Adaptive Methodology for Ecosystem Sustainability and Health (AMESH): An Introduction

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I: Introduction: Coping with Complexity

Researchers and development practitioners have, since at least since 1987, struggled to operationalize the concept of sustainable development with a view to improving human health and nutritional security without compromising the integrity of underlying ecological structures and processes. Many of these efforts have resulted in lists of quantitative variables expensive to measure and difficult to integrate, and qualitative models, often restricted to heuristic devices and context-specific applications. To go beyond the current doldrums we will need to: 1) elaborate a fundamental systemic theory for complex socio-ecological realities; 2) define a theoretical framework for identifying, in any given situation, the practical implications of that theoretical understanding for sustainable practices; and, 3), based on 1) and 2), elaborate methodological processes which enable decision-makers to evaluate the implications, make “best possible” decisions, monitor the impacts of those decisions, and adapt to changes in context. To complicate matters, scholars and practitioners are faced with the prospect of dealing with all three domains simultaneously, in a context of great urgency and uncertainty, and working with research and governance institutions that are ill-equipped for the job.

Fortunately, most researchers and development workers see this as a challenge to rise to rather than a fatal impediment. This paper describes an Adaptive Methodology for Ecosystem Sustainability and Health (AMESH), developed in the context of several international development projects, which we believe incorporates much of our best current understanding in each of these domains. AMESH is rooted in theories of complex adaptive systems; the implications of this for practice are elaborated in a set of “guiding principles”; and the methodological processes are described in terms of sets of activities, themselves described in terms of “guiding questions.” Given the large body of literature already available for complex systems theories, this paper focuses on its

implications in practice (items 2 and 3 above). We incorporate examples from several projects in Peru, Kenya and Nepal to illustrate particular points.

II. Theoretical Basis

Bertalanffy's General Systems Theory was one of the first schools of thought that provided alternative models and modes of inquiry to the reductionist methods of disciplinary science. General Systems thinking emphasizes connectedness, context and feedback. Research questions identify and explain interactions, relationships and patterns. The essential properties of the parts of a system can only be understood from the organization of the whole, as they arise from the configuration of ordered relationships that is specific to that particular system (Bertalanffy 1968). Understanding comes from looking at how the parts operate together rather than from teasing them apart.

With the advent of the notion of complexity, a new understanding of systems, and in particular ecosystems, is emerging to augment General Systems Theory (Holling 1986; Kay and Schneider 1994). Complexity is an umbrella concept which incorporates the new insights of hierarchy theory, catastrophe theory, self-organization theory (including non-equilibrium thermodynamics), and chaos theory and the associated issues of uncertainty, surprise, and emergence across scales.

Several insights from the research into complexity and complex systems are particularly relevant to efforts to define and implement sustainable development. These include the notion that a truly complex system cannot be adequately "captured" or represented from any single perspective. The sheer diversity of elements and interactions requires a plurality of perspectives. Indeed, when we speak of "complex systems" in this context, we are referring to systemic ways of organizing our thinking about the complex socio-ecological reality within which we live. We cannot verify in any objective way that the reality is a system; however, we can usefully describe it using a variety of systemic models, narratives and pictures. The collective sense of reality which emerges from these we shall refer to as a complex system. Not only can complex systems be described from a variety of perspectives, but new properties emerge into view as one considers these systems at different scales within a nested hierarchy. Thirdly, the positive and negative feedback loops which characterize complex systems are reflected in self-organization into relatively resilient patterns (attractors), which are the result of particular, context-specific histories. Nevertheless, historical trajectories may change, and any given ecosystem may organize itself in more than one way; changes from one organizational state to another, when they do occur, may be sudden, with the particular outcome uncertain. These new insights into the nature of complexity necessitate a different approach to research into ecosystem sustainability and health.

A variety of scholarly efforts has been made to link basic insights drawn from the study of complexity to issues raised by efforts to define and implement sustainable development. These include: Complex Systems Theory (Schneider & Kay, 1994); Ecosystem-based management (Allen & Hoekstra. 1993); Post-Normal Science (Funtowizc & Ravetz 1994); Complex Adaptive Systems and Resilience (Gunderson,

Holling & Light 1995); Social and Collaborative learning (Rolings & Wagenmakers 1998); Soft Systems Methodology (Checkland 1981) and the Sustainable Livelihoods Approach (Chambers and Conway, 1992; Singh and Wanmali, 1998). Kay, et al (1999) summarize a theoretical approach, based on a Self-Organizing Holarchic Open (SOHO) Systems model, which has informed much of the development of AMESH. This model provides a conceptual basis and framework for an ecosystem description of a situation and, in particular, for the development of narrative descriptions of the potential future pathways of ecosystem organization which are relevant to the issues at hand.

AMESH has been developed in the context of research projects in the Ucayali District of the Peruvian Amazon (Rowley et al 1997; Murray, 2000; Murray et al 2001), Kiambu District in the Kenyan highlands (Gitau, 2000), and Wards 19 and 20 in old urban Kathmandu (Waltner-Toews, 1996). The Peruvian work started with a focus on complex systems theories and shifted in a second phase, to addressing health, nutrition and natural resource management in Amazonian villages. The Kenyan project was designed to work with agriculturally based villages in the highlands to help them determine viable pathways to achieve healthy agroecosystems. The Nepalese project, building on earlier community health initiatives in two urban communities, is working with those communities to promote ecosystem health. All three projects have received basic funding from the International Development Research Centre in Ottawa, under their Ecosystem Approaches to Health Program Initiative. Since all three projects are still in progress, much of the information about them has yet to appear in the peer reviewed literature. Ongoing reports from the projects are being posted on the NESH website (www.nesh.ca) as they become available.

In developing AMESH, concepts, assumptions and methods were drawn from all of the above approaches and integrated into a coherent approach, and then modified and adapted in the context of the specific projects. AMESH itself is a complex set of activities, and there is no “correct” way to present it. Fundamental to both the theory and practice, which demand context specificity, no single case study would be expected to reflect all the principles we wish to illustrate, nor can there be any straightforward technical (cook-book) systemic description. In order to clarify the approach, we have divided our discussion into a section which elaborates guiding principles, each based on a particular relevant insight from complex systems theory, a series of activities which are the essential elements of the approach, and questions to guide those activities. Examples, to illustrate these, are drawn from our three case studies. We have set these activities out in Figure 1 in such a way as to emphasize the key elements of AMESH, and to clarify its on-going, adaptive nature.

III. Guiding Principles

1. Methodological Pluralism and locally grounded Multiple Perspectives

> "A complex system is one which allows us to discern many subsystems (a subsystem is the description of the system determined by a particular choice of mapping only a certain set of its qualities or properties) depending entirely on how we choose to interact with the system" Rosen (1977)

Complex socio-ecological systems can be understood only from multiple, non-equivalent perspectives, with no single perception adequate to provide a comprehensive or adequate view of reality (Puccia & Levins 1985). Indeed, degree of complexity has been equated with the number of non-equivalent descriptions of a system (Casti 1986). These non-equivalent descriptions may furthermore result in non-equivalent evaluations, and hence imply different strategies for future development.

The need to incorporate multiple perspectives has important methodological implications. The plurality of different legitimate perspectives and the inability of one particular view to capture the whole, necessitates a variety of forms of inquiry, inclusion of, and dialogue with, persons representing different interests and different world views (Waltner-Toews & Wall 1996). Multiple modes of investigation and multiple sources of evidence are necessary to understand the system (Holling 1995).

