Planning and Management of Land:

Bringing Farmers' Decisions into the Picture

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1. Introduction

As a consequence of land-related emergencies, past approaches to the planning and management of land resources are undergoing important changes. From approaches that conceived land use planning as a sectoral exercise with a mainly "prescriptive", "statutory" function and a "normative" and "top-down" attitude, a new perspective is emerging. This perspective sees planning as an "action-oriented", integrated process of dialogue and negotiation where essential prerequisites are the development of an "enabling" environment for conflict resolution and the active involvement of a multiplicity of stakeholders. Apart from the enabling conditions which are "at the boundary", the planning processes themselves requires modifications. Also methodologies in their support must be devised which are coherent with this new perspective.

Information is at the core of the processes above: in this respect the role of information technology, namely in the form of information systems and decision-support systems (DSS) is increasingly acknowledged as an essential one in any planning methodology. In this paper it is argued that the planning methodologies suggested in support of the new planning perspective, (see for example FAO, 1995a) are not always in coherence with the underlying objectives: a normative and "top-down", rather than a "negotiation" and "communication" oriented approach is still, often promoted. For instance, despite the quest for participatory planning, the role of stakeholders is usually envisaged only at the final stages and not in the generation of information and models, the building blocks of any decision-support system.

Appropriate methodologies for the development of DSS should be used if the new planning perspective is to be promoted. The organizations involved must be scrutinized through an "information system development" perspective, i.e. their activities should be disassembled and critically analyzed in terms of their information and information processing requirements. It is further argued that the introduction of DSS and information technology at large, can induce positive transformations in existing planning organizations. However, these transformations most likely require a redesign of functions and changes in the organizations that cannot occur overnight and involve a substantial "learning" process. The institutional and organizational implications of introducing such planning support systems must therefore be carefully investigated beforehand.

In general terms DSS are not "neutral" means of information processing and cannot be isolated from their social and cultural context. DSS, it is argued, can no longer adopt all-embracing schemes but ought to be time and location specific. From this perspective it is important to observe that the problems related to planning and accompanying methods discussed above, are especially evident when referring to "complex, diverse and risk prone" (CDR) agricultural systems. In such systems small and "resource-poor" farmers are usually operating, characterized by being economically and technologically "poor" but possibly rich in terms of culture, social relationships and especially knowledge about their often "ecologically fragile" environment. History shows that such systems are by no means static: in the past they were in fact able to respond in innovative

ways to perturbations of their natural and social environment. However, traditional land management strategies in these environments are nowadays often not capable to cope with phenomena such as demographic growth, war, migrations, drought, reduction of available land due to degradation and competing land uses and, last but not least, adverse agrarian policies: some sort of external intervention, land use planning among others, is therefore essential.

The area selected as a case study (in the communal lands of the Zambezi Valley, Zimbabwe) is an example of a CDR system: the relevance of the issues discussed in the previous points is therefore evaluated against this specific context.

2. Farm household diversity and aggregation of land demand

Concerning the "subject-matter" the decision-support system is expected to address, the paper discusses in further detail one of the "key" aspects in land-related planning, i.e. the estimate of land "demand". In this respect it is essential that this estimate reflects the existence of different stake-holders, their problems and preferences and their interaction with the environment, hopefully placing due consideration to the poorest and most marginalized groups as well. This "cross-sectional" analysis of a rural community should be a major component in the generation of alternative land use scenarios, the basis for any effective negotiation process.

2.1 Farm household diversity

It has been argued that farmers in "complex, diverse and risk-prone" agricultural systems are often "slow" or unable to "adopt innovation" either in the forms of recommendations from agricultural extension or options envisaged by land development projects, etc. One important reason which has been pointed out to explain "non-adoption" is that differences between farm households (FH) have usually been downplayed in development and land use planning approaches (for a discussion see among others Chambers et al., 1989; Turner et al., 1987; Van der Ploeg, 1995). With specific reference to Zimbabwe one could for instance quote Polly Hill :

Too often have subsistence farmers, the "peasantry", been seen as amorphous. It is a myth palatable to planners - it eases their task considerably - but not to those who have to make plans work. For them, the complexity of real life is crucial. (In: Reynolds, 1991:40)

An even more enlightening comment is in Shumba:

"If you see one communal area you have seen them all" [...]. With this notion at the back of their minds, land use planners have often approached the task of planning for communal area farmers with a pre-conceived set of land use recommendations. These recommendations have often not been adopted or were partially adopted [...]. In the present land use planning process the same recommendations are made for all farmers by identifying what has come to be known as the average farmer. This average farmer is a blend of all variations in production technology, skills, constraints and opportunities that are observed in communal areas. Does this blending suit all farmers? [...] (Shumba, 1992:2,4)

2.2 Grouping of farm households

For most applications and certainly for land use planning it would be too costly and not practical to investigate farm household adoption behaviour individually. On the other hand aggregation inevitably introduces a bias.[1] Such bias may alter the results of the analysis, for instance overstating resource mobility by enabling farms to combine resources in proportions not available to them individually (Hazell and Norton, 1986:145). The process of grouping[2] aims at identifying relatively homogeneous entities (see for instance Hazell and Norton, 1996:143) where bias is eliminated or minimized. This is what Jenkins (1990:122) defines as a compromise between descriptive parsimony and predictive value. When empirical procedures (e.g. "representative farms" or "aggregate regional" approaches, see Hazell and Norton, 1986) are used, significant aggregation errors can be generated. In order to eliminate aggregation bias (conditions of "strict" sufficiency or "exact" aggregation), a number of homogeneity requirements have to be fulfilled, which are very demanding (Day, 1963):

- "technological homogeneity": expressing the fact that each farm in a group have the *same* production possibilities, types of resources and constraints, technology and managerial ability. The production or "technical" coefficients in a linear programming (LP) matrix.
- "institutional proportionality": expressing the fact that resource endowments of each farm are proportional to the average in the group. The constraint vector ("right-hand-side" coefficients) in a LP matrix.
- "pecunious proportionality": reflecting expectations about unity activity returns which for each farm are proportional to average expectations in the group. The coefficient of the objective function in a LP matrix.

