Ecoregional Research at ILRI: background[1]

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Abstract

This paper looks briefly at ecoregional research: what is commonly meant by the term and how it may be carried out. ILRI's involvement in various ecoregional consortia is discussed, together with problems and constraints that have been faced to date. The paper ends by listing a number of issues that require resolution if substantive progress is to be made in ecoregional research at ILRI and if the potential benefits of small teams of scientists located in different regions are to be realised. The object of the workshop is to work towards solving some of these issues, by sharpening both focus and methods of ecoregional research at ILRI.

1. Introduction

Since the 1970s, the CGIAR has focussed on research to improve agricultural productivity. Increasingly, sustainability of agriculture, especially degradation and loss of soil, water and other natural resources, has become a concern, especially in developing countries where agriculture is the driving force for food security and poverty alleviation.

The CGIAR approved the support to ecoregional research in 1992. Ecoregional initiatives were promoted by the Technical Advisory Committee (TAC) of the CGIAR as a vehicle for:

a) Increasing research on the conservation and management of natural resources, linking agricultural productivity with the sustainable use of natural resources, and

b) Rationalising CGIAR centre contacts with the National Agricultural Research Systems (NARS)

In *Priorities and Strategies for the CGIAR (1992*), the Technical Advisory Committee recommended improving natural resource management through ecoregional research as a fundamental goal for CGIAR research along with improving agriculture productivity. An ecoregion was regarded as an agroecological zone, regionally defined. The foci of natural resource management research are the agroecozones, which share common characteristics of soil, water, climate, etc. However, TAC also recognised the significant differences within and between agroecozones in agricultural practices and markets that are influenced by socio-economic, political, cultural and other non agro-ecological factors.

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TAC also acknowledged that the global research community did not have an appropriate paradigm for natural resource management research. Thus identifying a conceptual framework and effective methods for ecoregional research were regarded as goals of truly international relevance.

The following were identified as international outputs of ecoregional research:

1. Effective research and development approaches for Natural Resource Management (NRM) that bring sustainable improvements in productivity to rural communities.

2. Understanding of the principles of management of soil, water, and biological processes, and their interactions in different ecologies.

3. Effective mechanisms to link decision-making and policy formulation and implementation, with technological opportunities and social organizations as instruments of change, at different levels.

4. Understanding of the principles of farmer and community decision-making, particularly the trade-offs between short-term gains and the long-term sustainability of production.

5. Human resource capacity to help national research systems implement an effective research approach to natural resource management.

Following TAC's recommendations, different ecoregional initiatives have been organised by the CGIAR. TAC designated a CG Center to take the lead role to develop consortia of NARS, Advanced Research Institutes (ARIs) and other International Agricultural Research Centres (IARCs). It was left to the different consortia to define their mandate, their scope of activities and the roles of the different partners. These consortia then engaged in constraint analysis, priority setting, agreement on responsibilities, and development of proposals for funding.

2. The Nature of Ecoregional Research

What is Ecoregional Research?

Ecoregional research has been thrust high on the research agendas of IARCs and associated ARIs and NARS. The response of the sceptic is to dismiss it as old wine in new bottles, while to the convert it represents a paradigm shift in the way in which much agricultural research and development is conceived and implemented. As usual, the truth lies in between. There is undoubtedly a real need for ecoregional research, but there is not (yet, anyway) a cohesive modus operandi for doing it.

While it is not worth attempting to define "ecoregional research" (ER) with any precision – the term is rather like "sustainability" and "gender", whose meaning is now surrounded in a mist of imprecision – we can certainly identify some characteristics associated with it. For example, Rabbinge (1995), a tireless proponent and philosopher of the approach, writes that:

1. It deals with the region, not the farm and not the continent.

2. It bridges the gap between basic science and applied science.

3. It bridges the gap between the biophysical sciences and the socio-economic sciences.

4. It rectifies the common and erroneous assumption that the environment is an independent forcing variable.

5. It permits the systematic study of changes in land-use and in agricultural systems.

This concept clearly goes much further than the idea of an ecoregion as an agroecological zone, regionally defined. Such a list makes it easy to see what ER is not. It is not Farming Systems Research (FSR), for instance. FSR never generally dealt with 1 and 5, often included only token appreciation of 4, but did attempt 2 and 3. It is not the same as systems research; systems research deals with systems in general at every level in the hierarchy (but we may well say that ER is a subset or special case of systems research).