This assertion, often repeated in recent environmental, health and sustainable development literature leaves unanswered the question as to how various perspectives are selected and legitimized. Greater multi- and inter-disciplinarity in the research into and management of complex socio-ecological systems is necessary, but not sufficient. Left to themselves, researchers will inquire into those aspects of the system which they, for their own personal, disciplinary or political reasons, deem to be important. This is not a very sure foundation for learning our way into a sustainable future. Because these systems develop out of particular historical conditions, with no single preferred future state, and the goals selected for management are necessarily value-laden, the values, concerns and knowledge of local stakeholders and actors must be central to any inquiry.

AMESH has incorporated these characteristics of complex systems not just by creating spaces for qualitative and quantitative modes of inquiry, but by making involvement of local stakeholders through participatory methods central to the process of inquiry and management Pretty 1995; Ramirez 1999).

The importance of this was made apparent to some of us during the first phases of the research in Ucayali District in Peru. Conventional, multi-disciplinary analyses of land use in the Ucayali region described a ecosystem dominated by small-scale cattle ranchers struggling to maintain productivity in the face of declining soil fertility, focused on increasing commercial production in an area with major market infrastructure, technology and capital constraints. Figure 2 is a typical, technical, land-use systems model which could be used to describe agricultural activities in the area. Although this research provided many important insights into farm level production, land use change

and ecological constraints, it failed to.link land use processes with other resource sectors and actors at various scales in the region.

As the researchers using AMESH began working in the area,we discovered that cattle ranchers were only about one percent of the total farm population (only 1 in 5 farmers with pastures possess cattle), but they owned significantly larger farms than the average, were located almost exclusively along the main road to Lima in one sub-region of Ucayali and had differential access to government subsidies and tax relief. Cattle ranchers did not represent the diversity of livelihood systems that most often involved, in addition to farming, fishing, hunting, gathering and logging activities. These farmers have different priorities and technological demands than cattle ranchers and therefore their needs were not met by the research agenda. Looking within the household, the stakeholder analysis highlighted the important role of women in production activities. They are the critical link between resource use, nutrition and health. Native communities represent another stakeholder group that although comprising over 10% of the regional population, were not included in research agenda.

As the description of the system was expanded to include stakeholder groups other than the cattle ranchers, three main findings emerged that described very different forces shaping the development and dynamics of the region. First, timber extraction is the main economic activity in Ucayali. It employs the largest percentage of people, generates the greatest amount of revenue and represents Ucayali's main export product. Second, annual crops provide the majority of the staple foods consumed and household income, and fish is the key source of protein and other micronutrients. On the average farm, cattle do not play an important role in either food production or income generation. Lastly, coca, the invisible crop, is cultivated over an area larger than that of the two main legal crops - plantains and bananas -combined.

This example demonstrates the need to include a diversity of local perspectives in order to capture the complexity of the situation

2. Hierarchical and Cross-Scale Interactions

Although local participation is central to the process, however, this primacy of the local is not without constraints. Complex socio-ecological systems can be described as nested hierarchies, in which each layer in the system has a dual nature, both as a whole (organism, population, community) and a part (Allen & Hoesktra, 1993). Each component of such a nested hierarchical system is called a holon, the overall nesting being referred to as a holarchy (Koestler, 1978). The different layers (household, community, region) evolve within a variety of ecological and socio-economic contexts and constraints (Allen & Star 1982). In general, the smaller holons (genes, individuals) provide creative opportunities, whereas the larger holons serve as constraints (individuals to genes, communities to individuals).

In general, hierarchy is about both **scale**, the level in the hierarchy at which the system is located, i.e. farm, village or region, and **type**, the perspective of the observer i.e.

agricultural, forestry, urban (Allen & Hoekstra. 1993). Scale considers ecological and socio-cultural holarchies as well as more conventional political hierarchies.

As one passes from one hierarchical level to another there are systemic properties that are "emergent" since they only come into view at a particular level (Broad 1923; Holland 1995). Such properties would not be captured by examining only the parts of the system. For example the potential of a home computer connected to the internet, is an emergent property of the different parts (computers all over the world) when put together in a specific way to make a structured and functional whole (the WWW). Conversely, knowledge of all the individual computers, world wide, and the mechanisms for connecting them in a network (the internet), would not allow one to predict the emergence of the World Wide Web (WWW). The knowledge of individual risk factors for health (poor diet, smoking, "lifestyle") is not necessarily useful for describing population health risk factors (disparity in income; power relationships; poverty) or global determinants of health (climate change; ozone depletion) (McMichael, 1999).

There are several methodological implications of the multi-scaled, hierarchical and emergent nature of ecosystems. Understanding of ecosystems requires more than one level of analysis, or implementation method. The system must be investigated at different scales and from the perspective of different types[7]. This allows for the discovery of emergent properties that are present at only one level and describes the interactions across multiple scales that frequently represent the defining contextual relationships of the system.

In our project in Peru, expanding the frame of questioning to include different scales (eg. sub-region, region, inter-region) and type (eg. fisheries, forestry, coca), revealed a complex array of cross-scale interactions that affect the sustainability of the region as a whole. As shown in Figure 3 and Map 1, Ucayali can be divided into several sub-regions: (i) Pucallpa sub-region; the heavily populated area along the Pucallpa-Lima road and the Aguaytia river, (ii) Natural forest and main timber extraction areas towards the Tamaya and Upper Ucayali rivers, (iii) Extensive swamps and lakes of the Ucayali floodplain, (iv) Isolated uplands and hills of relatively undisturbed forest in the Purus river valley. Understanding Uyayali in terms of these sub-regions explains both farm and regional sustainability. At the farm level, because farmers migrate to different sub-regions depending on the season, they are able to exploit the differences in agricultural, timber, hydrological and fish harvest cycles to supplement and diversify their income. Farm level sustainability is essentially "subsidized" by the extraction of forest and aquatic resources from other regions and ecosystems. At the regional level, the more densely populated areas along the road and in the city, are sustained by the vast timber

[7] It should be noted that the necessity of hierarchy theory for different types of perspectives substantiates the first guiding principle.

and fish resources dispersed across the great area of Ucayali, and the coca growing regions in the southern uplands.

At the inter-regional level, the flow of goods and people link Ucayali with other departments in the upper jungle, Andean slopes and the Amazon lowlands. This inter-regional network increases access to commercial opportunities, land and labour. Seasonal and annual migration to these different regions and ecosystems, diversifies resource use activities and income sources and reduces risk for the family. This migration of colonists affects the socio-cultural environment of Ucayali by increasing the transient nature of communities and affecting the overall level of cohesion of social networks among community members.

Highly centralized economic and political structures at the national level restrict local capacity to manage and regulate resource use in Ucayali. As most commercial interests are owned and managed from Lima, in particular the timber industrialists, re-investment in local infrastructure and accumulation of regional capital, social and economic, are not a priority. Any efforts to address regional sustainability must take into account this national-regional relationship and confront the imbalances of power that affect regional development.

3. Self-organization

One of the defining characteristics of complex systems is self-organization. This self-organization occurs because of feedback loops among variables within a particular set of constraints. For instance, the use of protein supplements to increase milk and cattle production, coupled with economic and environmental incentives, led to the recycling of ruminant protein in the British (and other) agri-food systems, which created the necessary conditions for the emergence of the Bovine Spongiform Encephalopathy (Mad Cow Disease) epidemic. A traditional analysis of the problem focuses only on the recycling of the ruminant protein, rather than on the internal logic of the system within which this activity has naturally emerged. Similarly, large scale foodborne disease epidemics such as salmonellosis are embedded in a self-organizing system characterized by interactions between: demand for fast food, a desire for fresh produce and low consumer prices, consolidation and mass production, ecological simplification within the food system, economies of scale, and pressure for lower wages for agri-food industry workers (Waltner-Toews & Lang, 2000). For both Mad Cow Disease and salmonellosis, the agri-food system self-organized around a narrow set of economic efficiency goals without consideration for the social and ecological feedbacks which this also entailed.