In practical applications, rules or proxy indicators are used with the scope of at least minimizing the problem of bias (Hazell and Norton, 1986: 145-148), or what have been otherwise indicated as "sufficient conditions" for aggregation:

for "technological homogeneity" indicators expressing similar resource potential or, in other words, having the same type of land resources, level of technology, level of managerial ability. Such indicators reflect for instance differences in climate, soils, elevation, use of inputs and equipment, irrigation-rainfed conditions, etc. Possible proxies are: potential yields, agro-ecological zones, or land units, in combination with the various management options.

for "institutional proportionality" indicators reflecting similar quantity of resource endowments such as quantity of land , family labour (or land to labour ratios), capital. Possible proxies are the size of the holding, the number of family labour units, number and type of equipment.

in the case of "pecunious proportionality" proxy indicators which reflect expectations about unity activity returns. Proxy indicators are type of crops and produces, livestock species, yields.

Grouping of farm households can be performed for different purposes and at different scales: the importance of obtaining unbiased aggregation will very much depend on the above.

In macroeconomic planning more strict aggregation conditions are possibly justified. One could refer for example to the work of Day (1963); Hazell et al. (1986); and Singh et al., (1986: 3-11).

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[1] **Defined as the error of predicting aggregate outcomes for a group of farms by estimating their behaviour at a certain degree of aggregation, rather than estimating the behaviour of each farm individually (Wossink, 1994).**

[2] **The term "group" or "type" should be preferred to "class": classification as such requires taxonomic conditions which are usually too strict for entities such as farm households.**

In farming systems research there has been extensive work devoted to the identification of farm household typologies: already in the thirties De Vries (1931) defined farm types on the basis of homogeneous utilization units. Other well-known classifications, also stemming from work in agricultural geography include the one suggested by Norman (1979). For tropical conditions, the most quoted classifications are from Rutherberg (1976) and Beets (1990:130). Somewhat related to FH types are the “recommendation domains” in the definition of CYMMIT or the “zones” in the Francophone approaches (Fresco, 1986: 34-35).

For many years now “comparative analysis” has been a standard technique used by agricultural extension services and in farm management especially in Europe and the USA (see for example Jackson, 1958; Upton, 1973:235). One of the basis for such analysis is a comparison of farm group performances based on representative models. More recent work in this field has combined farm household classes with programming techniques for analyzing the impact of technological innovations (see März, 1990). Farming systems development approaches, which have evolved from the two above in more recent times, very much stress the importance of farm household groups or zones for a better targeting of interventions (see FAO, 1990a). In the case of farm management and of farming systems development at large, the problem of aggregation bias, though depending on the specific purpose of the study, seems to be less stringent. According to many authors, criteria which make farm household types “significantly different from each other in most technical and economic characteristics” are good-enough for the purpose above (see for instance Hanf, In : März, 1990).

The use of farm typologies in the analysis and planning of land use is relatively more recent. Examples are in Conway (1990: 75); Jenkins (1990:121); Fresco et al., (1992), Van der Ploeg (1995); and Schipper (1996). The minimization of the aggregation bias, depending on the objectives and the scale of the analysis will be of different importance.

2.3 Grouping criteria

Criteria for grouping could, at least in principle, cover a wide range of farm household characteristics or “determinants”. As pointed out for instance by Everitt (1993) for the initial choice of variables, which is in itself a categorization, there are only limited statistical and mathematical guidelines: though empirical by nature, the selection appears to be guided by two principles:

the objectives of grouping (as previously defined, e.g. for farming systems research, regional land use planning, etc.). This also defines what might be the level of an acceptable aggregation bias. The objectives also specify the degree of “stability” which is required for the classification criteria. Maxwell (1986) for instance argues that farming systems research very often requires a time horizon of 10-15 years.

He therefore suggested incorporating dynamic elements into the classification exercise in order to define relatively “stable” recommendation domains (Maxwell, 1986:67, 74). If for example the objective is the definition of a target group for the provision of input credit, the classification could be based on the prevailing cropping system. If the objective is a longer term stratification, a more “stable” criterion should be identified such as for instance the “life cycle stage” of the household (see Huijsman, 1986: 106). In the present paper the objective of grouping can be summarized as finding a reasonably unbiased substitute for individual farms responses. This must be seen also in terms of the specific nature of the present exercise: i.e. the calculation of land use demand as an input to local level land use planning.

the underlying conceptual model of the decision problem

In this case reference is made to farm household decision making on innovation adoption, as it will be discussed in section 3. Comprehensive lists of classification criteria are found for instance in Jackson (1958:2); Maxwell (1986:69-70); and in FAO (1990a: 69-74). The criteria indicated by Hazell and Norton (1986: 145-148) can be used as a reference and their adherence to the specific circumstances of the study can thus be evaluated. However the above criteria mainly reflect the production side of the FH functioning. As it is discussed in section 3 "ability" towards innovation must include not only production but all factors determining the "subsistence coverage" capacity.[3] Apart from the criteria expressing the "ability" of the farm household, variables reflecting the "attitude" towards innovations should also be included (see Jenkins 1990:119-120).

