PARTICIPATORY SYSTEMS ANALYSIS AN INTRODUCTORY GUIDE

Tim Lynam

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Participatory Systems Analysis
An Introductory Guide

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Preface

The *Local People, Devolution and Adaptive Collaborative Management of Forests* Research Programme of the Center for International Forestry Research (CIFOR) seeks to understand key processes that enable improved management of forests by local people, the conditions under which these operate successfully and the impacts they have on forests and people. CIFOR was established in 1993 as part of the Consultative Group on International Agricultural Research (CGIAR) in response to global concerns about the social, environmental and economic consequences of forest loss and degradation.

The Agroforestry: Southern Africa (AFSA) project is aimed at capacity building in agroforestry training and research. It is a joint project of the Universities of Alberta (UA) and Zimbabwe (UZ), funded by the Canadian International Development Agency (CIDA) of Canada. AFSA is a University Partnership in Co-operation and Development Project (UPCD) managed by the Association of Universities and Colleges of Canada (AUCC). The lead institution at UA is the Department of Rural Economy while at UZ it is the Institute of Environmental Studies. A wide range of other departments are represented on the management committees, reflecting the interdisciplinary nature of the project, including the Department of Agricultural Economics (UZ), the Department of Soil Science (UZ), the Department of Crop Science (UZ), the Department of Public Law (UZ), the Centre for Applied Social Sciences (UZ), the Department of Renewable Resources (UA), and the Forestry Commission (Government of Zimbabwe). The aims of the project include:

- developing curricula materials
- improving the agroforestry knowledge base
- training graduate students * developing library resources in agroforestry

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Introduction

Participatory Systems Analysis (PSA) has evolved as a logical combination of the broad range of formal tools and approaches developed in the field of Systems Science with the more recent developments in participatory methods as a key to successful development initiatives.

Systems are generally thought of as assemblages of parts that are connected together in an organised way to achieve some objective. A crucial issue that has prompted the development of systems thinking and hence systems science is the recognition that when different components are coupled together the whole may exhibit behaviours that are not predictable from examining the behaviours of the individual components in isolation-these behaviours or properties are called emergent properties or behaviours. In the development and agricultural context two very useful references, which provide a clear description of the need for systems approaches are the papers by Richard Bawden (1991; 1992), listed in the references section.

Analysis is the process of examining, in detail, the structure or behaviour of something-thus chemical analysis involves investigating the chemical structure of a compound and psychoanalysis involves investigating the behaviour of individuals.

Participation or participatory approaches, in the context of development thinking, are generally taken to be approaches or methods that have the target population group involved in the analysis. The degree of participation is often a cause of debate-but examples exist where local people have just participated in limited aspects of a project through to situations where local people have been full collaborators and even steer the course of the project. The paper by Andrew Hall and Silim Nahdy in the reference section provides a useful review of the development of participatory methods and approaches. In large measure these developments have come from the agricultural research field where there has been a great deal of interest in participatory agricultural experimentation. Two writers provided much of the stimulus for the participatory approach-Robert Chambers (Chambers, 1978) and Paul Richards (1985). Their writings revolutionised thinking about the involvement of local people-who, up until that time, had been thought of as incompetent and in need of western technology and assistance-in research directed at improving their lives.

With the emergence of the participatory paradigm in the late 1970's a whole host of research approaches (and acronyms!) developed and have become essential tools in working with rural communities. Rapid Rural Appraisal (RRA) was followed by Participatory Rural Appraisal (PRA), which in turn was followed by Participatory Action Research (PAR) and Participatory Systems Analysis (PSA). Each new generation brings with it a few new tools, some new jargon and an expansion of the original concept. In general the early methods were criticised as being rushed and despite proposing to be participatory they were perhaps just as extractive as the methods they sought to replace. As the suite of participatory approaches has evolved the toolbox available to the practitioner has become very rich and varied, providing a number of tools well suited to almost any analytical situation.

In this guide I provide a general outline of PSA as well as an introduction to some of the more useful tools that I have encountered over the years. There are many more tools available than I will discuss-this is inevitable with such a broad field. At root the participatory approach is one of experimentation and practitioners are encouraged to innovate and see what works. Adaptation is the key. At the end of this guide I provide some useful references for those who would like to pursue the fuller range of available tools. The next section begins with a general overview of PSA and discusses how it is linked to more formal systems analyses. Then, in Section 3, I discuss some of the tools that have proven most useful as well as briefly mentioning some that show great promise.

PSA - Broad overview

There are a number of different approaches to systems analysis but I will be focusing on what is generally known as the **hard systems** approach (a good reference for this approach is Bawden and Ison, 1992 - although focused on crop production it is a very simple, clear and useful description of the systems approach). The **soft systems approach** of Checkland (1981) is commonly used in industrial settings but it has not had as strong an influence on PSA as the hard systems approach. I will therefore, limit my discussion to the hard systems approach.

Typical of any discipline, systems science has often been criticised. In particular it has been seen as insufficiently flexible to deal with human and biological systems. See the Berlinski (1976) book for some very useful criticisms of the systems approach.

Systems analyses comprise a number of stages or interlinked sets of activities that usually start with some formal process of carefully defining the problem and ends with an operating system. The approach is often cast as a flow chart (Figure 1) in which each of the stages is presented. It is useful to briefly review what each stage is expected to produce as, very broadly speaking, a PSA would be expected to yield somewhat similar outputs at each stage. It is particularly important to recognise that the process is entirely iterative-at any stage in the process one should expect to return to previous stages or even to the beginning as new information might invalidate the output of previous stages and require that they are further refined before proceeding.

The complication that arises when doing systems analysis in a participatory mode is that the analyst will have to use tools that are suited to the partners or stakeholders. This has been both a blessing and a curse. It is a blessing when the analysts really do take the partners interests and understanding to heart and in so doing the partner will be involved in most, if not all, stages of the analysis. This type of development has a much higher chance of success than when the analyst takes note of partner needs at particular points in the analysis (e.g. problem formulation) but then ignores the partner until a prototype (model) system is delivered. The curse is that many of the well-tested analytical tools often prove too complex for use in rural situations-in particular many of the more complex simulation tools (e.g. most optimisation algorithms) are difficult to explain to people and may not be suitable for use with local communities. PSA is also very slow. VERY slow. The analyst should only move as fast as the community of partners involved in the process. It is often extraordinarily tempting for the analyst to forge ahead and bring the full weight of her knowledge to bear on helping the community move faster and more accurately. Unfortunately this becomes indistinguishable from the top-down approach to development, which has proven itself so unsuccessful in the rural African context.

