HG-03-109 / September 15, 2003

MULTIVALENT ANALYSIS TOOLS (MATS) PROJECT:

A Description of NetWeaver™ and GeoNetWeaver™ and of the MATS Training Program and Preliminary Outputs

By

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September 15, 2003

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"Facilitating Excellence℠"

Submitted to
US Agency for International Development
Africa Bureau / Office of Sustainable Development

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This report was made possible through support provided by the Office of Sustainable Development, Africa Bureau U.S. Agency for International Development, under the terms and conditions of Under Purchase Order Number: HFM-O-00-01-00129-00. The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of the U.S. Agency for International Development.

Introduction

This document highlights two decision support software tools—NetWeaver™ and GeoNetWeaver™--and their current and potential contributions to sustainable development and humanitarian assistance. This publication draws together the outputs of previous reports found at The Heron Group, LLC website: www.herongroupllc.com. The report briefly explains some of the unique aspects of NetWeaver™ and GeoNetWeaver™ that underlie their power and potential. It also describes some of the preliminary models that trainees have developed as a result of working with the software tools in a training program, funded by the U.S. Agency for International Development (USAID), Bureau for Africa, Office for Sustainable Development in 2002-2003.

Challenges of Sustainable Development

One of the major challenges to development and humanitarian organizations, like USAID, is to achieve sustainable development.

Contexts for Sustainable Development Efforts

- Complex Systems
- Dynamics of Change
- Unfixed Boundary Conditions
- Fuzzy Definitions of Variables
- Subjective Assessments
- Irrational or Different Kinds of Rational Beliefs

Sustainable development is an extremely difficult concept to comprehend, much less achieve. It has multiple and diverse ecological, economic, social, political, institutional, and other components that contribute both directly and indirectly to the diversity and complexity of the challenge. Consider just one element of sustainable development, the environment. Direct and indirect interrelationships with agriculture, water quality and quantity, human health, forestry, and public policy to name just a few exist. In addition, environment also involves numerous interdependent states and processes such as erosion, siltation, change of habitat, and desertification. Professionals must better understand and manage for these challenges. Yet, it is a monumental task to understand these complex interactions manage these challenges and at the same time, strive for sustainable development. For humanitarian assistance, required in order to reduce the impact of natural disasters, more prudent and sustainable development efforts must be in place, in such a way that achieving the sustainable development challenge can reduce the humanitarian assistance requirements in many cases.

New Decision Support Tools to Deal with Complexity, Uncertainty, Quantitative and Qualitative Data, and Much, Much More

Rigorous and relevant new tools are available for improved strategic planning, ecosystem management, data needs assessments, monitoring and evaluation. We focus on NetWeaver™ and GeoNetWeaver™ here because the U.S. Agency for International Development's (USAID) Africa Bureau supported their use to analyze determinants for successful Community Based Natural Resource Management (CBNRM) in Africa and the Agency's Eastern Europe and Eurasia Bureau used them to spatially reference performance monitoring data on progress toward achievement of results of its environmental Strategic Objective 1.6. Because of these uses in USAID and others for the Forest Service, the U.S. Fish and Wildlife Service, the National Park Service, and the Environmental Protection Agency, NetWeaver™ and GeoNetWeaver™ have a proven track record as tools to support decision-making and improved environmental and natural resource management (NRM).

NetWeaver™ is an interactive, computerized tool that uses models, data and information to generate knowledge in support of decision-making. Using NetWeaver™, a knowledge technologist works with subject matter (or domain) experts to better reflect the complexity and "shades of gray" that exist in the contexts and about conditions in which sustainable development and humanitarian assistance take place.

NetWeaver™ uses a transparent, participatory, facilitated process to:

1. represent the experts' common group understanding of a complex system;

2. help experts create, manipulate, test, and refine heuristics (i.e., decision models or the rules by which professional and indigenous experts understand and respond to a given situation or problem) that demonstrate the logical relationships between and among variables and linkages between the individual parts and the whole;

3. integrate models from across disciplinary fields to better reflect the complexity of the actual management decision-making context;

4. provide the ability to trace the logic structure from data to conclusions as well as from conclusions to data;

5. run and evaluate freshly elicited knowledge "real time" while the domain expert is present;

6. help decision makers interpret and utilize the outputs of the decision model that provides mathematically robust knowledge about complex problems and that has been used to evaluate less than precise information

GeoNetWeaver™

1. analyzes (using the power of its NetWeaver™ foundation), in full depth, all data across multiple scales (e.g.,1:5,000; 1:50,000) and from multiple sources (e.g., district profiles, soil maps, watershed assessments) for criteria being used for decision making at any and all places;

2. displays spatially referenced data or data not specifically spatially referenced (i.e., it may be from a tabular database at a country level but is not specifically spatially referenced to a given site) in map format;

3. provides a visual presentation of a geographic information system

Based on NetWeaver™, GeoNetWeaver™ extends NetWeaver's power to represent knowledge in new ways for managers and decision-makers with its powerful GIS capabilities. GeoNetWeaver™ is a decision support tool that combines the power of object-oriented knowledge-based reasoning with the visual presentation of a geographic information system. However, it does not have the overhead of learning and using a full-blown GIS. The output of a session with GeoNetWeaver™ is a fully featured map, displaying knowledge-based outputs. GeoNetWeaver™ conveniently analyzes data across multiple scales (e.g., 1:5,000; 1:50,000) and from multiple sources (e.g., soil type and vegetation type maps, district profiles). Thus, the criteria on which professionals or policy makers base decisions can be analyzed in full depth at any and all places.

Challenges of Natural Resource Management Professionals Working Toward Sustainable Development

One of the greatest challenges for Natural Resource Management (NRM) professionals is to be able to model human thought and convey the "mental maps", represented by those models, about the way humans think the world works. In fact, these "maps" or models change over time. The models also are different from one person to the next because of the different values that different perceivers hold. Various ways of representing the way this works include some of the following: straight lines, certain boundaries, curved lines, fuzzy boundaries, crisp sets, fuzzy sets. Linguistic imprecision often leads to erroneous conclusions because of different meanings, and different metrics of those meanings, etc. Decision support tools like NetWeaver™ and GeoNetWeaver™ can address these issues directly and provide knowledge for improved decision-making. They use fuzzy logic since it helps deal specifically with those challenges.

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REALITY IS!

Human reasoning processes and linguistic imprecision make reality fuzzy.

Therefore, we need to have fuzzy sets, fuzzy rules, fuzzy arguments and fuzzy systems

Fuzzy Set--A set whose members belong to it to some degree.

Fuzzy Rule**—**A conditional form of *IF x is A, THEN Y is B.* A AND B are fuzzy sets.

Fuzzy Arguments—The fuzzy argument represents a fuzzy set membership function. Fuzzy membership is "how much" something belongs to a given set. Fuzzy transitions between True and False exist rather than abrupt, knife-edge transitions that the "crisp argument" gives, e.g., it is hot when it is 80 degrees F but not when it is 79.9 degrees—that's "crisp".

Fuzzy System—A set of fuzzy rules converts Inputs into Outputs. The closer the Input matches the *IF* part of a fuzzy rule, then the more the *THEN* part applies.

Using NetWeaver™, a knowledge technologist works with subject matter (or domain) experts to better reflect the complexity and “shades of gray” that exist in the contexts and about conditions in which sustainable development and humanitarian assistance take place. This compares to “black and white” representations most people give, even though nothing is purely black nor is it purely white. NetWeaver™ uses “fuzzy logic” that all but eliminates bivalent logic. Even though most decision makers are most accustomed to using bivalent logic, one of the greatest advantages of NetWeaver™ is that it is only necessary to define the very best or the very worst scenario since all other scenario levels are indicated by their level of membership in the “fuzzy” set (e.g., we’re 75% toward achieving our goal or we are 30%). This provides decision makers with a greater sense of the reality they must deal with in making decisions.

In spite of human habits, the way we understand the world is not always bivalent, i.e., Yes / No, True / False, or “if we’ve not totally succeeded then we have totally failed”.

Bivalent Logic
Every statement is true or false (e.g., A **OR** not A)

Multivalent Logic
Everything is a matter of degree, including truth and set membership (e.g., A AND not A).

Rather, we need to apply multivalent logic to our understanding of complex systems. Multivalent logic allows us to think of and analyze things as being a matter of degree (degree of hotness, degree of success, degree of community cohesion, etc).

A NRM example of the fuzziness with which we have to deal is when experts articulate a subjective, but highly precise metric upon which managers can or must make decisions. Let’s use a hypothetical example. Experts have determined that a number of factors define what “old growth” in forests is. Among the factors are: kind of vegetation in the understory and canopy coverage. Another major characteristic, as determined by these experts is that old growth forest trees are 180 years old or older. Using these characteristics, a forest manager now has a (perhaps pseudo) scientific basis for implementing forest management and policy. In this case, the manager cannot legally cut a tree 180 years or older. If this is the case, one might question whether a manager would reject the idea that trees that are 179 years old are “old growth”. If not, the manager might proceed to cut these 179-year old trees before environmentalists get into a litigation process. That legal process in itself would probably give the trees time to grow to be “old growth” by the time the lawsuit ended.

The questions for the manager, using fuzzy logic instead of a crisp number like 180, might be: Is the 179-year old tree a partial member of what might be “old growth class”. Isn’t the basis for the 180 only an “opinion”, useful for some purposes but pretty subjective in the sense that reality of what is old and not old is an imprecise concept to crisply define? Would the fuzzy set show some degree of TRUTHfulness as compared to some arbitrary, perhaps highly subjective rule—180 years or it is not “old growth”—when it is applied? Is the arbitrariness of the precise number 180 a human decision and not necessarily a state in nature?

More About Fuzziness

Fuzziness does not mean that a system or state is All or Nothing nor that it is ambiguous (Allen and Hoekstra). In fact, the example below illustrates a classification dilemma—How do we classify what "warm" is? The example uses input from an individual to determine when it is warm and when it is not warm. In this case, there may be a range of temperatures that the individual considers to be warm, while other temperatures may be "cool" or "cold" or more than warm to the point of being "hot" from the individual's perspective.

Example

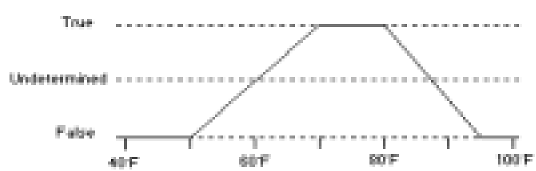
The following is an attempt to quantify the fuzzy argument "warm" for the data link "Temperature".

The transition points:

Temperature	Warm?
50	False
70	True
80	True
95	False

If we graph this, we see the range of what is warm clearly.

The fuzzy function graph:



The fuzzy function above can be read as: "It is not warm at all below 50° but is starting to become warm. At 70° it is definitely warm. At 80° it is still warm but it is becoming too hot to still be considered warm. At 95° it is too hot to be considered warm any longer."

Interpreting the function at some various points:

Temperature	Warm?
32	100% False
60	undetermined
65	50% True
75	100% True
90	33.3% False
100	100% False

Fuzzy set theory provides a formal algebra to deal with a condition, situation, state, etc, and, this algebra "is as particular as that which applies to discrete or crisp sets" (Allen and Hoekstra, 1992. Toward a Unified Ecology. NY: Columbia University Press, p. 295).

Further citing Allen and Hoekstra (pp. 296-297):

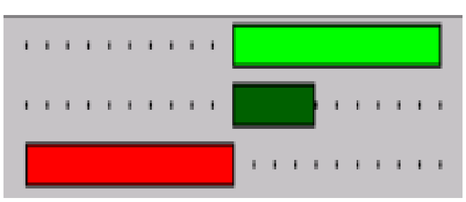
> "Multiple-resource management practices are the easiest example to explain the fuzzy description of ecological complexity. Multiple-resource management directed at recreation use is principally a landscape consideration (people mostly go to places and look across vistas, i.e., landscapes). Let us say that it is .8 a landscape question. However, it is also a community consideration, in that vegetation physiognomy is of recreation management importance; say it is .3 a community consideration. Degradation of land through recreational abuse, or degradation making it less useful for recreation both make recreation an ecosystem question in some small way; say it is .1 an ecosystem consideration.
>
> The objective of a multiple-use plan is to develop a systematic suite of management actions in a management area which involves a spectrum of community, ecosystem, and landscape aspects. The above recreational demand would position at .3 on the community axis, .1 on the ecosystem axis, and .8 on the landscape axis. It would be possible to define a particular management action in a three-dimensional community/ecosystem/landscape space. This procedure of fuzzy set assignment of different ecological criteria to a given action will permit a systematic series of fuzzy classifications for a management area, ordered on an increasing scale of the management action."

NetWeaver™ and GeoNetWeaver™ Depictions of Fuzzy Set Membership

NetWeaver™ depicts this in a variety of ways. The degrees of membership in a fuzzy set may appear, therefore, on a bar graph, as coloration on a map (in GeoNetWeaver™), numerical analysis, data sets, etc.

