DINTER 0010

REPORT OF CIAT EXPERT PANEL ON THE USE OF GIS FOR DECISION SUPPORT

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EXECUTIVE SUMMARY

The Expert Panel prefaced their report by a clear statement that any recommendations made were intended to be catalytic rather than prescriptive and that CIAT should build incrementally on NRM strength First working definitions on all aspects of Decision Support Systems (DSS) were provided Second the demand for community based DSS was identified as being made up of both external pushes (e g demand made by donors end users and those led by the nature of the problem) and internal pushes (e g the need for integration maintaining connections between research themes and institutional memory)

Priorities perceived by the Expert Panel regarding their terms of reference were related to

- Institutional Issues Integration of activities are taking place but methodologies also need to be integrated
- Research There is a need to develop scenarios trade-offs risks sensitivity scaling out, and scaling-up methodologies
- Outreach Training impact analysis making more effective use of CIAT s GIS resources supporting a common language between farmers and scientists and stakeholder participation are important issues that need attention

Points were made as to how each of the above perceived priorities could be fulfilled A strong recommendation was made for the implementation of appropriate model based DSS These should be process based data lean simple in their process representation and tightly coupled to field observations A number of considerations in the development of such DSS models were made These included points of caution on modelling and the question of outsourcing vs insourcing of model development

It was concluded that established modelling approaches should be brought in through collaboration but with a view to building capacity in house to make model

modifications thereby giving control over the tools and providing a strategic overview of scientific and technical integration

The Panel made recommendations concerning GIS and DSS under the following themes

- Methodological integration through encouragement of a DSS modelling approach
- Stakeholders as co-owners in the endeavour
- The application of a case study as an integrator from science to end users through modelling
- A strategy to retain institutional memory
- Sustaining enhancing and possibly adding to the capacity in regard to integration of GIS and modelling approaches
- Support for training
- The issue of scale consideration
- The role impact assessment should play

The bottom line is that integration is the name of the game and the future is not what it used to be Invest in integration Invest in model based decision support systems and the associated technologies because these will maximise the returns on the Natural Resource Management s already considerable investment on interfacing end users and on developing spatial data analysis capacity (GIS)

1 TERMS OF REFERENCE

Advise on the

- Need for community based decision support
- Current capacity at CIAT and future requirements
- Suitability of current organisational structures to provide strong leadership and prevent fragmentation of research effort
- Capacity of DSS to deliver the research portfolio of CIAT
- What kind of conceptual framework is required to acquire a cumulative research process from CIAT s programme of community based research
- What monitoring and evaluation methods could be used to assess the effectiveness of the participatory approach
- What principles can be drawn to improve CIAT s ability to design future research in this area
- What should be CIAT s entry points in this area given its special advantages
- How can CBNRM be positioned in relation to broader strategic requirements
- What is needed to integrate the knowledge from diverse disciplines necessary to tackle the complex issues related to NRM

2 PREAMBLE

2 1 *Modus operandi* of the Panel

2 1 1 The Recommendations Made Here are not Intended to be Prescriptive but Catalytic

2 1 2 The Recommendations are Intended to Build Incrementally on CIAT s Existing Strengths Seen as

- Scientific strength on soils GIS participatory approaches enterprise and training
- A mature recognised organisation with sound institutional history
- A strong reputation among stakeholders and permanent presence in the field
- Well resourced in human and infrastructural terms compared with others (in terms of quality and quantity)
- A well established technical capacity
- Enormous and unique data collections
- Genetic resources

2 2 CIAT s Aim in CBINRM

INRM = the boundary between agriculture and environment
Integrated natural resource management through the production of demand driven knowledge and technology that contributes to achieving agricultural productivity agro ecosystems health and social capital for rural innovation focusing on outcomes

2 3 The Requirements of CBINRM Research

Research should have

- Common objective
- Be able to switch between scales and locations (transferability)
- Combining reductionist concepts with community based research
- To utilise previously unforeseen potential in IT
- The need for research to be truly cumulative
- The challenge of integrating knowledge from a range of disciplines

2 4 Definitions

2 4 1 Decision Support

Any information knowledge or process on social or environmental systems which supports the development of appropriate decisions having the intended desirable outcomes

2 4 2 Decision Support Tools

Any product or methodology (but not framework) for decision support applied to a particular problem

