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Scenario-based decision support systems: their use in
sustainable development of rural land in Central American
hillsides

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SCENARIO BASED DECISION SUPPORT SYSTEMS; THEIR USE IN SUSTAINABLE DEVELOPMENT OF RURAL LAND IN CENTRAL AMERICAN HILLSIDE REGIONS

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Abstract

The Royal Agricultural College (RAC) has been engaged, with other institutions, in a three year project in Honduras, Central America, aimed at developing methodologies for helping communities in the hillside regions of that country to manage their natural and agricultural resources in a sustainable manner. The output of this project will be a decision support system (DSS), with accompanying training and facilitating materials, which can be used by those communities in the sustainable development of their own localities. Several DSS methodologies have been explored, with the RAC working on the scenario based methodology being considered at the *International Centre for Tropical Agriculture (CIAT)*, the lead organisation for the project.

Scenario modelling does not attempt to predict the future, nor to set specific goals to be achieved, nor even to address current problems. Instead, it accepts that whatever happens, there will be a future reality. Using available data, such as soil information, farm censuses, local knowledge, demographic models, meteorological records and satellite images, a number of scenarios are developed, which are narrative descriptions of futures which *could* come about, and are plausible, logical and consistent. The driving forces for these different scenarios are identified, so that decisions can be aimed at controlling these forces, rather than at just solving specific, current problems or achieving particular, but possibly conflicting goals. In this way, it is intended to encourage the emergence of desirable scenarios and not of undesirable ones. The future which *does* come about will be unlike any one explorative scenario, but hopefully it will be of a desirable type.

Introduction

The Royal Agricultural College (RAC) is one of several international institutions engaged in a sustainable land management project in Honduras, Central America. The project is funded for three years (1997-2000) by the *Trust Fund for Methodological Support to Ecoregional Programs*, the project lead organisation being the *International Center for Tropical Agriculture (CIAT)* (Amézquita *et al* 1998, Bebbington and Thiele 1993) based in Cali, Colombia (fig. 1). The full project title is *Community-led management of watershed resources in hillside agro-ecosystems of Latin America*.

The aim of the project is to develop decision support systems (DSS) which can be used by the rural populations of the hillside regions of Honduras in the management of their own natural resources (CIAT 1998 a). This should lead to better long term land management, because decisions will be based on local knowledge, as well as on external perceptions. The local population will also better understand and support the changes and benefits the decisions are intended to bring about. The challenge of the project is to make

sophisticated, computer based DSS accessible and comprehensible to all stakeholders in the region, whatever their educational, experiential or cultural backgrounds.



Figure 1. Central America and CIAT

The importance of the hillside regions of tropical Latin America

The hillside regions of tropical Latin America provide an agroecosystem of 96 million hectares (Jones 1993) and form the major agricultural resource for many of the countries in the region. Amézquita *et al* (1998) state that of that total, 25 million hectares is already highly degraded and 53 million hectares are experiencing rapid rates of degradation. Because of the importance of these areas for the Latin American agrarian economy, it is vital that they are managed on the basis of long term sustainability, which is not currently the case. The purpose of this project is to enable the people living in and depending on these hillside agroecosystems (the permanent stakeholders), to take an active part in the management and development of the natural resources of their own environment. The outcome will be a DSS which will allow those stakeholders to analyse their present conditions and speculate, in a reasoned manner, on the future reality that they and their descendants may face. Using these speculations they can make decisions on how best to achieve their desired future conditions.

In the first instance the study area of the project will be the country of Honduras, for which a large collection of environmental and resource data has been collected and compiled into a spatial database by CIAT (CIAT 1998 b). Honduras also has all of the economic and environmental problems which affect all Central American nations (Norsworthy and Barry, 1994) and so would benefit immensely from a successful methodology for managing some of its over exploited natural resources. If successful, the methodology for developing the DSS will be transferred to other countries in the Central American and Caribbean region, with advice and assistance on building and maintaining suitable geo-spatial databases of their own regions. (A considerable amount of work has already been done by Winograd

(1998) on building a GIS of environmental indicators for the whole Latin American/Caribbean region.)