Example of Evaluation Windows in NetWeaver™ and GeoNetWeaver™

Brightest Green = 100% TRUE
Black = UNDETERMINED
Brightest Red = 100% FALSE
Colors in between = varying degrees of TRUE, FALSE, or UNDETERMINED



Example Bar Graph from NetWeaver™

Example of map format results in GeoNetWeaver™

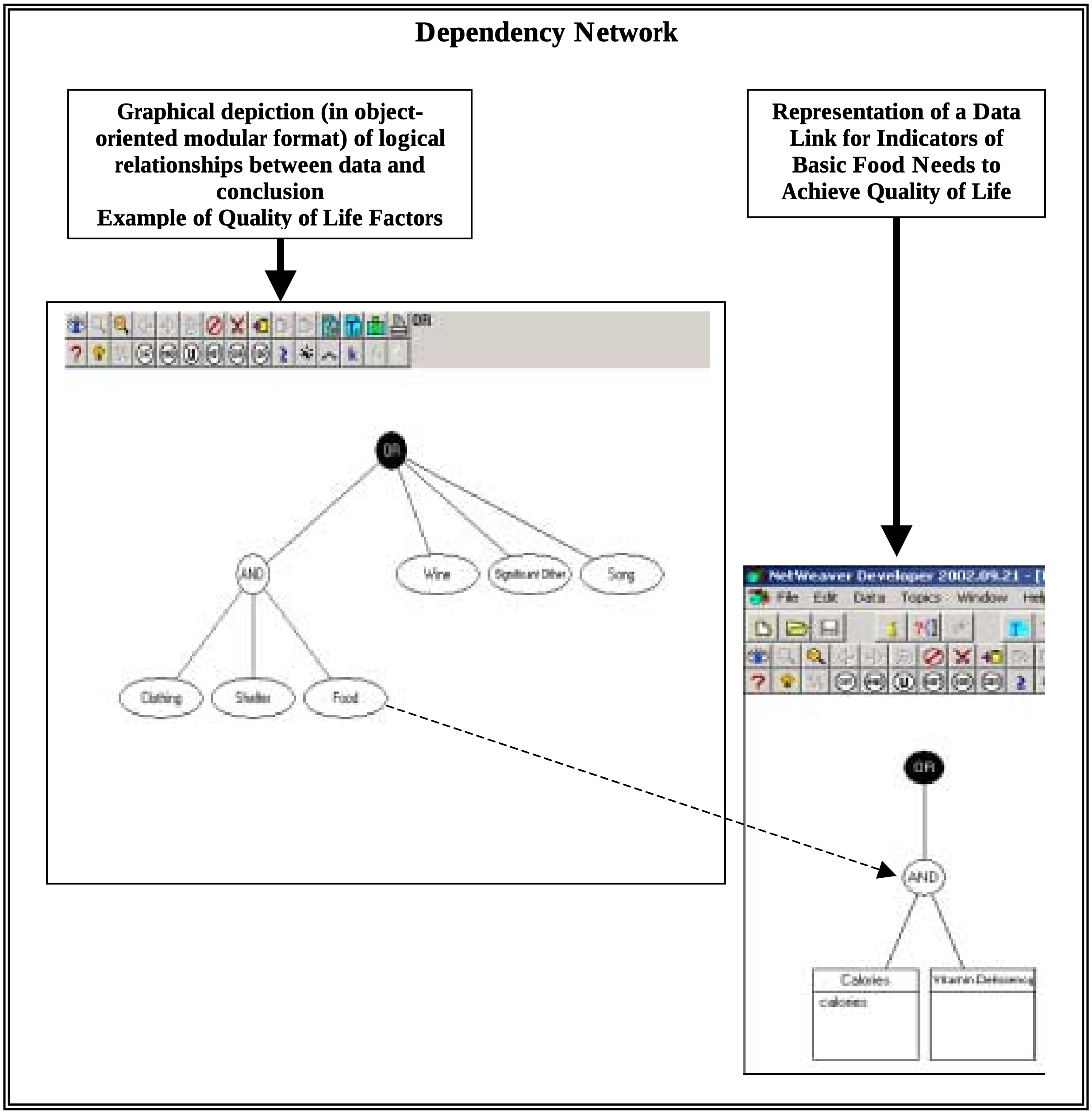
On the bar graph, the membership from –1 to 0 to +1 is shown. Bright red means that there is no membership of the specified factor—i.e., it is 100% FALSE. Darker colors of red indicate that there may be membership, but it is generally trending toward the false. As the color nears black on the graph, it means that it is basically at 0 or undetermined. As the color tends toward dark green as shown in the graph above, it means that it is trending toward some positive membership in the specified set (e.g., it is getting closer in the case of old growth trees to being OLD). When the color is the brightest green and toward the far right of the graph, it means that it is unequivocally 100 % True—it is definitely Old growth.

The "truth value" expresses the degree to which evidence supports or contradicts the proposition(s) that the knowledge technologist, working with domain experts, designs the network to test. If all evidence antecedent to a proposition supports the proposition, then the "truth value" for the network is 1 (i.e., completely TRUE). If all evidence is contrary to that proposition, the "truth value" for the network is –1 (i.e., completely FALSE). If there is no evidence for or against the proposition, then the "truth value" is 0 (i.e., Undetermined). "Truth values" also may be partially true or partially false in NetWeaver™.

Among the various reasons for partially true or partially false truth values is that some data needed to fully evaluate the network or node may not have been provided when the evaluation was being performed or that data are actually missing or not available and therefore cannot be supplied. Other more complex reasons are possible as well (see Help function for NetWeaver™ Developer for a more complete discussion of this under the topic of "Dependency Networks"). However, in the examples given above, evaluators do not simply ignore missing data, otherwise the network could become 100% True even without all the data, and evaluators do not assign missing data a minus 1 (-1) since they do not know if it will be false or not once it is known.

To return to the graphic above, the screen capture in the lower right corner demonstrates how same information can be spatially displayed. In this case, one can look at a portion of a map that shows a forest for which analysts have applied three criteria (ecological, social, and economic in this case), to determine potential for forest certification. There is one area that obviously does not meet one or all the criteria and therefore is red. A couple of areas show up in black and are undetermined relative to their potential for certification. One fairly large area tends toward having met all the criteria and is bright green, but has an area of undetermined qualities between it and another smaller area that meets all criteria. And, one large area is potentially certifiable (darker green). Using all the tools available in GeoNetWeaver™, it would be possible to determine what problems exist in the red area, what issues remain to be resolved in the black areas, perhaps identify where to allocate more resources to ensure full certification of the dark green areas, and move to find ways to sustain the certification in the brightest green areas. These are just some of the possible ways that decision makers might want to explore the information portrayed in map format in this example.

Key Elements of NetWeaver™ and GeoNetWeaver™: A View from the Screen



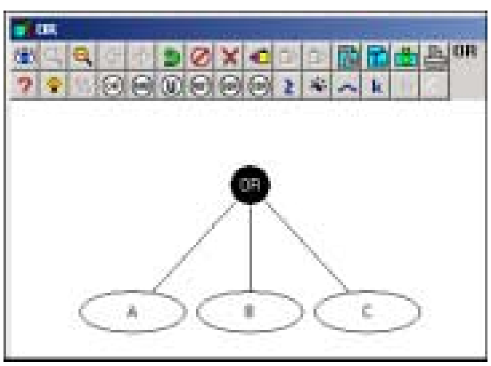
The dependency network (a more detailed explanation of this graphic appears below, but basic information about some of the components of what you see on the screen provides useful background for understanding the network) plays a central role in NetWeaver™. The Knowledge Technologist uses it to represent a problem to be evaluated by the knowledge base. Networks generally encapsulate human perception, understanding, and/or ability to articulate what things exist in the real world and how those things are logically connected to one another. For example, roads exist and they interconnect towns with towns, and towns with cities.

Thus, a dependency network is a formal logical representation of how system states (including the array of components, structure, relationships, conditions, flows, processes, etc.) at one level of a conceptual model affect or are dependent on antecedent states. An "antecedent state" literally means "coming before something else". In NetWeaver™, the more specific meaning is that the software allows the expert to articulate all states of the system that possibly can be articulated and represented in the propositional logic of the conceptual framework. This representation will be in the form of a:

1) network (see example above and view other examples in some of the following slides on CBNRM);
2) relational node (e.g., AND, OR); and/or
3) data link (e.g., an object that fetches data and compares the value of the data against an argument in order for interpretation relative to the dependency network containing the data link. NOTE: Goals (i.e., the dependency networks) are in "ovals" in the above diagram and data links are in "boxes".

The beginning point of any NetWeaver™ graphic is the Boolean Operator "OR" as seen in the above dependency network. NetWeaver™ and GeoNetWeaver™ use Boolean and other logic and functional (e.g., multiplication, division, etc. that can be used to construct mathematical expressions for calculated data links and comparison) nodes. Domain experts and/or users create nodes to define the logical and mathematical dependencies among problem-specific objects.

Boolean Operators



OR

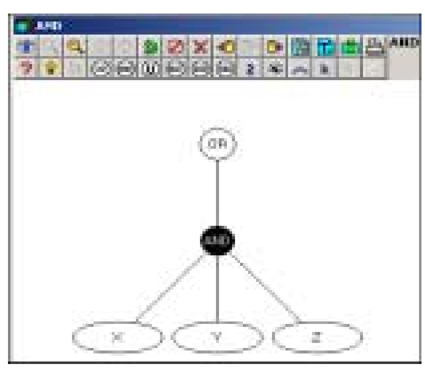
TRUE if any path to a node is TRUE

FALSE if all paths to it are FALSE

AND

TRUE only if all paths to a node are TRUE

FALSE if any path to it is FALSE



The “OR” node at the top is convention. It is a major object in this object-oriented system. An “OR” node is TRUE if any path to it is TRUE. It is FALSE if all paths to it are FALSE.

An “AND” node is often used in developing dependency networks. It is another Boolean operator, e.g., IF this AND this AND this AND, THEN this is TRUE. But, the AND node is TRUE only if all paths to it are at least partly TRUE. It is FALSE if any path to it is FALSE.

In addition to the “OR” and “AND” nodes, other nodes are found in NetWeaver™ and GeoNetWeaver™. For example, an important recent addition is the “UNION node (i.e., the “U” node). It is a new development, not demonstrated in the current version of the NetWeaver™ CBNRM Initiation Model. The value of the “U” node is the weighted average of the nodes immediately below it. The developers of NetWeaver™ and GeoNetWeaver™ devised this node to give some flexibility when combining results. Effectively its response is somewhere between the “AND” node which is very conservative and the “OR” node which is very liberal. Saunders and Miller, the developers, found that there are circumstances where you want to be able to combine outputs of nodes in a fashion that lets them all contribute to the result.

The above dependency network provides one person’s view about what constitutes Quality of Life. The dependency network by default begins with a Boolean OR. In this case, the domain expert articulated the following set of logical representations:

a) Quality of life depends on a set of “ANDed” (i.e., they flow from a Boolean AND) that include: clothing, shelter, food.
b) The domain expert also indicated that Quality of Life might actually be dependent upon three factors all linked to the top Boolean OR. These factors are: Wine, Significant Other, and Song.

While this somewhat facetious set of “logical representations” illustrate how a dependency network might appear in NetWeaver™, it is important to note that complex relationships, much more serious than these, do exist. It is also important to emphasize that NetWeaver™ can represent them in their full complexity and test their validity.

The additional element of this graphic that is important to highlight is that a domain expert can represent indicators of specific goals/critical factors (in the ovals) that can have metrics associated with them that then can be analyzed. In this example, for the factor “food”, the domain expert identified two key indicators that appear in boxes as shown to the right in the graphic. In this case, the data links (which can have either quantitative or qualitative metrics) for food are “calories” and “Vitamin Deficiency”.

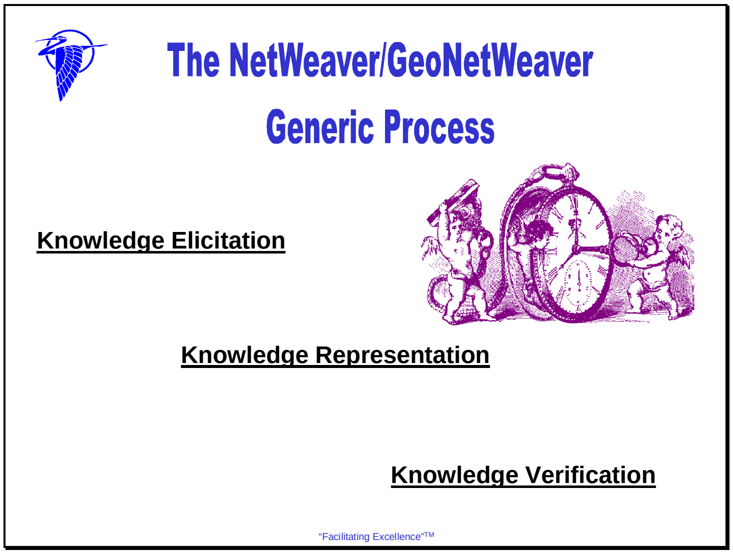
The developers of NetWeaver™ designed the inference engine so that dependency networks have three basic behaviors:

1) they query antecedent networks on which they depend to determine the state of the latter;

2) they evaluate their own state, based on the state of all their antecedent networks; and

3) they inform higher-level networks that depend on them about their state.

Some Details on the Knowledge Engineering Process: A View from Inside the Screen and the Knowledge Technologist



Knowledge Technologists use NetWeaver™ as a tool, working with Domain (Subject Matter) Experts, to build knowledge bases that produce executable models. NetWeaver™ is an interactive, computerized tool that uses the following process:

Knowledge Elicitation--This involves the transfer of area specific knowledge from Domain Experts to the Knowledge Technologist.

Knowledge Representation—This involves the coding of the elicited knowledge by the Knowledge Technologist into NetWeaver™ or GeoNetWeaver™

Knowledge Verification—This involves the testing and verification of how well the incorporated knowledge represents what the Domain Expert knows

Through this process, it is possible for Domain Experts to articulate the logical relationships and linkages between the individual parts and the whole. However, new tools, like NetWeaver™ and GeoNetWeaver™, increasingly are available to condense, process, filter, organize, categorize, and analyze disparate pieces of information and then present it as a new synthesis, as knowledge.

We have used NetWeaver™ to model, for example, dependency networks related to initiation of Community Based Natural Resource Management in Africa. As with all NetWeaver™ and GeoNetWeaver™ models, WYSIWYG (i.e., What You See Is What You Get—as well as WYDSIWYAG (i.e., What You Don't See Is What You Also Get). What we mean by this is that the evaluation window with the bar graph on NetWeaver™ or the map you see in GeoNetWeaver™ are like the face of a watch with the hands on the dial.

They are straightforward, easily read, and easily understood with the legend. What the graph or map alone does not show are the actual dependency networks, the data, the inference engine, and the analytical tools “inside” that are the foundation of the graphs and maps. Because like any watch, it isn't necessary for everyone to understand how the watch works in order to tell time. The Knowledge Technologists (the cherubs above) know the inner workings. However, it is possible for others to learn how to access the dependency networks/results framework and data by “drilling down” into the model.

NetWeaver™ Community Based Natural Resource Management, i.e., CBNRM Initiation Model: A Example

AFR/SD/ANRE and BHR/OFDA provided support for development of the CBNRM model. Additional acknowledgements go to those who participated in the process of developing this first phase of the model: Paul Bartel (AFR/SD), Mike McGahuey (AFR/SD), Henri Josserand (Associates in Rural Development—ARD), John Woodwell (University of Maryland), Bob Winterbottom (International Resources Group—IRG), Asif Shaikh (IRG), Yves Prevost (World Bank), David Gibson (Chemonics), and other colleagues at ARD.

More details on the process that this group followed to develop this first phase model of determinants for Initiation of CBNRM are found at www.herongroupllc.com, Report Series No. 105. The next series of figures touch on only a few steps in the process and provide some insights into the power and potential of NetWeaver™ to provide decision makers with relevant, useful and testable data, information, and knowledge on the determinants for CBNRM.