Recognising that systems are organised to achieve some objective it is vitally important to establish, right at the outset, and as precisely as possible, exactly what the objective is. Perhaps even more importantly, and especially in PSA when you will be working with your partners, it is important to identify whose objectives (needs or problems) are to be addressed. It is clear that rural communities in the Southern African context comprise a wide range of interest groups and power is often vested in small elites. It behoves the sensitive analyst to be careful in identifying the actual target or partner group that the analysis is expected to serve. Much time can, and often is, wasted on developing elegant solutions to the wrong problem or targeted to the wrong people.

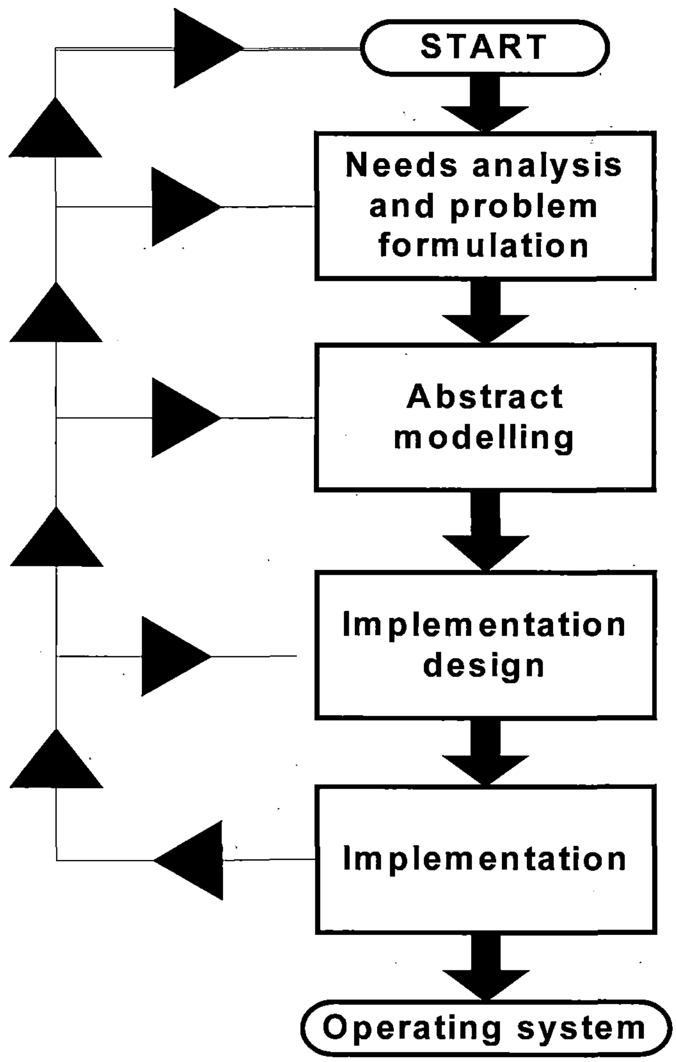

Figure 1: Generalised outline of systems approach.

Needs analysis and problem formulation

Setting project or analytical objectives is one of the more important activities in PSA. The analyst should expect to go through more than one iteration or refinement in attempting to define workable and achievable objectives. Objectives are often formulated in quite general terms such as " *To improve the quality of life of the local community members.*" But these provide little tangible guidance as to what should actually be done or what the problem is. Rogers and Bestbier (1997), working in the Kruger National Park, developed a very useful approach to defining objectives, which were seen as being hierarchical-each broad level objective could be broken down into sub-objectives, which could in turn be broken down into sub-sub-objectives. At the finest level of resolution the objectives would provide tangible guides for action (the paper by Lynam et al., (in press), provides a Zimbabwean example). It is well worth the effort to spend the time developing project objectives or problem formulations in sufficient detail that activities are readily identified.

The major outputs of this phase of a systems analysis will be clear statements of what the system needs to do. This would be just as appropriate whether the problem is a design problem (e.g. design a new grazing management plan for a given community), a management question (e.g. what is the best way of managing these resources to achieve these objectives?) or an analysis question (e.g. given this set of inputs and this system structure, what will be the long term outputs?). It is vitally important, when working in a participatory mode, that all partners are sure that the defined problem or question is what they want addressed.

Abstract modelling

One of the characteristic processes of the systems approach is the use of abstract models. By model I mean any abstract representation of some structure or process of interest. By convention, models in the systems approach are either systems dynamic models or some form of optimisation models. System dynamics models are those in which the system is modelled as a set of components linked by flows. For the most part it is the dynamic behaviour of these models that is of interest. Optimisation models are models that are designed to find a best (optimal) set of inputs or the optimal system structure given a set of constraints.

There is a very broad range of modelling tools and approaches and a full discussion of them is beyond the scope of this guide. Some simple and particularly useful approaches will be described in later sections but many of the more complex approaches will be ignored, as they are difficult to use in rural settings.

The major outputs of the abstract modelling process depend to some extent on the problem that has been defined. In some instances the output will be a validated model, which is the end product. In other cases it will be the outputs of the model that are the outputs of the process. For example, if the problem was defined as determining the optimal configuration of land uses to achieve community objectives, then the model might be used to identify which configuration was most likely to achieve the best combination of community objectives. It would be the configuration of land uses that would be the outputs of the process.

It is also important to recognise that, in combination, the two processes of needs analysis and abstract modelling would be expected to yield outputs that are economically, socially and politically feasible-it is essential that the important process of creative thinking is coupled to strong reality checks to ensure that what emerges has, at least, a strong chance of being implemented.

Implementation design

Once the system, the set of inputs or the management activity plan have been devised and tested in the abstract modeling phase the real world implementation of these must be planned. This is a crucial step that is often overlooked. Many things can, and often do go wrong in implementing major changes to established systems-which is most often the case in rural development situations. What is the key sequence of events? Who must do what, when and where? It is often the case that particular events or structures must be in place before anything else can go ahead-in rural southern Africa, for example, the requirement for political acceptance from local leaders or the local government is most often an essential precursor to successful change.