In the project in Kenya, researchers worked with villagers to create influence diagrams tracing feedback loops between important issues (both positively and negatively viewed outcomes). Based on these diagrams, new understandings were created both within the agricultural communities, and among the researchers. In one village, for instance, the goal of improving the local school facilities was achieved by improving water distribution, which would reduce water-hauling time for women and children, increase agricultural productivity, and increase income available for investment in school

facilities. In another village, their understanding of feedbacks led them to focus on road improvement as a way to increase income and allow them to obtain the materials and labour to expand classroom space. In Nepal, community members conceptually linked recycling of organic waste (through composting) to gardening and tree-planting. These activities, in turn, were expected to decrease direct run-off and flooding, and increase ground water recharge. This, in turn, would provide more water for improving hygiene and reducing disease. In all these cases, it became clear that working toward specific desirable outcomes, such as improved education or hygiene, required an understanding of the kinds of systemic feedback patterns within which these activities were embedded.

4. Unpredictability and Uncertainty

Not only do complex systems self-organize through feedback loops, but their openness predisposes them to dramatic re-organizations at critical points of instability (Nicolis and Prigogine 1977). These instabilities and the resulting jumps or abrupt changes in the system, are caused by self-amplified internal fluctuations mediated especially through positive feedback loops. These give rise to the spontaneous emergence of new structures and forms of behaviour. Amplification is thus a source of new organization and complexity in the system. At the points at which these new structures emerge, the system may branch off into one of a number of quite different organizational states[8]. The existence of multiple stable states, multiple possibilities, necessarily implies indeterminacy, as which path is taken depends on the system's history, and various external conditions that can never be completely predicted (Nicolis and Prigogine 1989). Thus the unpredictable nature of complex systems. For example, shallow lakes have been described as having two alternative organizational states. One state is dominated by a benthic (bottom vegetation) association and the other by a pelagic (eutrophic) association (Scheffer 1998). In a given summer, which association dominates in some lakes has been shown to be a consequence of the nature and timing of the spring melt, an unpredictable event.

Thus, in principle, in many situations it will not be possible to make quantitative models that accurately predict the future. As the transition to different states is unpredictable, the more conventional approach to decision making, that of using cause and effect explanations to build forecasting models which will anticipate the consequences of decisions, is not sufficient to deal with the complexity associated with socio-ecological systems.

The implications of this for research and management are profound. The role of scientist in decision making shifts from inferring what will happen, that is, making predictions which are the basis of decisions, to providing decisions makers and the community with an appreciation, through narrative descriptions, of how the future self-

[8] Often referred to as attractors

organization of the socio-ecological systems might unfold. Decision-making and management processes must be adaptable and flexible, able to deal with surprises and promote a capacity to adapt to changing environmental conditions (Holling 1995; Kay et al 1999). In all of our projects, this has reinforced the need to keep the process open-ended, with a monitoring program clearly part of the process; that is, there is no finite end-point to the research or management, only continual re-evaluation and adjustment. It has also reinforced the need to involve all the legitimate stakeholders, so that the tradeoffs, risks and benefits can be better understood and more equitably distributed.

IV. Methodology

From a practical viewpoint, there are two important aspects we have had to consider as we implemented AMESH. In the first place, the boundaries between research and development, and analysis and action have been constructed, through negotiation, as part of the process, rather then being taken as a given. Secondly, the roles and responsibilities of the actors are be defined at each step. In general, the steps related to describing the socio-ecological system (historical reconstruction, stakeholder and governance analysis, analyzing and synthesizing systems descriptions) tend to be the primary responsibility of the researchers. Similarly, seeking solutions, implementing them, monitoring and adjustment tend to be the primary responsibility of the community members. However, our experience has been that scientists, villagers, planners, bureaucrats and development practitioners work together throughout the process, with a lot of give and take.

From the outset necessary institutional arrangements and mechanisms are required to guide and control the entire process, ensure clear “rules” of negotiation, ways to involve stakeholders at the appropriate times, means to address conflict, and sufficient organization to maintain the continued involvement of the stakeholders until the process is complete. Collaborative platforms, such as specific forums, workshops, or regular group meetings, are needed to facilitate dialogue among relevant stakeholders (e.g. producers, scientists or governmental agents) and provide the necessary environment in which they can genuinely participate in the research and development activities.

The research process is comprised of a variety of activities, each characterized by a set of guiding research questions. Although they are depicted graphically as sequential, they often, in practice, occur simultaneously or “short cycle” a few times before moving to other activities (Figure 1). We may group these activities into five major areas: an entry point and initial description; an analysis of the relationships among stakeholders, issues and governance; the multiple narratives and systems descriptions which emerge from the previous analysis; a full systems analysis and synthesis; and the translation of this understanding into into ongoing collaborative learning and action.

The Presenting Situation

We intrude on various situations – communities, ecosystems – because of some research or development agenda, presenting complaints, perceived problems. There are essentially two parts to this element of the process. First, we need to articulate what

the agenda is (what problems are we trying to help resolve? What research or development issues are we addressing?). This step is important so that unspoken, or assumed, or hidden agendas, with their assumed power roles, do not "hi-jack" the process.

Once the presenting issues and agendas are on the table, we need to bring together the given history of the community we are working with.

The Given History

The goal of this step is to develop a narrative of the key changes, overall trends and patterns, as perceived by current or past stakeholders and researchers. This provides the baseline understanding of how the system has evolved to its current state. It is not exhaustive, rather establishes a rich context in which more specific research questions can be located[9].

- What has been the overall historical development of the system; eg. establishment of a frontier town, expansion of the frontier, economic booms etc.
- What have been the key ecological, economic, demographic, political, governance and social developments in the system? What kinds of rich inter-connections have occurred?
- At what level have the changes taken place? (eg. farm, village, region or nation)
- What or who have been the agents of change?
- Which are the critical fast, medium and slow variables within this overall development?
- Is there historical evidence suggesting sudden shifts or changes in the structure or behaviour of the system?
- What has stabilized the system? What has tended to destabilize the system? Have there been surprising changes? Perverse stability?
- What are the positive and negative feedback loops?

Projects may be undertaken at the behest of a research agency. In this case another important historical issue is the history of the research agency in the community. The past experience of the community with the research agency will impact upon all future work the research agency hopes to do. It is also important to understand past projects that other groups have attempted, especially in a similar problem area. Past failures will colour the community's perception of the utility of working in a given area, while past successes might narrow the range of alternatives a community is willing to consider.

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[9] It is important to note that any history reflects the interests of the researchers as well as the adequacy of the records available. They are open to re-orientation as the research unfolds, as involvement of new stakeholder groups may cast different patterns of light and shadow on the available evidence.

- What past projects have the research agency, or other groups, undertaken with / in the community?
- Who was involved in these projects?
- What was the outcome of these projects?

Most of the work of constructing a history is based on synthesizing secondary sources of data such as government reports, maps, and previous research done in the area. In all areas, research projects based on more narrowly defined, or at least different, questions preceded the current projects.