The Summary of Steps in the NetWeaver™ Process to Develop the CBNRM Initiation Model follow, however, variations on this process exist:

First Technical Group Meeting—“Herd Milling and Sniffing”

1) Documentation Shared;
2) Common frame of reference established;
3) Discussion between Knowledge Technologists and Domain (Subject Matter) Experts followed; 4) Major Themes Highlighted

Second Technical Group Meeting—Knowledge Elicitation, Representation, and Preliminary Verification (Scoping and Bounding the Model

1) Introductory Comments Made by Domain Expert;
2) Introduction of a Model to Work With Proposed by another expert as part of Scoping;
3) Increased Focus in Preliminary Knowledge Elicitation Stage;
4) Beginning of Questions to Direct Knowledge Representation in NetWeaver™ CBNRM Model;
5) Developing Initial Array of Variables for Exploration and Linkage in the Model;
6) Illustrative Example of One of the CBNRM Determinants Proposed;
7) Further Bounding Occurs;
8) Initial Set of Dependency Networks Developed;
9) Data Links Identified;

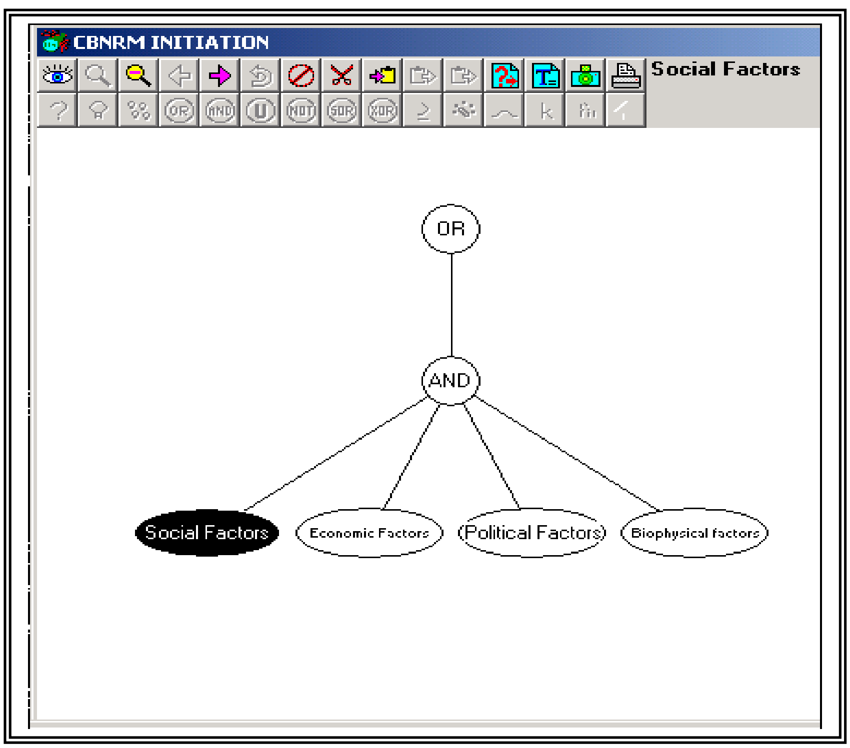
10) Iterative Process of Input Proceeds;
11) Initial Verification Process Begins as Elicitation Process Continues;
12) "Capturing" Details to Enhance the Model Begins and Continues

Third Technical Group Meeting—Model Verification by Additional Domain Experts

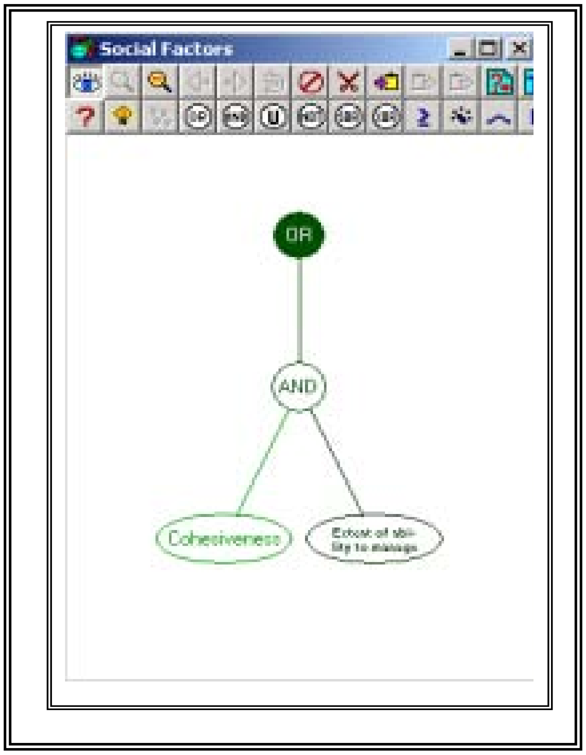
1) Use of Questionnaire in Verification of the Initial Mode;
2) Lack of Response to Initial Questionnaire Acknowledged and Alternative Sought;
3) Value of a Pre-Test of the Questionnaire;
4) Revised Questionnaire Re-Sent to Selected Respondents

Fourth Technical Group Meeting: Model Verification and Modification

1) Review of Database from Expert Responses to the Revised Questionnaire;
2) Model Modified Based on Sensitivity Analysis of Data and Associated Modification of Questionnaire;
3) Review by Other Members of the Technical Working Group;
4) Discussion about What the NetWeaver™ CBNRM Model Can Tell the Manager/Decision maker—Model Outputs and Products During This Phase;
5) Analysis of the Data;
6) Follow-up Steps and Products to Prepare for Next Phase

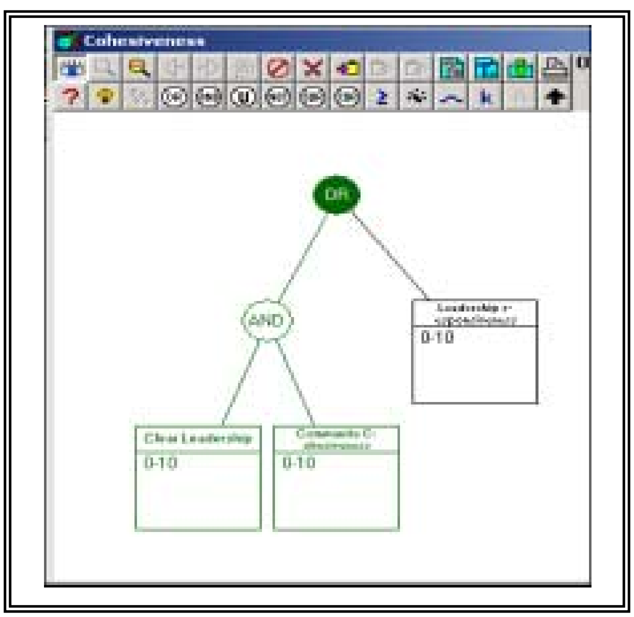


The above is an example of first level array of potential determinants (i.e., social, economic, political, and biophysical factors/goals in ovals) provided to the Knowledge Technologist by the Domain Experts. Please note that the darkened oval has been selected for our process of "drilling down" further to see what we can learn from a decision support tool.



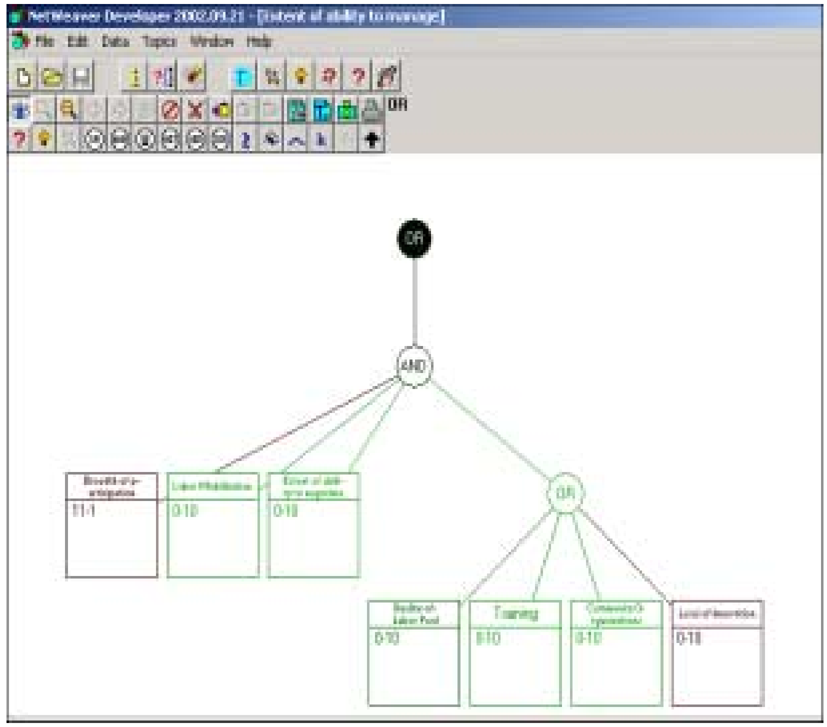
NetWeaver^{TM} analysis of data obtained on Social Factors indicates that this set of determinants is 29.98 % TRUE. The colors in these screen captures of NetWeaver^{TM} CBNRM Initiation Social Factors shows coloration from bright green to black to red (the convention in NetWeaver^{TM} display). "Drilling down" into this network further, looking solely at social factors in this example, one finds a second level dependency network identifying Cohesiveness [60% TRUE] and Extent of Ability to Manage [17.5% TRUE].

These highlight how each element of the dependency networks demonstrated in the screen capture to the left has numbers arising from the NetWeaver^{TM} analysis of the data during the first phase of model development. These numbers, in percentage, illustrate how data can become information—i.e., by showing degrees of TRUTH—for discussion and converted into knowledge for decision making about this particular set of determinants of CBNRM Initiation. This is one of a variety of ways that NetWeaver^{TM} provides data for decision support. Going directly into the NetWeaver^{TM} CBNRM database is another example of how data are made available in this tool.

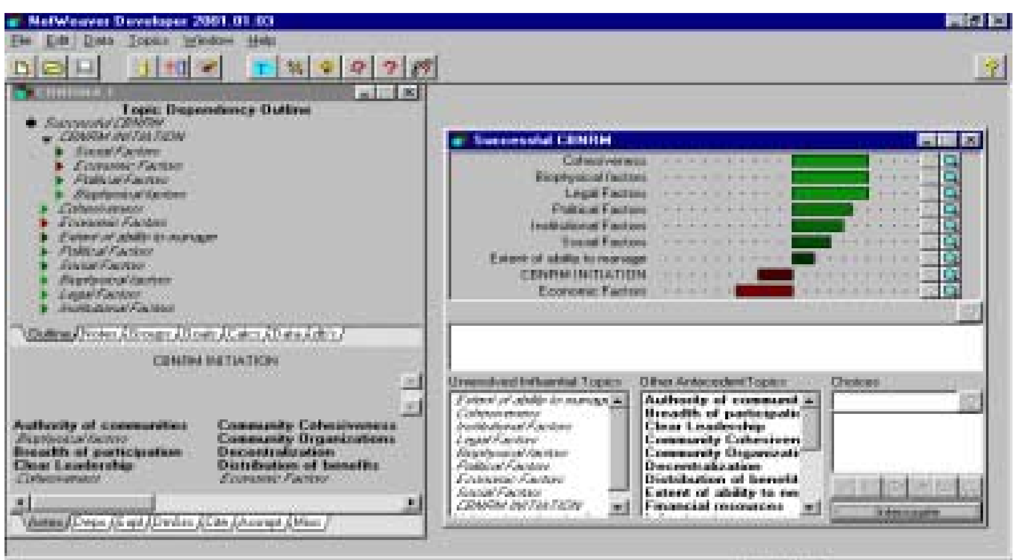


Drilling further down, one finds data links for cohesiveness, in this case at one of the sites for which data were input, that include measures for cohesiveness (described in detail on the previous slide) as being clear leadership [40% TRUE] AND community cohesiveness [40% TRUE] OR leadership responsiveness [UNDETERMINED].

Drilling further into the Extent of Ability to Manage, data links, one finds, at the same site: Breadth of Participation [20% TRUE] AND Labor Mobilization [60% TRUE] AND Extent of Ability to Negotiate [60% TRUE] AND Quality of Labor Pool [40% TRUE] OR Training [60% TRUE] OR Community Organization [60% TRUE] OR Level of Innovation [20% FALSE]. Many questions arise out of this opportunity to look "real time" at the results of the analysis of the questionnaire that provided these data. Where there is success, questions about "why" might be appropriate. Where there is something less than success or a trend toward failure, any number of questions might arise: "why", "what if we reallocated more resources to this effort", etc.



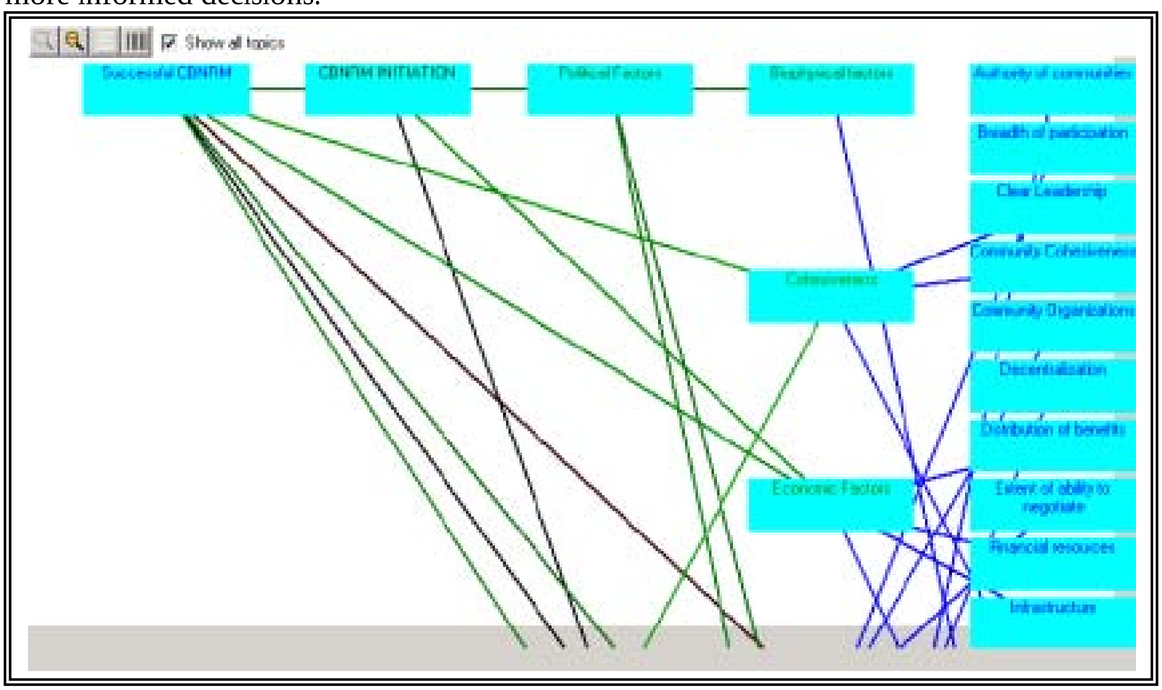
Topic Dependency Outline and Evaluation Window (side by side)



This slide above provides an array of information for decision support. The Topic Dependency Outline is open to the left. It provides a list of the primary goal groups that one can then see on the right side in the form of the evaluation window with the bar graphs. The colors in the Dependency Outline provide some immediate cues. Each of these can be clicked on to open a Dependency Network. When linked to the data from the 13 responses (for this screen capture, the results reflect a batch processing of all 13) to the questionnaire, the analysis of the data appears in the evaluation window on the right side of the screen capture.