The implementation design process yields a clear implementation plan, which has the agreement of all concerned. It is important to recognise that system design is often the easy part-things most often fail at implementation. It is wise therefore, to plan the implementation with frequent testing of the individual sub-components of the overall system so that mistakes or problems can be rectified before too much time or too many resources have been invested.

Operating system

The final stage is of course the operating system. Even at this level it is important to recognise that the analysts task may not be over. Is the system achieving what it was designed to? When the process of change may only occur over the long term then what aspects of the system should be monitored to provide evidence of movement towards the desired set of states or behaviours? What would be early indicators of success or failure?

It is rare that the analysts will have much more than five or so years involvement in any one situation or community. It is important, therefore, that the analyst includes in her design of the implementation, components or sub-systems to maintain system performance and, more particularly, respond to changing circumstances. We are remarkably weak at predicting the future of complex systems and we should expect local people to adapt to a constantly changing set of circumstances. System design is seldom able to foresee all likely outcomes or changes. We need therefore, to build into the design process as much flexibility and adaptive capacity as possible. For the most part this will involve training local people and providing them with the skills to carry out their own systems analyses. In essence the task becomes one of enhancing the adaptive capacities of local resource managers.

Participation

Formal systems analysis has always recognised the importance of close interaction with the partner group-participatory systems analysis is therefore, somewhat of a redundancy in terms.

But in the context of rural development or resource management in southern Africa the term participatory is added because it emphasises the contrast between the formal approach of bringing experts in to solve a given problem-the western industrial conception of systems analysis-with the need to have local communities participate in the analysis and to distance itself from the unfashionable "top-down" approach to development which is the use of external experts to "parachute" solutions into a community.

But what is participation and how is it achieved? How much participation is necessary and with whom? Should external agents of change just stimulate the change and then stand back to see what happens or should they use their knowledge to try and guide the process of change? If they do this is that not a "top-down" intervention? Should they be there at all?

The nature of participation with local communities is perhaps more difficult than the systems analysis itself. Whilst there is a considerable body of literature on working with local communities it remains more of an art than a science-some people are inherently good at working with local people and others are not that good. Probably the most important thing is for each of us to roughly place ourselves on this continuum and ensure that we work in collaboration with people that add value to our strengths through being strong where we are not. Very often a good analyst will not be that good at community work and the good community worker will not be that analytical-but the two of them together may make a strong and useful team. Working with communities is very much a process of facilitation-learning how to bring the best out of people, to make them feel important and to ensure that they know that their contributions are valued. It is also important to avoid imparting too much of the external expert's views into the analysis (but how much is too much is a very difficult question to answer). Very often facilitation of PSA requires significant conflict resolution skills as important problems that have been bubbling along within a community for many years may burst into the open when the problem is probed.

Participation requires great care and sensitivity but perhaps most of all it needs honesty and a willingness to accept other people's views and beliefs and not to hold on to one's own views at all costs. The ability to stimulate discussion and debate and so keep the process going without getting immersed as an emotionally involved actor is an important attribute. To prompt and then stand back to observe is the essence of good facilitation.

Methods and applications

In this section of the guide I present a number of methods and tools that I have found to be particularly useful. I present these in sections that relate to the different processes of systems analysis. This does not imply that methods presented as being useful for one application may not be well suited to another application. The essence of good PSA is adaptation-adapting the tools to the problem at hand rather than adapting the problem to suit the tools available.

Problem formulation

As already discussed, careful formulation of problems and objectives is an essential and vitally important step in a systems analysis. It is the foundation upon which all else will be built. If you get the foundations skewed you are likely to have a very difficult time getting the rest of the structure to do what it is designed to do.

The key element of problem formulation is to ask the right questions. It is therefore, important to obtain a general understanding of the system of interest before getting too involved in detailed analyses. It is often well worth the effort to spend time walking around an area, with some trusted local informants, to look at the system you are working with but also to talk to people in their work or leisure environments. Remember to try and obtain as broad an image as possible of the different actors and opinions as well as the different resources available through space and time. Avoid focusing too quickly on the issues that you believe are of primary concern. In particular, look out for:

- Key events - rare or crucial events that might happen (or have happened) very infrequently BUT which have a major impact on the structure or functioning of the system;
- Key resources - are their important resources that play a crucial role in the functioning of the system-water points, riverine feed resources or particular vegetation types;
- Differences in local beliefs as to causes, ownership or importance as these may often indicate conflict or gaps in understanding;
- What things are important or of value and to whom;
- Who controls what, for whom and why?

Much of this general or reconnaissance understanding is well described in the RRA or PRA literature-the references by Mascarenhas et al., 1991, and National Environment Secretariat of Kenya (1991) in the reference list are a good start. As your reconnaissance progresses you should begin formulating tentative hypotheses as to how the system works. By hypotheses I mean an explanation or mental model of how the system of interest functions. The next task is to begin confronting these hypotheses with reality and the best way to do this is to ask well-focused questions of your local informants.

Questioning of local people is a crucially important component of any PSA-you will almost invariably have to rely on local knowledge for most of your understanding of the system. It is rare that there is much scientifically collected data available for the specific site in which you will be working. It is almost always best to develop a set of key questions that you seek to have answered and use these to focus your interviews or questioning. These should have emerged from your initial (reconnaissance) survey. One very useful technique that I have developed and used is what I call a ***spidergram***. This is a methodology that provides a mechanism to structure your questioning and to help you focus on the most important elements of the answer.

Spidergrams

Spidergrams are a flexible tool that are used to identify the components and relative importance of the components of answers to specific questions. They were particularly useful when the answers to a question were likely to be decomposable into independent components. Where the answers to questions comprised a number of inter-dependent factors spidergrams were not considered to be as useful.

To start with, the facilitator asked the Village Representative (VR) group a clear and specific question. For example, the following question would normally be asked:

"What does an average household need in order to lead an adequate life in this community?"

