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Decision Modelling for the Integration of Woody Plants in Smallholder Farms in the Central Highlands of Ethiopia

M. Krause [*1], **H. Uibrig** [2] and **Berhane Kidane** [3]

Abstract

Farmers' perceptions of the utility and the constraints of locally available woody species are assumed to influence the decision-making and the behaviour of tree and shrub integration into current land-use types. Accordingly, the objectives of this study are (1) to analyse farmers' decisions in making use of woody plants under perceived constraints and (2) to analyse influencing factors that determine the deliberate tree and shrub growing behaviour.

The methodology bases on the approaches of the 'Farming Systems' and the 'Behavioural Decision-Making'. Influence diagrams are constructed incorporating the perceived utility and decision determinants of deliberately grown woody plants. Modelling of the tree adoption behaviour of farmers employs the 'Discriminant Analytical Approach' taking into account the identified external and internal influencing factors.

Results from the decision modelling reveal that woody plants are grown on-farm in view of the perceived utility of the species, predominantly fuelwood and timber-based produce, followed by cash-generation. Service functions pertaining to the protection of land gain secondary importance to the tree produce. Major decision determinants comprise resource-based factors, e.g. the shortage of land and seedlings or competition with agricultural crops, over stochastic-environmental factors. Results of the 'Discriminant Analysis' confirm that the adoption of trees is characterised by the available resource base, the access to infrastructure and support services as well as by personal characteristics of the farmers.

Keywords: farming systems, behavioural decision-making, discriminant analysis, land-use pattern, non-competitive tree growing, agroforestry

1 Introduction

In Ethiopia, about 90% of the total population directly depend on agriculture and live in rural areas. The land use policy as pursued since about 30 years has led to the expansion of the agriculturally used land area. This has preferably been at the expense of forested

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land. The depletion of still remaining forests has been caused by cutting trees, gathering tree produce, grazing animals, etc. which are common livelihood activities of the rural people.

The advancement in deliberate management of trees and shrubs outside the state forest reserves has remained below expectation. Research works on tree-based land use practices have mainly focussed on production technologies. Less is known about the factors which influence farmers' decisions on tree and shrub growing, their perceived utility and preferred woody species. This is to assume that decision-making processes of small farmers in Ethiopia have not been studied sufficiently yet.

Participatory approaches to understand local people's needs, perceptions, and objectives as well as to build on local knowledge and experience for decision-making are assessed undeniable for the successful integration of woody plants on-farm. Accordingly, the objectives of the study are (1) to shed light on smallholders' decision-making with the focus on their perceptions to better understand farming constraints and utility of decision outcomes; (2) to embed this investigation into tree adoption studies to cross-check farmers' perceptions as decision determinants.

2 The Study Area

Arrangements had been made to carry out the study near the Holetta Agricultural Research Centre (HARC) in the Central Highlands. The criteria for selection of the particular locations were (1) the Agro-Ecological Zone (AEZ) and (2) the access to a paved road network to contrast between the villages as well as to identify differences between tree growers and non-growers. Assumed differences in tree resources endowment made a critical criterion for the selection of two villages in different AEZs (MOA, 2000). The study sites were selected in Dendi and Ejere districts. The villages under study were assigned to M 2-5 "Tepid to cool moist mountains and platea" and M 3-7 "Cold to very cold moist mountains" respectively.