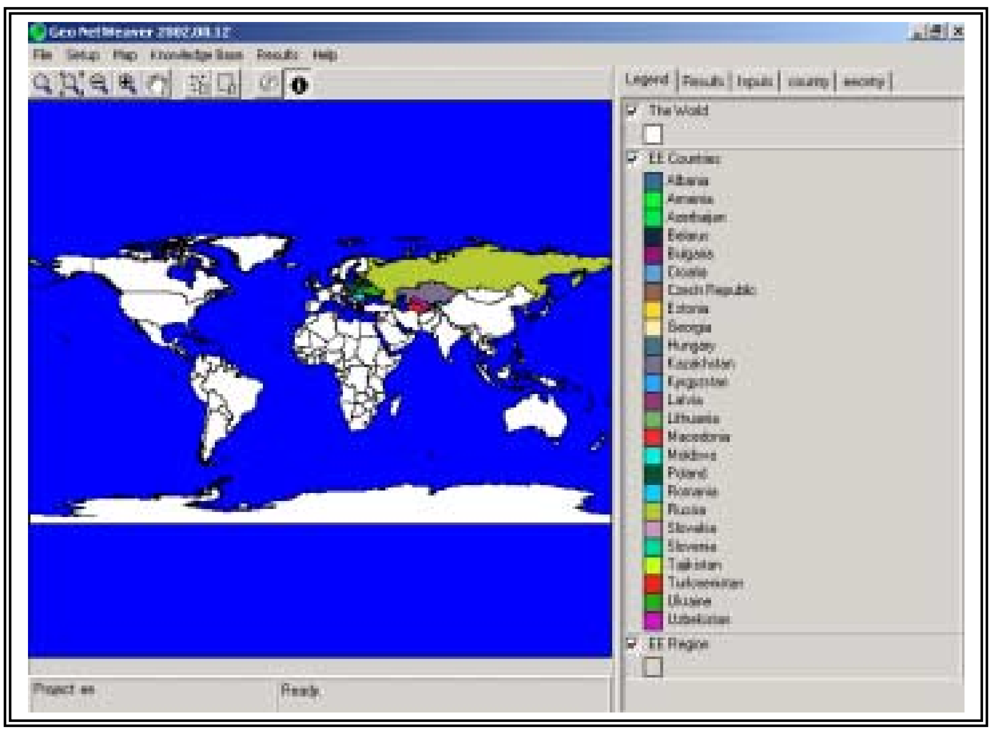
There are several important cues to interpreting the analysis of the data. It appears that CBNRM INITIATION at the 13 different sites reported on in the questionnaires was somewhat questionable. One of the main problem determinants was Economic Factors. However, it would be important to also explore where problems might exist for Social Factors and for the Extent of the Ability to Manage. Questions about the indicators being used might be important to raise. Questions about the reliability of the questionnaires is also an important question to consider, but given the "efficiency" of using questionnaires instead of having the Knowledge Technologists go through a face-to-face facilitated process with domain experts at each site, this is perhaps the best available information at this point in time. But, other questions about the exact nature of the problems with any of the determinants to successful initiation of CBNRM need to be explored.

Decision makers can use tools like NetWeaver™ to understand what is happening, but they will need more information to explain the "why" of what is happening. However, using the example of Economic Factors, a decision maker may decide that, before initiating a CBNRM effort, staff members must give due consideration (stating the obvious) and support to economic factors otherwise some degree (perhaps total) failure is likely to occur. These and many other points may be useful for discussions among managers and decision makers since a tool like NetWeaver™ provides a framework and analytical basis on which they can make more informed decisions.



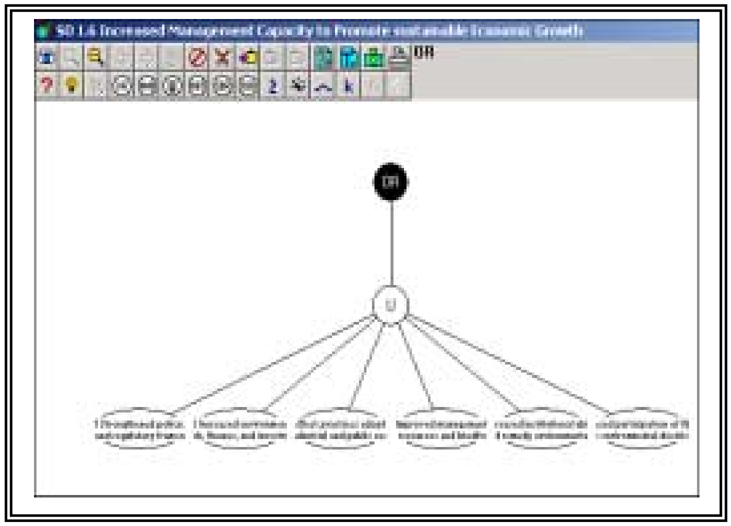
The Dependency Overview (screen capture above) provides a graphical browser of the dependency networks. This Dependency Overview illustrates the connections/linkages between CBNRM determinants (objects) in the knowledge base. Clicking on a topic button, like "Successful CBNRM" highlights the linkages for that topic. As with other windows of NetWeaver™, the end user can see the red and green and blacker colors that demonstrate degrees of TRUEness, FALSEness and Undetermined. This is only a small portion of the Dependency Overview. When the model is executed on a computer it is possible to zoom in or out, scroll up, down, or to the side to view all the linkages. And, clicking on the topic button opens the window for that topic. In other words, it will take you back to the Evaluation Window with the bar graphs, or to the dependency networks that are related to the topic, and/or to the data links.

The following provides some details on the capabilities of GeoNetWeaver™. Specifically, we use the example of a performance measuring effort being undertaken by USAID to assess progress being made toward achievement of results of one of its Strategic Objectives in the Eastern Europe and Eurasia Bureau.



This provides a GeoNetWeaver™ view of E&E Region, with each country in color. When the E&E project in GeoNetWeaver™ is opened, a map of the world appears. If you want to select a given region, the software can be directed (as above) to show just the countries in that region, with borders between countries, with different colors to differentiate what country is where, and a legend to link the name and country for easy reference as above. It is also possible to include country names on the maps for easier reference to the countries being viewed.

The Strategic Objective (SO) highlighted in the GeoNetWeaver™ SO 1.6 Environmental Model focuses on: Increased Environmental Management Capacity to Promote Sustainable Economic Growth. USAID staff articulated the results needed to achieve this objective. The IRs appear in the model as ovals as seen in this screen capture. They are:



IR 1: Strengthened policy, legal and regulatory framework

IR 2: Increased environmental trade, finance and investment

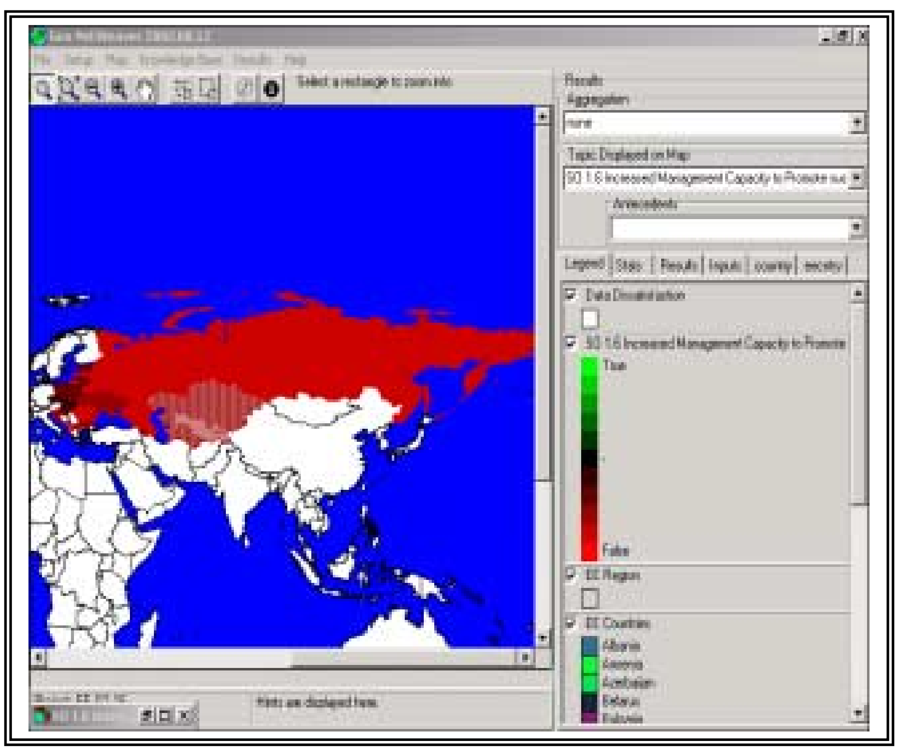
IR 3a: Best practices adopted by industrial and public sectors

IR 3b: Improved management of natural resources and biodiversity

IR 4: Increased institutional ability to identify and remedy environmental problems

IR 5: Increased participation of NGOs and citizens in environmental decision-making

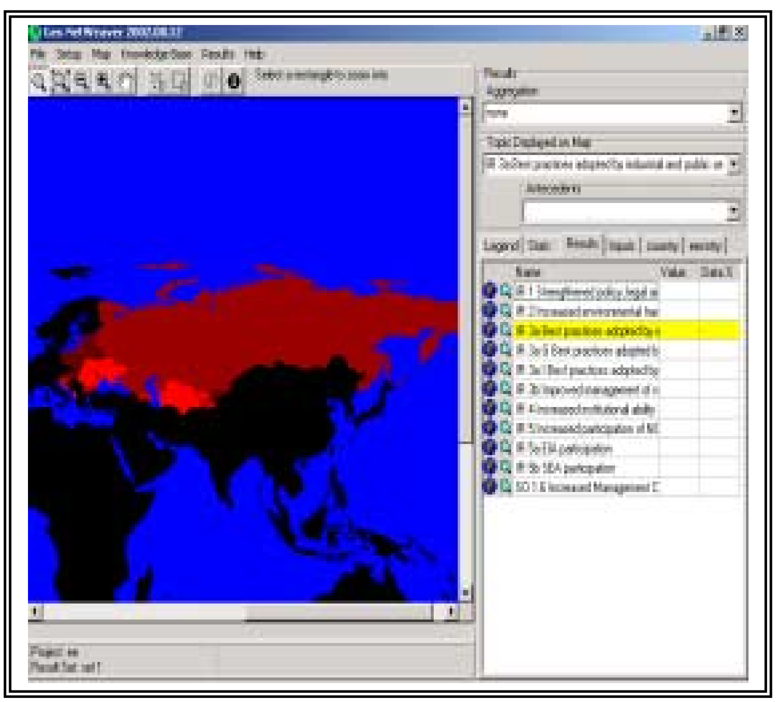
When one loads the data for each country into the GeoNetWeaver™ model, this screen capture shows the analysis in terms of how the data show progress toward achievement of results for SO 1.6 as a whole across USAID's E&E Region.



Most of the region appears in various shades of red, indicating that progress toward achievement needs to be improved. Note the area in black. This reflects that some progress likely has been made in this country (Poland). Also note that some countries have some cross-hatching and appear here with more whitish coloration (e.g., the region called the "Stans" including Turkmenistan, Uzbekistan). If you look at the "Legend" tab that appears on the right hand side of the screen, you will see that a small box, called "Data Dissatisfaction" has been checked. This is a helpful feature of GeoNetWeaver™. It immediately identifies areas where data not all needed data are available for analysis. The data dissatisfaction coloration ranges from clear to opaque white with breaks at 25%, 50%, and 75%. GeoNetWeaver™ developers included this to visualize data gaps.

NOTE: The data used in this model are for a 2-year period. The data sources are from non-USAID references, including FAO, EBRD, and WRI. Indicators are as direct as possible, but some are proxies. No regional data per se were available for the indicators. The subject matter specialist collected the data at the individual country level, therefore, actual "results for the region" are based on country results that only reflect regional progress in an indirect sense.

One of a number of important lessons arose from the analysis performed by GeoNetWeaver™. All too often data are aggregated and can be meaningless. Intermediate Result (IR) 3a (Adoption of Best Practices by Industrial and Public Sector) under the SO 1.6 GeoNetWeaver™ model provides an excellent example of different kinds of information arising out of data that are aggregated as compared to when we disaggregate them.

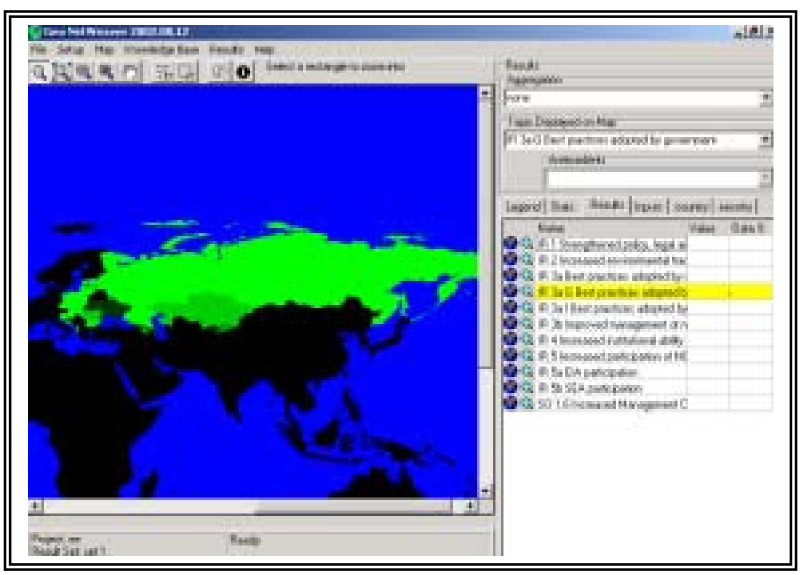


This shows the GeoNetWeaver™ analysis of data by country on progress toward achievement of results when you combine the data for both industry and public sector efforts to adopt new practices. You can see some changes in color in terms of less overall bright red as compared to the previous slide that shows results at the overall SO level. Here we see a country like Russia seems to be making some progress when we look at the combined data (it is a dark red as compared to the brighter red displayed above for overall characteristics that indicate it is trending toward lack of progress toward achievement of results). Poland still remains in the category of almost making positive progress. But, it is important to look at differences when data are disaggregated—i.e., by industrial sector and public sector, as per the next screen captures. They tell a different story than this one because of the process of disaggregation.

The GeoNetWeaver™ analysis of data for the industrial sector show some significant differences from the previous screen capture where we left the data combined. As before, even when disaggregated, most of the countries are on the bright red to darker red side. There seems to be less "data dissatisfaction" on the part of Domain Experts relative to the data portrayed here.

In general, this map provides decision makers and managers with an opportunity to discuss issues related to where and how progress might be made on a variety of fronts in the industrial sector. They may want to rethink the validity of the indicators (i.e., GDP per unit energy use, Industrial CO_2 emissions, and wastewater treated). They may want to discuss issues such as reallocation of resources from other IRs to make progress in this sector overall or perhaps only in given countries. Or they may decide that resources should not be allocated to this sector at all, etc.