The answer to this question would typically be a list of goods and services. A circle was drawn in the ground or on a flip-chart sheet, by a member of the VR group to represent the question. If necessary, a word or object was placed in the circle as a symbol of the question. The components of the answer (i.e. the items that would appear on the list) were then added to the spidergram by a member of the VR group drawing a line radiating from the circle edge and ending in a circle or symbol that represented that component or item. In the example question above these items or components might include food, land, water, cash and neighbours. These five things would be drawn on the diagram as shown in **Figure 2** and comprised the **first level** of the spidergram. Once the components of the answer had been identified and all members of the VR group agreed that the question had been answered then the components were scored to reflect their relative contribution or importance to the answer.

Relative importance scoring was a key activity in the development of spidergrams and one that required careful thought. The resulting scores, called **Relative Importance Weights (RIW)**, provided an important part of this methodology. When asking the VR group to score the components of an answer (i.e. the radiating arms of the spidergram) the scores assigned often reflected a different question to that originally posed. Care must be taken to ensure that the question asked when the VRs were to score the component of a spidergram that they had just completed was clear and unambiguous and that the facilitator understood and recorded what VRs implied by the scores given to each component.

Two scoring approaches were used. In the first method, the **bounded** scoring approach, a set number of points were allocated to each radial arm of the spidergram. Five points or counters for each radial arm was a standard I generally used. Too many points and it becomes difficult to

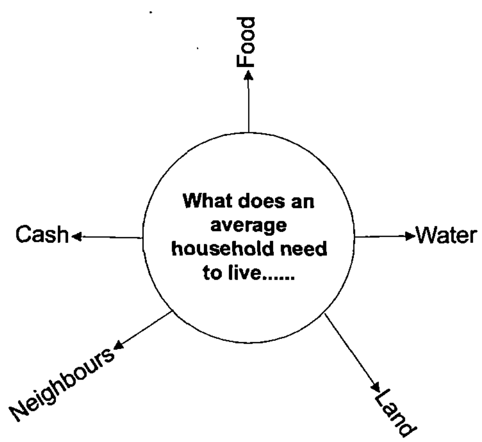

Figure 2: Basic spidergram showing the first level of (hypothetical) answers to the question *"What does an average household need in order to lead an adequate life in this community?"*

manipulate. Too few and there is insufficient resolution. The facilitator would then ask the VR members to collect sufficient counters to use as points. Sticks or stones were used as points or counters where spidergrams were drawn on the ground, numbers or strokes were used when spidergrams were drawn on flip chart sheets. The facilitator then asked the VR group to allocate all the other points to reflect the importance of each component.

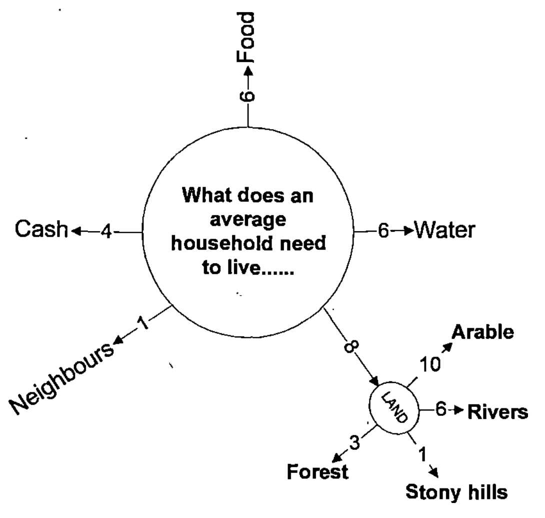

Figure 3: Spidergram showing second level and RIW scoring for the question *"What types of land are found in this ward?"*

The **bounded** scoring approach was used when the components of the answer were best represented by a finite allocation of resources such as a fixed budget or a fixed amount of labour. In the example of **Figure 2** a total of 25 points might be allowed (five points each for the five components) and the VR's would be asked to allocate these among the five items identified **(Figure 3).**

The second scoring approach used was an unbounded or **open-ended** scoring approach. The basic scoring principles were the same as for the **bounded** scoring approach except the VR group could allocate as many points as they liked to a component. The only constraints the facilitator imposed were that the least important component of the answer was given one point and that all other scoring was done in reference to that component. It was important, in the open ended scoring approach, for the VRs to first identify the least important component of the answer and then to score all others with reference to the score given to it.

Once the scoring was complete the group then proceeded to develop the next level of the spidergram. In taking that next step facilitators needed to be careful about what was being asked. As with virtually every aspect of these methods the results achieved were only as good as the questions that were posed. In general the next level of questions began with the component of the first level of the spidergram that had been given the highest RIW. For example, if in their answer to the question illustrated in Figure 2 the VRs had identified land as being the most important factor contributing to a household's ability to satisfy its basic needs then the facilitator would ask the VRs to draw a circle around the Land component of the spidergram and answer the following question:

"What types of land are found in this area?"

An example extending the spidergram of **Figure 2** is shown in **Figure 3** with scoring reflecting the relative importance of each land type to enabling households to satisfy their basic needs. Two different scores were given to each component of the answer to this question. The one reflected the relative importance of land types to household well-being and the other reflected the relative areas of each land type available to households. The two scores were represented using different counters (sticks vs. stones) or some other means of differentiation (stones in a circle vs. a pile of stones).

A spidergram could be extended level by level almost without end. As each new level of a spidergram was begun the component of the previous level that was of interest became the focus of a new question. Scoring at each level was independent of scoring at previous levels.

Spidergrams provided a flexible tool for exploring the knowledge, values and objectives of people. The RIW approach to scoring provided a means of targeting a time-limited inquiry to the most important components of a system.

Major outputs of a spidergram were; a) a listing of the components and sub-components of the answer to a question; b) scores (RIW) that reflected the relative importance of each component of an answer; c) graphic representations of a question or system.

In developing spidergrams with the VRs the following were assumed: 1) VR members could translate the verbal concepts or components of an answer into abstract, graphic representations on paper or the on ground. 2) The components of the answer to a question were separable or independent. 3) When scoring the VR members were able to identify the relative importance, compared to some base or reference component, of the components of an answer.

The major disadvantage in using Spidergrams is the difficulty of representing feedback processes or cross linkages with them.

