knowledge and skill”, and that we judge this constraint to be highly relevant to the extensive smallholder stakeholder group - we give this a maximum score (9), “highly relevant”, as we believe that training and extension could have an enormous impact on the extensive smallholders in our example.



Next, we define an outcome, “increased sale of dairy products”, and judge this to be very important to livelihood status - i.e. if the extensive smallholder could sell dairy products, the impacts on their livelihood status could be substantial. We give this a 4 out of 5 - the 5 we might reserve for the effect of this outcome on an intensive smallholder group, for example, on the basis that a larger proportion of household income may come from dairy products in such households.

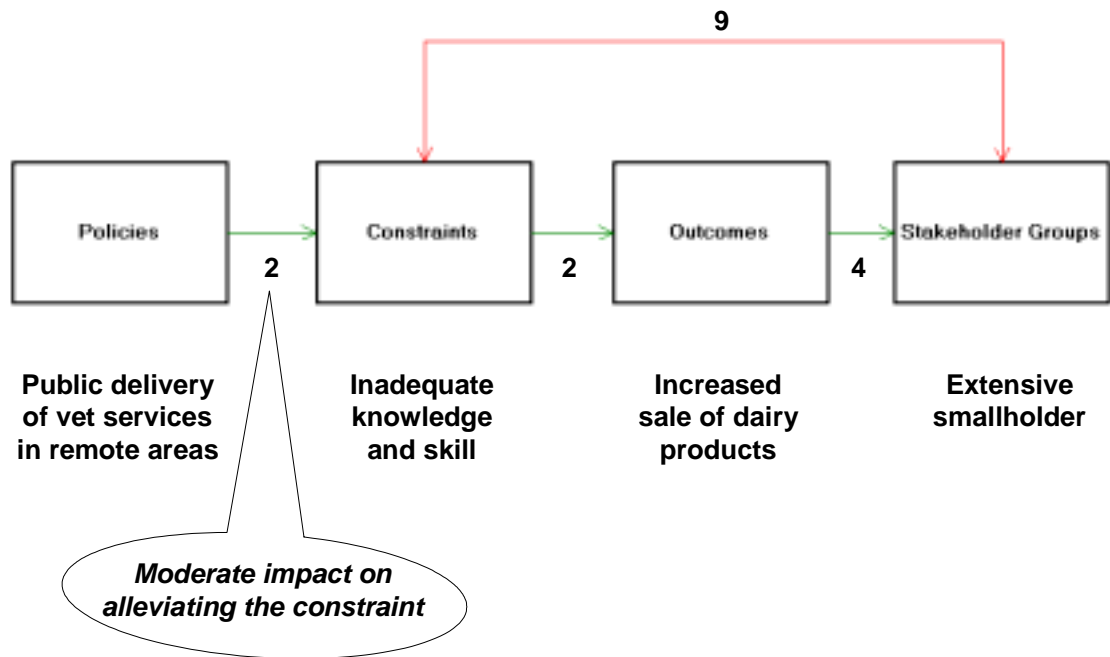


Next, to complete defining the status quo (see Figure 2), we assess the impact of the constraint “inadequate knowledge and skill” on the outcome “increased sale of dairy products”. If that constraint is alleviated somewhat, we think that this will have a moderate impact on the outcome, so we give it a 2 (out of 5). In our environment, for example, we think that there are other constraints whose alleviation would have a greater impact on sales levels of dairy products (lack of a ready market, for instance).

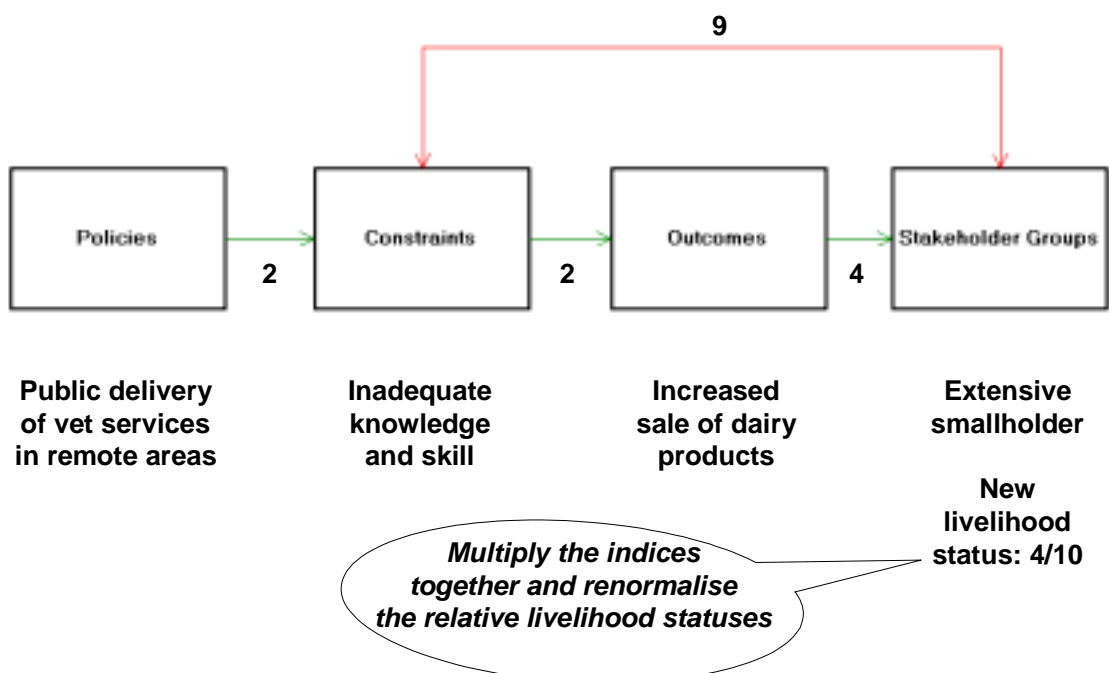


Now, we can look at the impact of a policy. Suppose that we are looking at the impacts of public delivery of veterinary services in remote areas. What would be the likely impact of this on the constraint “inadequate knowledge and skill”? In our example, we think it would have a moderate and positive impact on the constraint,

because visits by vets to livestock keepers can provide excellent opportunities for disseminating information about animal husbandry and other management issues - so we give it a 2 (out of 5).



So what is our estimate of the effect of this policy on the extensive smallholder group? The impact numbers are multiplied together ($2 \times 2 \times 4 = 16$), the result is multiplied by the relevance of the constraint to the stakeholder group ($16 \times 9 = 144$), and this number is then renormalised against all the other calculations made for this one policy on the other constraints, outcomes and stakeholder groups in the model (which, for clarity, are not shown), to arrive at a new (relative) livelihood status of 4.



From this, in a purely hypothetical example, we can conclude that provision of public delivery of vet services in remote areas will have a beneficial impact on the extensive smallholders in the region. As their relative livelihood status increases from 2 to 4, and if this is a stakeholder group that we are particularly keen on reaching, we might mark this out as one that is worthy of further study as a potentially “pro-poor” policy.

For the case of more than one policy, successive “increments” of changes to livelihood status are calculated for each policy in turn, across all stakeholder groups. In this way, sets of particular policies can be reinforcing or conflicting, depending on whether they add or subtract value to livelihood statuses. This means that certain policies may decrease livelihood status for some stakeholders in certain situations.