Much of the confusion about ecoregional research probably arises because of the notion of "region" – what is it, and how is it defined. Rabbinge (1995) defines the region "… in terms of its natural, administrative or socio-economic boundaries, within which the main rural and land development issues are made explicit" (the second half of this sentence is not very clear). So what is an ecoregion? Is it an agroecological zone, a recommendation domain, a natural resource management domain? Is an ecoregion contiguous, or simply made up of parcels of land of particular characteristics? Clearly, an ecoregion may be any of these; it depends purely on the purpose of the agglomeration and the analysis proposed. In this respect it is just like a "system": it is defined purely for the purpose of the analyst. In the same way that it makes no sense to collect data in the absence of an underlying hypothesis, it makes no sense to define an ecoregion in the absence of a purpose.

There are two ramifications of this. First, there is no such thing as The Ecoregion – it is explicitly a dynamic idea, a construct to facilitate analysis. Second, it forces the agricultural research to think about the level of analysis. For any field-based research activity, the idea of extrapolating from the particular site where the experiment was done to the ecoregion, where the ecoregion is defined (say) as the semiarid regions of Africa, will often be meaningless. It is quite likely that at such disparate scales, the very processes being investigated at the plot level are of no relevance (or do not even operate) at the continental scale. Agricultural research is making tentative movements towards encompassing the notions and concepts that have been used in ecology for years. As in many traditional disciplinary areas, there are tremendous synergies to be gained from swapping and adapting tools and concepts, particularly amongst agriculture, ecology, geography and economics. ER has a vital catalytic role to play in all of this. This scale issue is of central concern to ecoregional research. Somehow, results of experimentation at the plot, parcel, and watershed levels have to be generalised to much wider regions, if the process is to

work. For the basic biophysical processes, such as the transformations of N in the soil, for example, this is comparatively straightforward: good, reasonably mechanistic models exist of such processes that are independent of environment, and can thus, with appropriate input data, be applied in environments in general. There are many other processes that are either at higher levels in the hierarchy or for which understanding is much less complete. For processes such as these, generic and generalisable models lie considerably in the future.

How is it Done?

Two important questions are, can ecoregional research actually do the things listed above, in the list distilled from Rabbinge (1995), and if so, how?

It may be useful to think of ecoregional research as an agriculturally-orientated extension (or subsystem) of systems research. Seen in this light, an illustrious forerunner was the FAO meeting of 1986 (Bunting, 1987), and even then they were grappling at the large scale with the issues of data availability and databases, modelling, and identification of minimum datasets for studying biophysical and socioeconomic processes. Another forerunner, at a higher scale, was the IBSNAT project and the DSSAT set of crop models; this project also sort to identify biophysical minimum data sets to facilitate comparison and extrapolation (Tsuji *et al*., 1998).

The issues of NRM at the regional level were clearly to the fore even in the late 1980s, even if the tools to address such issues were not as well developed as they are today. The ideas of compatible global databases, linking socioeconomic factors into recommendation domains, and linking detailed biophysical models with resource economic models, have a surprisingly long history. It is still the case that tools outstrip data – data really are critical to the approach, and until we have more extensive compatible, global-level biophysical and socioeconomic databases, ecoregional research is going to be severely constrained in its effectiveness.

As noted above, continual consideration has to be given to the level in the system hierarchy at which the analysis is being carried out; the processes are different, and the tools required to study them are also different (Figure 1). In agricultural science, at least, the ways in which level of detail, system level, the processes operating, and appropriate models to study them, have not been very well elucidated, despite some attempts in this direction (e.g. Fresco, 1995; Bouma and Hosbeek, 1996).

Wherever in the hierarchy studies are undertaken, agricultural research is often represented as an iterative process, from characterisation and diagnosis through technology generation, technology testing, delivery, adoption and impact on appropriate target beneficiaries (Figure 2). The characterisation and diagnosis phases, if concerned with agricultural systems or component systems, will often involve some form of formal or informal modelling, as a theory about how the system works, to enable (or at least to help) constraints to be identified and interventions assessed.