In Nepal, a three-year project to understand and prevent transmission of the parasitic zoonosis echinococcosis (Hydatid Disease in people), concluded that more systemic, participatory and integrative approaches were required to resolve even narrowly defined medical problems. This initial project was followed by a consultancy to gather and synthesize background information needed for the new project; this involved both key-informant interviews and secondary data sources. This was followed by a major workshop, with representatives from the communities, government agencies and several non-governmental organizations. The second, expanded community-action phase of the research was designed at this workshop. In Kenya, previous research with smallholder dairy farmers in the area had established a high level of trust between the Kenyan researchers and the villagers, as well as providing baseline information. The project in the Peruvian Amazon was based on a wide variety of research projects in the area. Using complex systems theories, a synthesis of these projects was assembled and served as the starting point for understanding what had occurred. In both Kenya and Peru, a series of participatory activities and workshops were held in each village to supplement secondary data. In all cases, we found that the research team needed to include people fluent in local languages (Kikuyu, Newari and Amerindian languages) as well as the more global languages (Swahili, Nepali, English and Spanish)

Historical data were not gathered with a complex systems framework in mind, and, indeed, only in Peru were they organized in such a way that they could be interpreted in complex systems terms before the more participatory aspects of the project commenced. This is particularly true for the description of feedback loops and attractors. In all cases, holarchies and hierarchies were relatively easy to define, and informed both the range of stakeholders (individuals, families, neighbourhoods, etc), and the decision-making spheres of influence in terms of the ecosystem. In both Nepal and Kenya, a complex systems interpretation of both historical and current information emerged from the multiple narratives of the stakeholders, rather than from the a prior data collection. The advantage to this is that the community members can be part of this process; the disadvantage is that this historical interpretation has less opportunity to influence the design of the research itself.

The goal of this historical work is to gain a deeper understanding of the dynamics, constraints and opportunities that have characterized the system, and perhaps offer some insights into future options.

Analysis of Stakeholders, Issues and Governance, and their Relationships

Once a situation has been identified as being problematic (the health in our village is poor) and an effort has been made to understand how the situation came into being, the next stage involves three concurrent and mutually informing activities. These are:

- identifying who is involved in the situation now and hence will influence resolving the situation;
- what the problems and related underlying issues are understood to be;
- how decisions get made and implemented.

These activities lay the groundwork for developing an understanding of the situation and its resolution.

Stakeholder Analysis

Any complex system can be viewed through multiple windows of observation(Engel 1997). Each "window" may be seen as representing the perspectives of a variety of stakeholder groups. (Sometimes, a stakeholder group may be characterized by a single perspective, but this is uncommon, and problematic, in that it conflates conflicts between issues and conflicts between groups.) Since the stakeholders define the problems and issues and hence the solutions, identifying who the stakeholders are (as well as their issues and powers in the system) is a critical step in the process. The goal of this step is to determine who could, or should, take part in the further steps of the research and management. Stakeholders perceive their reality through different methods and means and describe reality according to different objectives (Ramirez 1999). The stakeholder analysis (SA) draws attention to such different "versions" of reality and provides a systemic means to expose, incorporate and reconcile them within the research agenda. AMESH is by definition interventionist and therefore must address the concept of *agency* or capacity to intervene. The SA establishes who has the legitimate role to intervene, under what conditions and with what purpose (Ramirez 1999). Guiding questions in this section include:

- Who are the principle stakeholders?
- What is the process for identifying stakeholders?
- Under what and whose selection criteria will they be considered stakeholders?
- What are the critical discriminating features that allow us to differentiate the groups of stakeholders?
- What other groups, perhaps not directly related to the issue at hand, exist in the community?
- Which groups have been excluded?
- What are the factors that stakeholders perceive as being within and outside of their control (exogenous and endogenous)
- What are the power dynamics or relationships among and between stakeholder groups?
- What are the barriers and constraints to communication and collaboration between the different stakeholder groups?
- What are the main resource coalitions?
- What goals/interests do these coalitions share?

- Which stakeholders are excluded from these coalitions and what are the consequences of this?
- What are the conflicts of interest, which organizations are in conflict and why?
- What are the important gender relations among and between stakeholder groups? How do gender differences define people's rights, responsibilities and opportunities to participate?
- What are the assets and resources (skills, financial, materials, connects etc.) of each stakeholder group?

The research team is a stakeholder in its own right and needs to be examined as such, with similar guiding questions:

1. What is the role of the researcher as stakeholder, and what power does the researcher wield to convene the others?
2. How was the research team selected?
3. Are they local or non-local?
4. What is their level of experience with the research issue?
5. What training have they received?
6. What skills training does the team need?
7. Does the research team have the necessary skills to conduct the AMESH analysis?
8. What is the research agency's mandate?
9. How might this mandate bias the AMESH process?
10. What is the power relationship between the research team and the local stakeholders?
11. What gives the research team legitimacy to work in the community?
12. What power structures does the research represent to the community?

Local leaders are used as an entry point into the community and as a source of a list of potential key informants for the research team – as was the case in Nepal, the Ward Committee recommended potential candidates for the four Community Researcher positions – in this way the bias of the Ward Committee or local leaders, in terms of who they know in the community enters the research process. Realistically, using the local leaders to recommend key informants may be the only way to successfully gain entry into the community. Thus it becomes very important for the research team to understand the political dynamics of the community early on so that they can aim to contact as broad a cross-section of the community as possible and ensure that they are not favouring one group over another or only listening to one political perspective.

Because both these sets of questions have important ramifications for the entire direction of the process, they tend to be politically loaded, and need to be asked in a variety of ways. They are naturally asked as one develops the historical picture of the area, as well in the participatory research (interviews, structured workshops, etc). In Kenya, a relatively straightforward picture emerged; there were no formal governance structures at the village level, for instance. Since the villages we were working with were quite small (hundreds to a few thousand) and local village organizations were few and obvious (churches, community-based organizations), we were able to work with stakeholders to develop new, inclusive, Agroecosystem Health Committees.

In all cases, we have needed to revisit these questions as the research progressed. In Peru, we found that a "stakeholder representative" group created by an earlier research project specifically designed to create such a group reflected intellectual and business interests based outside the Amazon, in Lima. In Phase II of the project, our team leader had to begin again, from the ground up, creating a coalition of local government officials, individuals, and representatives of non-government women's, Amerindian, and other organizations.

An important aspect of stakeholder analysis has been to identify the level of holarchy/ hierarchy to which the participants pertain. Thus, in working at the neighbourhood level in Kathmandu, we needed to identify national players who were making decisions that strongly affected the communities, ward level organizations (governmental and non-governmental), neighbourhood level (toles and marabuhils), households and individuals. Given the fairly rigid social stratification, we also needed to identify, for instance, hierarchies of street cleaners, shopkeepers, and butchers.

Ecological and Social Issue Analysis

Once key stakeholder groups have been identified, several participatory techniques can be used to determine the issues (problems and opportunities) most affecting them and their vision of the future. The relevance of an issue stems directly from its relationship with a stakeholder group. As in the historical reconstruction, the scale of each issue must be made explicit. This will help identify the endogenous and exogenous variables of each issue and the cross-scale interactions among issues. The goal at this point is to identify the key elements in the systems descriptions that local stakeholders consider important, and hence represent the motivating force behind making changes or protecting the status quo. These issues are "mapped on" to systems descriptions arrived at through more conventional kinds of ecological and sociological inquiry.

- What are the critical issues?
- How do they relate to one another?
- At what spatial and temporal scale do they occur?
- For which stakeholder groups are these issues critical?
- How does the resolution of these issues come together in a vision for the future?