2.4 Grouping procedures

After selecting the classification criteria, the problem is how to identify suitable grouping procedures. These may be coarsely subdivided in (see Vandueren and D'Haese, 1989):

"Pragmatic" approaches

Based on "pre-existing" grouping criteria; the procedure can be also referred to as "extrinsic" or "supervised" (Jain and Dubes: 1988 56). Criteria are derived from *a priori* reasoning and based on established empirical findings. In fact, many farm household classifications found in the literature are based on pragmatic approaches.

Automatic classification

Consisting in automatic procedures based on cluster or other multivariate analysis. Also referred to as "unsupervised" classification. Examples are in Vandueren and D'Haese (1989); Jenkins (1990, 123-124) and Schipper et al., (1995).

Both pragmatic and automatic procedures imply a number of accompanying steps, including the reduction of variables (eliminating the ones inter-correlated, selecting those with greater discriminating power) and procedures for the interpretation and "validation" of the grouping.

2.5 Interpretation and "validation" of grouping

For an interpretation and a "validation" of the groups identified, informal and formal procedures exist which are mainly used for assessing clustering solutions. In this paper the approach by März (1990) is followed, where "inter-group" and "intra-group" evaluations are used. Whatever the approach selected the grouping is followed by a formal examination of the relationships between FH types and of their characteristics (see also Jenkins, 1990:123).

Inter-group analysis serves the two objectives of verifying the validity of the groups obtained, as well as interpreting the differences between FH types, mainly in terms of statistical significance.

Intra-group analysis can be seen as a more detailed analysis of the FH sub-systems: it also evaluates the magnitude (and not just the significance) of the differences between FH types.

[3] **Otherwise an overstatement (similar to that observed for resource mobility) could result, for instance in terms of food crops, between "deficit" and "surplus" households.**

3. Farm household evaluation: a basis for estimating land "demand"

The approach suggested in this paper consists in deriving such demand at the "micro" level, basing the requirements on the analysis and evaluation of the farm household's decision making.[4] The above land demand is further aggregated at the planning unit level and compared with an evaluation of land supply (derived for instance from a land suitability assessment), providing a number of allocation scenarios.[5]

The need for modeling farm household decision-making arises in different application fields. In macroeconomic planning for instance, agricultural household models are built in order to predict the reaction to specific agricultural policies and programs, including pricing policies and investment projects (see for instance Caillavet et al., 1994; Singh et al., 1986; Hazell et al., 1986). Applications where spatial information is linked to the analysis and modeling at the household level include population census small-area statistics (Visvalingam, 1991:14) , geo-marketing (Goss, 1993), service planning and the development of social policy at large (Worral, 1991:2,6). In the case of land suitability evaluation not much has been done in this direction. Referring to the application of GIS techniques Openshaw pointed to:

[...] the lack of any relevant inbuilt notions of the microbehaviour of people or of the social and political processes responsible for the societies that lie behind the map patterns". Openshaw, 1991)

In the analysis and planning of land use however, applications of farm household modelling are not new. Drinkwater, for instance, observed that in Zimbabwe the Land Husbandry Act in 1951 envisaged the use of an "ideal economic and viable" farm household unit as the benchmark for land allocation.[6] In the Department of Agricultural and Technical Extension Services (Agritex) in Zimbabwe, current planning procedures use the estimation of "standard" (i.e. average) farm household subsistence and cash requirements as the starting point for land allocation. These requirements are further translated into land use demand, based on various assumptions on yields, farming practices, marketing facilities and producer prices (Agritex, 1989): in practice, on a simplified model of the farm household system.

The approach suggested here is that of further exploring the application of farm household modelling for land allocation decisions. In other words an effort is made to link what Eastman et al., (1993:1) refer to as "descriptive decision analysis" (i.e. modelling the decision behaviour of individuals), with what they referred to as "prescriptive decision analysis", (i.e. making decisions on resource allocation). Such link could help in anticipating the likelihood of adopting land use options and their overall financial, economic, socio-cultural implications (see Thornton, 1991:19 and Jenkins, 1990). A few recent examples of such applications do exist, though applied mainly in the case of western agricultural systems: see for instance Harvey (1990:45) and Jenkins (1990:121). The following sections discuss objectives and underlying concepts for modeling the farm household decision making.

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4 In the present context the farm households are the most important land users encountered and in the rest of this paper reference is mainly made to them.

5 For the description of the whole procedure, see Ceccarelli (1997).

6 Drinkwater (1991) further argued that the economic and technical bases of the above model "did not stand up to scrutiny", since it was constructed on a very narrow database and for instance, very much overestimated the production potential of the households (1991:66-69).

3.1 Land use and innovation adoption

The selection of land use options can be regarded as one of the possible choices in the decision making of any farm household. When speaking about newly introduced land use options one would then refer to decision making as to a process of innovation adoption. [7] The final outcome of such decision making is the preferred (from the viewpoint of the FH) level of a newly introduced activity. Since the main interested here is in "land based" activities, the outcome represents in fact the land demand as expressed at the FH level. The calculation of such land use demand requires procedures for evaluating the potential for adoption of innovative land use options. This should be based in turn on an conceptual model of "adoption behaviour". Approaches based on behavioural theory (see for instance Rogers, 1962; Brossier et al., 1977; Saint et al., 1977) provide an insight into the nature of decision making processes. The idea is suggested that innovation is conditioned by:

an "internal (demand) environment" given by to "the relative innovation potential of adopters, which is in turn influenced by a set of farm household characteristics".