2 4 3 Decision Support System

A framework which supports the taking of appropriate decisions through the provision of information and understanding by means of tools ranging in sophistication from simple consultations through multi process integrated mechanistic models wrapped in transparent, adaptive and flexible software interfaces Such systems may include

- Scientific consultations
- Scientific reports
  - Field guides
  - Field methodologies
  - Maps and GIS output
- Participatory approaches
- Decision Trees
- Simple logical models
- Scientific models
- Software based Integrated DSS models
- Distinction between simple paper tools for bottom consumption and complex DSS for higher level activities

The purpose of DSS can be summarised in Table 1

Table 1 The Requirements of a DSS

SIMPLIFY	to distil complex but good data and science into usable models or simple rules
INTEGRATE	to integrate research results from very different disciplines in a common and formal language (mathematics)
COMMUNICATE	to hide complex science from the end user and link scientists with policy advisors
FLEXIBLE	to be flexible in the analysis of scenarios for change and policy options
INTERACTIVE	to be interactive fast and easy to understand
PROVIDE	to provide the end user with information they want at the scale they like when they like

2 4 4 Model Based Decision Support Systems

The most technically sophisticated type which can combine GIS models advanced interfaces and sophisticated scenario analysis and policy comparison tools Such systems are characterised by

- Modularization
- Transparency
- A problem of issue focus rather than methodological focus
- An integration of disciplines and across scales
- An ability to extrapolate through up scaling and out scaling
- The incorporation of feedback processes and loops
- The agility to translate information into knowledge (i e present not just results but also conclusions)

Research and research models have fundamentally different requirements than policy and policy models For this reason research models and research cannot successfully be transplants as is into the policy arena the approaches tools and models have to be problem focused and purpose built for decision support

Table 2 Research vs Policy Models

Research models	Policy models
Accurate representation of processes	adequate representation of processes
Complexity and resolution reflect processes	complexity and resolution reflect data
Accurate representation of spatial variability	adequate representation (existing data)
Scientifically innovative	scientifically proven
raises more questions than answers	provides simple(?) definitive(?) answers
Interesting and worthwhile in its own right	interesting and worthwhile only through its output
Process centred	input/output centred
Numbers validatable	outcomes validatable
as complex as necessary	as simple as possible

2 4 5 Discussion Support

Communication centred system providing a common language to facilitate a bi directional interaction between scientists and other stakeholders for example negotiation and conflict resolution systems

2 4 6 Decision Makers and End Users

At a range of scales

- Farmers community committees other stakeholders (decision support decision support tools)
- Governments and international donors and CIAT themselves (decision support systems model based decision support systems)

3 WHAT IS THE DEMAND FOR COMMUNITY BASED DSS?

3 1 Outside of CIAT (External Partners)

3 1 1 Demands Led by Donors/End Users

- A move from spatial snapshot targeting of aid requirement to integrated modelling of the impact of targeted aid in the long term and in a changing environment
- A move from the requirement of reports as outputs of research to tools as outputs
- A move towards empowerment of decision makers with scientific capacity (without making them scientists)
- A move towards testing multiple policies in computer before releasing them into landscapes
- A move towards searching out long term sustainability of policies as well as short term impacts CIAT faces some important challenges as focus continues to shift away from increased production to production which is productively sustainable at the farm scale and environmentally sustainable at scales from the micro catchment to the region

3 1 2 Demands Led by the Nature of the Problem

- A move towards identifying emergent surprises producing undesirable outcomes of a policy or community intervention in unexpected systems or at unexpected scales
- A move towards tackling much more multi process and multi agent issues (climate change biodiversity)
- A move towards the need to identify multi agent best bet solutions compromises and conflict resolutions

3 2 Inside of CIAT

The increasing need for an integrative force drawing together diverse disciplines (i e between projects) in a problem solving approach and making use and re use of all appropriate research results Added value cost efficiency

- The need to maintain connections between research themes in a diverse and fashion-conscious donor market in which research integration and continuity is fragmented by funding trends
- The requirement for more apparent institutional memory and more transparent and less bureaucratic review systems provided through the strong research framework provided by model based DSS

4 PERCEIVED PRIORITIES BY THE EXPERT PANEL

4 1 Institutional Priorities

How can the excellent research base at CIAT be sustained as the research questions and needs change and how should it adapt in order to keep up with these needs?