The issues of importance to the stakeholders emerge as a normal part of most participatory action research processes: that is what they are designed to do. What most of these processes do not elicit, however, is a clear sense of how local people see the connections between, say, education, water quality, childhood disease, soil erosion, roads and agricultural production. We found that in Kenya villagers were able to move well beyond lists of issues, constraints and action plans to systemic loop or influence diagrams linking both positive and negative outcomes (see next stages). In Nepal, these interactions were seen by community members and researchers as part of a kind of meta-narrative; only later in the project did systems diagrams emerge, and conflicts, interactions and complementarities were clarified. As described earlier, as our systemic understanding of the Peruvian situation was enriched, the issues of interest broadened from cattle and pastures to include fish and river systems.

It is important to separate the perceptions the research team has of these issues and the issues as they are identified and articulated by the community. A part of this analysis needs to be a comparison of the two sets of issues with an attempt to reconcile differences in perceptions regarding the magnitude and importance of specific issues. All research teams are mandated to work in a pre-defined set of issues. The most important ecological and social issues for the community will not necessarily coincide with the mandate of the research team. The research team needs to be honest with the community regarding their own capabilities and limitations, so as to not set false expectations for the community. Is also important to ask whether the vision and objectives of the research team coincide with the critical issues of the stakeholders.

Policy and Governance Analysis

Identification of stakeholders is not only closely related to identifying important issues, but also to describing the relevant policies and governance structures that constrain or facilitate local capacity to cope with such issues. The goal at this point is to arrive at an understanding of the mechanisms by which solutions are currently be sought and the feasibility of introducing changes. We are also looking more broadly at the policy context which may need to be altered to allow local communities to achieve sustainable goals.

- What are the key policies affecting the capacity of local stakeholders to sustainable manage their natural resources?
- At what level are these policies formulated and implemented?
- How do informal and formal governance structures affect local capacity to adapt to and deal with stresses?
- At what level are these governance structures formulated and implemented?

The researchers need to be aware of their own role in the politics, both formal and informal, of the situation. A research team often needs to gain the sanction of local leaders before starting its work, especially in a very hierarchical society. However, that very process can instantly toss the research team into the political landscape of the community. The community might quickly identify the research team with a particular political group in the community, thereafter influencing how the community perceives the research team.

People and their Stories

What emerges from the previous stage of teasing out stakeholders, their issues and their policy context, are a series of narratives, pictures and systems descriptions of both what the situation is, and a vision of what the situation ought to change to. These do not emerge without some deliberate efforts, of course, on the part of the researchers. All the tools of Soft Systems Methodologies and Participatory Action Research (mapping, time lines, Venn diagrams, influence diagrams, rich pictures, story-telling, Freireian consciousness-raising, visioning exercises and the like) come into play here (see the PAR website at http://www.rcpla.org/, as well as Pretty et al 1995). These stories, in

their various forms, serve as the foundation for a more formal process of developing a systematic understanding of the situation

Systems Descriptions and Narratives: Developing a Systemic Understanding

This part of the process has two major components: analyzing the system, both qualitatively and quantitatively, and synthesizing the system, that is, bringing together our best current understanding of how the various narratives interact with each other to create the emergent whole which we recognize as “the system”. The purpose of this exercise is to generate an understanding of the situation which suggests some possible directions forward

Systems Analysis

By combining the results of the stakeholder analysis and the issue analysis with the story lines within which they are embedded, researchers can begin to distinguish foreground from the background, and stakeholders as a group can decide what is to be ignored and what is to be focused upon. Stakeholder groups, including poor villagers, are quite capable to creating sophisticated loop diagrams of their systems. Researchers can help them go a step further, however, to detect influential points in the system and some possible consequences of intervening at those points. In both Kenya and Nepal, Thomas Gitau and Cynthia Neudoerffer respectively, have taken complex systems diagrams, drawn from conversations and workshops with local villagers, and identified where possible feedback loops amplify or dampen relevant social or ecological processes.

Stakeholder participation is essential to understand what the important issues are, and how decisions regarding them are made. Once the issues as raised by various stakeholder groups are identified, however, they need to be linked to systemic understandings from various perspectives. During this stage of developing system descriptions there tends to be a transition from active stakeholder involvement to an activity done in the more traditional mode of academic, “non-engaged” research.

In Kenya, the complex loop diagrams were first assessed qualitatively by the field research team and villagers, and then used as a basis for implementing some actions. In the meantime, members of the research team have been subjecting the diagrams to more formal analyses, using methods described by Puccia and Levins (1985).

In another project in Chennai, India, the Cooum River Environmental System was studied in order to identify means of improving the health of the river and its environs including human settlements (Bunch 2000). After the process of issue identification, generating rich pictures and influence diagrams and developing system descriptions, the researcher returned to his office and generated a GIS and environmental modelling system based on the community input. These tools allowed him to perform a systems analysis of the situation. One surprising result was that the analysis demonstrated that one particular intervention, which was commonly felt to be badly needed, would make the situation worse. Specifically it was felt to be important to put a sewage collection

system into slum areas. Currently these slums act as multiple diffuse sources of pollution of the river. However it was demonstrated that putting in place a sewage system in the slums would overload the existing treatment plants resulting in ALL the sewage entering the treatment plants flowing to the river untreated. The effect of adding a sewage system into the slums would have been to increase the total pollutants entering the river and also create one very large point source of pollution which would overwhelm the assimilative capacity of the river. This pointed out the need to dramatically increase the sewage treatment capacity before adding sewage systems to the slums. The tools developed by the researcher to examine these interactions were subsequently taken over by the community to allow them to design their own interventions and to integrate their monitoring efforts.

Systems analysis is about building a systems description, essentially a conceptual model of the situation which describes what the key elements of the situation are and how they are interconnected and interrelated. This description will be multilayered both in spatial and temporal scale and type of description. The systems description is used to identify the important processes that shape the situation. The behaviour and dynamics of these processes are then explored and narratives about system's behaviour are constructed.

The questioning in systems analysis can begin in a qualitative and relatively simple manner, and this alone often provides very powerful insights and suggestions for action. When information and/or theory allow the analysis can proceed to a quantitative stage involving statistical models, simulation and spatial analysis using GIS. .

Usually the researchers begin with an analysis of the system from each perspective, before integrating them. For each of these analyses it is important to answer the following questions:

- What is the core purpose or essence of the system from each perspective?
- To whom are they of interest and why?
- How do we define and delimit the system?
- What are the spatial and temporal boundaries and scales of observation?
- What are the key ecological and social processes that define the system?
- What are the different subsystems of interest?
- What are the relevant subsystem behaviours?
- What are the relevant subsystem variables?
- What is the nested hierarchy in which the system is situated?
- What are the defining contextual relationships between the system and its subsystems and the larger system in which it is embedded?

In some cases, where very good historical data are available, one may even begin to frame the questions in explicitly complex systems terms and to build narratives about how the system behaves. For instance:

- What are the discrete organizational states[10] which may be accessible to the system?
- How the system behaves in the neighbourhood of each discrete organizational state, potentially in terms of a quantitative simulation model?
- What are the positive and negative feedbacks and autocatalytic loops and associated gradients which organize the system about a discrete organizational state?
- What might enable and disable these loops and hence might promote or discourage the system from being in the neighbourhood of a discrete organizational state?
- What might be likely to precipitate flips between discrete organizational states.

After these systems analyses, from different perspectives, have been undertaken it is necessary to synthesis them into a multilayered coherent understanding of the situation.