3 How to Approach Farmer's Decision Making and Behaviour

3.1 The Farming Systems Approach (FSA)

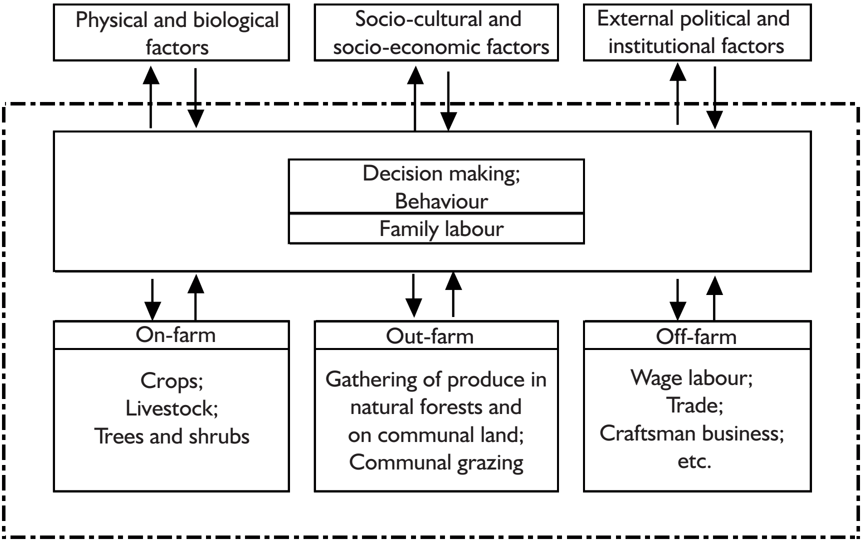
According to (Beets, 1990, p.725) a farm system "is a unit consisting of a human group (household) and the resources it manages in its environment" (Beets, 1990, p.163) (Figure 1).

The FSA is appropriate to embed the farmers' decision-making and behaviour into the frame of influencing factors. It centres the farm household system as the basic unit of assessment (Beets, 1990, p.727).

3.2 The Decision-Making Approach

The Decision Theory is based on the assumption that each choice or decision entails consequences (called 'outcomes') and that each of the actors making the decisions has preferences for the different outcomes (Gladwin, 1989; Barlett, 1980). The Descriptive or Behavioural Decision-Making Approach focuses on decisions incorporating

Figure 1: Basic model of the farm system of a farmer's household

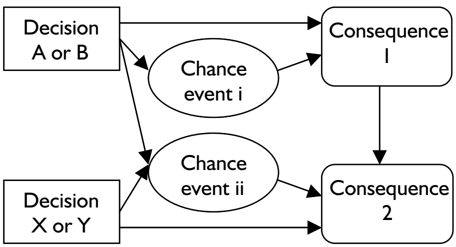


Source: modified from (Beets, 1990, p.163)

alternatives that people actually take. It has been proven that the Behavioural Decision-Making Approach is highly suitable to actors in an agricultural surrounding and to address decision-making constraints (Barlett, 1980; Gladwin, 1989; Negussie, 2003). Influence diagrams are notably simple visual representations of a decision problem and reflect a snapshot of the perception in a decision situation (Figure 2).

The relationships among decision alternatives ('decision node'), uncertain events ('chance node'), and consequences ('consequence node') are common elements depicted in rectangular boxes with sharp edges, elliptical circles, and rectangular boxes with smoothed edges shapes respectively (Barlett, 1980; Gladwin, 1989; Franzel *et al.*, 1996; Lindley, 2003).

Figure 2: Concept of an influence diagram



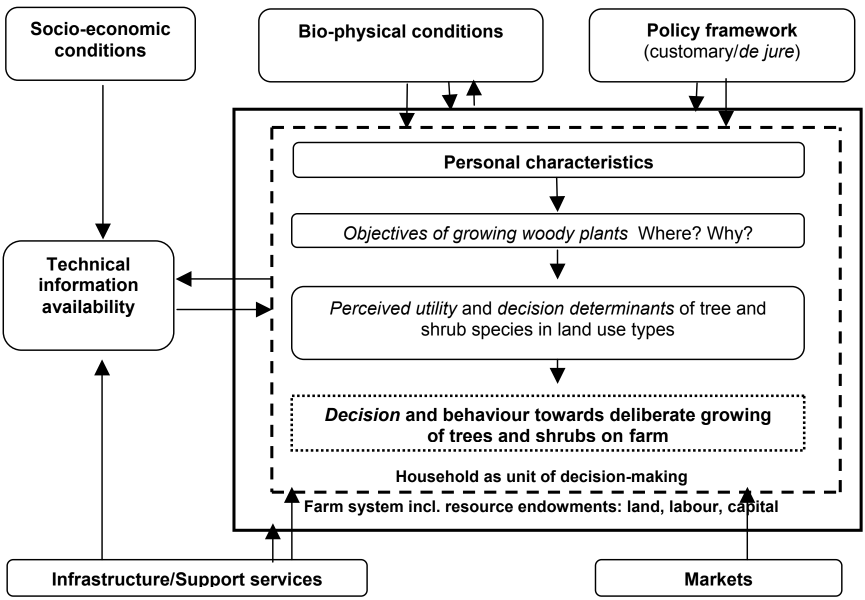
Source: modified from (Boon, 1995)

The influence diagram clearly shows the dependencies among the variables by use of arrows. It does not necessarily imply that there is a causal relation, flow of material, cash or data between the respective variables; but it rather expresses the knowledge of relevance.