4.3 SLATE

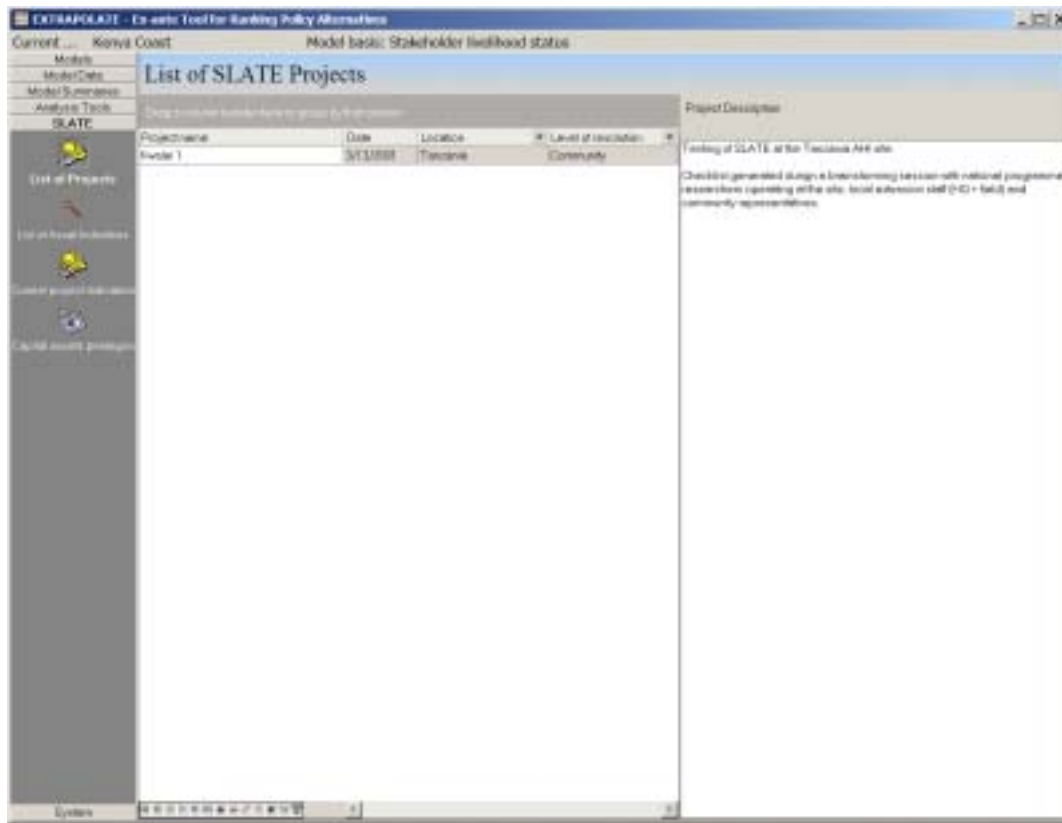
EXTRAPOLATE contains SLATE, a tool designed to assess strengths and weaknesses of households or communities in terms of the “Sustainable Livelihoods” framework; see Carney (1998), for a detailed description. The framework is based on the notion that households and communities have a range of capital assets that can be used in the pursuit of sustainable livelihoods. These may be of five different types:

- Human assets, such as access to health care.
- Natural assets, such as access to communal forage resources.
- Physical assets, such as access to electricity.
- Social assets, such as benefits derived from kin-based networks.
- Financial assets, such as access to credit.

In the context of EXTRAPOLATE, SLATE (Sustainable Livelihoods Asset Evaluation) may be a useful tool for helping users to think about the livelihood status of different stakeholder groups in an EXTRAPOLATE analysis. SLATE allows the user to evaluate the balance of livelihoods assets in a target household, community or region. It uses a set of Sustainable Livelihoods indicators that may be specified by the user to assess areas of strengths and weakness in capital endowments. In this way, it may assist in the estimation of livelihood statuses in an EXTRAPOLATE model. It should be remembered that, while SLATE is accessible from the EXTRAPOLATE shell, integration of the two packages does not go further than that, at this stage. Closer integration of these tools may be done in a later version of the software.

SLATE can be accessed from the main menu (Screen 1), as the fifth major menu item on the left-hand side of the screen. On entering SLATE, the user is taken to the project description screen (Screen 9), where general information about each project stored in the software can be viewed, entered and edited.

Screen 9: SLATE: Project description page.



Using the left-hand panel menus, and moving to the item, “Current project indicators”, the screen that results (Screen 10) can be used to add, modify or delete indicators of livelihood capital assets that are relevant to the current project. A library of these is included with SLATE, and can be accessed using the “List of asset indicators” button. For each indicator, the type of asset (human, physical, natural, social and financial) of which it is an indicator needs to be specified. In addition, a default weight may also be set. The weight represents, on a scale of 1 to 10, the relative importance of a particular indicator amongst the group of indicators used for each form of capital in an asset evaluation. For example, when evaluating human capital, we might argue that infant mortality rates were a more important consideration than primary school completion rates. Thus we might weight the former at 8 and the latter at 4. (Note that the default weight is the value assigned when the indicator is included from the library in a specific asset evaluation). For each indicator selected, it is necessary to assign a rank to each indicator for the target household or community. These ranks are based on a scale of -5 to +5. A rank of -5 means that, for the household or community assessed, the indicator represents a very strongly negative influence on livelihoods, whilst +5 means that the influence is strongly positive. The same indicators may be positive in some circumstances and negative in others, but these may be catered for.

Screen 10: SLATE: Project livelihoods page, showing project indicators, weights and ranks.

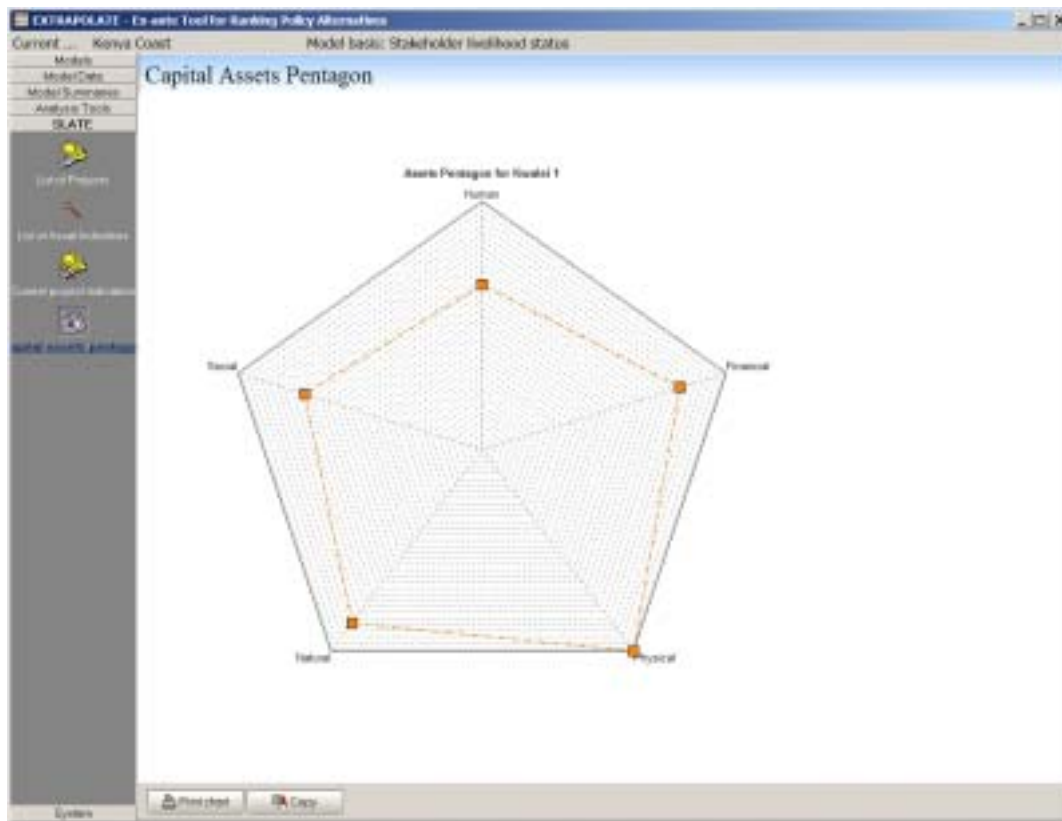
Indicator name	Asset type	Weight	Rank
*Family size	Human	0	5
*Education level	Human	10	5
*Percentage of women in labour availability	Human	0	(1)
*Life expectancy	Human	10	4
*Birth rates	Human	4	(2)
*Number of children in school	Human	4	(1)
*Access To Health Care	Human	4	4
*Proportion of unproductive household members	Human	0	(4)
*Access to indigenous technical knowledge	Human	0	5
*Incidence of disease	Human	0	1
*Land tenure system	Social	0	5
*Division of labour by gender	Social	0	(4)
*Transfer of information amongst households	Social	0	4
*Gender cooperation amongst households	Social	0	4
*Balance of traditional community leaders	Social	0	(2)
*Gender of household head	Social	10	1
*Adherence to tradition	Social	0	1
*Impact of religion	Social	0	1
*Marriage practices	Social	0	(2)
*Stability of household members	Social	0	(1)
*Adoption of new technology	Social	10	4
*Presence of food aid	Social	0	0
*Access to recreation centres	Social	0	1
*Green pasture	Natural	10	5
*Sustainability of soil crop-vegetation	Natural	10	5
*Access to forest land including woodlots	Natural	10	5
*Livestock ownership	Natural	0	4
*Access to water resources	Natural	10	4
*Adoption of perennial cropping	Natural	10	5
*Land size	Natural	0	(1)
*Quality of the land	Natural	0	4
*Fertilizer/pesticide	Natural	0	5
*Minerals (good quantity etc)	Natural	0	1
*Funding allocations	Natural	0	1
*Crop diversity	Natural	10	(4)
*Soil fertility	Natural	0	(1)
*Livestock disease	Natural	10	(4)