Synthesizing the System Descriptions

In systems synthesis, the different system analyses are rejoined and assessed in terms of health and sustainability of the whole system. Again, this may be done in terms of searching out the linkages among narratives, and the way in which the larger narrative of the community emerges. It may also be done using a variety of sophisticated models. This synthesis enables researchers to identify what are thought to be key points of intersection between various sub-models and various worldviews. This "reconstructed" model of the whole or future narrative forms the basis for making hypotheses about probable outcomes as the result of particular interventions. These models and narratives are fundamental to the development of policies that are capable of accounting for multiple perspectives and multiple goals. They will enable decision-makers to define their range of feasible management options and assess trade-offs.

- How do the different system models articulate with each other?
- How do the parts of the system that can be modeled (e.g. Hard systems, historical components) articulate with those that cannot (e.g. Soft systems, future-expectation models)?
- What are the possible future states of organization of the system?
- What is our understanding of conditions under which these states might occur?
- What are the tradeoffs which the different states represent?
- What is the range of feasible and desirable management actions?
- What are appropriate schemes for ensuring the ability to adapt to different situations?
- What is the appropriate level of confidence that the narrative deserves, this is our degree of uncertainty.

[10] Often referred to as attractors.

While the description, analysis and synthesis of the system can be done as part of re-interpreting history systemically, and hence can (should) be done from the "outside" as well as the "inside", the remainder of the process, in which research slips into an interventionist mode, can *only* be done with full participation of local stakeholders and actors.

Collaborative Learning and Action

With a rich systems description and understanding in hand, we can begin to work with ecosystem stakeholders to find ways to negotiate trade-offs, generate visions, implement changes and monitor those changes in such a way that we learn from them. In short. we can help the community put in place an adaptive collaborative learning process for ecosystem sustainability and health.

Cross Talk and Seeking Solutions

Using the system understanding developed in the last stage, the next more delicate step involves reconciling the different perspectives of reality that bring together the different groups of stakeholders. This is a social process that involves conflict resolution and compromise, and is very much dependent on the decision-making capacities and processes of the different stakeholders. In the end, the process should generate a common vision for the future.

- What are the areas of conflict and complementarity among stakeholders?
- What are the feasible interventions that account for the multiple perspective goals and multiple perspective impacts?
- How can the different perspectives be synthesized?
- How are the different perspectives and descriptions of reality reconciled?
- What are the necessary trade-offs?
- What are the desirable management options?
- What is the combined vision of the stakeholders?
- What are commonalities and differences within that vision?
- How can the stakeholders design a more sustainable future?

The visions and aspirations that the stakeholders hold for the future may be elicited by asking questions such as:

- How can the stakeholders design a more sustainable future?
- What story do you want your grandchildren to tell about their home? How would you like your community to look in twenty years? What changes would you like to see?
- What needs to happen to realize these goals?
- What barriers and constraints are stopping you from achieving these goals today?
- How might these be overcome?

In Kathmandu, systems diagrams of actors, activities, concerns, impacts and needs identified differing perspectives as to who was "at fault" for accumulation of solid waste in the street. The low class street sweepers tended to see the problem as one of

irresponsible actions on the part of residents; wealthier residents saw the issue as one of inefficient garbage collection. These differing perceptions were laid out explicitly at a workshop attended by members of all castes and social classes - from political leaders to professionals, street sweepers and butchers present – was to ask them the question: what do you want you grand-children to say about the community you live in? . They then broke into small groups to work on this, and devise pictures of where they wanted to go, and possible strategies for getting there. The amount of time allotted did not allow for a full future development strategy; rather, it served to re-focus their thoughts on many of the common ideals and plans they had articulated throughout the years of the project. It thus served as a heuristic and motivational tool. Later, members of the Kadgi caste, which includes the butchers, and who are in the contradictory position of being both low caste and the source of the economic wealth for the communities, held a special ceremony to thank the researchers for having created a sense of collective community which transcended caste.

Design of an Adaptive Approach for Implementation of the Vision and Collaborative Learning

It is one thing to negotiate a set of trade-offs and possible futures that the entire community is willing to strive toward – or at least to live with. It is quite another to come up with explicit strategies and organizational plans for achieving that future. In many situations, especially in industrialized countries, detailed engineering plans, complete with recommendations on land-use zoning, and institutional and budgetary arrangements, need to be made explicit, by law. This was certainly true for the development of the master plan for the Huron Natural Area in Kitchener, Ontario, which was the result of a long series of studies and meetings involving local politicians, land-owners, developers and researchers (http://www.fes.uwaterloo.ca/u/jjkay/HNA/).

In other situations, a direct and explicit approach may be too threatening to local political power structures, and a more indirect method of working with emergent, virtual governance structures may be more appropriate. Also appropriate institutional sturctures may not exist, requirung that new ones be invented and these may have to exist outisde the traditional infrastructure. In Kathmandu, one of the strategies for dealing with solid waste was to have community clubs – usually comprising activist young people – facilitate recycling and garbage collection activities. This kind of emergent, “virtual”, governance enabled them to avoid direct confrontation with authority, and to find ways for political leaders, shop keepers, butchers and community residents to work together more effectively. This has allowed them to be successful in building river-side parks and recycling programs. Such strategies may involve working with community service clubs, as in Kathmandu, or semi-official non-government or quasi-governmental groups such as “round tables” including business and public health or community activist leaders.

Some of the questions which might be asked at this point are:

- What are the management directives, goals and objectives?

- What are the desirable and feasible changes in the systems, in order to reach the identified goals?
- What institutional arrangements are necessary to support these changes?
- How can they be implemented?

Implementation

Once a plan – official and explicit or unofficial and understood – has been created, it must still be implemented. At this point in the process, it becomes clear just how successful (or not) one has been in recruiting local actors and stakeholders, and the extent to which they have come to "own" the successes and failures of systemic change. In the Kenya project, we considered it a success when one of the villages attempted an intervention: confronting the railway company which built the embankment that was seen as the cause of the road erosion. This confrontational approach failed, after which the villagers concluded that they, not the researchers, needed to find a new strategy. They then approached the research team for advice and facilitation to identify engineers in the railway company who could help them, which the researchers did. This second cooperative strategy is still underway. There is much in the management sciences literature on change, agents of change, organizational development, and innovation. Some of it will be helpful at this stage in the process.

Some key questions which need to be asked in this step include:

- What are the steps, and in which order, which need to be part of the implementation process?
- Who will take responsibility for ensuring that each of those steps is implemented?
- How can they be implemented?
- How can people be motivated to adopt the suggested changes?
- How will implementation be sustained, both in terms of finances, and in terms of personnel and logistics?

Monitoring and Evaluation

In an adaptive process, monitoring and evaluation provide the feedback to close the loop on the process so that it truly becomes ongoing and adaptive. Appropriate indicators to monitor progress and performance of the newly developed plans and strategies are developed by local stakeholders and researchers[11]. These are incorporated into an ongoing monitoring and evaluation process in which the current situation and pertinent issues, described at the beginning of the research process, are re-assessed and consequently the AMESH cycle may begin again. In Kenya, the multi-disciplinary research team and the villagers each developed separate lists of indicators

[11] For a review of literature on this topic see Boyle (1998).

representing what were deemed to be important attributes of agroecosystem health. We found that villagers, not surprisingly, were more likely to measure and respond to their own indicators rather than those devised by researchers. While being scientifically validated, many researcher-identified indicators proved difficult, costly and time-consuming to measure. A more feasible design would seem to be that villagers identify what they see as being important, and how to measure it (e.g. soil quality, assessed by running it from hand to hand); the researchers then determine what this indicator means in more quantitative scientific terms, as well as scanning for variables that are being missed. In Kathmandu, a mix of scientific monitoring of water quality by one of our Nepalese research partners, with community monitoring of visible outcomes such as street cleanliness, has emerged.