3.3 Integrated model of decision making and tree integration behaviour of farm households

Decision-making in tree and shrub growing and the behaviour of smallholder farmers is influenced by external and internal factors (Beets, 1990; McGregor *et al.*, 2001) Referring to the FSA and the Behavioural Decision-Making Approach an integrated model was elaborated (Figure 3). To choose from the decision alternatives - either the deliberate growing of woody species in a particular land use type or not - base on the decision-makers' individual objective as a consequence of the capability to assess and other external influencing factors. The chance events constitute decision determinants that may hinder farmers from growing, whereas the consequences correspond to the outcome or perceived utility of growing woody plants.

Figure 3: Integrated model of external and internal decision and behaviour-influencing factors



Source: modified from (Negussie, 2003, p.26)

This study followed a two-pronged approach,

(1) to identify influencing factors in decision-making from farmers' point of view. The direct eliciting of factors from farmers' point of view is the backbone for the construction of the influence diagrams by means of perception ratings of prevailing decision determinants and the perceived utility from woody plants, and

(2) to complement internal and external factors which explain subsequent behaviour of deliberate tree and shrub growing. Herein, a multivariate modelling approach served as a tool to statistically test the factors which characterise tree and shrub growers and non-growers.

3.4 Operationalisation of factors influencing farm households' behaviour towards deliberate tree and shrub growing

In line with the integrated model operationalised factors affecting the tree and shrub growing behaviour had to be identified. The present study makes use of literature on agroforestry to incorporate determinants, which are empirically and intuitively assumed to contribute to tree grower and non-grower classification (Pattanayak *et al.*, 2002; Mahapatra and Mitchell, 2001; Rapando, 2001; Franzel, 1999; Alavalapati *et al.*, 1995; Caveness and Kurtz, 1993). Influencing factors were aggregated to factor groups corresponding to the elaborated integrated model. Subsequently, variables were assigned to groups of external factors as they are (1) socio-economic conditions, infrastructure/support services, technical information availability, policy framework, and (2) bio-physical conditions. Internal factors were represented by variables on (3) resource endowments and income/returns, as well as (4) personal characteristics.

3.5 Study design

The present study was designed as a case study. Employing the integrated model (see Figure 3) in two villages (PAs) allowed (1) contrasting between the cases regarding tree and shrub growing decisions in selected land use types and (2) cross-checking by means of variables characterising behaviour. Contrasting between the villages required the analysis and assessment at the village level, too. The research was cross-sectional, which expresses a snapshot with observation at one point in time (Neuman, 2000).

Two stages set up the methodological base in field research (1) the Rapid Rural Appraisal (RRA), and (2) the formal survey. At the first stage the gathering of qualitative data was realised by means of secondary data review, general and focus group discussion, key person interviews, transects, sketch maps, direct observation, etc. (FAO, 1995; Fink, 1995; Mwanje, 2001). The standardised questionnaire formed the backbone for household interviews at the second stage. The sampling frame consisted of a list of all registered and unregistered households settled in either the villages. In the present study, 130 households (15 per cent of total population) were systematic-randomly selected in probability proportionate to size (PPS) regarding the affiliation to intra-village settlements. The quality of data was significantly improved by triangulation of natural resource endowment, common farm practices, investment and household income, and use of woody plants.

The Likert scale turned out to be the appropriate rating technique employed for eliciting the perceptions of farmers due to the ease of use in formal household questionnaires and its clearly distinguishable, ideally equidistant scale (Bortz and Döring, 1995). In particular, the farmers' perception of the utility ('very bad' to 'very good') of tree and shrub species and decision determinants ('for sure' to 'certainly not') elicited from key farmers beforehand, were subject for inclusion. The statistical modelling was accomplished by means of the Discriminant Analytical Approach (DAA). This approach is directed, firstly, to identify independent variables which significantly characterise distinguished classification attributes (of the dependent variable) and, secondly, to check and assign individuals according to discriminating variables to the affiliation to one of the classification options. The tree growing behaviour was modelled by means of the DAA.