The internal environment includes determinants or components that are under some degree of control of the decision-making unit. Though other authors classify the determinants differently - Frank (1995:295) for instance makes a distinction among "extrinsic situational", "managerial" and "intrinsic personal"- the underlying principles are basically the same.

an "external (supply) environment", "dominated by the strategies and policies implemented by the diffusion agencies in the external environment to induce adoption" (Ilbery, 1992).[8]

The external environment includes, inter alia, an institutional, an economic, a socio-cultural environment and a bio-physical environment. The determinants that are related to the "external environment" normally are not under the immediate control of the farm household. In recent applications of behavioural approaches innovation is not regarded as desirable *per se* but rather as a function of the "perceived reward" that [innovation] offers as a means for achieving personal satisfaction[9] [and a function of the individual] "environmental life-space" [or "environmental field"] where farmers take decisions. (Frank, 1995:294)

The process of innovation adoption is seen as being initiated when one's "environmental field" reaches a state of disequilibrium: conditions both of a sufficient "perceived reward" and of an enabling "environmental field" promote the adoption of innovations. Moreover the perceived reward and the environmental field are specific to a particular spatial and time context and refer to single, discrete innovation "entities".[10] In the present paper the concepts of environmental field and perceived reward have been operationalized and used in a procedure for evaluating innovation adoption potential.

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7 **The concept of innovation adoption has been questioned over recent years, in favour of an approach where farmers are seen as active actors in promoting innovation (see for instance Chambers, 1989). The definition used here however, does not imply any judgement on how "innovation" is generated.**

8 **The concepts above are widely recognized among farming systems research and rural sociology authors.**

9 **"Perceived reward" can be seen as a composite utility function resulting from the combination of U (usefulness) + P (financial profitability) + S (personal satisfaction) + N (social acceptance): see Frank (1995: 309-310).**

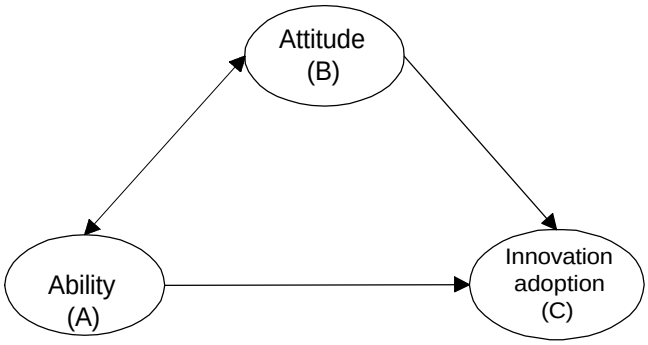
10 **For a discussion of the significance of specific types of innovation and their relationship to "innovation risk", see for example Huijsman (1986:207).**

Perceived reward is considered as being equivalent to “attitude” towards adoption, [11] which refers to the willingness to adopt a land use option and is determined by “the psychological make-up of the individual” (Huijsman, 1986:5).

The environmental field is expressed in terms of the “ability” to adopt, or in Huijsman’s definition (1986:5), “the resource availability and access to additional means of production and consumption”. “Ability” is therefore the result of a complex of determinants influencing, or inherent to, the farm household system.

The main relationships in the conceptual model for innovation adoption can therefore be represented schematically as in Figure 1.

Figure 1. A conceptual model of innovation adoption



Source: modified after Frank (1995:293)

The arrows indicate the assumptions that should be investigated to verify the validity of the conceptual framework.[12] The relations between “ability to adopt” and “attitude” towards “innovation adoption” are also relevant in the adoption model above.
However these influences are regarded as being valid over a time horizon longer than the one normally regarded as valid for a medium-term-planning period. At least in the short run “attitude” *per se* cannot modify the ability to adopt. The reverse is also true: a change in the “ability” alone makes it difficult to modify the “attitude” towards innovation, which can derive, among others, from deeply rooted social and cultural factors.

“Ability to adopt” (A) influences actual “innovation adoption” (C)
Ideally proxies should be derived to best represent the entities in Figure 1. In the case of adoption “ability”, a proxy (subsistence coverage capacity) has been used which expresses the FH’ s excess capacity to cover basic subsistence needs with the revenues of farm and non-farm activities. This is close to the “subsistence coverage factor” employed by Huijsman for the analysis of “risk taking” capacity. It incorporates the production capacity of the farm household, non-farm income, disposable assets and number of consumer units (Huijsman, 1986: 113, 116, 163).[13]

“Attitude towards adoption” (B) influences actual “innovation adoption” (C)

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11 Though the two concepts are not strictly equivalent: see Huijsman (1986: 37).

12 For testing the relations above a variety of techniques can be selected. Conway (1990) for example uses path analysis in conjunction with linear regression analysis for deriving explanatory models of how social and situational variables explain inter-farm variation in land use. Frank (1995: 294) also derives causal path models from a large set of variables related to perceived reward and environmental field, which are initially tested for association, then included in a classification analysis and finally correlated with proxies for adoption behaviour.

13 The selection of this proxy reflects the hypothesis that innovation adoption largely depends on the household’s sensitivity to income security.

As far as “attitude” is concerned the techniques used for eliciting proxies are generally not very satisfactory. For a comprehensive discussion see Huijsman (1986:5, 266). For actual “innovation adoption”, when introducing totally new technologies, proxies are difficult to derive. Since decisions are taken under conditions of uncertainty their treatment becomes anyhow very questionable (Huijsman, 1986:35).