A whole series of questions can and should be asked about indicators, regarding both practical and scientific issues. These have been discussed in detail by Boyle et al (2001). However, we might highlight a few of those questions here. For instance:

- What are the relevant indicators that can measure performance in terms of the identified goals?
- Who "owns" the indicators – that is, who will use them for making decisions?
- Who will measure them?
- How will decisions be made on when to take action?
- Who will take action?

In closing the loop of this approach, researchers will find that they have become part of the community and its history. Even when they leave, it is important to be clear and cognizant about what they have changed by their interventions, and the sustainability of the processes they leave behind. At its best, AMESH will have altered the community's perception of itself, to the point where they see themselves more eco-systemically, and have the confidence and organizational structures to make decisions and take actions despite the uncertainty of the outcomes. While the creation of riverside parks in Kathmandu and water management projects in Kenya are gratifying, it is this aspect of AMESH – the emergence of ecosystemic vision and self-reliance – that we believe are its most important legacy.

V. Conclusion

AMESH is a methodology that is theoretically grounded in our most current understanding of complex systems, and is, at the same time, practical and participatory. It is currently being tested in urban, rural and frontier contexts, and appears to be adaptable to a wide variety of settings. Some parts of the methodology – particularly the more practical aspects of how one undertakes such interventions, and the later steps of monitoring and adjustment - have been well tried. Other parts – like the substantive issues of how one can best formally analyze and then synthesize such multi-dimensional systems in ways that make both scholarly and "common" sense – are still at early stages of being worked out. Nevertheless, we have found that, by emphasizing both participatory methodologies and systems understandings - the process itself

promotes the ends – health, sustainability, and ecological integrity – that it seeks to achieve.

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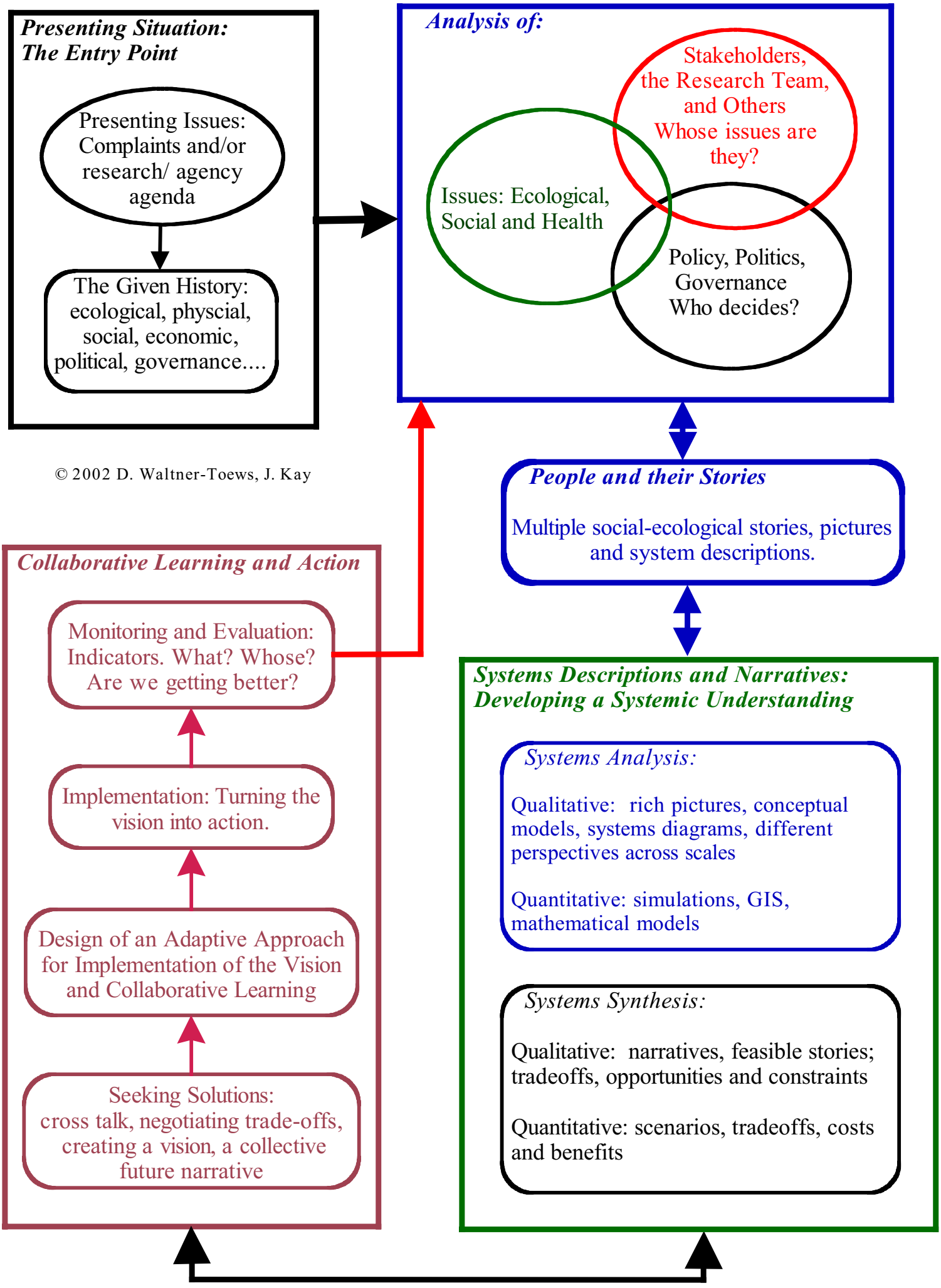
Figure 1: Adaptive Methodology for Ecosystem Sustainability and Health (AMESH): The Research Process

SEE NEXT PAGE


Presenting Situation:
The Entry Point
Presenting Issues: Complaints and/or research/ agency agenda
The Given History: ecological, physcial, social, economic, political, governance....
Analysis of:
Stakeholders, the Research Team, and Others Whose issues are they?
Issues: Ecological, Social and Health
Policy, Politics, Governance Who decides?
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People and their Stories
Multiple social-ecological stories, pictures and system descriptions.
Collaborative Learning and Action
Monitoring and Evaluation: Indicators. What? Whose? Are we getting better?
Implementation: Turning the vision into action.
Design of an Adaptive Approach for Implementation of the Vision and Collaborative Learning
Seeking Solutions: cross talk, negotiating trade-offs, creating a vision, a collective future narrative
Systems Descriptions and Narratives:
Developing a Systemic Understanding
Systems Analysis:
Qualitative: rich pictures, conceptual models, systems diagrams, different perspectives across scales
Quantitative: simulations, GIS, mathematical models
Systems Synthesis:
Qualitative: narratives, feasible stories; tradeoffs, opportunities and constraints
Quantitative: scenarios, tradeoffs, costs and benefits