Figure 1 Some of the levels in the agricultural system hierarchy.

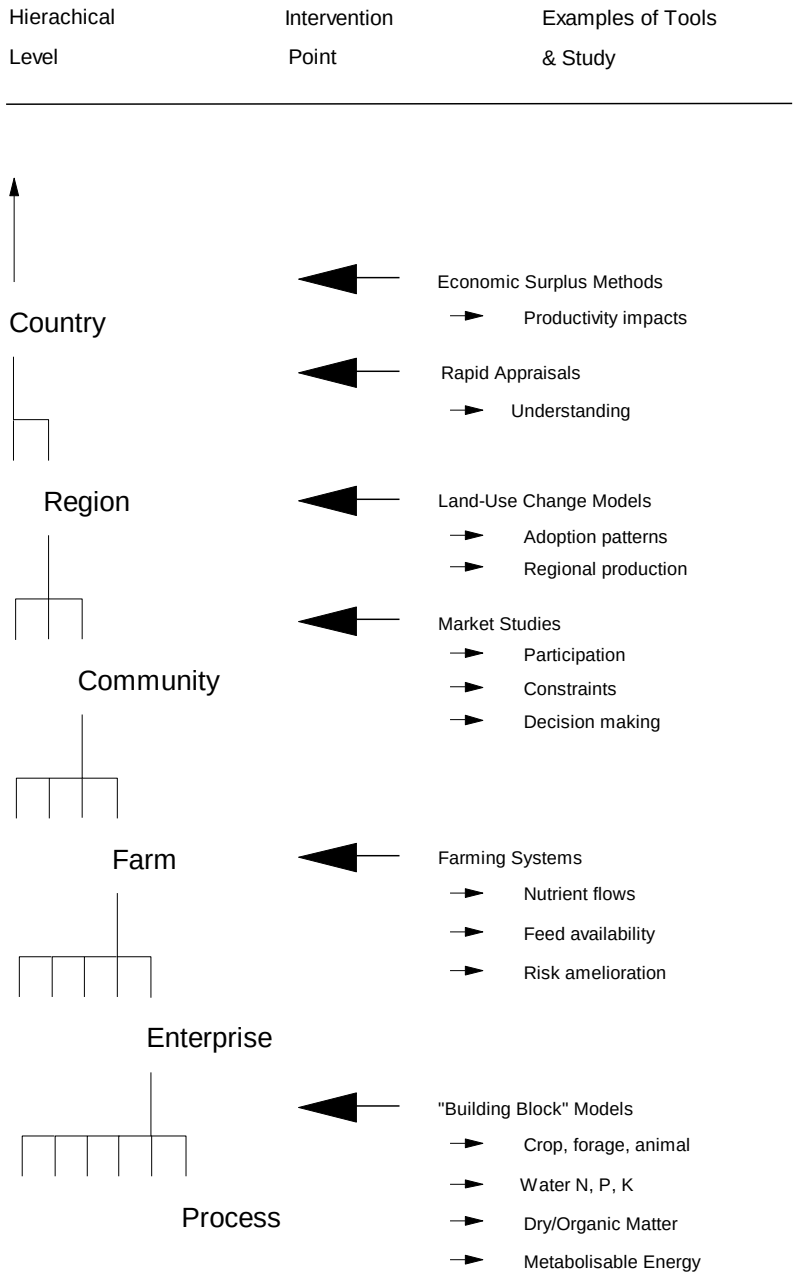
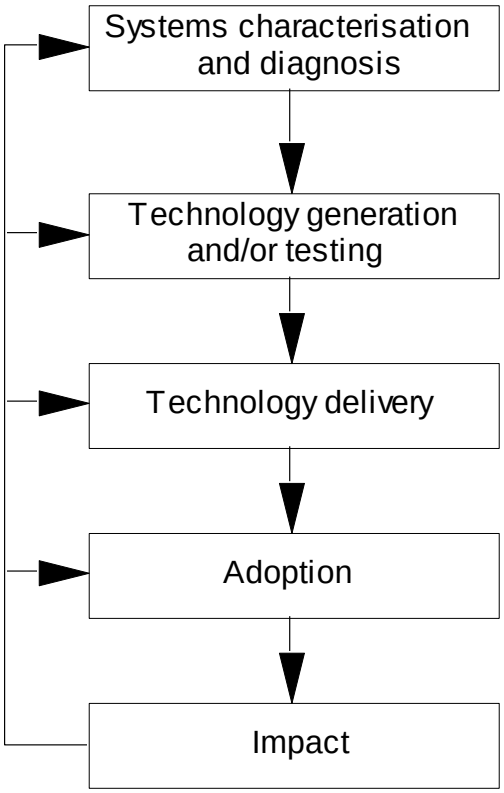