Mapping

Mapping with local people has proven itself to be a very powerful tool in aiding understanding of the spatial relationships among problem or system elements as well as understanding spatial use of resources. Several different types of mapping are in use and which approach to use under what conditions is a choice that is largely dependent on the objectives of the analysis as well as the resources at the disposal of the analyst. Many problems in natural resource use are related to the size of a resource area to be used or the location of a resource in relation to people's homes of some threat. Mapping with local people can be a useful way to identify; a) what people note as being important features or attributes of their landscape; b) how they choose to represent the two dimensional space that is of concern to them; and c) the use of space by the people themselves or animals. Although for detailed quantitative analyses the analyst would prefer to get reasonably accurate estimates of areas and distances we have found this very difficult to achieve without resorting to the use of GPS (Global Positioning System) equipment, or devoting considerable energy to training enumerators in map reading and interpretation and then testing their spatial acuity.

I will briefly describe two types of mapping that we have found useful. The one, general sketch mapping **(Figure 4)** has been particularly useful in preliminary analyses to identify broad spatial relationships and patterns of resource use. The other involved local enumerators mapping where household activities took place. These results were then digitised into a GIS (Geographical Information System) to be used in analysing the areas of spatial use.

Sketch mapping is the simplest of mapping activities and simply requires that local informants be assisted to represent their mental maps of the areas of concern on some two, or three-dimensional medium. We have found it very easy to use the ground as a mapping medium but this can be very time-consuming. Most people are able to use flip charts and pens and can readily sketch a map on a sheet of plain white paper. Some people do however require a little assistance to overcome shyness if they are not accustomed to using pens and paper.

Two issues have assisted us in getting the most out of sketch mapping. Firstly, although it is often not the exact spatial relationships that are important we have found that it enhances the representation if the informants are asked to start by listing notable landmarks or features in the area of concern. They are then asked to draw these on the sketch map and to play close attention to the relative positions of these features. Once these features have been put in place it is then easier to put other attributes such as households or vegetation patches on the maps. It is important however, not to try and get too much detail on maps when this is not required. Making maps are a lot of fun and people can spend hours and hours developing very beautiful representations. But this may not be what is wanted or what is important. This is the second issue of concern-make sure that you get the simplest representation of what is needed for the purpose at hand.

Simple maps that show the general patterns of resource use are often very useful in the early stages of an analysis. In **Figure 4** we show a map developed in a reconnaissance workshop in Zimbabwe where the informants were describing the use of graze and browse resources by livestock in a drought year. We were able to use this sketch map with others of a normal year's movements to see how to include extreme events (like droughts) in our analyses.

To generate more accurate spatial maps we used the following approach. Each enumerator was given sufficient copies of base maps for the ward in which the household she was observing was located. The base maps were traced directly from geo-referenced topographical maps at 1:50,000, but were considerably simplified. Enumerators were trained to identify the features and locate the observed households on these maps. Each week the enumerator would note on these maps where activities had occurred. These activities were marked either as points (e.g. fishing or the collection of water) or as polygons (e.g. grazing of animals, firewood or thatching grass collection). The position of the observed household was also marked on each map each week. Maps would be dated and have the household number marked on them. Each activity sketched on the map was marked with the code that linked it to the mother and daughter sheets that were used to collect more detailed information on what occurred at each location and who was involved. The result was very much like a GIS with a linked attribute database except it was paper based!

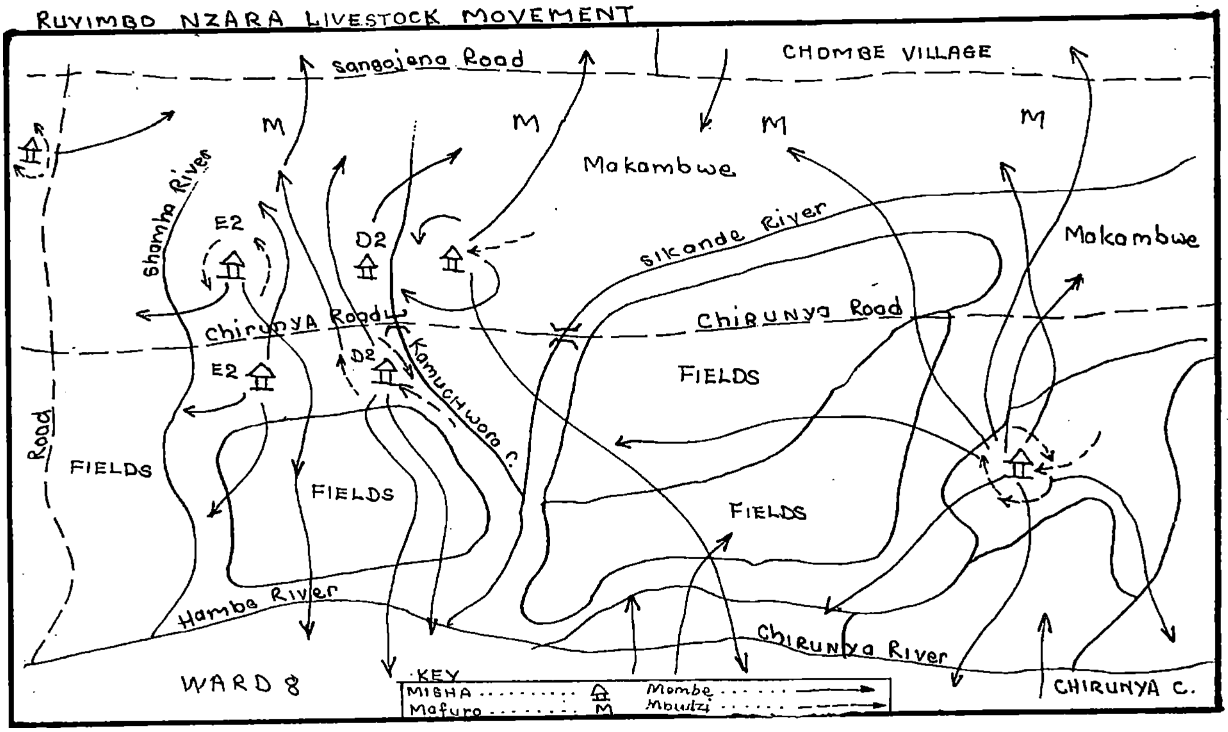

Figure 4: Sketch map of Ruvimbo Village movements for cattle (mombe) and goats (mbudzi) during drought years.