Both weights and ranks may be derived from any kind of assessment exercise, such as a Participatory Rural Appraisal (PRA), or through reference to previous studies, for example.

Once the appropriate indicators, weights and ranks have been entered for a project, the “assets pentagon” menu item can be used to generate a pentagon that graphically represents the balance of livelihood assets in the target household or group of households (Screen 11). In the example below, physical and natural capital assets are relatively strong, while human assets in particular are somewhat weak.

The library of asset indicators can be accessed using the “List of asset indicators” button. From here, capital assets can be added, deleted, and modified, and default weightings changed.

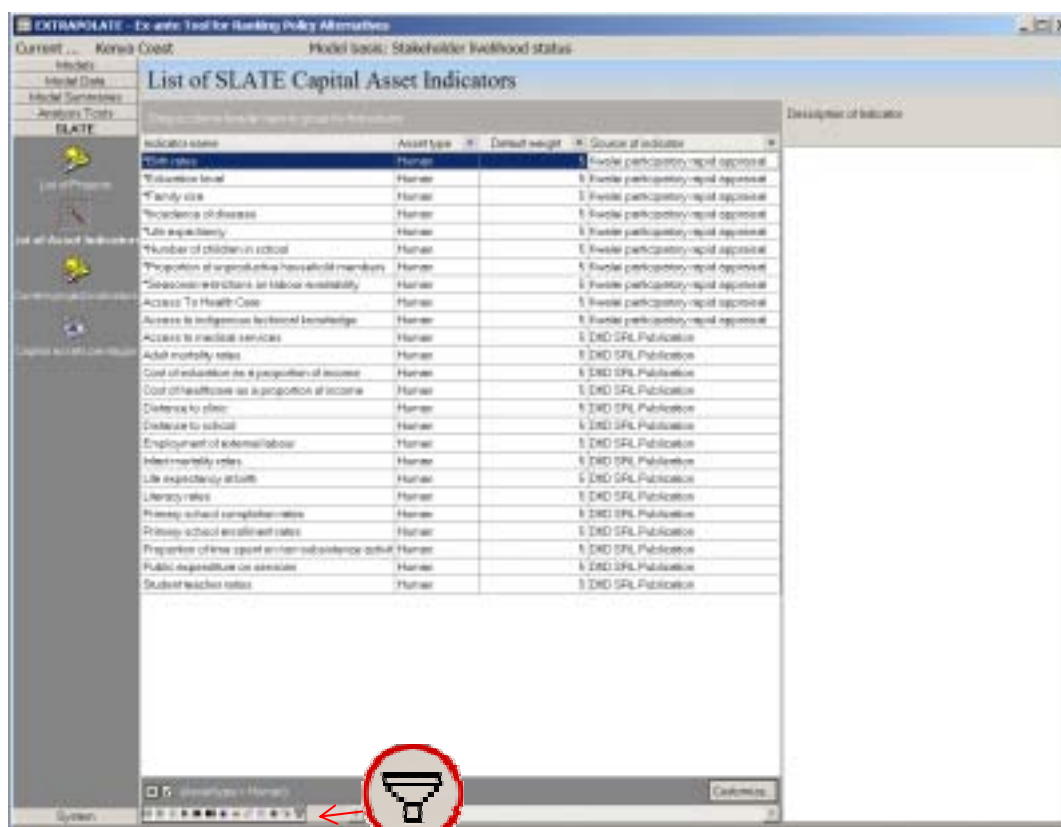
Screen 11: Sample assets pentagon in SLATE.



There are also options to filter indicators, both in the library and in the current project list, example by type of capital asset and source of the indicator. The filter builder is accessed by clicking on the button circled in red on Screen 10, and Screen 12 shows the result of filtering all entries to show just those associated with human capital. Note that the current filtering condition is shown at the bottom of the screen, and this can be turned off by clicking on the "x" to the left of it.

Some users may find SLATE to be a useful tool in helping them to think about livelihood status of stakeholder groups. SLATE also may allow analysis to be carried out with respect to different capital asset categories. If appropriate indicators can be defined, then the impacts of policy on key household natural capital assets could be investigated using EXTRAPOLATE, for example.

Screen 12: Filtering the library of asset indicators in SLATE: human assets.



4.4 PRIMAS

The link between EXTRAPOLATE and PRIMAS is in the process of being made operational, and will be completed by the end of 2005.

PRIMAS (Poverty Reduction Intervention Mapping in Agricultural Systems) is a CD-ROM-based tool that is designed to generate an integrated series of maps on the location of resource-poor livestock keepers and associated natural resource, climatological, communication and marketing data layers for different systems. The general idea is simple: from an understanding of the problems and needs of resource-poor livestock keepers, there may be several technology options appropriate for the production systems under study. Each of these options may be expected to go some way to solving a perceived problem, or opening up new opportunities for livestock keepers. The PRIMAS tool enables options to be filtered by attempting to match the characteristics of particular options with the characteristics of particular target groups in the landscape (as far as this can be done sensibly in terms of spatial data).

The prototype of PRIMAS was developed for Kenya, and contains spatial information related to climate, weather, soils, forages and forage availability, roads, markets, cities and towns, predominant livestock species, human and animal population densities, and pest and disease risk (Thornton *et al.*, 2005). PRIMAS includes a small database of interventions for pastoral and dairy systems. These are summarised