In spite of the difficulties discussed above, the assumption of the present investigation is that even under the circumstances analyzed, characterized by uncertainty in a number of spheres and strong social and cultural influences, farmers exhibit choice patterns which are governed by rational behaviour. A model for adoption behaviour can therefore be derived and used to evaluate the potential for adoption (see later in this section). The conclusion whether adoption depends mainly on “attitude” or on “ability” entails important consequences in the definition of appropriate policy measures.[14] If on the one hand it is certainly very difficult to modify at least in the short-run the “attitude”, on the other hand the lack of “ability” can be addressed by specific interventions. In other words adoption can be promoted by channeling resources towards FH whose attitude is most favourable to the desired changes (see for instance Thornton, 1991:18 and Huijsman, 1986:5).

3.2 The choice of modeling approaches and techniques

At the micro level, different approaches to farm household modeling have been developed which can assist in understanding and structuring an adoption choice: these include models based on adaptive behaviour theory, production theory and technical functioning (Brossier et al., 1990:198). In the model the functioning of a farm household system is simulated and the introduction of various land use options can be evaluated against a number of technical, financial, economic and social criteria. There is a wide range of techniques for modeling the farm household. In this paper a “rule-based” model in conjunction with “whole-farm” budgeting (FAO, 1990a:174) techniques are used. The latter are derived from farm household income analysis [15] and consist of “simplified programming” or “program planning” (FAO, 1989:63; FAO 1990a; Upton, 1973:291; Luning, 1969).

Program planning (PP) is a modeling and evaluation technique that can (only) approximate optimization. As opposed to optimizing techniques such as linear programming, PP is a “trial and error” procedure that relies on a combination of formal (though empirical) “rules”. Advantages of the PP technique are its simplicity and interactivity. Disadvantages include, apart from the non-optimality, a limited number of activities that can be handled, the subjectivity in the definition of the rules and the difficulty in taking into account interrelationships between activities such as cropping and livestock raising (FAO, 1989:66). This technique can be seen as an extension of the “step by step” allocation procedure used at present by Agritex for the calculation of land use requirements (Agritex, 1989).

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[14] **In a study of decision making in the Philippines Huijsman observed that “risk attitude” and perception parameters did not explain differences between categories of households, while behaviour between the same categories was “highly influenced by cash and resource flows and possibly by resource-induced risk aversion”. The observations above pointed to the limits of “target group specific” policy measures, addressed towards risk attitude and perception (Huijsman, 1986:267-269).**

[15] **In the proposed approach the model also includes information on the location of the residence and of the various elements of the resource base (including communal properties and resources of exclusive use of the FH). It should be in fact be referred to as a “geo-referenced” farm household model.**

3.3 A procedure for evaluating the potential for adoption

For the purpose of evaluating the potential for innovation, a procedure is developed which is intended to approximate farm household decisions on adopting a specific land use option.[16]

The procedure consists of two steps:

- A first step refers to the discrete choice on whether or not to adopt an innovation. A set of rules is defined which, based on proxies for both the "attitude" and the "ability" to adopt are assumed to reflect the decision above.[17] The rules are used for "screening" a range of innovative production systems or land use proposals.
- A second step consists in evaluating how much (i.e. the level) of the specific production system encompassing the innovation will be carried out. Program planning techniques based on a "whole-farm" model are applied here.

The main assumptions in this case are that :

- the elements and the procedures in the program planning could simulate the functioning of the farm household system (i.e. its objectives, production systems, and resource endowments).
- the level of the production system largely depends on constraints to production, mainly due to family labour availability.

Actually the use of the "whole-farm" model is twofold :

- it describes and evaluates the functioning of the "current" farm household system.
- it describes and evaluates the impact of new land use options. The procedure for evaluating innovation is used to test the feasibility of land use options for an aggregated "average" FH and for "single" FH types. Rules and thresholds used in the screening procedure or in program planning are defined specifically for each farm household type.

4. Findings from a case study

A number of prototype applications have been developed as components of a broader planning-support system (see Ceccarelli, 1997). Such applications were used for experimentation with a real planning case study in Nabusenga Ward [18] in the Zambezi Valley, Zimbabwe. What follows are the major findings related to the estimate of land demand:

in the analysis of the current situation the presence of different interest groups with often conflicting objectives was observed. Among the most important interventions the identification of suitable drought-resistant crops was stressed. Also the urgency of cultivating clay soils presently not utilized was indicated, devising at the same time appropriate management practices and draught power sources;

between the different interest groups, emphasis was given to the farm household stratification. Initially, an aggregated FH analysis was conducted highlighting the major determinants in the farm household system: this has been the basis for further selecting the grouping criteria.