Figure 2 Agricultural research as an iterative process



Ecoregional research does not, however, necessarily encompass all the steps in the process (Figure 2). In fact to define whether particular research is truly "ecoregional" is not always easy – but if it addresses the five points from Rabbinge enumerated above, then it probably is (or could usefully be considered) ecoregional research.

The Tools and Activities of Ecoregional Research

Some brief comments follow on particular aspects of various tools and activities of ecoregional research.

Ecoregional characterisation

Ecoregional characterisation need not be limited to spatial characterisations in terms of climatic or edaphic conditions, for example. As noted above, it has to be related to some purpose, and the socioeconomic factors are likely to be the most problematic in the characterisation, principally for two reasons: first, because social factors are not generally spatially contiguous (unlike soil types in a landscape, for instance); and second, because although economics is at bottom about the geography of money, with one or two exceptions economics has not yet really dealt with its spatial and geographic roots. The latter is changing, but the former reason is a stumbling block, because the analytical treatment of contiguous and non-contiguous variables is different. This is presumably one more reason why so little progress has been made (or even can be made) with respect to definition of a minimum data set of socioeconomic variables that parallels the relative success of a minimum data set for crop modelling purposes.

Ecoregional characterisations may use rather gross proxies of certain socioeconomic variables, such as human population density, to add to the climate, soil type, elevation, slope and aspect data from digital elevation models, infrastructural data and land cover/land use maps that are often overlaid and treated to provide agroecological zonations. The problem of data remains; the mountains of time and effort required to collate and treat appropriate census data to form many of these coverages are known well only to those people who are actively involved in doing this (and this does not include the collection of these data at the primary level). Much more work is required on suitable socioeconomic indicators that can serve as proxies for a wide variety of variables. Being able to target particular potential beneficiaries (of a certain wealth or poverty class, for example) is becoming increasingly important.

The issue certainly becomes more complex as transregional relevance comes to the fore. Many agricultural technologies have some degree of locational specificity that limits returns to scale in research and makes adaptive research a prerequisite for diffusion. In these cases, farmer preferences, attitudes and other stakeholder-related considerations become increasingly important for defining recommendation domains.

Ecoregional modelling

It is hard to see how ecoregional research can proceed very far in the absence of models. It is possible to envisage that just about any model could be used for ecoregional studies, particularly in a step-wise approach (such as using detailed biophysical simulation models to generate input-output coefficients for mathematical programming models). These models may operate at nearly any level in the hierarchy (Figure 1), from detailed plot-based biophysical models to multisectoral economic models. We might make an initial distinction between non-spatial and spatial models, although as usual in such distinctions, there is often overlap.

For non-spatial models (or models that are not spatially explicit), there is a wide variety available. Thorne (1998) reviews some existing crop and livestock simulation models, with a view to elucidating the ease or otherwise with which they could be put together to investigate crop-livestock interactions in the various regions where ILRI works. There are certainly examples of such models being put together to study NRM issues at the household and watershed levels – Hansen (1996) is a notable example.

Much of the Dutch work in ecoregional research has revolved around the use of mathematical programming at the regional level – a good example of a hybrid approach that can generate useful information. Mathematical programming models are not of themselves spatially explicit, although optimisation problems can be formulated in such as a way as to take account of space at a fairly coarse scale. Tools such as crop models, GIS and goal/linear programming have been linked quite successfully to study how various socio-economic, ecological and agricultural objectives can be achieved and traded off against each other (Rabbinge and van Latesteijn, 1992; van Keulen and Veeneklaas, 1993; van Latesteijn, 1995) Such methods are currently being used to look at land-use options in West Africa (van Duivenboden, 1998) and Asia (Roetter and Hoanh, 1998).