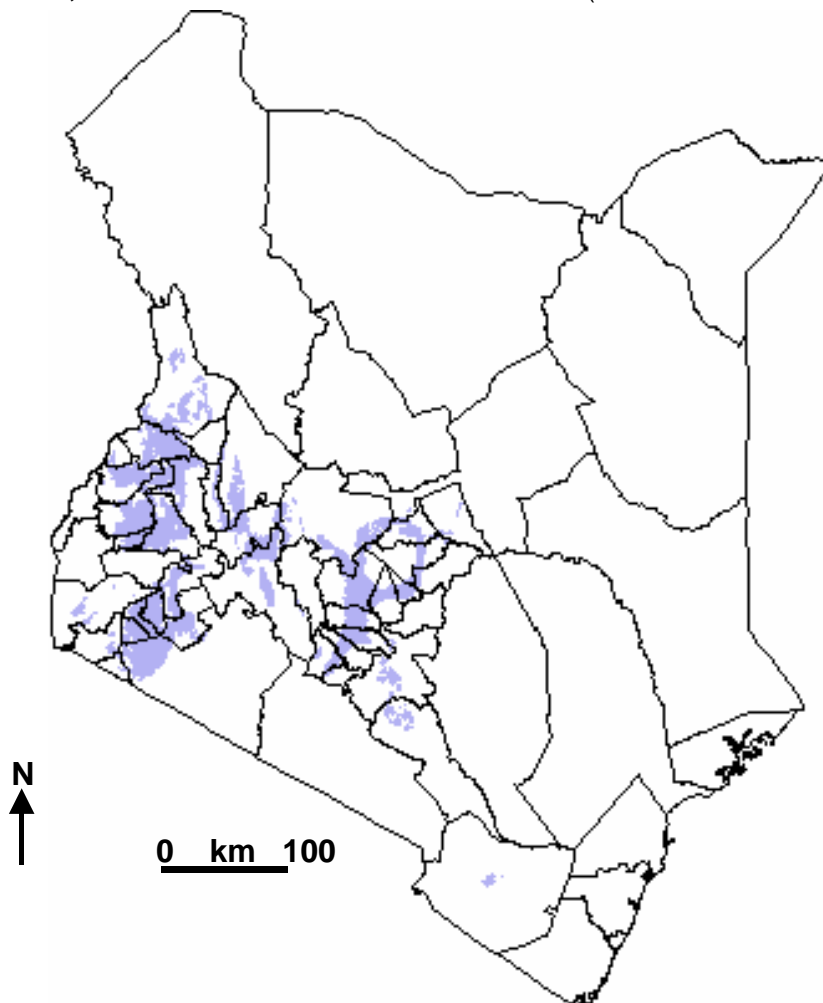
according to a common format that describes the intervention, who was responsible for developing it, and where it has been (or is being) applied. PRIMAS allows the user to browse all the available data layers, using a 'map explorer'. The user can carry out a set of overlays, which are basically simple intersections of different spatial data layers. The user can also do simple weighted overlays, where scores or weights can be assigned to the probability of a particular value being associated with a particular spatial variable. Weighting may be useful in assessing variables such as the degree of market integration for target groups, where it decreases with distance from markets and all-weather roads, for example.

A simple example is the distribution of *Pennisetum purpureum* (Napier grass). To map this distribution in PRIMAS, some description of the areas in Kenya where it thrives is needed. Using the information in KARI (1992), these areas can be described in terms of three constraints: altitudes between 1500 and 2000 m above sea level; rainfall in excess of 750 mm per year, and soil pH greater than 4 (of course, domains may be determined in much more sophisticated ways based on multivariate analysis using discriminant analysis or logistic regression analysis, for example). Figure 4 shows the results in PRIMAS of running (overlying or intersecting) these three constraint layers. The shaded areas are those that satisfy the constraints relating to altitude, soil pH and annual rainfall, together with tabular output that summarises the area of the domain, the human population, the livestock population, and the number of resource-poor livestock keepers (Thornton *et al.*, 2002). In this example, the *P. purpureum* domain contains about 33% of Kenya's human population, but less than 3% of the land area of the country.

Figure 4: Kenya and district boundaries, shaded areas showing a domain for *Pennisetum purpureum* (Napier grass).

Shaded areas:

Human population,	7.27 million	(32% of national total)
Poor people,	4.37 million	(33%)
Number of cattle,	893 thousand	(9%)
Area,	150 thousand km ²	(3%)



PRIMAS is now linked to EXTRAPOLATE, the idea being that GIS spatial data layers can be used to characterise some of the elements in an EXTRAPOLATE model. These include locating and quantifying particular stakeholder groups, and identifying where particular constraints apply and how many people may be affected. For some stakeholder groups and constraints, it makes sense to map these and make use of the information that PRIMAS can provide; for example, particular stakeholder groups defined by distance to market; and constraints defined by agro-ecological conditions. Over time, it should be possible to build up sets of common libraries of information that are accessed by each tool as appropriate, where each entry in a library has a default set of spatial and/or non-spatial characteristics associated with it. This default set could be changed by the user as required. Table 3 shows some simple examples for various libraries associated with PRIMAS and EXTRAPOLATE: policies (forming the policy options database), technologies (forming the technological options

database), constraints, outcomes, and stakeholder, all of which can contain entries that may have some spatial characteristics associated.

Most processes of adoption or policy impacts will have a mixture of spatial and non-spatial factors can perhaps be illustrated in relation to an example. For example, the probability of adoption of a grade cow in the smallholder systems of coastal Kenya is a function of a variety of spatial factors (agroecology, tsetse risk, distance to population centers, etc) and non-spatial factors (education level of the household head, ethnic background, stage of life, etc). Likewise, the policy impacts of veterinary service provision at the coast will depend on a range of similar factors. This highlights the importance of including both spatial and non-spatial factors in any analysis. In terms of an EXTRAPOLATE model, looking at the appropriate spatial factors and overlaying these in relevant ways would go some way to quantifying the likely recommendation domain of the policy impact, especially in terms of the possible number of resource-poor people who might be affected.

PRIMAS can be accessed from within EXTRAPOLATE from the "Model data" menu. A full user guide for PRIMAS is available in hardcopy or on CD-ROM (Thornton *et al.*, 2004a), with a PowerPoint slide show to illustrate the use of the tool (Thornton *et al.*, 2004b).

Table 3: Elements in PRIMAS and EXTRAPOLATE, with examples of entries with spatial and non-spatial characteristics.

Element	Example	Example Characteristics or Determinants	
		Spatial	Non-spatial
Policies	Subsidies for vet services	Location of vet service providers	Level and nature of subsidy
	Fertilizer subsidy	Crop agro-ecological suitability Market access	Level of subsidy Appropriate packaging Ease of transporting and application
Constraints	Livestock disease	Areas of high disease risk AND Areas of high livestock density	Management ability Access to resources
	Lack of livestock keeping tradition	Tribal coverage AND Ethnic group density maps	Exposure of households to outside influences
Outcomes	Increased household food security	Areas of high agroecological vulnerability AND Areas of high poverty rates	Households' asset base and livelihood options Access to resources
	Increased milk consumption	Areas of high poverty rates AND Urban and rural areas close to dairying systems	Household health status Access to nutritional information Stage of life cycle in household
Stakeholder groups	Pure pastoralists	Livestock production system maps LESS Cropping area maps	Households' asset base and livelihood options Access to resources
	Hired labourers	Areas with high density of rural landless poor	Households' asset base and livelihood options Access to resources
Technologies	East Coast Fever (ECF) vaccine	Effectiveness area (a function of high-risk ECF areas and necessary infrastructure available?)	Effective delivery mechanism Affordability
	Napier cut and carry	Agroecological suitability Labour availability	Household objectives Household attitudes

5. AN EXAMPLE: THE USE OF LACTOPEROXIDASE IN KENYA

Infrastructure in most of Kenya's farming community is either lacking or inadequate. The roads are poor and electricity is lacking and hence there are inadequate milk preservation facilities. As a result, most of the milk producing regions either do not efficiently milk their animals or experience losses due to spoilage (SDP Reports, 2004). In order to deal with these constraints some farmers have resorted to the use of harmful chemical such as hydrogen peroxide and antibiotics to preserve their milk, decrease spoilage and waste, and hence protect their eroded profits from milk sales.

The ideal milk preservation technology is cooling but given the constraints related to poor roads, lack of electricity and high tariffs, limited capacity of smallholder production systems, other technological options need to be looked at. One option is the use of the Lactoperoxidase system (LPS). Both the FAO/WHO Expert Committee on Food Additives and the Codex Alimentarius Commission have approved the use of LPS for local and regional use but its use in milk and milk products intended for international trade is prohibited. Some countries such as China have pursued a two-pronged approach, where LPS is legalized for use for local trade and consumption, and prohibiting it for use in milk and milk products intended for international trade.

The LPS is an ideal milk preservation technique developed for smallholder farmers in conditions with poor market access. LPS can be used strategically to preserve milk during flush production periods in the wet season, as there may be delays in delivering milk to processing plants (long queues) and for preserving the evening milk.