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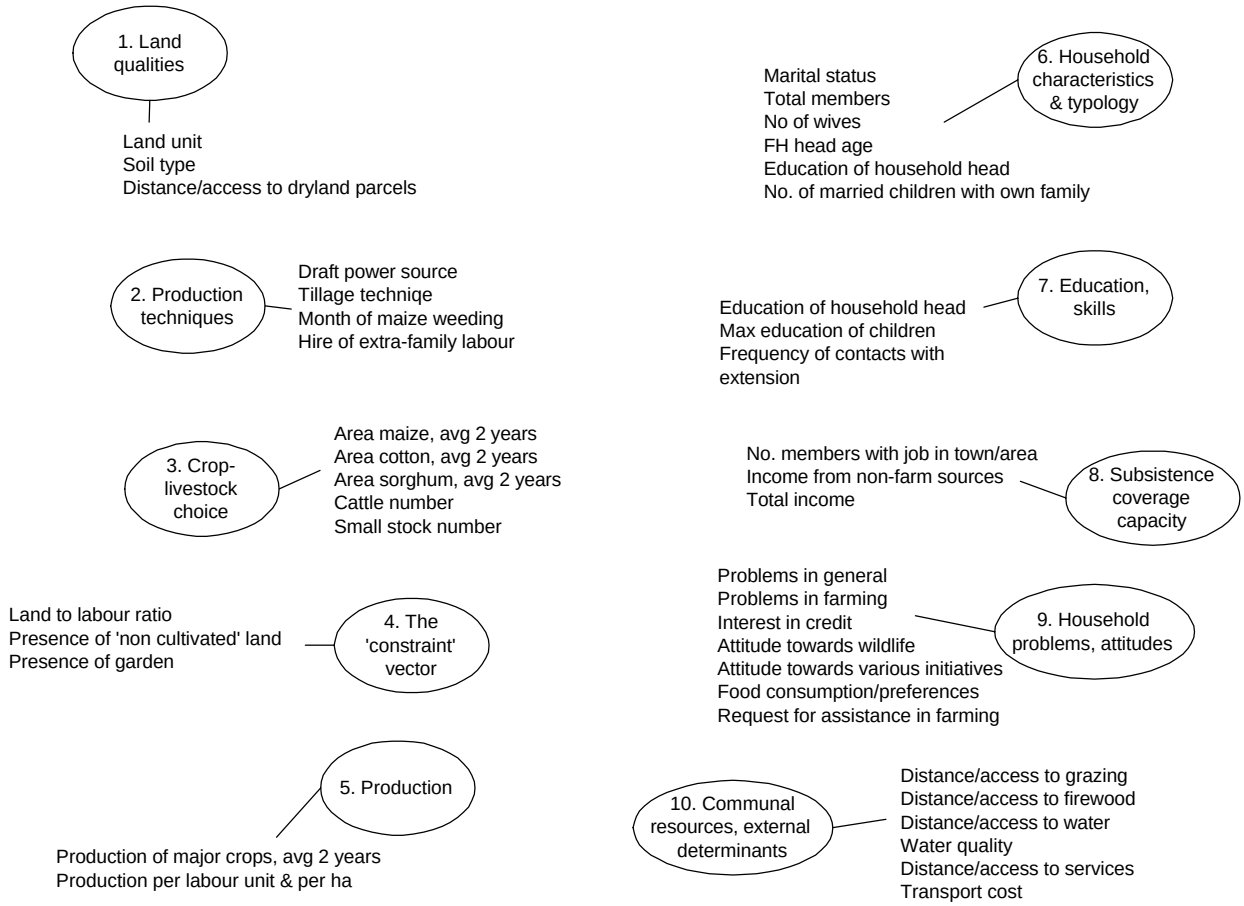
16 The term land use option here includes different types of innovations: i.e. at the level of techniques, technologies or whole production systems and other land use proposals.

17 For the construction of a similar "rule-based" framework see for instance Thornton (1991:13).

18 Nabusenga is part of Binga District, Matabeleland North Province. The Author has worked in this area for over two years as a land use planner with an Agritex/FAO project and subsequently, as a researcher.

as stated earlier grouping variables are the expression of the objectives of the exercise as well as of the underlying conceptual model. Variables used in the analysis, arranged in homogeneous themes, are summarized in Figure 2.

Figure 2. Variables used in the aggregated analysis



For the grouping, both a “pragmatic” classification and a cluster analysis were performed. Five farm household types were finally identified, mainly on the basis of their “subsistence coverage capacity” and of their “life cycle stage”. The results were evaluated by statistical tests and then used to draw “farm household profiles” giving a characterization of the typologies identified. Differences between FH types, (also in terms of their hypothesized evolution in time) are summarized in Figure 3.

In this case the “family life cycle” process from “early” stages, to “middle aged” and to “old” households, was given much emphasis. It was also assumed that an evolution took place associated with the attainment of different levels of “ability” (see “subsistence coverage capacity”). Other relevant farm household variables were also related to the different evolution stages, among others, those related to the adoption “attitude” of the FH .

Also based on the results of the investigations above, potential land use options were selected, including proposals for arable, perennial crops and gardens, livestock, etc. The above options were modeled as components of land use systems and input-output coefficients and other assumptions were derived for use in farm household modeling.