4 1 1 Integration

The group perceives that integration of *activities* is being achieved rapidly while integration of approaches methodologies and commonalities of thinking are not happening as fast as they could Separation by methodological boundaries may be an impediment to this integration

4 1 2 Cumulative Effects

Turnover of scientist s leads to changing research priorities and reduced institutional memory

4 2 Research Priorities

How are these evolving as a result of changes in the external priorities for INRM

4 2 1 Scenarios and Trade Offs

Poorly predictive processes require a precautionary approach meaning that multiple options need to be looked at The future is not what it used to be The only thing we know for sure about tomorrow is that it will be different to today New focus therefore on placing spatial data within a projective time domain

4 2 2 Risk and Sensitivity

Increasing emphasis on global change (challenge) in fragile environments requiring a need for the understanding of system and system component sensitivity to change and its spatio- temporal variability in a non-linear environment

4 2 3 Scaling Out and Scaling Up (in Time and Space)
The need to identify and focus on critical scales within CIAT s operational realm and developing tools that can allow site based research results to have wider applicability in time and space

4 3 Outreach Priorities
4 3 1 Training
Continued emphasis to close the loop on training processes to bring research results into use at the community scale and beyond (training the trainers training end users production of action plans and monitoring and evaluation of action plans)
4 3 2 Impact Analysis
Importance of understanding impact, especially for more abstract (e g non germplasm) research products and of involving impact at all stages in project preparation
4 3 3 Putting to More Effective Use the Impressive GIS Resource of CIAT
Would identifying more clearly the ***actual needs*** of end users increase uptake or are there other (say political) reasons for end user apathy at scales above the community scale
4 4 4 Supporting a Common Language Between Farmers and Scientists
Unifying the questions and knowledge streams of farmers (and end users in general) and scientists to guarantee intended understanding the role of discussion support
4 3 5 Stakeholder Participation
Engendering end user ownership of research products through participatory co development

5 HOW CAN THESE PERCEIVED PRIORITIES BE FULFILLED?

5 1 Institutional Priorities
5 1 1 Integration
Modularization of scientific outputs and the ability to link them in a multidisciplinary context allowing scientists to remain specialists whilst still providing solutions to (cross-discipline) generalist problems Model based DSS in particular is problem driven and not methodology or person driven and is thus integration friendly
5 1 2 Cumulative Effects
Models cumulate knowledge over time in an iterative manner and are thus repositories of the state of the art and allow seamless transition between outgoing and incoming scientists and projects therefore increasing institutional memory in an environment of changing funding priorities Within the context of DSS models allow the formalisation of expertise and its application to specific research issues

5 2 Research Priorities
5 2 1 Scenarios and Trade-Offs
Model based DSS allow the development of what-if type questions to compare multiple (policy) options under unknown conditions in a trending environment
5 2 2 Risk and Sensitivity – model based DSS allow the identification of variables and processes which are sensitive and the spatio temporal mapping of these processes and their interactions with society to determine changing landscapes of risk
5 2.3 Scaling Out and Scaling Up (in Time and Space)
Model based DSS provide the capacity of conducting science and providing results at sites and over times for which data were not available or collected (away from the

reference sites and into the future) Tools for the analysis of error propagation and uncertainty analysis can indicate the level of confidence of these extrapolations

5 3 Outreach Priorities

5 3 1 Training

The distillation of scientific knowledge into an interactive model based DSS can empower stakeholders with a scientific capacity of their own without the metamorphosis of mental model of the environment and social systems which comes with a scientific training

5 3 2 Impact

Like GIS model based DSS may be seen as rather abstract research outputs compared for example with new varieties However impact is best measured over very long timescales so that long term and cross scale sustainability is as important as short term production benefits are for impact Model based DSS are an important tool for understanding unintended or surprise consequences of new technologies which emerge into the future

5 3 3 Putting to More Effective Use the Impressive GIS Resource of CIAT

CIAT has developed enormous and unique (spatial) datasets which are a source for solutions given the appropriate data mining tools which are capable of distilling the data to information Model based DSS can achieve this by formalising the data within process to produce outcome and thus indicator