When using local knowledge accuracy is just as much of a concern as when using scientific measurements. It does not matter so much, that measures or knowledge may be inaccurate-we expect it to be. But we should strive to at least know how accurate or inaccurate key data sets are. So, for example, we required an estimate of the accuracy of the local enumerator mapping. The ability of enumerators to accurately identify where activities were occurring was checked by using a GPS to identify the actual position of the household, and then by comparing this post corrected position with the positions identified on the enumerator maps. A Trimble Pathfinder instrument was used with a base station located at the Department of Surveying, University of Zimbabwe, Harare. Positional observations were made at 47 households. The root mean squared error in both the x and y directions was about 330 metres with a coefficient of variation of 87.2 % and 104.5% in the x and y directions **(Table 1).**

The accuracy of enumerator depiction of the areas (i.e. polygon areas) in which activities had occurred was not investigated. It was assumed, given the locational accuracy discussed above, that the position of polygons was relatively accurate but the areas were of unknown accuracy. Their accuracy was not however, considered to be very high.

Table 1: Positional error associated with enumerator locations of the households they were monitoring.

	X-Axis	Y-Axis
Mean[1]	330.97	323.57
CV	0.872	1.045
n	47	47

1. The mean deviation was calculated as $\left(\sum\sqrt{(x_{map} - x_{gps})^2}\right) / n$

From these data we were able to generate reasonably accurate estimates of household home range and to identify, which areas of the local landscape were under the greatest pressure from local resource users.

Institutional and organisational analyses

The term Institutions is used to mean many different things and as such, can cause considerable confusion. In this guide I follow the practice of Douglas North (1991) and use the term institutions to refer to the rules, norms or general beliefs that we all use in virtually every aspect of our lives. Examples include laws and by-laws as well as traditional rules and beliefs. Many people commonly use the term institution to mean an organisation as well as a rule. To avoid this confusion I shall use the term organisation to mean those structures that people create to develop, maintain or enforce institutions or to make their activities more efficient or proactive. Firms, NGOs and governments are all examples of organisations.

Much of the PRA literature on institutions generally has to do with organisations-Venn diagrams are commonly used to identify organisations and their overlap. The literature on participatory institutional analysis is much weaker and methods of institutional analysis are not well developed. Most of the work I have seen involve informal interviews with members of a community. In the rural, southern African context, institutions are very difficult to define clearly as they evolve through time and different people may have different definitions of them. The issues that the analyst needs to investigate are clearly what the rule or belief is; what resources or activities the rule influences; how these are influenced; who is influenced and in what way; and perhaps most importantly how the rules or beliefs are changed. A second set of questions would involve the degree to which people respect or disagree with a particular institution and the degree to which the institution influences people's behaviour.

These are difficult questions and I have not seen any convincing participatory methods that directly address these questions, with the exception of some modelling methods I will present next. However, I suspect that with carefully framed questions some of these issues could be addressed using the tools, such as spidergrams, that were presented earlier.

A more recent development has been the use of multi-agent systems (MAS) models to explore the development of emergent properties when multiple agents or actors interact in a particular institutional framework. The models use very simple rules and can be used to explore the effects these rules might have on the use of given resources, based on local knowledge or perceptions (see the paper by Lynam et al., (in press), for a simple description of use of these models).

Although a very powerful tool these models run on computer software platforms that require the user to be able to program in SmallTalk (the Cormas system from CIRAD in France) or in Objective C (the SWARM system from the Santa Fe Institute in the USA). Thus at the moment this type of simulation tool will be out of reach of many research and development groups. However, the use of role games as a simple way of exploring institutions is an alternative that should yield rich insights. Their use in the field does however, require careful thought and a lot of planning. What actors should be involved in the role-play? How can the system be simplified? What rules should be used and how can they be simplified? What is the most appropriate time step? Are actors allowed to coordinate their response in the game or must they behave as independent agents?

Abstract Modelling

As modelling is one of the core activities in systems analysis, and hence in PSA, I shall present several modelling tools that we have had some success with or that I know other groups have used successfully. There is little information in the literature on the successful use of modelling in rural development setting so I shall present a little more information than in other sections.

One of the more common simulation tools and one that has achieved great success is the use of role-playing games. A good example of a relatively cheap and widely used game is Green Revolution, which was developed by Graham Chapman (1973) in the UK. In this game, which is used over several days in a workshop situation, different people in the workshop are given different roles to play in the simulation. The "system" comprises a small, technologically poor agricultural village. The village consists of farms and trading infrastructure. Farmers are able to interact with each other, with traders and with a banker. The game is capable of simulating a wide variety of situations, limited in large measure by the imagination of the players.

Other, very successful board games have been developed and are being used in rural situations. Ivan Bond (1998) for example, has developed a game that is based on Monopoly, and is used to train local managers in issues of financial management.

Board games with different role-plays require considerable preparation to use and even more if you intend to develop them yourselves. Whenever you are going to use them, try them first with friends and see how they work before going into the field.

Possibility diagrams

A major problem facing the collection of knowledge or information from local community experts is how to facilitate the collection of quantitative information with some indication of uncertainty about the reliability or accuracy of the information. I developed a tool called ***possibility diagrams*** (Lynam, 1993) that enabled the informant or group of informants to express the likelihood of different outcomes from a given set of conditions. These likelihoods were perceived as being the subjective probabilities of specific events occurring under specific conditions. The resulting information was a cumulative subjective probability distribution from which the mean as well as a standard deviation could be estimated. This approach was preferable to other quantitative data collection methods, which did not yield estimates of uncertainty or variance. This technique was used extensively in the Zimbabwean studies and is described here in detail.

As with most other methods used with VRs the facilitator had to ask a clear and unambiguous question of the VRs. A common approach was to define, quite specifically a state or set of environmental conditions in which the events were to occur. For example the VRs might be told that they were to investigate the possibility of achieving specific yields of maize on a virgin field of a particular soil type with an average rainfall season. The VRs were then asked to identify the maximum yield that they were absolutely certain everyone in their community would achieve under these conditions.