The choice of watersheds as area management units

A large proportion of the population in Latin America is descended partially or wholly from European and African immigrants, some recent, many from hundreds of years ago. Much of this population does not have ancient or strong links with any politically defined geographic area, other than the overall nation states in the region. This means that it is hard to gain useful local information about municipal districts because the inhabitants do not identify closely with those districts and do not base their economic and social relationships on them. At the same time, government statistics on population, agriculture, economy and so on are collected within such municipal districts, and funding allocations and local legal ordinances are applied to those same districts. This is a classic example of the so called *modifiable areal unit problem* (Openshaw 1984), where different data are known about overlapping but non-congruent areas, making integration and correlation of those different data either difficult, unreliable or impossible.

To overcome this problem the project has chosen to use watersheds (drainage basins or river catchments) as the basic area units for the hillside regions being considered. These basins tend to coincide with the true local cultural regions, largely because population groups have little alternative to farming and living within their own valleys. These local cultural regions may well extend outside the absolute watershed to include nearby market towns and such towns may be part of several, overlapping local cultural regions. The matter is further complicated by the choice of either complete, macro-watersheds of a whole river, or the smaller, micro-watersheds of tributary streams. This choice will probably be made on basis of local research and analysis and may differ from region to region.

It should be noted that watersheds are unlikely to form suitable definitions of local cultural regions in areas of flat or gentle topography, such as the Caribbean lowlands of Honduras and Nicaragua.

Decision support systems

Whenever a choice has to be made, some form of decision making theory is invoked. In the case of a computer controlled system, these choices can be hard coded into the machine in the form of specific actions to be taken when specific inputs are given, e.g. if a egg weighs more than 10 gm, divert it to the left, if it weighs less than 10 gm, divert it to the right. On a more sophisticated level, neural networks can be used, where the computer learns from a history of its actions, which ones produced more acceptable outcomes and are thus reinforced as the best actions to take. This can result in situations in which the programmers of the computers do not know how the computer is arriving at its apparently increasingly correct decisions (Haykin 1998).

In the case of human decision making, the process is inevitably more complex and the validity of different decision making theories can never be scientifically tested in real situations. It is impossible to either establish a genuine control for a decision making experiment, or to repeat a decision making process with identical parameters. Having carried through one decision making and implementation process, the decision making environment is irretrievably changed by having implemented that decision.

For these reasons, and possibly for even more complex cultural reasons, such as beliefs in fatalism or predetermination, it is not surprising that developments have focused on *supporting* decision making rather than on *making* decisions. This need for a methodology

for decision support becomes even more important if worthwhile benefit is to be gained from the huge amounts of data now collected and maintained in computerised databases. This leads to the idea of decision support systems methodologies which can aid making decisions based on huge amounts of complex data. There are many decision making methodologies, all of which have their strengths. In real situations, combinations of methodologies are necessary. It then becomes most important to develop a way of gaining an overview of the whole system in which the decisions are being made. The scenario based methodology described below aims at giving this overview.

Problem solving DSS

Problems are encountered and will always have to be addressed and solved, either by solution, elimination or avoidance. The classical case of problem elimination was Alexander the Great's cutting of the Gordian knot rather than wasting time trying to untie it. Peer Gynt avoided the problem of the monstrous but immobile *Borg* which blocked his path by just walking around it and carrying on his way. Many problems simply do not need to be solved! This is a serious point, and highlights one of the weaknesses of using a problem solving methodology as a basis for strategic decision making. In this methodology, present conditions are defined and analysed. Problems with those conditions are identified and appraised. Actions to tackle those problems are designed and resources needed to implement those actions calculated and acquired. Decisions are then made on how best to mobilise those resources, to initiate those actions, to solve those problems. The flaw with using this methodology for strategic planning is that decision making should be aimed at achieving aspirations, not simply as a means of overcoming unexpected problems, which will arise chaotically and unpredictably. Simply tackling problems may take the problem solver in equally chaotic and unpredictable directions. Just solving problems is the activity of a manager who wishes to appear busy, but who does not know where the enterprise is going. Both Alexander and Peer had goals. They aimed for those goals and eliminated or side-stepped any problems which did not actually stand in their planned route.