The dairy team at ILRI has found that farmers in Bomet District and Nyandarua District incur significant post-harvest losses in milk because of poor road infrastructure. The costs of cooling range from KSh 1.10 to KSh 1.30 per litre in large-scale chilling plants (with a potential capacity greater than 20,000 l per day) to about KSh 1.80 per litre in a small-scale plant (with a potential capacity of 1200 l per day). Electricity costs account for up to 30% of the cost of cooling. Small-scale cooling is associated with various problems: first, no price premium is received for supplies of chilled milk to the dairy processors even though chilling increases the operational costs of suppliers significantly. Second, small-scale coolers are often inadequately equipped (for example, with no standby generator), leading to frequent cases of milk spoilage. Use of LPS in these Districts costs from KSh 1.02 to KSh 1.09 per litre, suggesting that it could be economically substituted for a small-scale, underutilised cooler. Nevertheless, the prospects of LPS helping dairy farmers to realize higher profits through preservation and sale of evening milk is limited by low productivity of animals during the dry season, and milk marketing problems in the formal dairy sector such as delayed payment and low milk producer prices. Gender issues also need to be considered in promotion of the LPS technology, as its adoption may lead to a shift in the control of benefits from milk sales from women to men. While LPS is preferable to other, illegal chemicals, there is need to strive to lower its cost and make it more broadly available (ILRI, 2005).

We thus felt that LPS would make an interesting example for applying PRIMAS-EXTRAPOLATE in Kenya. In the discussion that follows, the various elements of the "model" were assembled through meetings of project personnel at ILRI. In other on-going case studies, these elements are being assembled through a series of participatory workshops, involve many more stakeholders, and thus the results should be more robust than in the example that follows. However, it illustrates the process well enough.

Table 4 shows the various elements in the model: stakeholders, constraints, outcomes, and policies. The eleven key stakeholder groups are assigned an index from 1 to 9 as a proxy for their current livelihood status. The various constraints that are faced by these various groups are identified in Table 4, and include access to preservation technology and to milk markets, the constraints associated with

existence of cooling facilities, the high tariffs on electricity, the problems associated with economies of scale in the use of cooling facilities, and the problems of idle capacity caused by highly seasonal milk supply. The outcomes that contribute to the livelihood status of the stakeholder groups are increased household milk consumption, increased milk sales, improved household nutrition, better access to cash by women, and improved enterprise profitability. Two policies were investigated: the promotion of LPS for local use, and the legalisation of LPS for international trade (Table 4).

Table 4: Model elements for the LPS example.

Stakeholders	Livelihood Status	Constraints	Outcomes	Policies
B01 Milk Bulking Agents	5	C01 Access to Preservation Technology	O01 Household milk consumption	P01 Promotion of LPS for Local Use
B02 Large Scale Plants	9	C02 Access to Milk Markets	O02 Milk Sales	P02 Legalisation of LPS for International Trade
B03 Small Scale Plants	6	C03 Electricity and Cooling Facilities	O03 Household Nutrition	
B04 Dairy Processors	9	C04 High Tariffs on Electricity	O04 Access to Cash by Women	
B05 Producer Households	2	C05 Economies of Scale in the use of Cooling Facilities	O05 Profitability	
B06 Women in Producer Households	1	C06 Seasonal Milk Supply (Idle Capacity)		
B07 Consumer Households	3	C07 Hazardous preservatives in milk		
B08 Hired Transporters	7			
B09 Distributors	8			
B10 Sedentary retailers	4			
B11 Mobile retailers	2			

Large-scale plants have a capacity of greater than 20,000 l per day
 Small-scale plants have a capacity of about 1,200 l per day

Having defined the model elements, the various element matrices needed to be completed. The stakeholder groups have an ex ante livelihood status, the result of current conditions or the status quo. The purpose of running the model is to assess the impacts of the policies identified on the livelihood status of the stakeholder groups, were they to be implemented. Four sets of relationships have to be defined, to enable this to be done. First, the various constraints that are faced by the stakeholder groups have to be scored, in terms of their relevance to each group; not

all constraints are relevant to all groups, and constraints are not equally relevant. Second, the importance of each of the outcomes identified on the livelihood status of stakeholders has to be assessed; for marginal changes in each outcome, how strong is the resulting impact likely to be on livelihood status? Third, the impact of the policies to be examined on relaxing the constraints has to be scored; and is this impact likely to alleviate the constraint to some degree, or will the effect be negative and increase the problem associated with the constraint? Fourth, the impact of a marginal alleviation of each constraint on each outcome has to be defined. These scorings for the LPS example are shown in Tables 5, 6, 7 and 8 below. Together, these tables constitute the data required for defining a model in EXTRAPOLATE.

Screen 13 shows the potential mean impacts of outcomes (averaged across all impacts) on stakeholder groups for the LPS example. Screen 14 shows a summary of the potential mean impacts of the two policies, "Promotion of LPS for Local Use" and "Legalisation of LPS for International Trade", on the seven constraints. As is clear from Table 8, major impacts are foreseen on the first two constraints, "Access to Preservation Technology" and "Access to Milk Markets", with no impacts (as defined in the model set-up) on the constraints "Electricity and Cooling Facilities" and "High Tariffs on Electricity".

The results of "running" this model are shown in Screen 15. This shows a comparison of livelihood status for the 11 stakeholder groups before and after the implementation of the two policies. Results indicate that consumer households may be slightly worse off because of the policy changes (a small negative change in livelihood status). This is essentially due to the prospects of increased hazardous preservatives in milk (i.e., other preservatives passed off as lactoperoxidase but being something different), and in the model this is outweighing the nutritional benefits that may arise because of increased milk consumption. There may thus be some human health issues that would need to be addressed at the same time as promoting LPS. However, other than consumer households, all other stakeholder groups are benefiting from promotional policies for LPS, particularly women producer households, mobile retailers, and distributors. Of the groups that appear to benefit most, in terms of a relative change in livelihood status, producer households, women in producer households and mobile retailers have the lowest ex ante livelihood status in the model, so these LPS policies would appear to be relatively pro-poor. Because the impacts of the two policies considered on the constraints are quite similar (Table 8), there are no differential policy impacts in this example, and the two policies are self-reinforcing. In more complicated examples, this will not always be the case, and there will often be tradeoffs to be considered between different policies.

Table 5: LPS example: relevance of the constraints to the stakeholder groups.

Relevance of Constraints on Stakeholders	B01 Milk Bulking Agents	B02 Large Scale Plants	B03 Small Scale Plants	B04 Dairy Processors	B05 Producer Households	B06 Producer Households, Women	B07 Consumer Households	B08 Transporters	B09 Distributors	B10 Sedentary retailers	B11 Mobile retailers
C01 Access to Preservation Technology	9	1	1	1	7	8	3	4	8	6	7
C02 Access to Milk Markets	9	2	5	5	8	9	0	4	9	9	9
C03 Electricity and Cooling Facilities	4	2	2	1	0	0	0	0	0	3	1
C04 High Tariffs on Electricity	2	9	9	4	0	0	0	0	0	5	0
C05 Economies of Scale in the use of Cooling Facilities	1	2	6	0	0	0	0	0	0	0	0
C06 Seasonal Milk Supply (Idle Capacity)	5	4	6	8	8	9	8	9	8	7	9
C07 Hazardous preservatives in milk	4	4	4	6	2	2	9	0	2	1	1

Table 6: LPS example: impact of outcomes on the stakeholder groups.