It is likely that spatially-explicit models will be of particular value in ecoregional research. Such models include land-use models, systems analysis models, and other types of models linked in some way to spatial databases or Geographic Information Systems (GIS). Models of biophysical processes (rainfall, hydrology, plant growth, nutrient dynamics, livestock productivity) are commonly linked to spatial databases in order to demonstrate change. As noted above, socio-economic processes have been neglected because they are less amenable to modelling in the same fashion. Nevertheless, it is possible to portray social, cultural and economic processes in space; the challenge is to find a way to link the two, in a spatial framework. To this end, simple and well-focussed models based on typologies or qualitative relationships, for instance, may be more practicable at present than complex diagnostic models.

Much spatial modelling originated in spheres other than agriculture; its application to agriculture-related questions can be expected to result in substantial cross-fertilisation of concepts. Much of this modelling work may be described as "exploratory", in the sense that the ultimate utility of these models is uncertain; if they are useful, then the methods and models can be developed further; if not, then that particular line of inquiry can be abandoned before too much time has been spent on it, and something else can be attempted.

The importance of spatial arrangements and relationships in many of the processes that define the environment within which human activity is carried out (including agriculture) is receiving increasing attention. A wide variety of methods that seek to have an impact on problem solving has been developed. Examples include: spatial models of herbivory including SAVANNA (reviewed by Coughenour, 1991); landscape ecology models (Turner, 1990; Turner *et al*., 1996); human and livestock population distribution models (Deichmann, 1996; Wint, 1996); static and dynamic systems analysis models (Shepherd and Soule, 1996); semi-econometric models to explain deforestation patterns (Chomitz and Gray, 1996); and simple Markov rule-based models of land-use dynamics in a watershed (Thornton and Jones, 1998; Stoorvogel, 1995). In addition, there is a whole array of regression, statistical, economic, and ecosystem models that contain some spatial components to study land use and deforestation processes (reviewed by Lambin, 1994).

The reviews cited above provide excellent overviews of what has been done and what remains to be done in these various modelling areas.

Ecoregional adoption and impact

Assuming that an ecoregion has been characterised in some way, constraints and interventions identified, technology tested on the ground, and subsequently delivered to target beneficiaries somehow (assumptions of heroic proportions), then adoption and impact should follow, together with studies showing these. So far as we are aware, there are as yet no studies of ecoregional adoption and impact as emanating from ecoregional research *per se*, but presumably this will change in the future. The tools and techniques for adoption and impact studies are likely to be the same as for non-ecoregional studies, except that if the characterisation work has been done, then appropriate baseline data exist with which to analyse “before” and “after” scenarios. The provision of good baseline data to carry out adoption and impact work is increasingly important. It is generally far preferable to do a time series impact assessment (“then” and “now”) rather than a cross-sectional assessment involving “adopters” and “non-adopters”, in an attempt to minimise the confounding of survey data.

Transregional analysis

This is probably the “holy grail” of ecoregional research: the point at which the research carried out in one ecoregion is transferable and applicable to another ecoregion. The practicalities are currently formidable. A detailed mechanistic crop growth and development model is, in a sense, a good metaphor for transregional research, since it should be applicable anywhere, with minor modifications and extensions. How this operates at higher levels in the agricultural system hierarchy, or in situations where we do not understand very well the processes going on (thus precluding the idea of a mechanistic model for the time being), is much harder to say.

3. Livestock in the Ecoregional Context

Livestock are of particular importance in the ecoregional context. They are often the key to maintaining productivity and sustainability of agricultural systems. However, the specific role and the relative importance of livestock in production systems and natural resource management vary across agroecozones (e.g. from the dry to the wetter regions). Moreover, livestock products are increasingly important as urbanisation, income growth and population expansion stimulate markets for meat and milk. In some ecoregions, livestock are often the important "cash crop" available to smallholders; while in others they contribute to subsistence crop agriculture through the use of traction and manure.