The other fundamental flaw in a problem solving methodology is that it assumes progress or development is only driven by problems. If we have no problems then we would make no decisions, which would lead to a moribund and non-sustainable culture. This thinking is exemplified by Fukuyama's book *The End of History and the Last Man* (1993) in which it was assumed that as the "problem" of communism was "solved" by the collapse of the Soviet Union and its satellite states, there would be no more history, but a cultural steady state of benign free-market capitalism. Events have not borne out this theory.

Goal driven DSS

Alexander and Peer Gynt both had goals, and they set about reaching them. Alexander failed because he died young. Peer failed because it was in his nature to fail. But at least each knew where he wanted to go and had set about getting there. This is the basis of goal driven decision support systems. Put simply, your present conditions are identified, your desired future conditions are defined and then your path from one to the other is mapped out. This map, like a navigator's chart, will have way points, or indicators, whose successful achievement will show that we are still on course for our goal, or whose failure of achievement will show how far off our path we are, and may help identify remedial actions which could be taken to regain the path.

The basis of goal driven DSS is sound and forms the implementation method of any viable DSS. It does however have a major limitation in any system with even a small level of complexity. Any such system will have multiple stakeholders with different, possibly

incompatible goals. When looking at a system as complex as the agro-eco environment of a watershed, pure goal driven strategies cannot achieve the overview that is necessary for success.

An example of the problems that can arise from the conflicting goals of different stakeholders in the same system is seen in the current dispute between the United States and the European Union over banana imports to Europe. Disregarding any hidden agendas, or cynical feelings about politicians' true motivations, each region has a clear goal. The Americans want simple, basic free trade in which all banana producers compete on the same economic basis. The Europeans wish to give favourable support to imports of bananas from poor, former colonies which are inefficient producers, but have few other means of generating significant income.

Both goals are laudable, as presented, but each could lead to extremely undesirable outcomes. The American desire for unrestricted trade could lead to the economic collapse of a number of small nation states, which are then likely to become centres of drug trafficking and disaffected populations which could form the basis of terrorist insurrections. The European plan could lead to the growth of protectionism and the distortion of markets, as major economies support only favoured suppliers. This in turn could damage the economies of emerging nations, and even the small banana based economies the plan was meant to protect.

Both parties are stakeholders in the same environment, that of global trade, but neither is trying to see the whole system, only the isolated goal that each wishes to achieve. What is needed is a methodology for considering the whole, rather than just the parts.

The other weaknesses of a pure goal driven DSS for strategic planning are that it assumes that history is episodic, i.e. things start, develop and finish. We may set ourselves a goal to be achieved in five years time, but after five years we are likely to find that the goal is no longer relevant because of five years of change to all of the constituents of the environment.

What is needed is a methodology which encourages an overview of complex interactions, and allows that overview to be kept under continual review. The one being considered for the project in Honduras is an explorative scenario based methodology, leading to an *intelligent team/decision support systems (IT/DSS)*.

Scenario based DSS

In the preceding section, two situations were described; that which could come about if the banana market were opened to complete free trade; and that which could come about if trade barriers were imposed. These are two examples of scenarios, descriptions of futures that possibly could develop from present conditions. By studying these scenarios, decision makers can think about their possible influence on the future, without actually trying to predict that future.