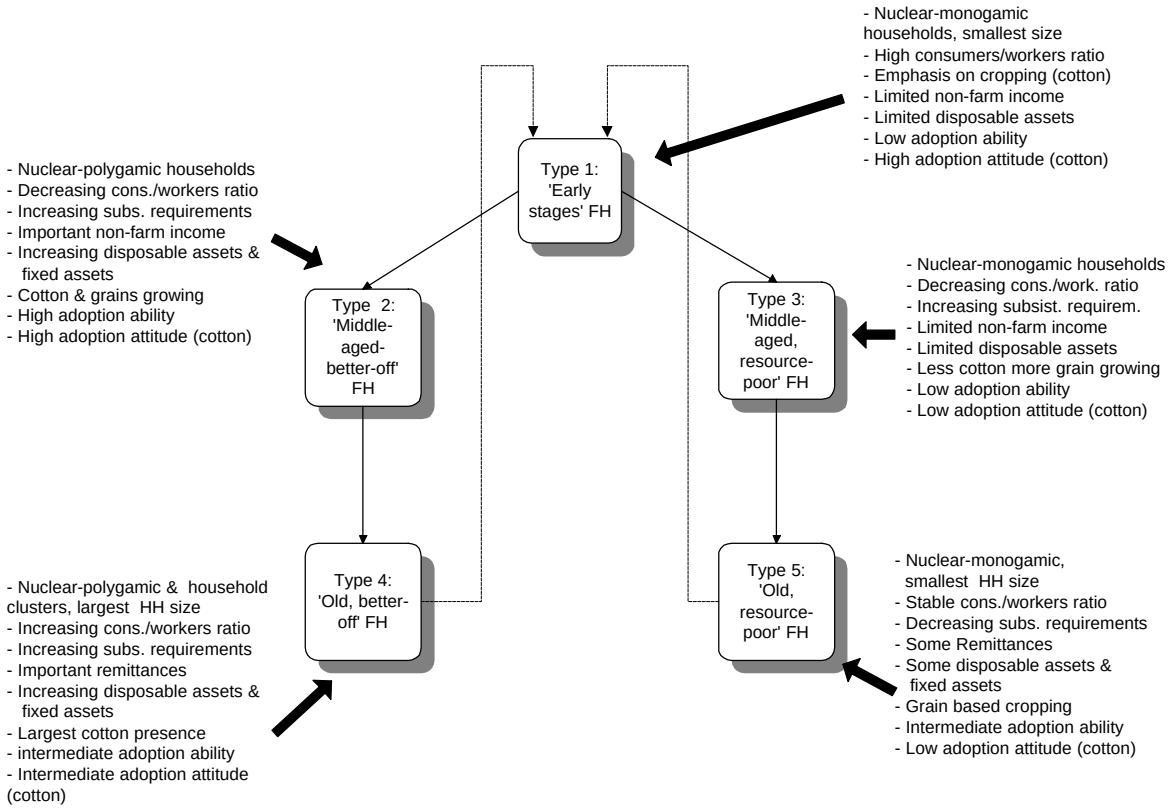


Figure 3. Hypothesis on the evolution of farm household types

As discussed in section 3 the evaluation of farm households consisted in the application of a "rule-based" model. This was implemented in the form of a decision table where combinations of FH types and production systems were screened for potential adoption. The following decision rules were applied:

- Rule 1:
  - If attitude = high or intermediate
  - and ability = low
  - then adoption
  - and supporting intervention = type 1[19]
- Rule 2:
  - If attitude = high or intermediate
  - and ability = intermediate
  - then adoption
  - and supporting intervention = type 2
- Rule 3:
  - If attitude = high or intermediate
  - and ability = high
  - then adoption
  - and supporting intervention = type 3
- Rule 4:
  - If attitude = low
  - and ability = low, intermediate or high
  - then no adoption

[19] **It was assumed that the type of external intervention required by each FH type depends on its current ability to adopt a specific innovation (i.e. the lower the ability, the larger the support).**

Subsequently land demand for the different options was estimated by means of program planning. This was done for each FH type and for an aggregated farm household; In the application of program planning the whole-farm model was used for investigating the introduction of new production systems/land use options. A "what-if ?" simulation was carried out based on the following rules:

Production systems, that "satisfy" the "rule-based" evaluation, were selected.

The production system that yields the largest gross margin was subsequently introduced in the "whole-farm" model until the family labour supply (the most limiting constraint) covered the additional labour requirements.[20]

A rotational-fallow constraint must have also been satisfied.

Additional production systems were introduced at the level allowed by the residual availability of family labour and by the rotational constraint.

Tables 1 a, b, c, show the outputs of Program Planning under different assumptions. The outputs include the area allocated for each crop production system, the expected small stock off-take, and indicators of farm household viability such as the maximum labour peak observed,[21] surplus income, and subsistence coverage capacity. In Table 1a the results refer to an "average" [22] or "aggregated" farm household: it is worth observing that the most frequent labour peaks coincided with the first weeding of cotton in December. Peaks were also observed in the period April-May-June, when the harvesting of cotton and subsequently maize and small grains, took place. Considering the assumption that the household family can extend the average working day of around 2 hours,[23] the production systems introduced would seem viable.

Table 1a. Results of program planning (using average coefficients)

	Product.			Systems		Viability		indicators	
	Cotton	Maize	Sorghum	Total arable	Cashew/ garden (1)	S.Stock off-take (2)	Max. labour peak (3)	Surplus income (%)	Subs. coverage capacity
Allocation (ha)	0.8	1.2	0.6	2.6	0.25	2.5	- 2.2 (Dec)	9	1.7

In Table 1b the land allocations resulting from the previous table are used as an input in "whole-farm" models, in this case constructed separately for the different FH types. The resulting viability indicators show that cotton is constrained by the availability of family labour in FH type 1, 3, and 5:

[20] The assumption was that daily labour requirements given by the introduction of new land use options were covered by the actual availability of family labour. It was also assumed that no extra family labour was hired by the farm household.

[21] The month when the peak occurs is also indicated.

[22] In terms of the input-output coefficients used in the "whole-farm"model.

[23] In December the FH will be relying on the grain stocks from last year. In April-May the harvest of maize starts; in both cases there are sufficient resources for the FH members for a limited increase in the labour that is usually provided. Also, family members normally engaged in other activities are concentrating their presence in the peak periods.

Table 1b. Results of program planning (using allocations from 1a and coefficients of the different FH types)

	Viability indicators		
FH type	Max. labour peak	Surplus income (%)	Subsistence cov. Capacity
1. “Early stages”	- 3.5 (December and May)	33	2.3
2. “Middle- better off”	- 1.5 (December and May)	-5	1.7
3. “Middle-poor”	- 2.7 (December)	17	1.9
4. “Old better-off”	- 1.0 (April)	- 27	1.2
5. “Old poor”	- 2.7 (December)	37	2.3

Finally, in Table 1c land allocations are derived from “whole-farm” models build separately for the different FH types.