When disaggregated from the industrial sector, the data for the public sector show a considerably different picture. Things look pretty good since so many countries graphically appear to be on the more positive side (as portrayed by different colors of green, with the brightest shade being the most "true" or positive).



Decision makers may decide that no further effort needs to be expended in this sector. However, looking at the indicators (proportion of urban population with access to sanitation, safe water, and garbage collection) that the analyst had to use may provide decision makers with an opportunity to reflect on what these results really mean. This is especially true given that all the data were from capital cities and in no way reflected practices necessarily adopted in non-capital areas.

The preceding provides introductory materials for the next section of this document that focuses specifically on some of the preliminary outcomes of a project funded by USAID's Bureau for Africa, Office of Sustainable development.

MATS

The project acronym MATS stands for Multivalent Analysis Tools (MATS) for improved strategic natural resource management.

During the summer of 2001, The Heron Group, LLC responded to a USAID RFQ for training of African field practitioners on the knowledge engineering process and the application of NetWeaver™ and GeoNetWeaver™ to problem domains of concern to trainees. USAID awarded the contract to The Heron Group, LLC in September 2001. This included purchase of the proprietary software, available through The Heron Group, LLC.

The **major mechanisms for MATS to achieve results** have been through: 1) intensive training to build capacity, 2) networking to ensure opportunities for interaction after training, and 3) the provision of additional technology transfer information for continued enhancement of understanding about these decision support tools and their potential applications.

The **anticipated results of MATS**—as written in the proposal and as achieved—were:

- Increased capacity

    1) of a targeted group of African professionals in use of decision support tools for analysis of natural resource management problems, enhanced development and testing of hypotheses using decision support tools, and enhanced capability to use the decision support tool for performance monitoring, and/or related aspects of USAID efforts across the region.

    Basically, the initial results of this effort will be the trainees' use and application of the tool to a problem they bring to the training session and as identified by the missions for which or with which they work.

2) of a regional representative who eventually will serve as first line of technical support on continuing use of the tool—i.e., training of trainer

- Development of small informal network of technical people in Africa who can utilize and apply new decision support technology to address natural resource management issues in the region

- Improved information via tech transfer materials for continuing capacity development of African professionals in use of selected multivalent analysis tools for hypothesis development, analysis of complex NRM problems

The Heron Group instituted a **course design** (later modified, based on experience and input from trainees) for the first training session in Johannesburg, South Africa, to accommodate the intensive nature of the training. The intent was to optimize the quality of the learning environment for trainees, as well as to maximize opportunities for interactions between participants for development of a nascent network of field practitioners using these decision support tools.

Therefore, we phased the training such that Group 1, with 4 participants began 3 days of intensive training. As Group 1 entered its 3-day period during which members worked on individually or group-selected practicum topics, Group 2 arrived for their 3 days of intensive training. Then, as the second group entered their practicum, members of the first Group returned to a mini-workshop environment in which they and members of the second Group demonstrated preliminary results and got feedback from trainers and colleague trainees.

The **highlights of the curriculum** presented during the course are outlined below:

- Introduction to fuzzy logic
- Introduction to knowledge engineering
- Comparison of knowledge engineering using previous methods compared to using fuzzy logic and NetWeaver™/GeoNetWeaver™
- Use of NetWeaver™
- Project/problem selection and discussion
- Knowledge engineering workshop
- Introduction to meeting facilitation skills
- Introduction to integration of GIS and knowledge-based spatial data analysis
- Concepts of GeoNetWeaver™ (how GNW goes about spatial data analysis)
- Use of GeoNetWeaver™
- Data integration workshop
- Wrap-up dialogue

For this training effort, the trainers used **technology transfer materials** including a tutorial modified with pre-MATS materials as well as materials that included both a training module drawing from the development of the Community-Based Natural Resource Management (CBNRM) model developed during the "proof of concept" phase described above. The materials for the module to learn how to use GeoNetWeaver™, focused on a mock up of a country, region, and set of communities, (using data from a county in the State of Pennsylvania) and how to input data for CBNRM into spatially referenced format. A hard copy of the compendium of software functions accompanied the tutorial.

Other materials developed over the past 3 years of work with USAID were also available at The Heron Group website: www.herongroupllc.com. The materials deal with:

- An introduction to NetWeaver™
- The process of developing the NetWeaver™ CBNRM Initiation model
- An overview of many aspects of the foundation of NetWeaver™ and GeoNetWeaver™, including fuzzy logic, multivalent tools, and applications to a variety of problem domains, and
- Application of GeoNetWeaver™ to E&E's SO 1.6

The participants in the South Africa training program included:

- Musisi Nkambwe—University of Botswana, Botswana
- Leonard Dikobe—African Wildlife Foundation, Botswana
- André Bassolé, EIS-AFRICA, Burkina Faso
- Greg Overton—USAID, Madagascar
- Jean-Michel Dufils—PACT, Madagascar
- Jean Roger Rakotoarijaona—National Environment Office, Madagascar
- Robert Waggwa Nsibirwa, Eastern Africa Fine Coffees Association, Uganda

Problems Addressed by Trainees. The trainees in the first MATS Training Program in South Africa addressed an array of issues, both at a national level and at a transboundary level. Trainees in the course used NetWeaver™ and/or GeoNetWeaver™ to address the following problems:

1. determination of and analysis of key factors for increasing coffee farmer incomes for a tree crops project;

2. analysis of management options to ensure sustainability of a conservation corridor;

3. exploration of the sources and the affects of silt on a lake in one country because of land use practices in another country that then has further downstream impacts of flooding in yet a third country;

4. tracking the flow of information from conservation units to ensure the sustainable coordination and flow of information sharing in a research network; and

5. determination of the extent to which an area can be used as a wildlife passage corridor between two core conservation areas in two different countries.

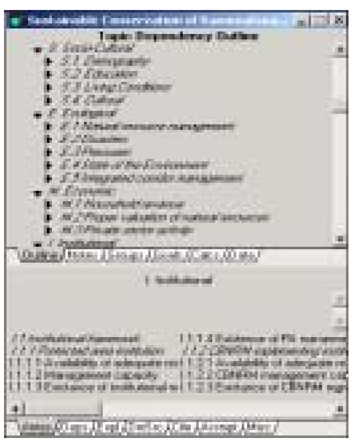
During the practicum phase, trainees developed preliminary models of each of these problem domains. They presented their results as they ended the training and received input on how to move forward to further develop their models after the training program ended. They also received a “help desk” follow-up opportunity after the training.

Examples from Models Developed By Trainees

The following are selected examples. The models were not complete even though trainees put a tremendous amount of work into the development of each during the course of the training.

The screen captures below help illustrate some of the topics the trainees explored, some of the preliminary outcomes of their efforts, and some of the features of NetWeaver™ and GeoNetWeaver™ they used to move forward in their efforts.

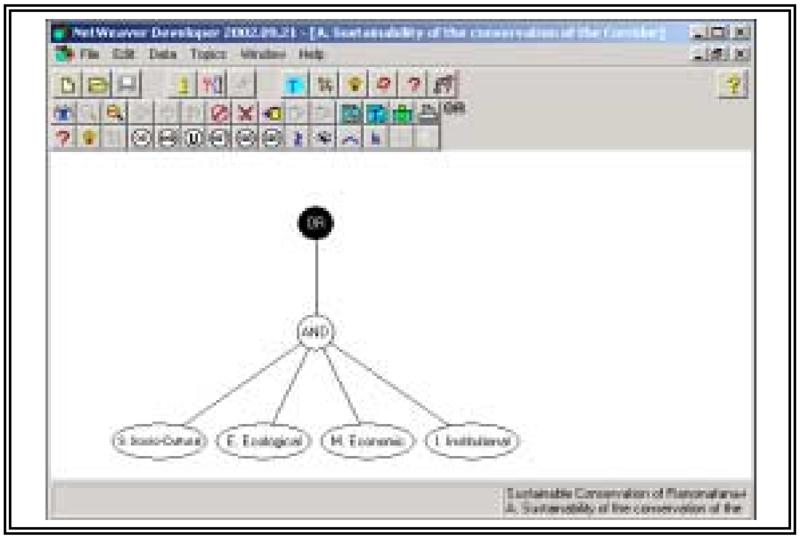
Madagascar Project-Sustainable Conservation of Ranomafana-Andringitra Rainforest

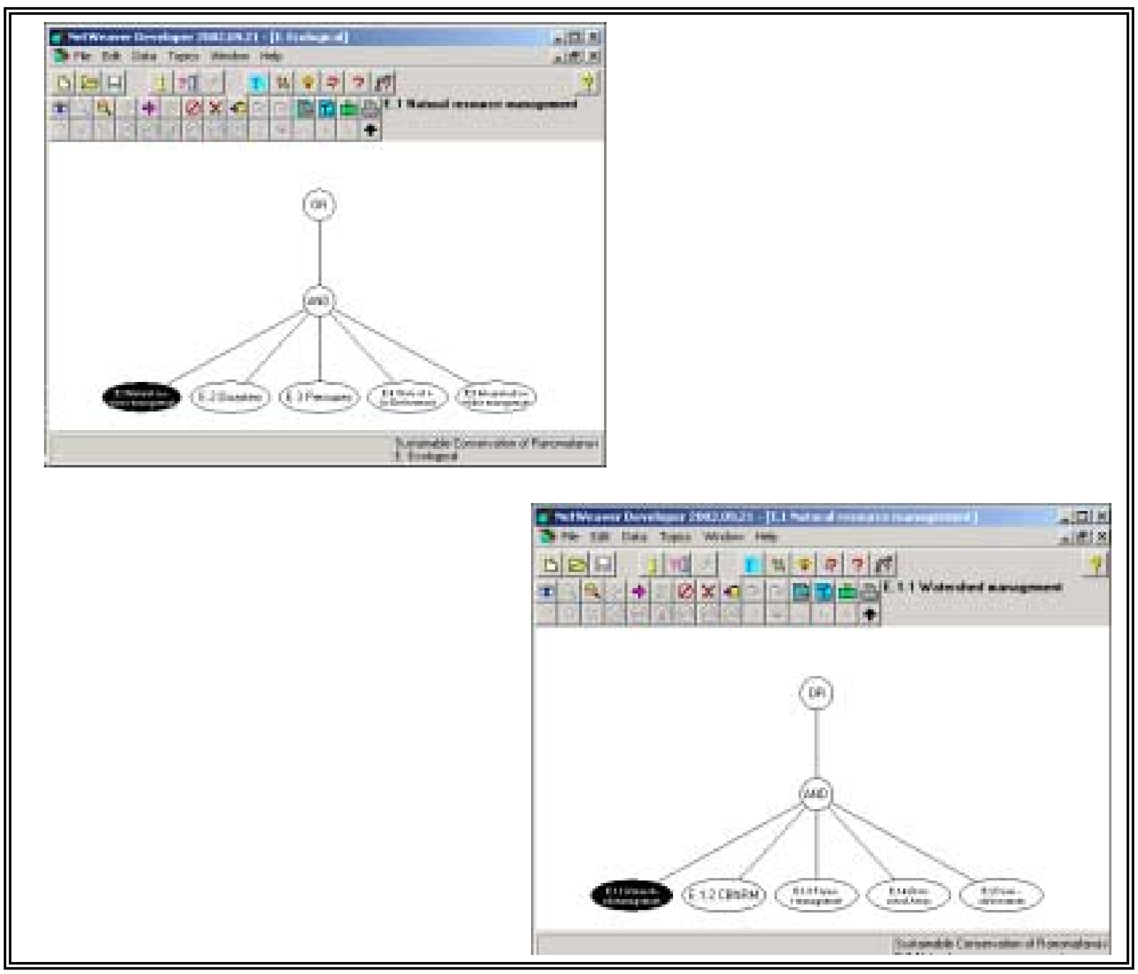


The focus of the Madagascar project during the MATS training was the use of GeoNetWeaver™ to improve decision-making for the sustainable conservation of the Ranomafana-Andringitra Rainforest in Madagascar.

The 3 person team—Jean Roger Rakotoarijaona, Greg Overton, and Jean-Michel Dufils—hoped the software would assist in carrying out “analyses to better understand: (i) the multiple consequences of deforestation in a rainforest corridor; and (ii) the relationship between the main population pressures on the natural resource base and the forest corridor in order to better plan and monitor the various interventions aimed to avoid the destruction of this unique ecosystem.”

The preliminary Madagascar model looked familiar in the sense that it mirrored the CBNRM dependency network to some degree (e.g., social, ecological, economic, and institutional goals). The Madagascar team developed this model to have many more layers of causal linkages, however.



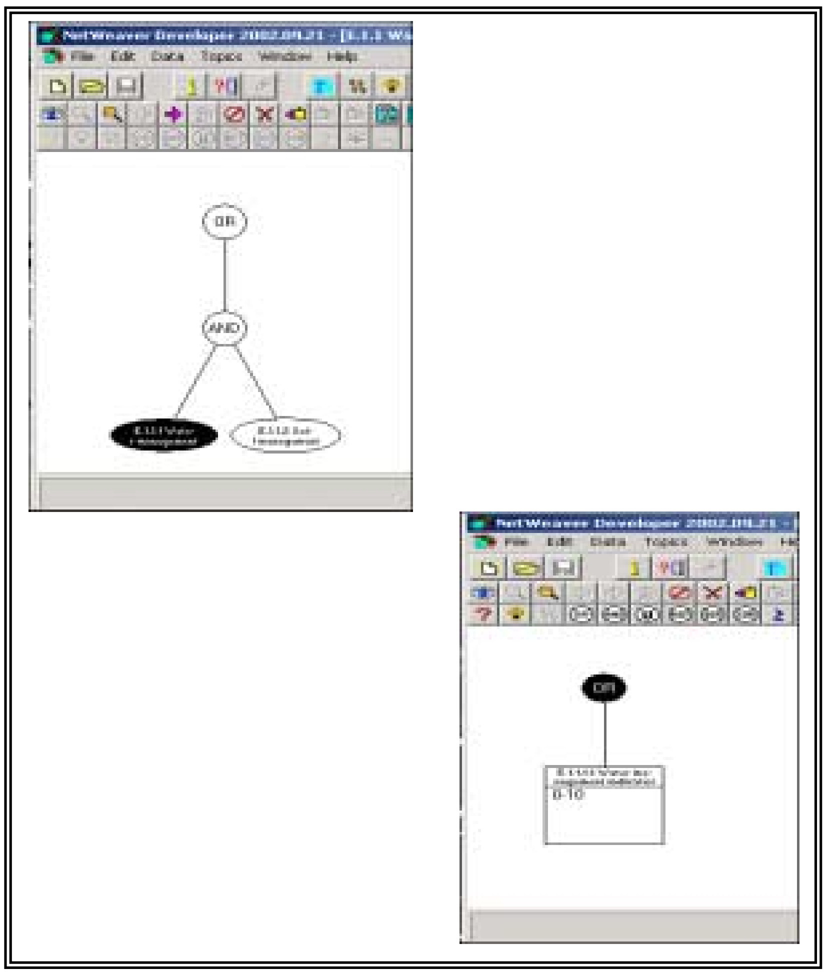


The top screen capture in the figure above would appear if we had clicked on the Oval in the preliminary dependency network that deals with Ecological issues. Here, we see, from left to right, 5 goals that are linked to Ecological Factors affecting sustainability of the Ranomafana Corridor.