Impact of Outcomes on Stakeholders	B01 Milk Bulking Agents	B02 Large Scale Plants	B03 Small Scale Plants	B04 Dairy Processors	B05 Producer Households	B06 Producer Households, Women	B07 Consumer Households	B08 Transporters	B09 Distributors	B10 Sedentary retailers	B11 Mobile retailers
O01 Household Milk Consumption	2	1	1	3	5	5	5	1	3	2	5
O02 Milk Sales	4	2	3	3	5	5	0	4	5	2	5
O03 Household Nutrition	0	0	0	0	1	2	5	0	0	0	1
O04 Access to Cash by Women	1	1	1	0	3	5	0	0	0	1	0
O05 Farm Profitability	5	5	5	4	5	5	0	5	5	4	5

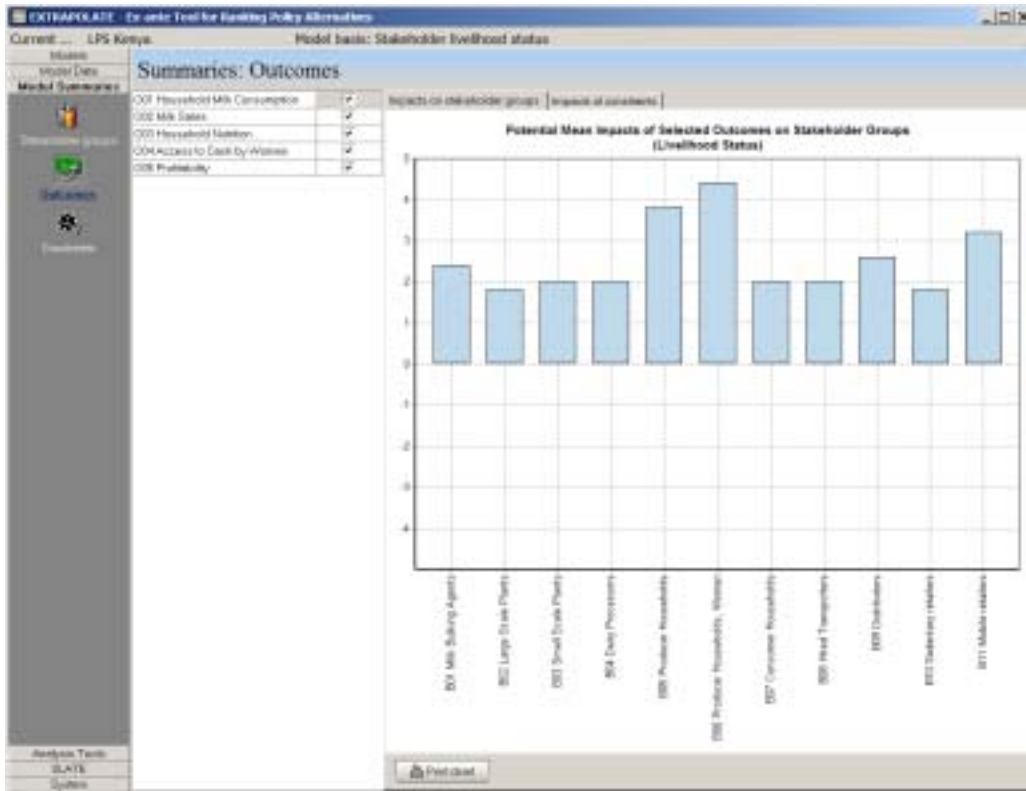
Table 7: LPS example: impact of constraints on the outcomes.

Impact of Constraints On Outcomes	O01 Household Milk Consumption	O02 Milk Sales	O03 Household Nutrition	O04 Access to Cash by Women	O05 Profitability
C01 Access to Preservation Technology	2	3	1	-4	2
C02 Access to Milk Markets	1	5	2	1	3
C03 Electricity and Cooling Facilities	1	2	1	-3	2
C04 High Tariffs on Electricity	1	1	0	-1	1
C05 Economies of Scale in the use of Cooling Facilities	1	3	0	-2	2
C06 Seasonal Milk Supply (Idle Capacity)	2	2	1	0	3
C07 Hazardous preservatives in milk	-2	-2	-5	0	-2

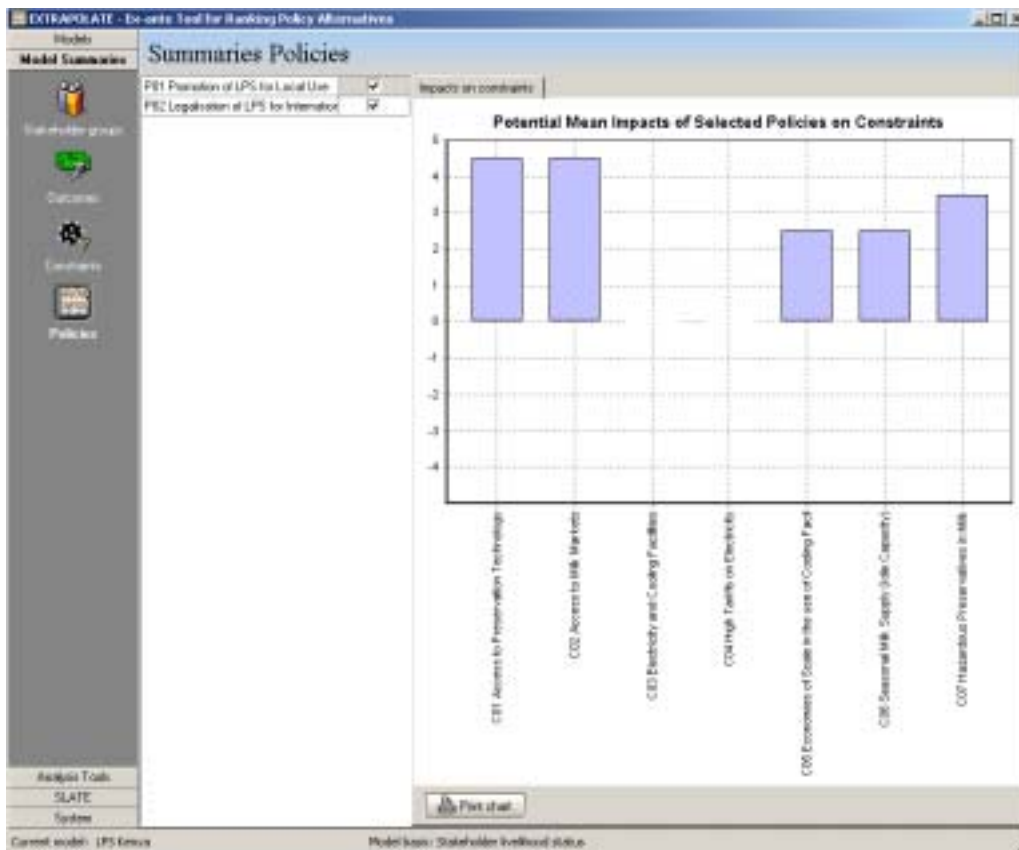
Table 8: LPS example: impact of policies on the constraints.

Impact of Policies on Constraints	C01 Access to Preservation Technology	C02 Access to Milk Markets	C03 Electricity and Cooling Facilities	C04 High Tariffs on Electricity	C05 Economies of Scale in the use of Cooling Facilities	C06 Seasonal Milk Supply (Idle Capacity)	C07 Hazardous preservatives in milk
P01 Promotion of LPS for Local Use	4	4	0	0	2	2	3
P02 Legalisation of LPS for International Trade	5	5	0	0	3	3	4

Screen 13: Data summary charts in EXTRAPOLATE: showing the potential mean impacts of outcomes on stakeholder groups for the LPS example.



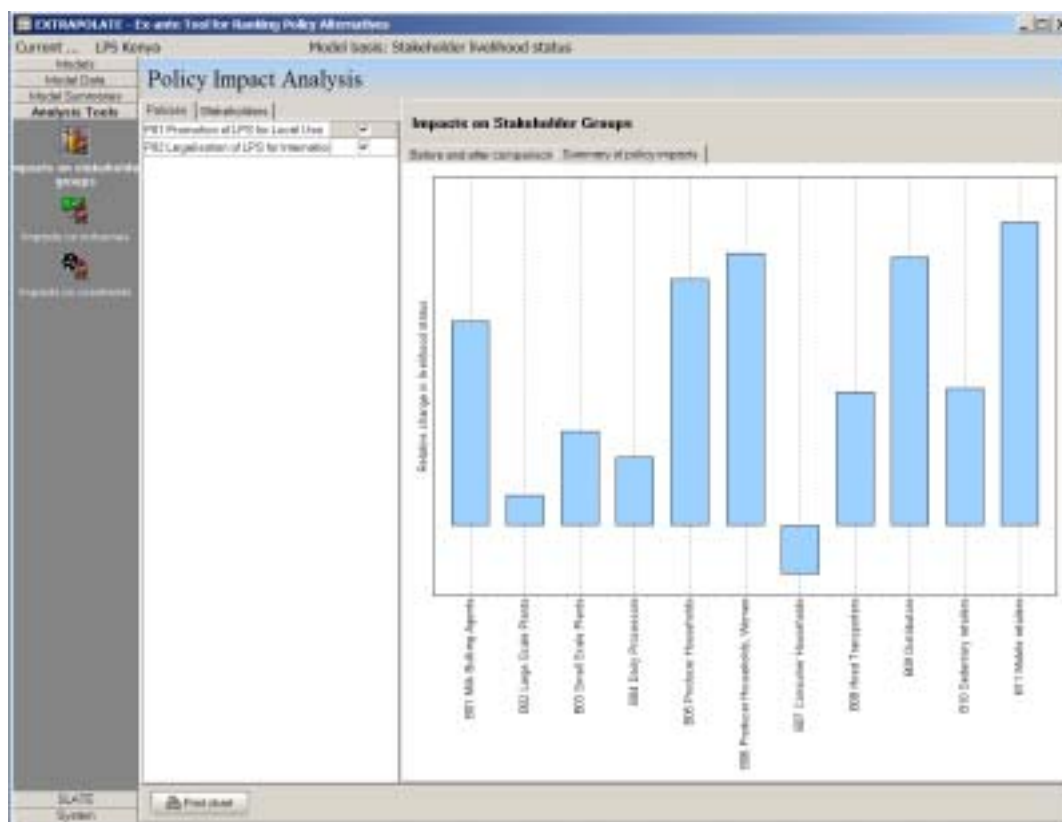
Screen 14: Data summary charts in EXTRAPOLATE: showing the potential mean impacts of the policies on the constraints for the LPS example.