Once this yield was identified, as an example say 2 bags an acre (bags being 90kgs), then this value was placed at the bottom of a column drawn on the ground or on a flip chart sheet. Ten points (sticks or stones) were then stacked on top of that yield figure, rather like a histogram. The ten points represented a probability of one. The maximum yield to be achieved with certainty (the 2 bags in this example) was then incremented by one unit (in this example one bag) and the VRs were asked to estimate the likelihood of households in the community achieving this slightly higher yield. It was very carefully explained to the VRs that the ten points assigned to the first yield figure indicated that there was no doubt that under the specified conditions absolutely everyone in the community would achieve at least that yield. The VRs were then asked to assign a number of points to the newly incremented yield that would reflect the likelihood of households in that community achieving this new yield. Once these points had been allocated the yield figure was incremented once again by one unit and the VRs were asked to allocate points to reflect the likelihood of households achieving at least that yield. The procedure continued until the VRs assigned a score of zero to a yield figure. The final diagram might look something like that shown in **Figure 5.**

These results were first converted into kilograms per hectare and then the mean of the distribution was calculated as follows:

$$E(x) = \sum_{i=1}^{n} p(x_i).x_i$$

and the variance was calculated as;

$$V(x) = \sum_{i=1}^{n} (p(x_i).x_i^2) - E(x)^2$$

Where x_i was a particular yield level in kg ha^{-1} and $p(x_i)$ was the probability of achieving that yield level. In the example shown in Figure 4 the mean yield (i.e. E(x)) would be calculated as follows:

(1.0-0.8)*445 + (0.8-0.5)*667 + (0.5-0.4)*889 + (0.4-0.2)*1112 + (0.2-0.0)*1334 = 867.2

or

0.2*445 + 0.3*667 + 0.1*889 + 0.2*1112 + 0.2*1334 = 867.2

The mean yield so calculated would be 867 kg ha-1 with a variance (standard deviation) of 103634.8 (321.9). Note that in the calculation the scores were standardised to 1 (i.e. divided by 10).

The same approach was used to obtain estimates of a wide range of information. Crop yields, livestock birth and mortality rates, time to complete specific tasks both for people and using livestock draft and the amount of grass required to thatch houses were examples of information collected using this technique.

The combination of spidergrams, possibility diagrams and subjective probability estimates provides and excellent set of base conditions for the development of Bayesian Networks or BNs (see Jensen 1999, for a general introduction). These are computer software based networks of nodes with each node representing a variable in a model or belief system. We have recently used spidergrams to build a BN with a community in the Zambezi valley, Zimbabwe (see the paper Lynam et al., (in press) for details). The process was very successful and in one week yielded a powerful and manipulatable model of several key issues that the project, which seeks to improve the productivity of the livestock system, must address.

Basically one can think of BNs as linked probability statements (or estimates) where the probability of the central node state is defined by the states of the input variables. These causal links can be developed either as deterministic relationships (like coupled IF....THEN statements) or as probabilistic statements that use Bayesian statistical theory.

Whilst quite simple to develop using off-the-shelf software, the mathematics underlying BNs is daunting to say the least!

We have also used a very simple technique of drawing a gird on the ground to represent fields of one acre (or some convenient unit). We have then allocated strips of the grid to different soil types and allocated these land parcels to the actors in the game. Actors choose what crops to plant and then we randomly determine a yield based on a random rainfall figure and the yields that farmers provided through the use of possibility diagrams described earlier. These games were complex to run but did enable farmers, and researchers to explore different cropping or management strategies in a relatively low cost way.

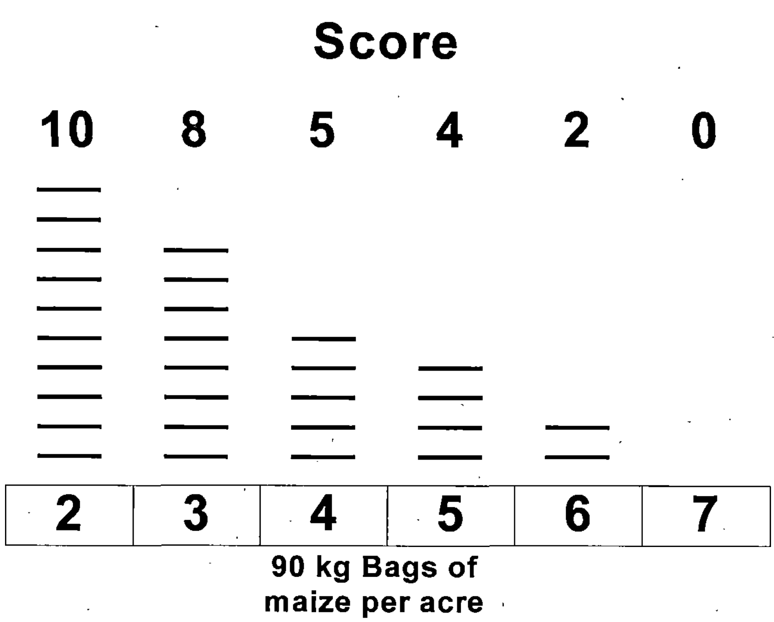

Figure 5: Hypothetical example of a possibility diagram illustrating the expression of maize yields.

Spreadsheet models are perhaps one of the more widely used tools in the commercial world but a set of tools that have been largely overlooked in the development context. They provide one of the more accessible modelling toolboxes and have been used to generate excellent models of population dynamics as well as being used as simple raster GIS systems (see Carter, 1999 for example). Spreadsheet models are very easy to set up (if somewhat tedious) but the very symbolic representations used in the formulae may make them difficult to use or discuss with villagers. Although I have not used them in this context, I do see them as being potentially far more useful than their current use suggests.

Tony Starfield has developed a number of very simple modelling techniques that require the barest minimum of mathematical representation and are ideal for use with local communities. The simplest of these is perhaps his rule based modelling approach (Starfield, 1990) in which the model is developed using nested PRODUCTION RULES or nested IF..THEN statements. These models are relatively simple to develop and understand as they can be based either on qualitative or quantitative rules. Their use does require someone with basic programming skills in a high level language, as I do not know of any software developed specifically with their use in mind. The more recent development of ***frame-based*** modelling (Starfield et al., 1993) is similarly constrained in that a programmer is required to write the computer code. In frame-based models a number of different frames are defined with each frame representing a picture of the ecosystem. Rules are developed which determine when the system will change from one frame to another. These are rather like state-and-transition models but where the states are more complex and the transitions are governed by rules rather than probabilities.