These include:
-Natural Resource Management
-Disasters
-Pressures
-State of the Environment
-Integrated Corridor Management

Then if we click on the first oval (goal) Natural resource management, we find that the team identified the following factors that appear horizontally in the ovals of the second screen capture in this figure:

-Watershed management
-CBNRM
-Forest Management
-Protected Areas
-Law Enforcement



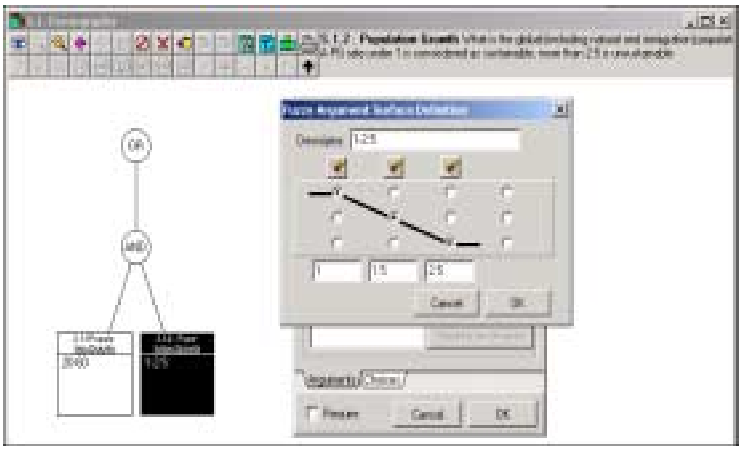
Then, if we click on the first oval (as seen in black above) which is Watershed Management, we see yet another level of factors for analysis in this preliminary model.

Here, we see the next layer of goals to be explored under the Watershed Management network. The two ovals in this screen capture identify yet another level of logical linkages to Natural Resource Management.

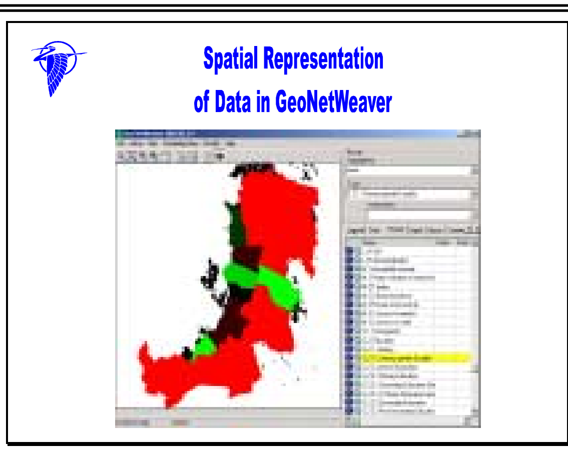
-Watershed Management
and
-Soil Management

Then, by clicking on the first of these two ovals, we final find a data link (box)—in this case, what they have temporarily denominated a "Watershed Management Indicator". When they went back to work on the model, they planned to work with subject matter/domain specialists in all of the different areas they identified to provide specific, valid, objective, quantitative and/or qualitative indicators that they will include in their model. However, this shows the depth of detail and the process this team of trainees went through to explore the potential linkages between and among factors (in this example, only one set of modules related to ecological factors) to develop their conservation corridor model.

Fuzzy Argument



The figure to the left illustrates another interesting aspect of the process the Malagasy team went through to develop their model. Drilling even further down into the dependency networks, it is possible to reach the data links that can be either simple or calculated and can include fuzzy arguments. This is an example where the Madagascar team looked at management options for conservation and included information on sustainability, depending on different degrees of membership in the fuzzy set of sustainability with population growth rates. In their fuzzy argument, they assumed that sustainability can be achieved with a 1 percent per annum growth rate but that anything over 2.5 would move the membership in the fuzzy set of sustainability (as measured in this case by population growth) into the state of being unsustainable. Degrees of sustainable, they argue in this preliminary model, might be achieved between 1 and 2.5% growth rates, but 2.5 will definitely affect the management options for sustainability. However, in multivalent analysis, there might be other factors that might offset this single factor of population growth in the conservation corridor that needed to be and were included in future versions of their model.



This screen capture provides a sense of the kind of information they believe they needed to use to populate their model. This is a map showing the conservation corridor of interest in Madagascar, approximately in the east central portion of the island.

This screen capture shows some "dummied" data they input for "Living Conditions" in the top left. Generally, the map shows that the data portray a set of living conditions that have no membership in the fuzzy set TRUE, i.e., that they are Not Good except for a few places where we see the black color that indicates that something is of an undetermined status or perhaps beginning to show a trend toward a more positive status. In this case, if we click on the "data dissatisfaction" box in GeoNetWeaver™, we get information that there are probably no data available for these particular areas. In other cases, where the data are considered problematic or are only partial, we would see different markings of black on the white background to indicate the system's analysis that the data are not sufficient. This helps decision makers understand where limits in knowledge hamper the ability of technical professionals to do analysis and for decision makers to make decisions supported by more appropriate, relevant, valid, and useful knowledge.

Other trainees also shared their preliminary models. Below, we demonstrate some selected elements of these models to highlight some features of the decision support tools they used.

Uganda Project: Increasing Small Farmer Income Producing Coffee

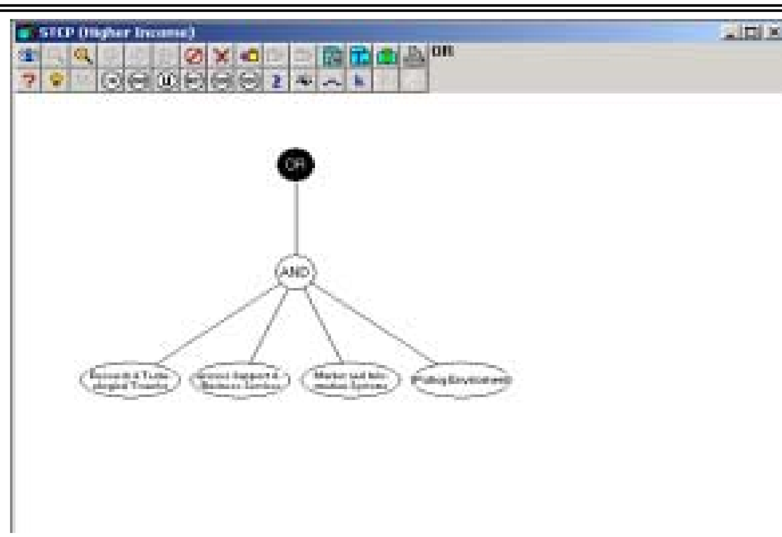
Robert Waggwa Nsibirwa of the Eastern African Fine Coffee Association focused primary attention on how to increase incomes of coffee farmers. The overall project goal was “Improving the State of Grower Support and Business Services in the Eastern African Region”.

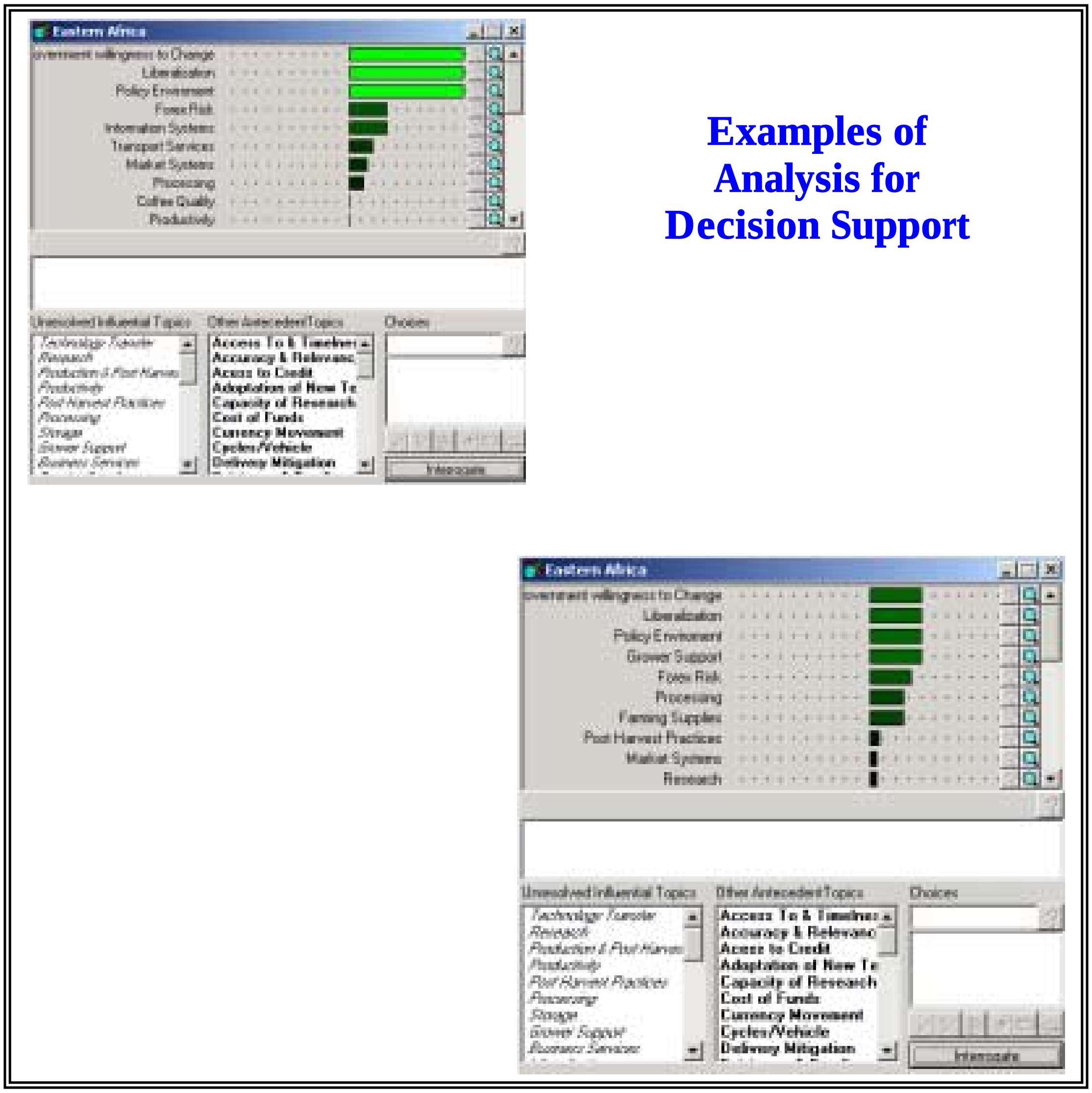
His interest focused on the reality that smallholders produce most tree crops in the developing world. He stated that, in terms of coffee, “70% of the production is by smallholders cultivating less than 10 hectares in 80 countries in Africa, Asia and Latin America.” He noted however that smallholders receive only about 20 percent of the retail price for their produce. Yet, he also observed that a great opportunity exists to improve this situation now that “globalization and market liberalization [are] sweeping across many producing countries”.

He particularly pointed to the advantages of Eastern Africa. He stated: “Uniquely, Eastern Africa in renown for its coffee quality and professional excellence. It grows all the main types of coffee. The best Africa Arabicas and the best African Robustas are from Eastern Africa. It can also be argued that the best Natural Coffees are also from Eastern Africa. These are the Ethiopian natural Arabicas and the natural Robustas from Uganda and Tanzania.”

Waggwa Nsibirwa took a fundamentally Results Framework approach to develop his model. He identified the following as key factors affecting the increase in farmer incomes (illustrated in the ovals in the figure to the right, reading left to right):

-Research and Technology Transfer
-Grower Support and Business Services
-Markets and Information Services
-Policy Environment

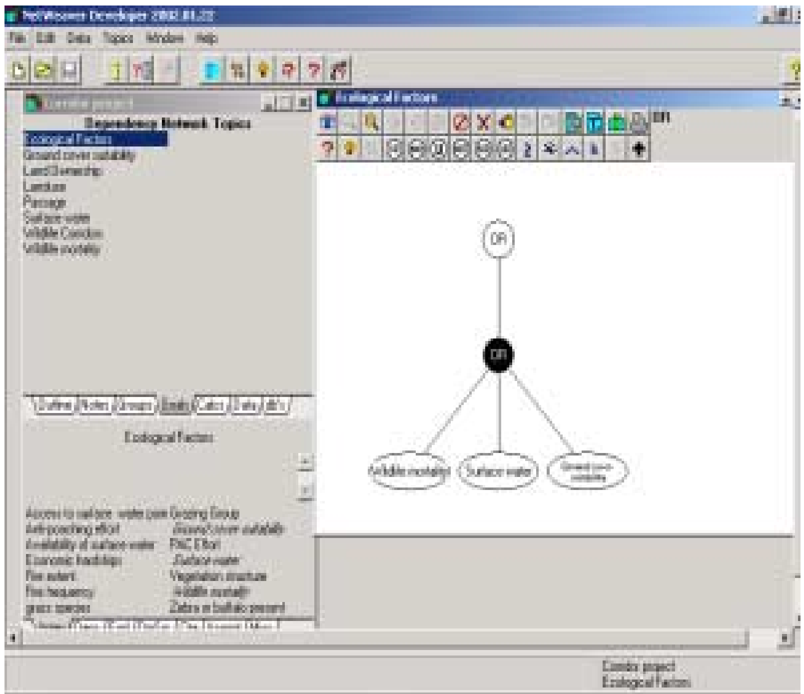




The figure to above provides examples of results from two of the 6 countries for which he input some data. It is clear in his model and using the data he did that “liberalization” is a strong contributory factor in one country (top left box) as compared to its partial membership in the fuzzy set of “True” for another country (bottom right).