Figure 2. Land-Use Transformations in the Ucayali Region

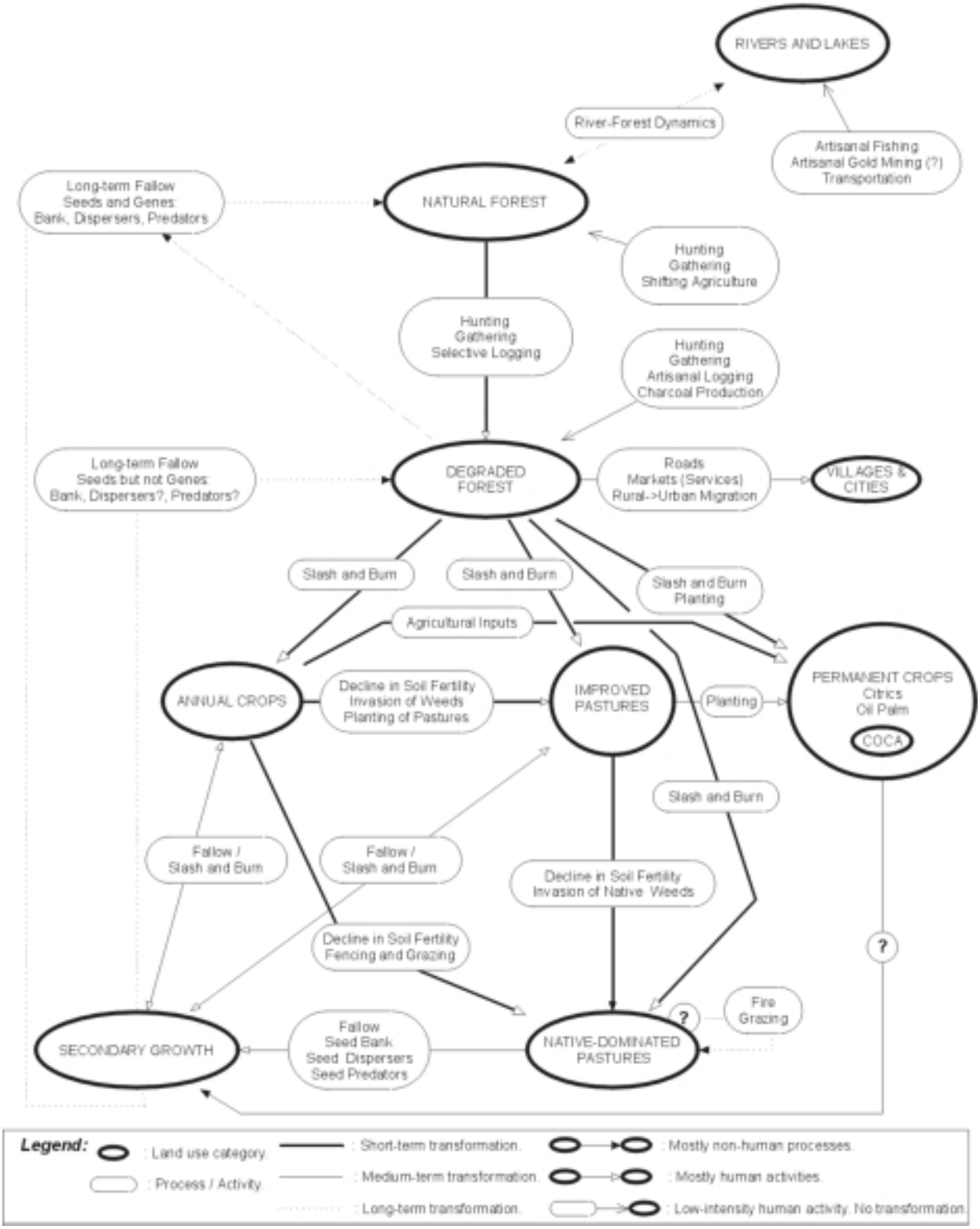
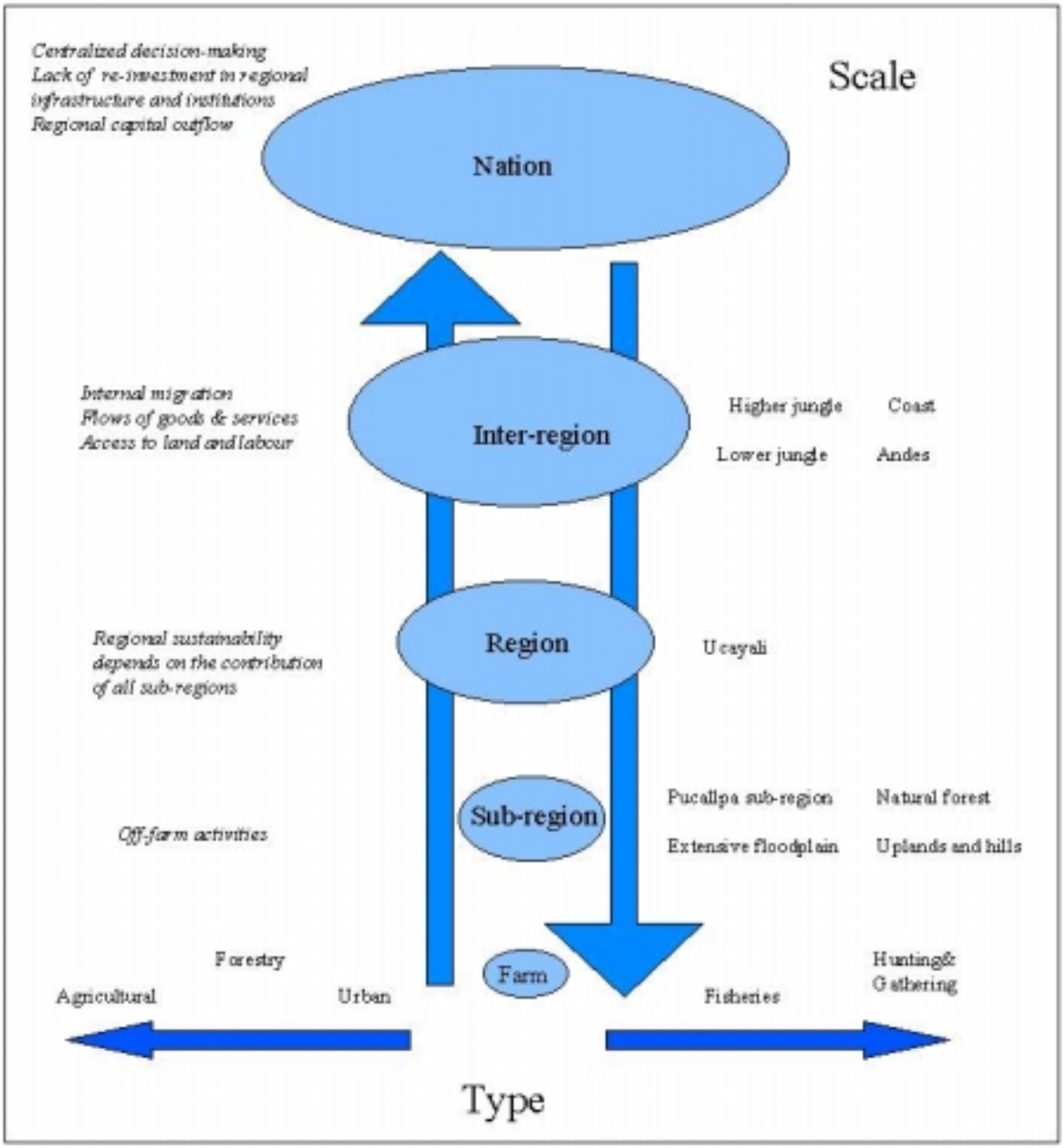


Figure 3: The Hierarchical and Multi-Scaled Ecosystems of Ucayali



Map 1: The case study site