Having established the likely qualitative impacts of implementing the two policies, the PRIMAS tool can then be used to identify the areas within Kenya where LPS might be a viable alternative. Building on the recommendation domain for LPS shown in the Dairy Toolbox (ILRI, 2005), we used PRIMAS to identify all areas in Kenya that conformed to the following three criteria:

1. Divisions (the third sub-national administrative unit) with an annual milk surplus (i.e., production - consumption) in excess of 10 million litres (from 1997 Ministry figures).
2. Divisions with high dairy animal numbers, in excess of 10,000 (also from 1997 Ministry figures).
3. Areas at least 5 km (Euclidean distance) from a road.

Screen 15: Analysis results: showing the relative change in livelihood status before and after application of the two policies promoting use of LPS.

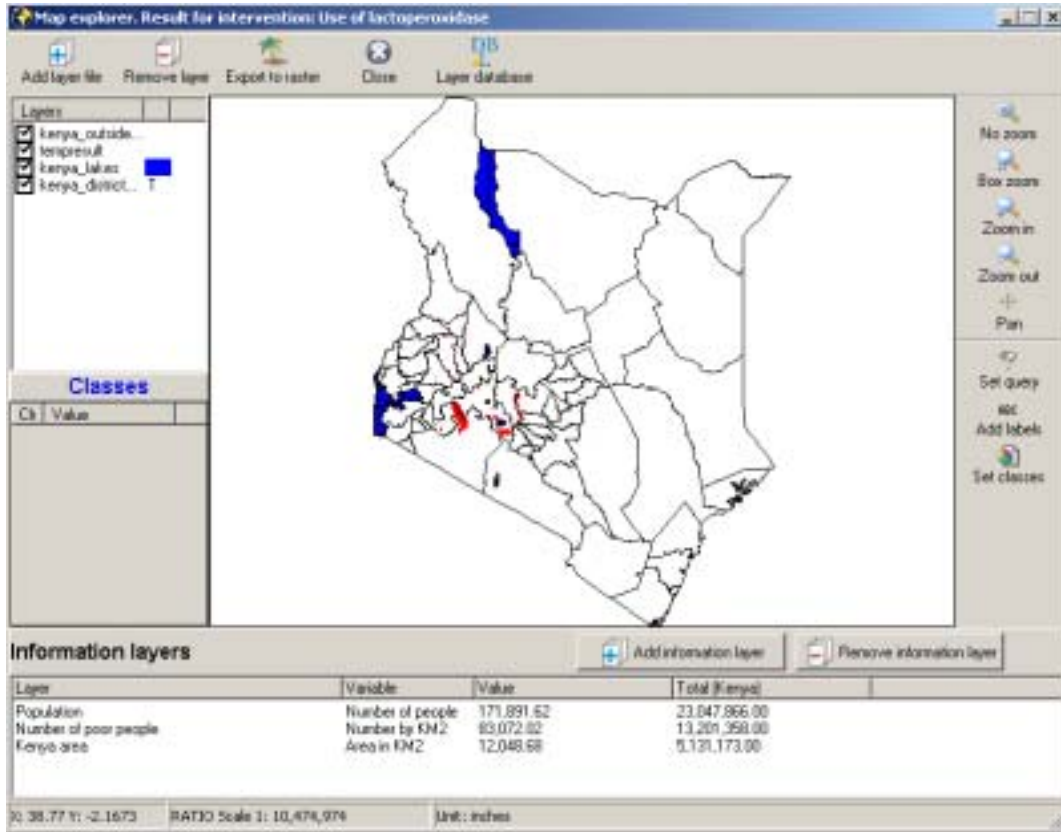


In other words, these are the areas of Kenya where milk production substantially outstrips milk consumption; where there are large numbers of dairy animals; and that are somewhat isolated from road infrastructure and markets.

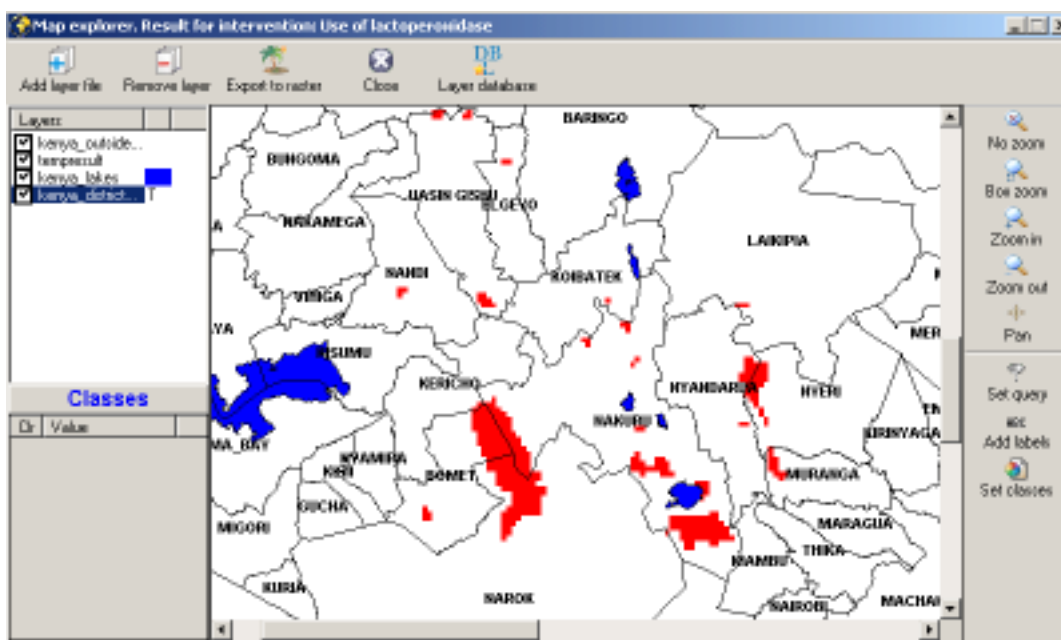
The results of running the PRIMAS tool on these criteria (the various layers are simply overlaid in a subtractive fashion) are shown in Screen 16. The information layer data indicate that the result area (coloured red) is 12,000 km², about 0.2% of the country's area, and contains some 172,000 people (0.8% of the national population), of whom 83,000 (0.6% of the national total) are classified as resource-poor livestock keepers. Screen 17 shows an enlarged map of the result area, overlaid with district boundaries and district names. It indicates that there are "pockets" of potential LPS

recommendation domain in various places, including Nyeri, Nyandarua, Kericho, Nakuru, Narok, Bomet, Nandi, Uasin Gishu, and Muranga Districts.