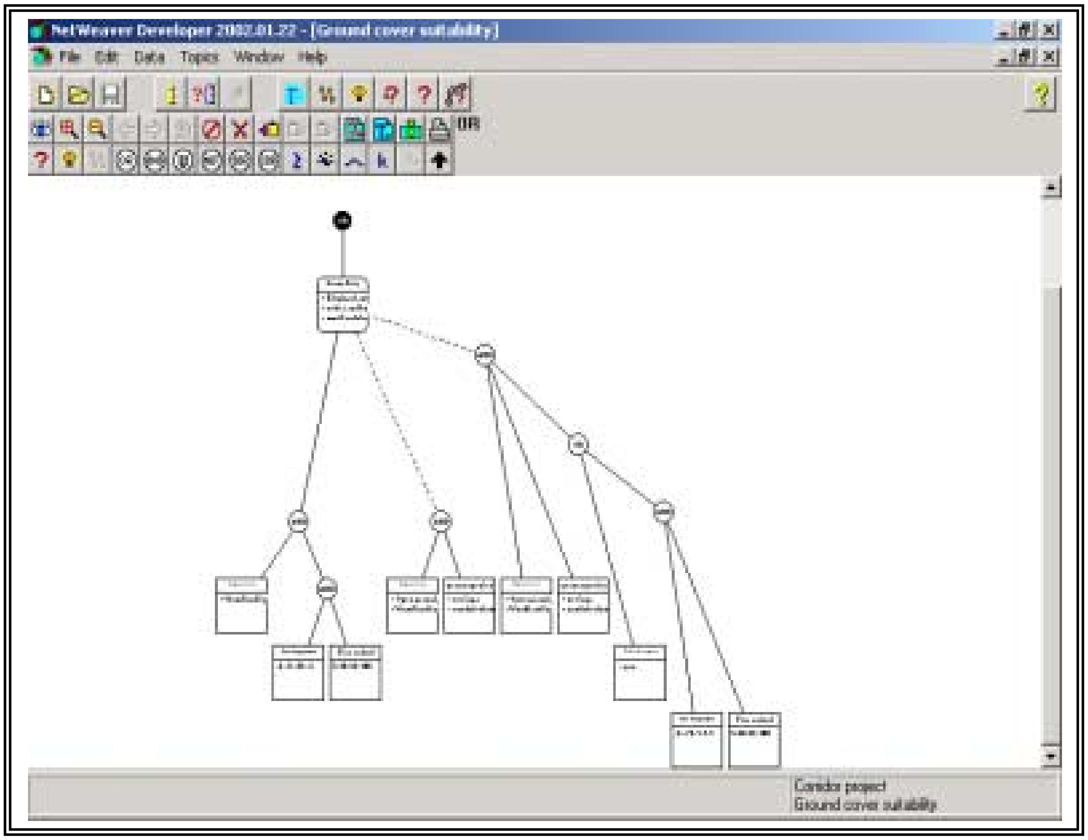
When he went back to work with his colleagues to modify his model and populate it with real life data (as compared to that used for the purposes of this practicum), these particular factors may show up as having a different level of potential influence. However, this indicated how he began to see the potential for utilizing the NetWeaver™ evaluation window with data represented in colors rather than in numbers in a datasheet for discussion purposes. As participants in the Association Task Force work together, they perhaps will want to explore the model and drill down into the deeper levels of the dependency network that he initially built. They may want to introduce new indicators or modify the indicators used in this preliminary model. And, with new input and modification, they may want to rethink the areas where their concern individually and collectively might be in Eastern Africa in terms of their efforts to increase farmer incomes.

Botswana Project: Ecological Connectivity of Core Wildlife Areas Within and Between Countries



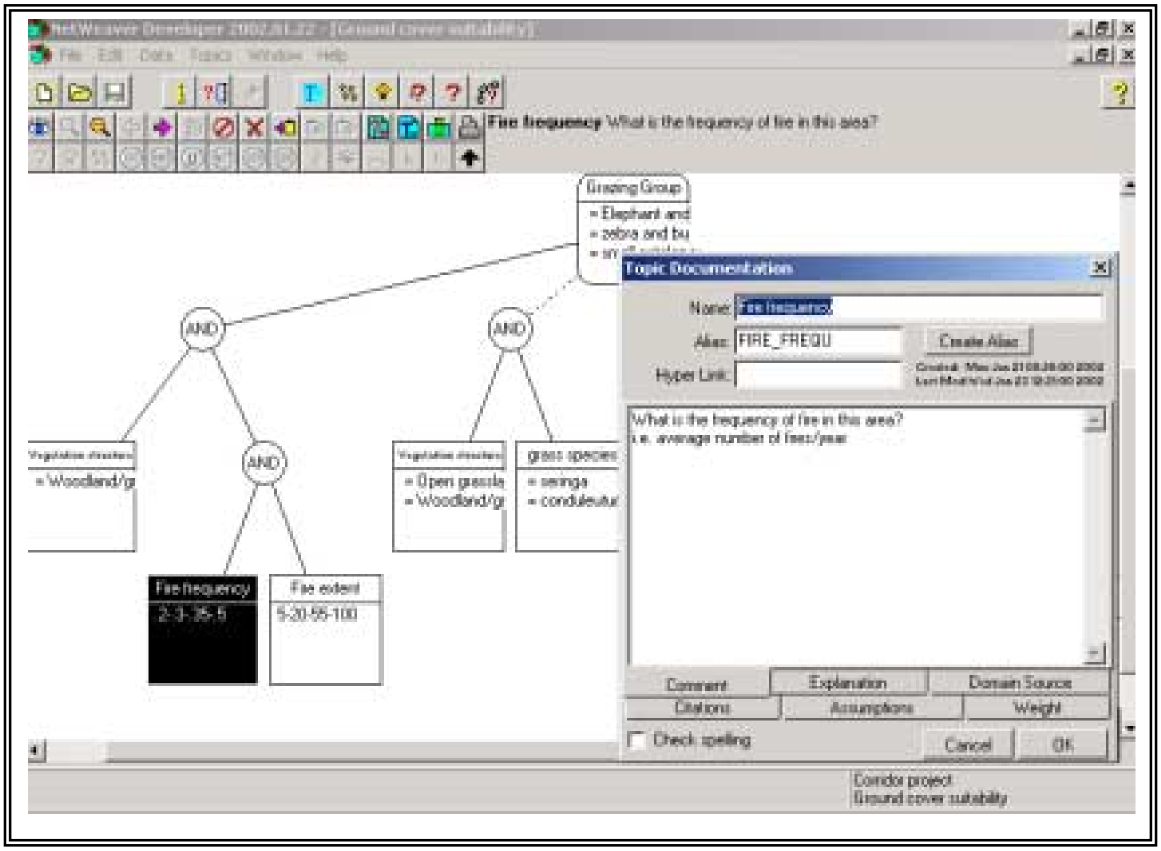
In yet another project, the trainee looked at a complex ecological issue. Leonard Dikobe works for the African Wildlife Foundation (AWF) in the "Four Corners" area, where Botswana, Namibia, Zambia, and Zimbabwe share a common border. The area provides, among other resources, a contiguous ecosystem comprising migratory wildlife corridors (i.e., habitat for elephants, buffalo, zebras, and other species) of generally high biodiversity, aesthetic tourist value, and potential for local income generation. He came with the problem domain of how to use GeoNetWeaver™ to assist in identifying across a landscape what the quality (good, fair, poor) of habitat is for a wildlife safe passage corridor for a variety of wildlife species but given the challenge of addressing a mosaic of land ownerships by the human species, in this case within and between the Hwange (Zimbabwe) and Chobe (Botswana) core wildlife areas in Zimbabwe and Botswana.

He discussed assumptions about what makes a good corridor, including looking at the land use type (e.g., industry, game management area), land ownership (e.g., State, private, tribal), ecology (e.g., vegetation, distribution of surface water), etc. (e.g., veterinary current fence, highways, electricity cables).



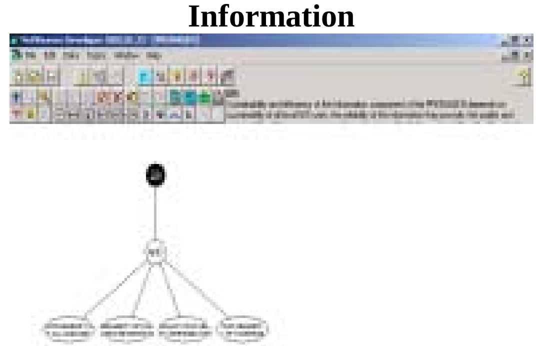
In the above screen capture of his model, Dikobe detailed some of the ecological factors in terms of wildlife mortality, surface water, and ground cover suitability.

This complex set of data links most specifically relates to ground cover suitability for three sets of species: elephants/rhinos; zebras; and antelopes (general). He explored, through this set of data links, the suitability of cover vis-à-vis fire, vegetative cover, grasses and other factors. He developed scales (i.e., from 0-10) to assess some of the factors but has identified more specific ranges of arguments for others.



In the case of frequency of fire, Dikobe most specifically asked the question: "What is the frequency of fire in this area? For this, he set a range from 3 times a year to 5 being the membership with 5 times being too many and 3 being the most acceptable for ensuring good habitat for elephants and rhino. The figures for zebras and buffalos and antelopes may be different, however, through this kind of analysis he can identify what is "good" for what species and potentially what and where it is "good" for all species and might best serve as a wildlife corridor where the countries might want to work to "buy" land uses (not land per se).

Burkina Faso Model: Sustainable Coordination of Flow of Information



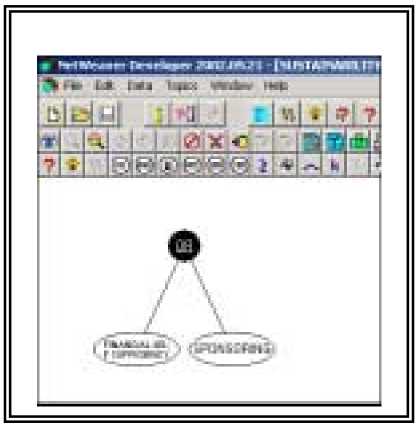
In still another model, Andre Bassole also took essentially a Results Framework approach to focus on the issue of how to ensure sustainable coordination and flow of information between local GIS units working at a group of Conservation Units. He wanted to explore some of the factors that affect management of a network, such that information is produced efficiently and in timely fashion for use in management of the conservation units.

Bassole's model looked at Sustainability and Efficiency of information in the PRONAGEN project.

He identified the above factors (goals):

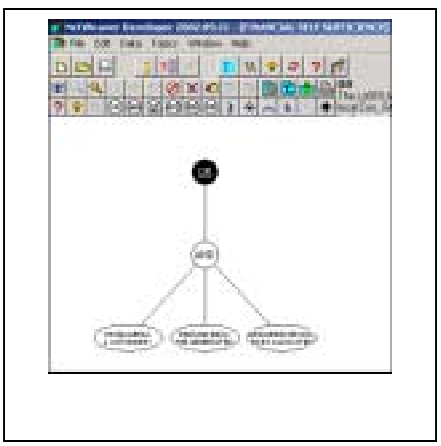
-Sustainability of all the LOGISUNSIs (local GIS units)
-Reliability of LOGISUNis information
-Quality/Sustainability of Community
-Sustainability of Coordination

Bassole then determined that another layer of logical linkage needed to be considered relative to the first oval in the previous network, i.e., the Sustainability of all LOGISUNIs.



If we clicked on that oval, we would see this set of goals/ovals

-Financial self-sufficiency (including being self-sufficient financially or being subsidized by the Government or a sponsor)

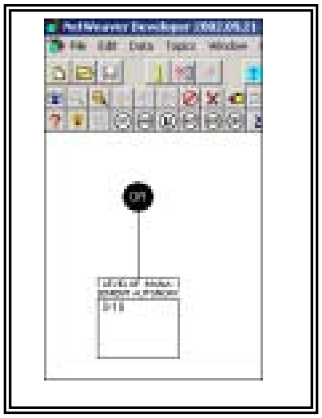


If we clicked on the oval dealing with financial self-sufficiency, Andre hypothesizes that LOGISUNIs could only be financially self sufficient if there was:

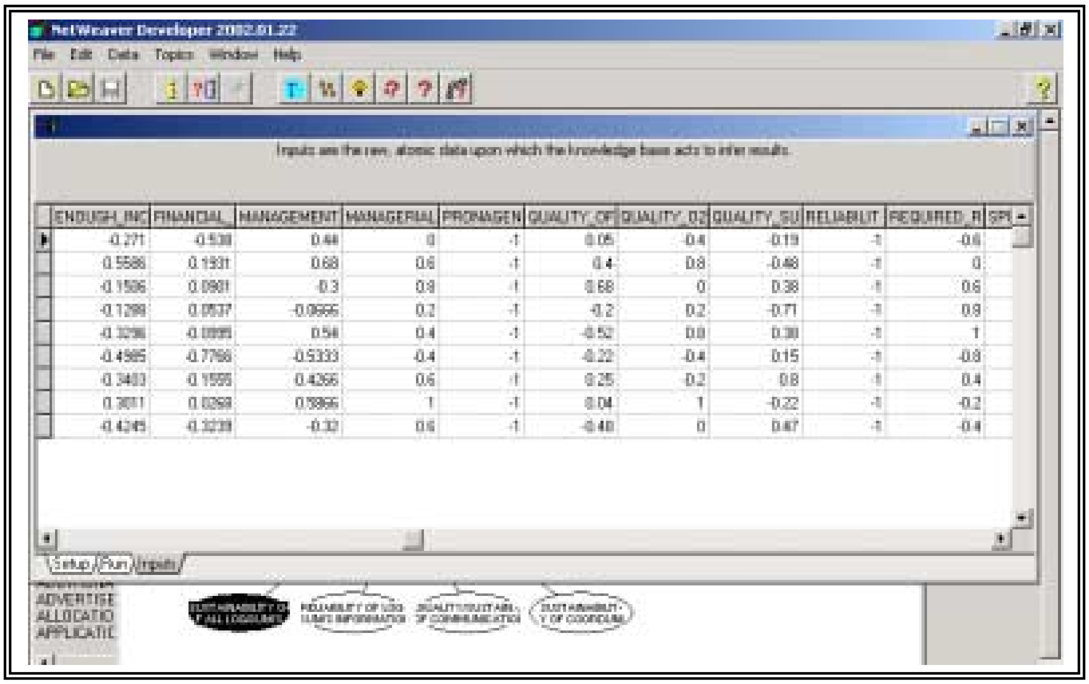
-Managerial Autonomy granted to the local Conservation Sites

-Management generated enough income, AND

-The level of Resources Required were allocated



If one clicked on the Managerial Autonomy oval, this would be the data link that Andre felt needed to provide data. In this case, he set the argument on a scale of 0-10. If a subject matter expert provided input into the analysis, the individual would be asked: “On a scale of 0 to 10, what level of managerial autonomy would you judge this conservation site to have?” Depending on the point on the scale that the SME or domain expert would place his or her evaluation, this data link and consequently the oval to which it provides a “conclusion” would appear from bright red (0 or no autonomy) to undetermined (somewhere around 5 on the scale) to bright green (10 or a high level of autonomy). This is a case where autonomy is potentially assessed at being all or none, but that some degree of autonomy might exist at different sites that might need to be identified and discussed by field practitioners and decision-makers.