ILRI is participating in the ecoregional initiatives in which livestock play a critical role in the production systems and natural resource management. They include the following:

1. The ICRISAT-co-ordinated Desert Margins Programme (DMP) through ILRI Project 15 (Semiarid Areas) out of Niamey.

2. The IITA-co-ordinated Ecoregional Programme for the Humid and Sub-humid Tropics of sub-Saharan Africa (EPHTA), through ILRI Project 14 (Subhumid Areas) out of Ibadan. Under this umbrella three consortia are operated:

   a) The Moist Savannah Consortium. This is the main focus of ILRI's activities linked to ILRI Project 14 (Subhumid Areas).
   b) The Inland Valley Consortium (IVC).
   c) The Humid Forest Consortium

3. The ICRAF-coordinated African Highlands Initiative (AHI), through activities of ILRI Projects 11 (Systems Analysis and Impact Assessment), 13 (Highlands) and 19 (Market-Oriented Smallholder Dairy).

4. The CIP-coordinated Consortium for Sustainable Development of the Andean Ecoregion (CONDESAN), through ILRI Project 16 (Latin America) out of Lima and Addis.

The System-wide Livestock Programme for which ILRI has lead responsibility is organised expressly to work through ecoregional research consortia on feed production and utilisation and on livestock-related natural resource management.

4. Status

The degree of participation of ILRI and the implementation of collaborative research activities have been quite variable. In all cases, ILRI has been involved in technical meetings and consultations, and preparation of research proposals submitted to donors.

The System-wide Livestock Program has also contributed resources for research activities of the consortia (formal and informal) led by ICRAF, CIAT and ICARDA.

Specific research activities include:

DMP (Desert Margins Programme)

- Biodiversity with relevance to climate change and land degradation. ILRI-DMP.

- Resource uses optimisation at village and district levels in the desert margins of West Africa. ILRI-DMP-GEF (Global Environmental Facility)

EPHTA (Ecoregional Programme for the Humid and sub-humid Zone)

- Development of sustainable crop-livestock systems in the lowland moist savannahs. ILRI-IITA-NARS (Nigeria, Ghana, Cote d'Ivoire, Benin).

- Developing a crop-livestock geographic information system (GIS). ILRI-IITA-NARES (National Agricultural Research and Extension Systems in Nigeria, Ghana, Cote d'Ivoire).

- Estimating the contribution of livestock to farming systems of the moist savannah ecozones. ILRI-IITA-NARES (Nigeria, Ghana, Cote d'Ivoire).

- Crop-livestock reciprocal benefits: crop residues/biomass as mulch, feed and/or manure. ILRI-IITA-NARES (National Animal Production Research Institute (NAPRI), Institut Des Savanes De L'Idessa (IDESSA), Institut National De Recherche Agricole Du Benin (INRAB)).

- Characterisation of dairy production sub-systems in the inland valleys of Cote d'Ivoire, Mali and Nigeria. ILRI-WARDA/IVC-NARES (NAPRI, IDESSA, Institut d'Economie Rurale-IER).

- Testing of *ex-ante* models targeted at the production, management and utilisation of forages grown on residual moisture for dairy production. ILRI-WARDA/IVC-NARES (NAPRI, IDESSA, IER).

AHI (African Highlands Initiative)

- Development of legume based feeding systems for smallholder dairy systems. ICRAF-KARI (Kenya Agricultural Research Institute)-ILRI funded by the SLP.

CONDESAN (Consortium for Sustainable Development of the Andean Ecoregion)

- Livestock in ecoregional research (LAC). ILRI-CIP/CONDESAN-NARS-IDRC-EDF (European Development Fund). It includes several experiments and studies, including: development of feeding systems, *ex-ante* assessment of technologies, modelling and simulation of production systems, testing of alternatives, policy research (credit), and training.

5. Constraints

The various ecoregional consortia are facing a number of constraints:

1. Relatively high transaction costs associated with awareness creation, formation of partnerships, definition of research agendas, and proposal preparation.

2. Restricted additional finances.

3. Over-expectations from partners.

4. Limited use of appropriate frameworks and definition of tools to be used in ecoregional research for integration of partners and information generated.