State and transition models are some of the simpler models to build and use but they do require considerable data to develop. In essence a state and transition model is one in which a system may be in any one of a number of clearly defined states-thus for example, a piece of land might be in one of the following states; thickly wooded, sparsely wooded, planted to crops, regenerating woodland or village. The transitions for each of these states are defined probabilistically and it is the derivation of these probabilities that requires considerable data. Although it would be feasible to use subjective probability estimates this is not the convention. These models can be used in large arrays to represent landscapes broken up into smaller units such as one-hectare blocks and the transition probabilities are applied to all units at each time step. In this latter mode large-scale landscape patterns can be simulated but the modelling can be very cumbersome.

Dynamic modelling is arguably, the cornerstone of conventional systems analysis. Fortunately several user-friendly modelling tools are available for those wishing to develop systems dynamics models. Stella is one of the more widely used commercial packages (available at http://www.hps-inc.com) but there is a very good free modelling package called SIMILE available from the University of Edinburgh (http://helios.bto.ed.ac.uk/ierm/ame/). Systems dynamics models are built up from a series of stocks and flows with the latter linking the former (Figure 6). For most purposes the AME application should be more than adequate. These modeling tools make the development and use of complex models very much easier than was historically true. But they still require computer equipment and an understanding of how to represent a system using system dynamic representations.

Despite their widespread use systems dynamics models do have many limitations, as models of this ilk do not easily represent some problems. In particular issues such as the interactions between multiple people or entities are not that easily represented in systems dynamics models. Although it is possible, they are also not readily used within a spatial context-thus it is difficult to represent the movement of organisms or processes over a spatially defined landscape. The newest version of Simile-is capable of simulating spatial processes.

In recent years there have been some particularly exciting developments in the modelling world. These include multi-agent systems models already described as well as models that represent people and systems as they really are-adaptive! (See Carpenter *et al.*, 1999 and Janssen *et al.*, 1999 for excellent examples). For the most part, these models are developed as mathematical statements and are therefore pretty intimidating for the average rural researcher. There is however, no reason that this class of model should not be developed using the simpler rule-based representations. These models generate behaviours that are difficult to analyse using conventional graphing and statistical techniques.

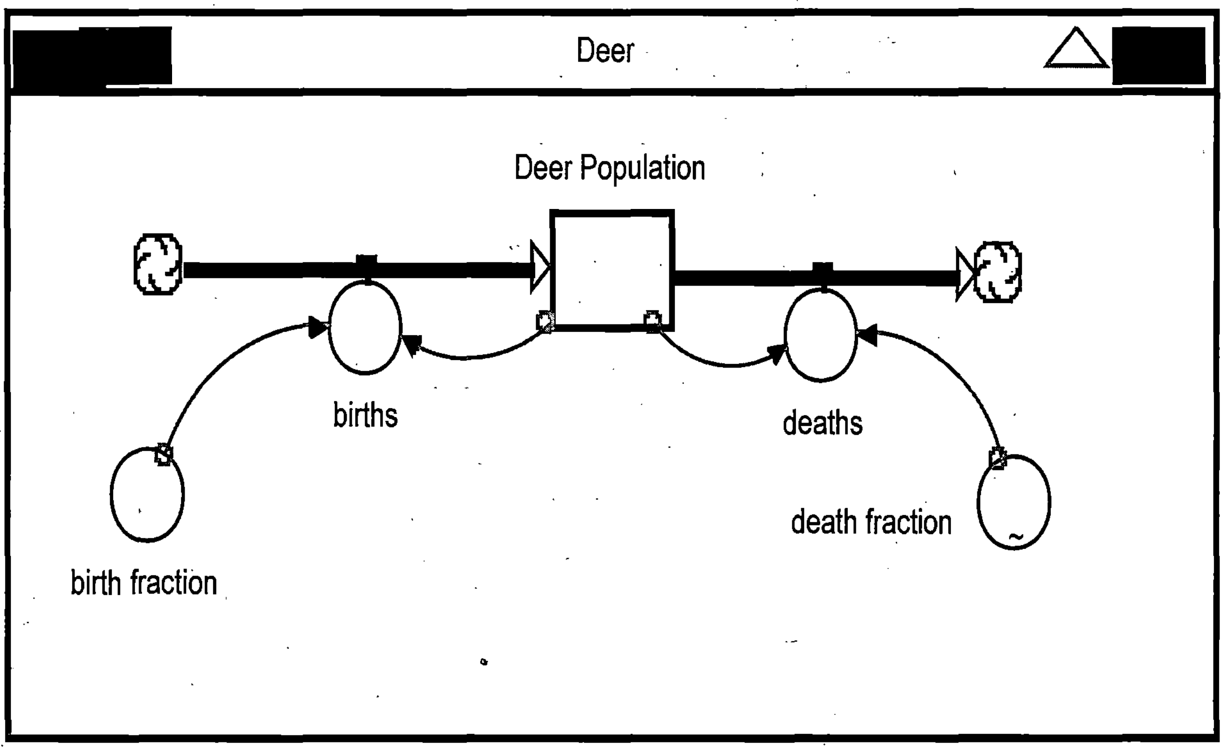

Figure 6: An example of a Stella representation of a deer population model.

Communication

Although the focus of this guide has been on data collection tools and analytical methods it is worth reminding ourselves that at some point the output from any analysis will have to be communicated to the partners that were involved. Oftentimes this communication has to be extended to the broader community as well. The issue of communication is deserving of a whole set of books and cannot be addressed here. We have been exploring several communication methods in our work and do have some sense of what works and what does not. But the communication of very technical information to a largely non-technical audience is very difficult and requires considerable planning and forethought. Those that appear to have been most successful in community development work have been they that spend a great deal of their time communicating with their partners. Whether through pamphlets, meetings, plays, posters or discussion groups the messages that are generated through PSA need to get back to the partner communities. Many a fine analysis has withered through lack of being communicated in a meaningful way to a receptive audience.

Summary

I have presented a broad overview of the processes in PSA and some of the more useful tools that I have used or seen reported. Some of these, and particularly the more advanced computing tools, will not have been used in a rural, southern African setting.

In general there are few clear-cut rules about what tool to use under any given set of circumstances. The best rule is to use your best judgement and rather change the tool than the problem.

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