5 3 4 Supporting a Common Language Between Farmers and Scientists

Scientific mental models and household or community mental models of the sample problem can we quite different How can we view each other s mental models and provide bridges between them facilitating a common language of understanding Model based DSS requires a proportional effort in interfacing to that expended in modelling and with this effort can allow the visualisation of complex processes by commonly acceptable means thus facilitating communication of abstract but critical multi process interactions and feedbacks

5 3 5 Stakeholder Participation

Conventional research activities and outputs (with the notable exception of participatory approaches) are rather elitist by nature of their codification in concept and language and are thus not readily amenable to stakeholder participation Model based DSS are intended to hide scientific complexity allowing stakeholder participation at the level of developing system diagrams scenarios policy options and impact indicators throughout a project

6 WHAT TYPE OF MODEL BASED DSS ARE MOST APPROPRIATE TO NRM?

6 1 Process Centred

- Because empirical approaches may be better predictors but they do not allow the identification of causal processes – which is the first step in providing solutions
- Because empirical approaches may be better predictors but they do not allow the identification of casual processes – which is the first step in providing solutions
- Because processes are more persistent in time and space than data are (and thus extrapolation is possible)
- Because understanding processes and their connection provides the capacity to understand unintended and unexpected consequences

6 2 Data Lean

- Because there are few data feasts especially in the most marginal environments

6 3 Simple (Though Spatio-Temporally Heterogeneous) In Process and Data But Sophisticated in Linkage and Feedback.

- Because environmental complexity is an emergent property of simple systems tightly connected

6 4 Tightly Coupled to Field Observations of Process and Outcome

- Because reality checks and feedback to model building are important

6 5 A Strong Focus on the Verification and Validation of Models for Which this is Possible Especially the Biophysical

Because too many modellers do not validate and one has to be very sure that process representation in DSS models is accurate if one (and thus ones end users) is to have confidence in the system

7 CONSIDERATIONS IN THE DEVELOPMENT OF MODEL-BASED DSS

7 1 General

- Model is a means to an end not an end in itself let the problem drive the process do not let the model drive the process
- Models produce information not facts DSS produce scenarios not realities Ensure that the systems are used in exploration of implication and in education not in prediction People like to predict but prediction is impossible especially with respect to the future Prediction does not solve problems
- DSS Modelling can only take place within the context of strong issue or problem led strategic plan which provides clear model objectives
- Careful thought needs to be given whether to outsource or develop in house capacity in model based DSS

7 2 Outsourcing

7 2 1 Advantages

- Takes advantage of a long history of model development and application outside
- Couples a data rich institution with model rich institutions inching CIAT as a data centre
- Requires less investment

7 2 2 Disadvantages

- Makes it difficult to incorporate strong CIAT science into model based DSS meaning a reliance on the external science which has developed these models (often under non tropical conditions)
- Externalises many of the institutional benefits (institutional memory integration) that would accrue from in house capacity
- Reduces in house control on the modelling process and its focus

7 3 Insourcing

7 3 1 Advantages

- Ensures that CIAT science as well as CIAT data feeds the decision support process
- Adds value to CIAT GIS and data by enhancing accessibility and analytical capability thus closing the loop
- Compliments CIAT's significant computing infrastructure and data strengths
- Internalises the institutional benefits (integration memory) of investment in model based DSS
- Allows much tighter control on the modelling process and its focus on end users within the context of CIAT s focus on end users

7 3 2 Disadvantages

- Requires a significant investment in specialist skills
- Expands the diversity of CIAT's investment further

7 4 Recommendation

The correct approach to take depends upon the relative importance of these advantages and disadvantages from a CIAT perspective but the panel recommends

- Use established approaches brought in through collaboration but which can be modified in house to use CIAT s scientific expertise
- Build the internal capacity to do this modification
- This provides an element of control over and understanding of the tools and provides a strategic overview of scientific integration (ensuring the combined tool makes scientific sense in the same way the individual components do) and technical integration (making sure that the individual components talk with each other and with the data sets and end users in appropriate way)

8 RECOMMENDATIONS OF THE PANEL CONCERNING GIS AND DSS

If CIAT is to adopt the integrative problem focused decision support system approach some thought needs to be given to fostering the environment in which that approach can readily grow Here the panel indicates some areas in which

- Model based DSS can assist CIAT overcome some of the current obstacles faced by NRM and
- The kinds of philosophies that will provide the environment in which model based GIS can help CIAT NRM achieve its mission

8 1 Research Focus

- A continued recognition of the importance of temporal as well as spatial variability and the need for projective and scenario based approaches to understanding outcomes of policy or farmer (or CIAT) interventions
- A continued recognition of the importance of understanding offsite emergent or unforeseen circumstances of interventions and environmental surprises in tightly coupled systems What are the long term or offsite or larger scale surprises and disbenefits that emerge from individually beneficial technologies at the farm scale?