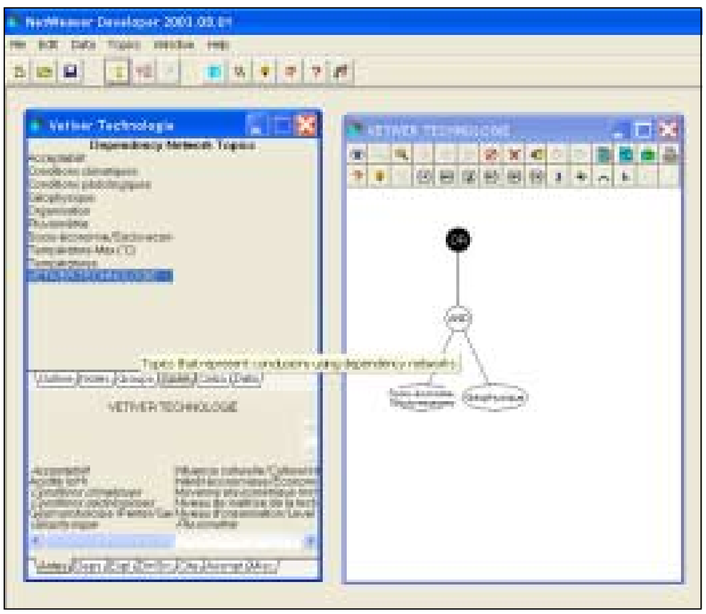
The above screen capture provides an example of the data table Bassole created and began to populate with “dummy” data for purposes of this practicum to begin to see how the model might respond. NetWeaver™ and GeoNetWeaver™ provide this capability to input data or to import it from any of a variety of sources as noted previously.

Outlined below are two examples of knowledge bases created by trainees at a recent MATS training session held in Dakar Senegal.

Three individuals from sustainable community and environment organizations worked together on developing a knowledge base focused on Vetiver. Vetiver is a grass (*Vetiver nigritana*) that has multiple uses in regard to site remediation and in handcrafted products. Site remediation uses include termite control, erosion control, water purification, wind breaks, and soil amelioration and products include woven mats, fencing, hats, thatch roofing and housing, and strengthening earth blocks for construction, etc.

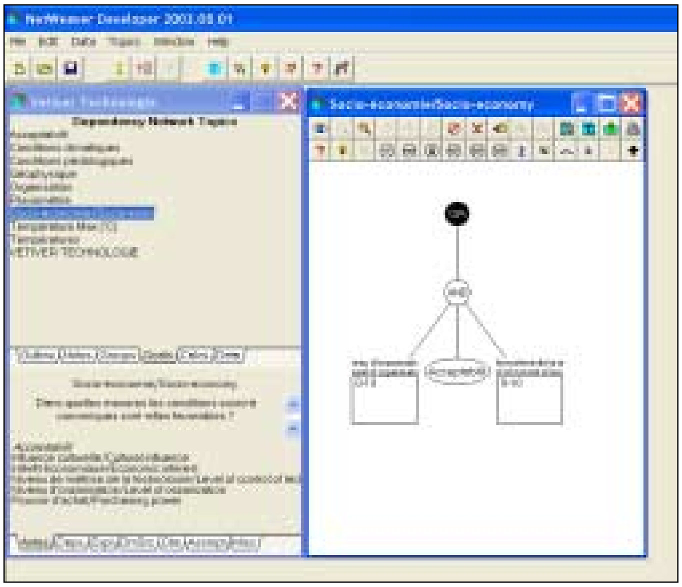
The individuals and organizations involved included:
Karim Guiro of CFPE (Centre de Formation et de Promotion de l'Entreprenariat);
Abdou Rahmane Tamba of SOS Environment; and
Ibrahima Diaw of Dynaentreprises

The question the group asked was "How to determine the suitability of Vetiver as an intervention for a particular need. The difficulty arises from the many factors that may be assessed to answer this question. Factors that may be related to the ecology of a site include soil conditions, moisture regime, past disturbance, etc., and to local socio-economics, acceptance of intervention by community, other community priorities, time commitment, etc.



The knowledge base "*Vetiver Technologie*" shown at the left therefore has a primary division into two dependency networks, *Socio-économie….* (Social-Economic) and *Geophysique* (Geophysical Environment). Within each of these dependency networks are a series of more detailed evaluations that address what the team considered to be the pertinent cultural, economic and ecological issues influencing the suitability of a site for Vetiver intervention.

The team investigated Communities in terms of their level of organization present and their acceptability of new technologies. The questions for these issues were simply framed with answers ranked from "weak" to "high" on a scale of 1 to10. The screen capture below shows an example of the knowledgebase and some of the questions posed.



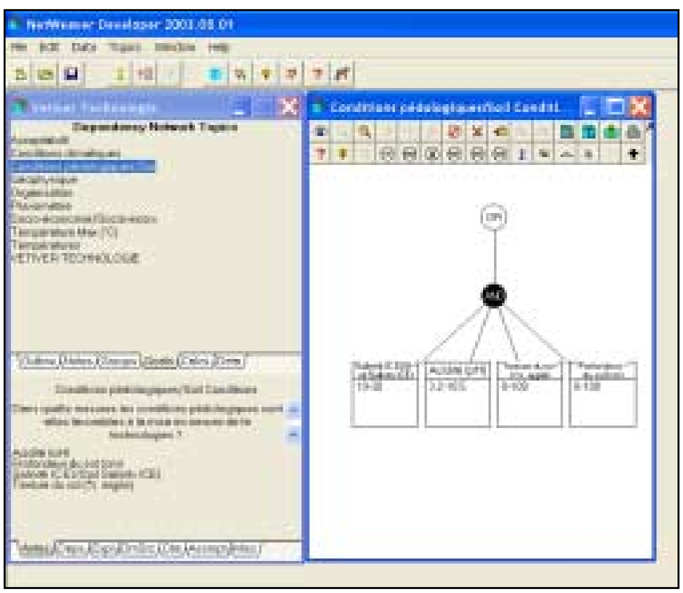
"Will the level of organization in the community support the implementation of new technologies?"

"What level of control does the community demonstrate when implementing new technologies?"

"Has the community demonstrated successful implementation of new technologies?"

"How has the economic status of the community influenced the adoption of new technologies?"

The team investigated the geophysical environment with questions related to topography, climate and soils. In NetWeaver™, they developed fuzzy arguments based on the team's understanding of the ecological amplitude of Vetiver in relation to what were considered key factors in the Senegalese environment. The screen capture below outlines a portion of the knowledgebase and some of the environmental factors assessed.

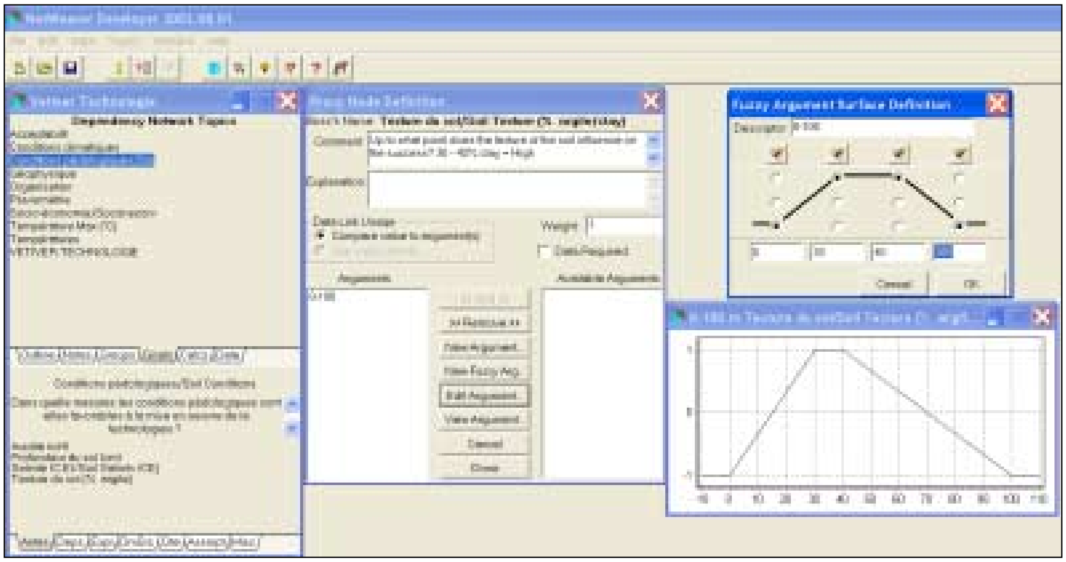


The team assessed topography in terms of percent slope, where increasing slope made introduction of Vetiver more difficult. They considered slopes above 60% as unsuitable.

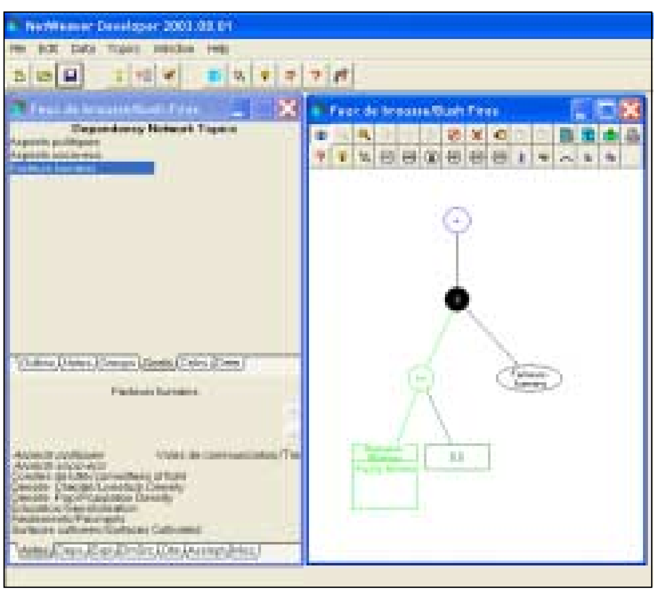
They considered climatic factors by looking at the maximum (>50^{o}C) and minimum (<5^{0}C) temperatures, the number of months with rainfall and total annual rainfall.

They assessed soils in greater detail with a consideration of salinity, acidity, texture and depth.

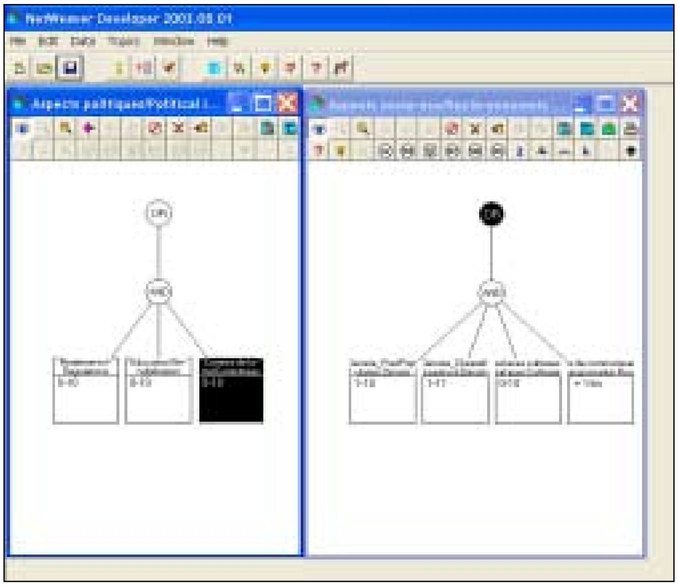
The screen capture below is the argument used to assess soil texture. It shows that a 30 to 40 % range of clay particles is optimal.



Another team at the MATS training in Senegal worked on a knowledge base directed at selecting communities that would be most suited to educational programs about the need for controlling bush fires. The environment of Senegal has a long dry season with dry tropical forests, savannah and Sahel vegetation. While fire (both naturally occurring and fires set by people) is historically a natural component of these ecosystems, recent human influences have lead to an increase in fire occurrence.



The team used the knowledge base to represent a primary "if statement" to assess the amount of vegetative biomass present in the environment. As the amount of vegetative biomass in the environment increases from 0 to 40 percent, the likelihood of bush fire increases and so to the need for education programs. Experts consider all environments with greater than 40 % vegetative biomass are prone to bush fires. All other assessments in the knowledge base are related to human factors.



The “facteurs humains” or human factors are split in to two groups: Socio-economic issues composed of relatively straight forward measures of population density, livestock density, road density, and the percentage of the surface cultivated; and Political issues composed of more subjective measures of existing regulations, local understanding about bush fires, and the presence of committees active in the prevention of bush fires.

NOTE: It is important to repeat that these are only preliminary models developed by trainees during the practicum session of the NetWeaver™/GeoNetWeaver™ session. They are not working systems, nor final models. However, they provide illustrative aspects and functions of the decision support tools presented during the training.

Results of Training Session in South Africa

1. "Proof of concept" of utility of NetWeaver™ and GeoNetWeaver™ achieved

2. Trainees developed preliminary models, addressing their own "real life" problems in the field with support from USAID/AFR/SD

3. Introduced tools to field professionals

4. Increased capacity of trainees to understand and apply new decision support tools

5. Nascent network of practitioners begins to form with participants in this training session as the first in Africa

6. Tech transfer materials improved and disseminated

7. More demand created at the field level

8. Power and potential of two cutting edge tools for development and humanitarian assistance demonstrated.

Demand Created at the Field Level

By emphasizing in point 7 above that the South Africa MATS training course created more demand at the field level, we mean that it:

- Improved use and integration of data

- Increased efficiency of learning and flow of information

- Elicited a request for training in the West Africa region

- Provided incentive for The Heron Group, LLC to translate the tutorial into French for use in training and technical assistance

- Provided additional "Help Desk" assistance via email

- Increased communication mechanisms (including a website) for sharing questions, answers, information and applications among trainees (see www.herongroupllc.com for Forum information)

Follow-up Possibilities Identified by Trainees

In closing, it is important to indicate that while this was a brief but intensive training course, participants left with ideas about how they might apply the software in the future. Among some of these very important and challenge possibilities are their ideas of focusing on:

- Transboundary issues related to natural resources

- Evaluating information in the selection of units, communities, or areas to identify projects that might have greatest potential for success

- Continuation of development of models initiated during the training

- Demonstration of model to task force working on 6 country effort and use of their input to "populate" the database for improvement in use of the software for decision support and to achieve consensus on a regional approach to solving a mutually identified problem across the region

- Application of the software for monitoring of project activities—i.e., use of the software as an adaptive knowledge tools that feeds knowledge back into implementation and redesign on a more regular basis.

- Application to development of Country Strategic Plan

Future descriptions of NetWeaver™ and GeoNetWeaver™ training program models will appear in a MATS series on The Heron Group website. These will help document that array of problems that trainees bring to the training, but more importantly the array of problems that exist in Africa that might benefit from the use of new decision support tools and processes.

Acknowledgements

The authors express appreciation to the trainees in the South Africa (January 2002) and Senegal (June 2003) training session in the use and application of NetWeaver™ and GeoNetWeaver™ as decision support tools for improved strategic planning and natural resource management. We requested that those interested submit their models to us for our use to highlight aspects of their models. The materials we have presented on their preliminary models are illustrative only. We are aware that some have pushed their models yet further. Others have used them to develop different models and apply them in other ways.

We also would like to acknowledge the support of USAID's Bureau for Africa, Office of Sustainable Development that funded the MATS effort that we have reported on in this document.