Scenario modelling is a business tool with its roots in military and multi-national corporate planning (Schwartz 1996). The essence of scenario modelling is the realisation that there *will be a future*, whatever decisions are taken. The explorative scenarios are narrative descriptions of what that future might be. They must be logical, consistent and plausible. A scenario based on the impact of glaciation on Central America would be quite implausible on even a medium term geological timescale. A scenario based on global sea level rising is highly plausible and a number of alternative effects of such a change could be considered (influx of refugees from lowland areas, loss of existing ports as access to markets and so on).

Scenarios are explorative tools which allow us to consider broad overviews of possible futures but they are not decision making tools in themselves. They give stakeholders in a system the ability to describe possible futures. These would then be used as the basis of communal discussion between those stakeholders, to agree which type of future is most desirable and to identify *sets of goals*, which taken together will form the *desirable future conditions* (DFC) that the stakeholders wish to bring about (Knapp, 1999). Some of these goals must be simple enough to be observable and measurable, acting as system indicators, and forming the framework of all other goals. Goal based DSS can now be used to achieve these identified and shared aims, using problem solving techniques to overcome difficulties which arise on the way to achieving them. The system indicators will act as the way points, but not as simple milestones on the way to our goals. The whole essence of scenario modelling is that the future is unpredictable, as time and change do not stop. As we move forward through time, we must reconsider our scenarios in the light of actual developments. History is not episodic but a continuous, advancing wave which we have to ride by adjusting our balance and viewpoint until we finally and inevitably fall off, passing all decision making responsibilities on to the next generation of stakeholders.

Scenario modeling in Honduran decision making

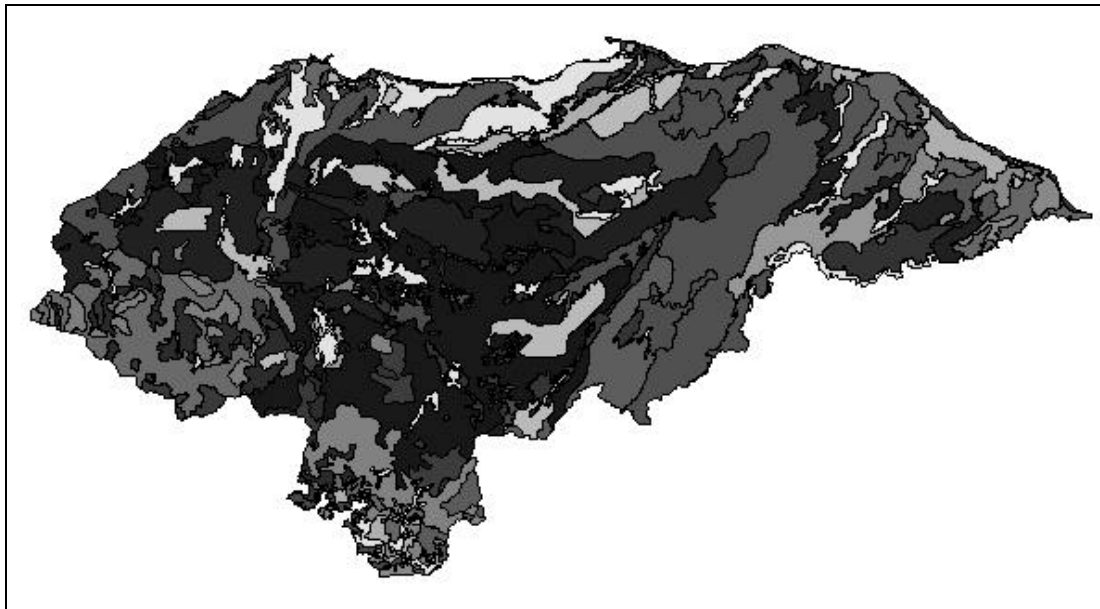


Figure 2. Honduran land use map (after CIAT 1998 b)

The full DSS methodology being considered for the Honduran hillside areas is based on four elements: explorative scenario modelling, definition of desirable future conditions, simulation modelling of key system variables and accessible databases of systems variables on which to base analysis and negotiation (Knapp, 1999). The first three requirements can be met in many parts of Latin America and the Caribbean region, with significant work having been carried out on environmental indicators for the whole area (Winograd 1995). Honduras satisfies the fourth condition more than most other countries because of large spatial databases of the country which have been assembled by CIAT from a great variety of sources (CIAT 1998 b) (fig. 2). These databases have been greatly augmented by the huge efforts made by the United States aid agencies, in the aftermath of Hurricane Mitch in late 1998, to assemble all spatial data that could be of use in the relief efforts (fig. 3) (CINDI 1998).