- A continued recognition of the importance of vulnerability and risk because of the marginality of the environments in which CIAT works

8 2 Methodological Integration and Integration of Approach as Well as Activity

Encouraging a modelling approach to decision support through the development of decision support systems focuses on issues and problems rather than methodologies and provides an overall unifying methodological framework For this to be achieved in existing projects may require

- Training towards systems thinking
- Exposure to modelling concepts and tools
- Recognising the need for spatio temporal approaches as opposed to just spatial approaches

8 3 Stakeholders as Owners

- Explore methods to involve national and international stakeholders and decision makers into the modelling and DSS building process to confer co-ownership and responsibility
- Sustain stakeholder participation at the community level and enhance it through the co development co application of DS tools

8 4 Case Study

Possibility of using *hillsides* as a case study in integration using a modelling approach from problem through science to decision support training and end user empowerment

8 5 Retaining Institutional Memory

Strategic planning to develop structures and an environment in which institutional memory is retained through

- Identification of strategic research foci
- To facilitate cross disciplinary integration
- To assure institutional memory and
- Facilitate interdisciplinary co operation and common goals in a diverse funding environment
- A review of organisational structure with a view to
- Encouraging a multidisciplinary approach
- Reducing the bureaucratic load
- Facilitating collaboration outside of NRM
- Project evaluation
- Sustained investment in impact assessment
- Evaluation streamlined with respect to an integrated approach to problem solving

8 6 Capacity

- Sustain and enhance the important capacity in

GIS
Participatory approaches
Training
Impact assessment
Scientific core

- Add capacity which allows the integration of GIS with modelling activities for decision support
- Invest in a scientific integrator for DSS

8 7 Training

- Further encourage training approaches in the application of decision support tools to ensure technology transfer and decision empowerment
- Continue to close the training loop through evaluation of its effectiveness
- Continue to innovate to bridge the communication gap between scientists and end users
- Build modelling capacity at CIAT over the long term by investing in the training of selected technical and scientific staff (short courses masters PhD) in these approaches GIS is a tool and can thus be trained in house in job modelling is a conceptual approach and research methodology and thus requires a more academic and less technical training

8 8 Model Attributes

Not all modelling approaches are appropriate for the type of research which CIAT undertakes Some characteristics of appropriate models are listed

Process based

- Because the systems in which CIAT makes interventions are spatially and temporally heterogeneous and are characterised by complex interactions Process based models are better suited to these interactions though the panel recognise that different approaches will be suitable in different systems (biophysical social economic) such that any one DSS will contain a diversity of approaches

Transparent

- Models can only assist in institutional (as opposed to individual) learning and integration where they are transparent to a wide audience The simplest way to achieve this is to focus on the development of model building blocks small modelling units describing a few processes which can be slotted into larger and more complex model based decision support systems as needed There must be a move away from the production of complex multi routine closed code models

Modular

- Model based DSS should be modular because as well as facilitating transparency modularity facilitates incremental problem solving and institutional memory A modular DSS approach requires strong scientific and technical integration and the development of quite specific protocols for module development This does not have to restrict research flexibility since the model is one of the outputs of the research not the driver for it
- As simple as possible the simplest models are often the best models in NRM and are often more transparent and more data lean

Data lean

- Making best use of limited data sets applicable away from test sites and with a concentration on data quality

8 9 Scales

- Different approaches to decision support are appropriate at different scales (in time and space)
- Recognise connectivity between separate communities and the emergence of properties at higher scales
- Develop methodologies to link approaches across scales (esp farm to watershed)

8 10 Impact Assessment

- Should be part of the project from planning to execution
- More emphasis needs to be placed on non production economics (e g environmental goods and services in impact assessment)

The bottom line is that integration is the name of the game" and the future is not what it used to be Invest in integration Invest in model based decision support systems and the associated technologies because these will maximise the returns on the Natural Resource Management's already considerable investment on interfacing end users and on developing spatial data analysis capacity (GIS)