Table 1c. Results of program planning (using coefficients of each FH type)

	Product.			Systems		Viability		indicators	
FH types	Cotton	Maize	Sorghum	Total arable	Cashew/ garden (1)	S.Stock off-take (2)	Max. labour peak (3)	Surplus income (%)	Subs. Coverage capacity
1.“Early stages”	1.0	0.6	0.4	2.0	0	2	- 2.2 (Dec)	13	2.1
2.“Middle-better off”	1.5	0.9	0.7	3.1	0	3	- 2.2 (Dec-Apr)	9	2.7
3.“Middle-poor”	0.5	0.7	0.7	1.9	0.25	2	- 0.3 (Dec)	13	1.8
4.“Old better-off”	1.9	1.3	0.8	4.0	0	4	- 2.3 (Dec-Apr)	11	2.2
5.“Old poor”	0.7	0.4	0.7	1.8	0.25	2	-0.4 (Dec)	16	1.6

(1) Area allocated to cashew-nut and garden. When set at 0 the area under “garden” is as in the present situation. (2) Animals/year. (3) In hrs/day/FH member (above average working hours): the minus sign indicates a deficit.

Figure 4 visualizes the final output of the “family labour requirements and availability” table in the whole farm model. The labour peaks are calculated as indicated in Table 1c; the example refers to FH type 1.

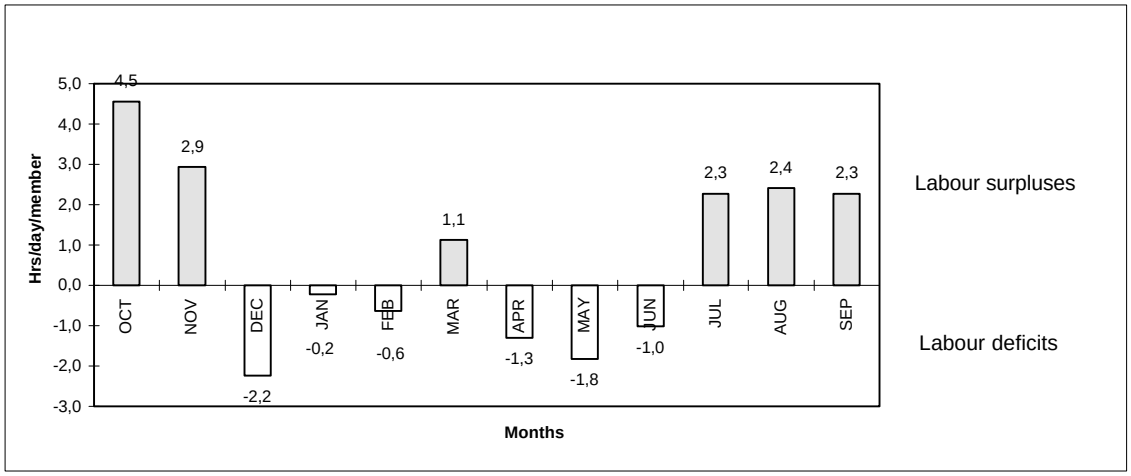


Figure 4. Visualization of the family labour peaks (farm household type 1)

From the results of the evaluation it could be concluded that using the "aggregated" FH model (i.e. average input-output coefficients) has a twofold effect:

On the one hand, as shown in Table 1b, it conceals family labour constraints (especially caused by the increase in cotton cultivation). When using the aggregated coefficients, the labour constraint is averaged out and the results for FH type 1, 3 and 5 would not indicate that the selected land use options are not sustainable due to labour peaks;

On the other hand, the remaining FH types (2, 4) do not achieve the expected indicators of surplus income (while they do in the current situation). This is a reflection of aggregated model which results in average land allocations and small stock numbers. For the wealthiest FH types, the above allocations are even lower than at present: a rather non-realistic assumption for a "with-intervention" model.

5. Concluding remarks

Drawing on the results presented in Section 5, a number of considerations can be made, also in respect to the current planning methods.

As to the analysis and grouping of farm households, the application of the methodology previously illustrated provided enhanced analytical capabilities and resulted in a better understanding of FH diversity in the test area. The procedures were automated only to a certain extent: a number of processes including the selection of grouping variables turned to be difficult to formalize, though supported by database management systems (DBMS) and statistical techniques. Grouping procedures appeared to be more straightforward, in the case of both the "pragmatic" and the "automatic" approach. The same applied for the subsequent "validation"/interpretation analyses. The main drawback was in data requirements, greater than in current planning procedures. Moreover, some of the statistical analyses proved to be rather complex: in case of application to actual planning activities, simplified grouping techniques (see the "rule-based", "pragmatic" classification) should be further investigated and reduced sets of variables identified.

Farm household modeling and evaluation procedures were tested against the actual data sets from Nabusenga. The procedures provided a flexible method for calculating land use requirements, simulating the functioning and the decision rules in the farm household system. Incorporation of models specific for each FH type was found to be particularly useful. Limitations

in the method were in the data requirements of the “whole-farm” model, certainly larger than in the current “step-by-step” allocation procedure. Also, the rules applied in the evaluation process appeared to be prone to subjective judgement.

When seen in perspective the application of the methods above require the development of simplified models (and consequently of reduced variable sets). As for the problem of subjectivity in the evaluation rules, in principle a better understanding of the underlying decision processes can reduce this. Evaluation models should also be thought of as interactive tools where the final users themselves are allowed to define/model their specific evaluation rules.

Of course the level of detail in the present paper is not always appropriate for an immediate application in “day-by-day” planning activities. It is argued however that its results may be of help in identifying where reduced data sets and simplified modeling tools would make the system work, even in current planning practices.

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