The first element is the creation of explorative scenarios, which can be initiated, or scripted, by any interested stakeholder. As Knapp says (1999), the role of explorative scenario modelling is to "...open and challenge the institutional mind, to stimulate strategic thinking and to establish a common language and frame of reference...the unexamined future may contain undesirable surprises." Scenarios develop from 'what if' questions, based on a knowledge of the environment being considered. A number of scenarios need to be explored, but not too many, otherwise the exercise becomes little more than a game. When particular scenarios have been created which are considered to be plausible, the driving forces of each must be examined, i.e. what factors might bring about each scenario. These driving forces may be intrinsic to the system, and possibly controllable, or completely extrinsic and beyond anyone's control, e.g. Hurricane Mitch. When making decisions on how to move towards desirable futures and away from undesirable ones, successfully handling these driving forces can be seen as solving the problems which stand between the stakeholders and their multiple goals.



Figure 3. Screen image from the *CINDI* Central American Digital Atlas showing the path of Hurricane Mitch through Honduras, Oct.-Nov. 1998 (after CINDI 1998)

The second stage, definition of desirable future conditions, will use the fore-mentioned concept of the *intelligent team/decision support system* (IT/DSS). This is described as an enabling environment which can draw together the expertise of many institutions and stakeholders to develop and manage multiple, overlapping goals. This environment is intended to be supported by a computer based *groupware* product, which will allow sharing and communication of knowledge by a dispersed collection of institutions and stakeholders. This product will be engineered to be able to learn from shared communications and make suggestions to aid collaboration. This computer product being explored for use in this way is the **Habanero**® groupware from the *National Center for Super Computing Applications*

(NCSA 1996). As well as allowing stakeholders to communicate and share knowledge, it will also allow them to access the databases of information which can aid their decision making. This can be done through simulations based on information from these databases, these simulations and databases forming the final two elements of the DSS process. The important point which needs re-emphasising is that this process does not stop. As time passes so new scenarios have to be explored to see how the system is progressing. Goals will need to be redefined as needs, conditions and desires change. A terrible reminder of how things can change has been the devastation wrought by Hurricane Mitch in Honduras and its immediate neighbours. All goals defined before October 1998 are now largely irrelevant or at least are indefinitely suspended. The new, immediate goals are food and health aid and the short term goals are rebuilding the transport infrastructure. Beyond that, we must develop new explorative scenarios, which will include the risk that Mitch could come again and that one day, inevitably, he will.

Application of the IT/DSS to date

The full methodology is still under development but it should be finalised by the end of 1999. Workshops have been held in Honduras to test some of the participatory activities with groups of stakeholders. Further workshops are planned in Nicaragua and Colombia for the first half of 1999. These will refine and test both the methodology and the **Habanero**® groupware, to see how well it can be used by people with very different experiential backgrounds and IT skills. Explorative scenarios have also been used in helping community based water resource management in a watershed in Colombia (Luijten *et al* 1998). Here scenarios helped in the analysis of real water uses and needs in the area, which could then be fed into the mathematical model of the system.

Conclusions

One of the fundamental dictums of the surveying profession is: "Go from the whole to the part". Establish an overview of a situation before you start looking at the detail. Add to this dictum the simple, overriding fact of existence: "Things change" and you have the basis of explorative scenarios as a way of looking at the World. Think of the whole and think how it might change. We know the present and the past, however imperfectly. We cannot know the future, but we can speculate on what it might be, and try to make good.

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