5. Lack of understanding of the new approach with implications for expanding partnerships.

6. Inadequate linkage between field and lab and station-based research activities at IARCs and among partners to address the R & D continuum.

Progress is being achieved to overcome these constraints, especially those numbered 1-3. The fourth is a critical one, not just for ILRI but for ILRI's partners too, because it is only through definition of a common framework and utilisation of common methods that comparison of results can take place, possibly including analysis across ecoregions of similar ecological conditions.

ILRI and its predecessors have a history of being involved in systems research. Originally, it started as ecozonal research. The idea was to select areas representative of broad regions of similar ecological conditions (rainfall, vegetation, temperature, soils, etc) in order to conduct farming systems research that would be applicable to the broader ecozone (recommendation domain). Jahnke (1982) has synthesised this work, based on the ecozone classification of FAO.

Various driving forces are combining to suggest that in future ecoregional research is going to develop considerably and have substantial impact:

a) Availability of tools. This relates particularly to developments in Geographic Information Systems that allow the incorporation of socio-economic and bio-physical data, remote sensing, computers and communication technologies that allow more extensive storage of databases and faster analyses, transferability of information, simulation modelling of systems, and accessibility to end users and stakeholders.

b) More experience in multidisciplinary research. Multidisciplinary research has often been a time-consuming process, partly because of perceived conflicts between more reductionist and more holistic approaches. These are two sides of the same coin, and must proceed in tandem to attack complex problems. Effective solutions to smallholders' problems are more likely to be forthcoming when stakeholders participate in problem identification, design of solutions and their testing. A greater critical mass of scientists with the skills for multidisciplinary research now exists.

c) Better knowledge of biophysical and socio-economic constraints. Past farming systems research tended to look at problems at the farm level, and mostly from a technological perspective. Many constraints are related to inappropriate policies, lack of markets for inputs and outputs, ineffective institutions, etc.

d) Financial constraints. In the past, relatively plentiful resources for research brought scientists the freedom to experiment and conduct long-term research. Current financial constraints impose a need for careful planning and targeting of efforts to solve problems of broad relevance, which can be identified with the help of *ex-ante* impact assessments.

e) Environmental concerns. Past research efforts have tended to emphasize production and productivity gains, with sometimes mixed consequences for the environment.

f) Social concerns. Emphases on societal, familial and intergenerational equity are very much to the fore, and research for development needs to address these concerns.

Given the evolving goals for research for development and financial constraints, it is not yet clear how ecoregional research can best respond to the challenge. Our toolbox certainly needs to be expanded considerably if ILRI is to become highly effective and efficient in carrying out NRM research at a regional level at spatially dispersed sites.

6. Conclusions

Ecoregional research should be considered as evolutionary. While some initiatives have undertaken a long preparatory phase (Desert Margins), others have taken a more pragmatic approach and have progressed much more quickly to the research phase (CONDESAN). Support to these initiatives will presumably increase, but probably not in a very dramatic way. In the future, participants will increasingly be expected to invest matching funds.

Given considerable pressures from donors, environmentalists and others about impact from livestock-related research, and more specifically their relation to NRM and the environment, ILRI will be expected to strengthen efforts in this area. Not doing so will have serious effects in terms of potential impact of ILRI's research, credibility with partners and donors, and overall future financing of the institute. There are some difficult questions to grapple with, however, including the following:

1. Do we require a framework as such, or is it more important to identify with considerable precision the focuses of ecoregional research at ILRI, from which a coherent framework can be derived?

2. Are the Sustainable Production Systems Programme teams located in the different regions necessarily "ecoregional teams" – in other words, is there a need for all (or even most) of their research to be ecoregional in scope?

3. To what extent do we require standardised data collection protocols and standardised methodologies and models for what ILRI is trying to do?

4. What is the most effective way to manage spatially dispersed research teams to ensure compatibility between activities, in the search for technologies of transregional relevance?

5. Which are the gaps in ecoregional methodology that are particularly relevant to crop-livestock systems, and how might these be plugged effectively?

Resolution of these issues will go a long way towards helping to strengthen the linkages between ecoregional and more strategic research at ILRI and helping to enhance the effectiveness of NRM research in the context of crop-livestock production systems.

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