Screen 16: Recommendation domain for LPS technology, based on stringent criteria relating to dairy animal numbers, milk surplus and distance to road (see text for details).

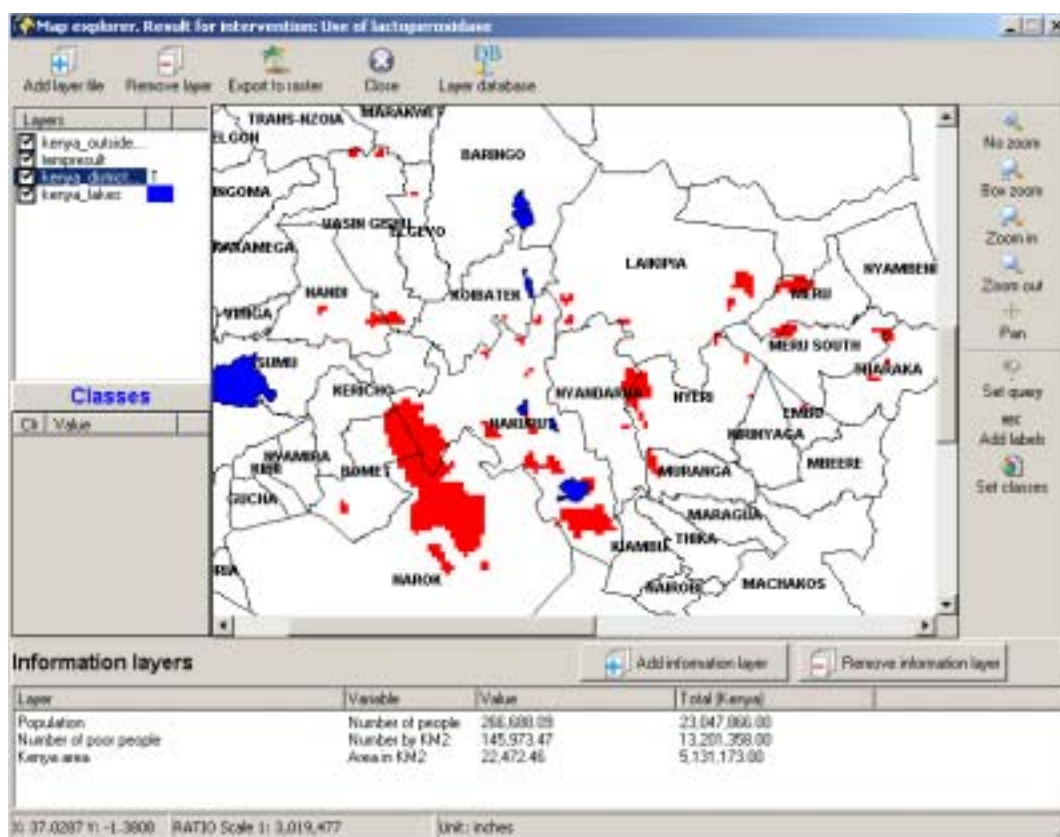


Screen 17: Districts related to the recommendation domain for LPS technology in Screen 16.



If the criteria are relaxed somewhat, to include the top 50% or so of Divisions with a positive milk surplus (a surplus in excess of 2 million litres), the top 50% or so of Divisions with the most dairy animals (more than 6000 animals in the Division), and areas at least 5 km from a road, the recommendation domain increases in size to some 22,500 km² containing 267,000 people, with substantial increases in domain size in Narok District, in particular (Screen 18).

Screen 18: Recommendation domain for LPS technology, based on less stringent criteria relating to the top 50% of Divisions in terms of dairy animal numbers and milk surplus, and distance to road (see text for details).



These results could be used as the first step in identifying pilot areas where LPS technology could perhaps be targeted, although of course there may be many other constraints to its use, and many other reasons why its use may not be viable in particular places. The combined PRIMAS-EXTRAPOLATE analysis does, however, lend some support to the view that LPS may be a useful technology in some niches. Results suggest that its impacts may be relatively pro-poor. In addition, the model as formulated here does not suggest that women householders will loose out through a transfer of benefits to men, and women may be able to reap some of the societal benefits that are likely to arise from implementing LPS-friendly policies. Results also suggest that some attention may need to be paid to possible human health issues at the same time, to prevent milk preservatives other than LPS, which may be hazardous, being used.

6. FUTURE DEVELOPMENTS

EXTRAPOLATE is currently being applied in a number of situations, and will inevitably be undergoing modification and refinement. These may include the addition of a capability to perform sensitivity analysis, i.e., to assess how robust a model may be to small changes in scores, and the ability to incorporate broader stakeholder groups in the analysis, if needed. At present, EXTRAPOLATE is based on the stakeholder household or community as the unit of analysis. Examples of broader groups would include government (for instance, some policy changes may simply not be feasible, for a variety of political reasons); cooperatives, in which group benefits may need to be accounted for differently; and other countries, in situations where there may be substantial implications for international trade.

7. GLOSSARY

The following are some terms used in this document that perhaps need defining to improve clarity of the text. Words in **bold** appear in the glossary.

Capital assets	In the sustainable livelihoods framework originally proposed by UNDP in the early 1990s, a household is described as having access to capital assets of five types: human, natural, physical, social, and financial. The operation of the household can be explained in large part by reference to the capital assets that it has at its disposal.
Constraint	Something that prevents a positive outcome being achieved by a stakeholder . "Low rainfall" might be a constraint in one situation, if crop productivity is hampered by it. However, for a situation with a more drought-resistant crop, or where irrigation is possible, low rainfall may not be a constraint, or it may be effectively by-passed.
Currency	The units of analysis of an EXTRAPOLATE model, i.e., the way in which outcomes and the status of stakeholder groups are defined and measured. It may be in terms of one or more of the livelihood capital assets , income, or food security, for example.
Element	Refers to the pieces that make up a model in EXTRAPOLATE ; these are the basic constraints , stakeholders , outcomes and policies that constitute the model .
Ex ante	"Before the fact", describing the situation before something has happened (implementation of a policy , the carrying out of a piece of research, etc).
Ex post	"After the fact", describing the situation after something has happened, such as a policy being implemented or research being carried out.
EXTRAPOLATE	Software that allows the user to screen different policies for their likely impact on different stakeholders . EXTRAPOLATE contains links to PRIMAS and SLATE , two other pieces of software that were developed in separate activities but contribute to making EXTRAPOLATE a more comprehensive tool.
Impact	The direct effect of something on something else; in terms of model elements , the direct effect of, for example, a marginal change in an outcome on the livelihood status of a stakeholder .
Livelihood	The ways and means used by members in a household to satisfy nutritional, economic, social and cultural requirements.
Model	An assemblage of elements and the linkages between them, that describe a particular situation, designed to be "run" so that relevant outputs can be examined - here, the impacts of policy changes on different stakeholder groups.
Outcome	Something that can be quantified that affects (negatively or positively) the status of one or more stakeholder groups, in terms of the currency being used for the analysis.
Pairwise comparison	A method of ranking many items in a list that has built-in checks for consistency, based on successive comparisons of pairs of items in the list (see Section 4.1).
Policy	A change that is effected at a level in the hierarchy that is higher than the household (community or national government, for instance), that may have positive or negative impacts on the constraints facing households.
PRIMAS	A piece of software that allows the user to map combinations of different spatial layers. Developed separately from EXTRAPOLATE , but able to be called from it, to map out certain constraints and stakeholder groups that can be at least partially specified in spatial terms.

Relevance	Refers to the linkage between constraints and stakeholders , and the relative strength of each constraint as it currently affects the various stakeholder groups
SLATE	A piece of software that allows the user to describe the capital assets that a household has access to, to try to determine strengths and weaknesses. Developed separately from EXTRAPOLATE , it can be accessed from it and used to help decide on the livelihood status of particular stakeholder groups.
Stakeholder	The various groups of people who are involved directly in the system being analysed, and who may be affected (both positively and negatively) by prospective policy changes.
Status	The relative standing of stakeholder groups compared with each other, in terms of the currency of the analysis; this may be in terms of income or poverty levels, for example.

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