3.6 Stages in the construction of tree growing models

The modelling followed the commonly accepted approach in analysis implementing two stages for variable selection and acceptance (Mahapatra and Mitchell, 2001; Caveness and Kurtz, 1993),

(1) The stage of pre-selection was designed to narrow the number of variables which were assumed to be influential;

(2) Passing variables entered the stage of discriminant analysis wherein they were either dismissed or retained to be finally included in the discriminant function.

At the first stage the suitability of influencing variables is pre-tested employing

(i) the Chi-square (χ^2) test of independency, which was conducted for each single independent variable towards the binary variable of growing or non-growing;

(ii) Correlation analysis using the Spearmans Rho (ρ) and Kendall's Tau (τ) coefficients for non-evenly distributed metric-scaled and ordinal-scaled independent variables.

(iii) the Mann & Whitney's U-test for non-evenly distributed metric data. Prior to applying the U-test the distribution of attributes of variables was tested by means of

(iv) the Kolmogorov-Smirnov-test to uncover even or non-even distribution.

The level of significance to be passed for entering the next stage of analysis was set to 0.10. As a rule of thumb, variables were tested and significance accepted if there was, at least, an expected value of 2 and above to secure validity of interpretation.

At the second stage, the DAA, the main focus was to form the specific discriminant functions according to the following equation (1) (Backhaus *et al.*, 2003):

$$d = a + b_1 * x_1 + b_2 * x_2 + \ldots + b_n * x_n \quad (1)$$

d	Discriminant value
a	Constant of canonical discriminant function coefficients
$b_1 \ldots b_n$	Canonical discriminant function coefficients (non-standardised)
$x_1 \ldots x_n$	Values of included variables

There are two principal uses of this approach - analysis and classification. The analysis is related to the existing data. The objective is to determine the coefficients in such a way that the values of the function discriminate the growers and non-growers. The interpretation of results reveals the power of the variables in the discriminant functions between the cases under consideration. A step-wise procedure incorporating the likelihood ratio criterion was selected to consider variables for inclusion in the discriminant model. The main concern is the minimisation of the test value Wilk's Lambda (λ), Wilk's ratio of determinants, through forward selection and backward elimination. The removal of interfering variables and step-wise iteration contributed to strengthening of the model. The confidence level for variables to enter was maintained at 0.05 to ensure the entry of important variables.

Finally, the number and percentage of correctly classified observations were determined, and misclassified cases identified. The probability of a classified case to belong to the predicted group was presented in a case to case-related chart.

4 Results and Discussion

Briefing on bio-physical and socio-economic conditions in the villages A quick glance at the bio-physical and socio-economic embedding of the villages in the region describes the setting in which the individual allocation of farm resources takes place. The socio-economic conditions shall be presented by means of the access to infrastructure (Table 1).

Annual minimum temperatures reflect that frost is a major constraint in agricultural production as well as in intended tree and shrub growing in PA 2 rather than in PA 1. The EDBA and DDBA as branches of Ministry of Agiculture (MoA) shoulder the extension programs through Development Agents (DAs). Villagers in PA 2 benefit from the paved road, linking the Ginchi and Geldu town by passing through the PA. The purchase of seedlings through regional markets offers a substantial option to acquire seedlings. In PA 2 peasants use a third option to sell farm produce, namely the availability of road access to sell eucalypt poles on a contractual basis to mid-men who purchase on location.

4.1 Decision modelling component I: Objectives of growing woody plants contrasted to other livelihood activities

The deliberate growing of woody plants on-farm is pursued by farm households as integrated livelihood activity. The identification of major objectives contributed to prioritise pertinent decision alternatives in land use types and thus to better tackle the modelling of tree and shrub growing decisions for homegardens. Based on different livelihood activities the respondents were asked to give reasons for being involved in the respective activity (Figure 4).

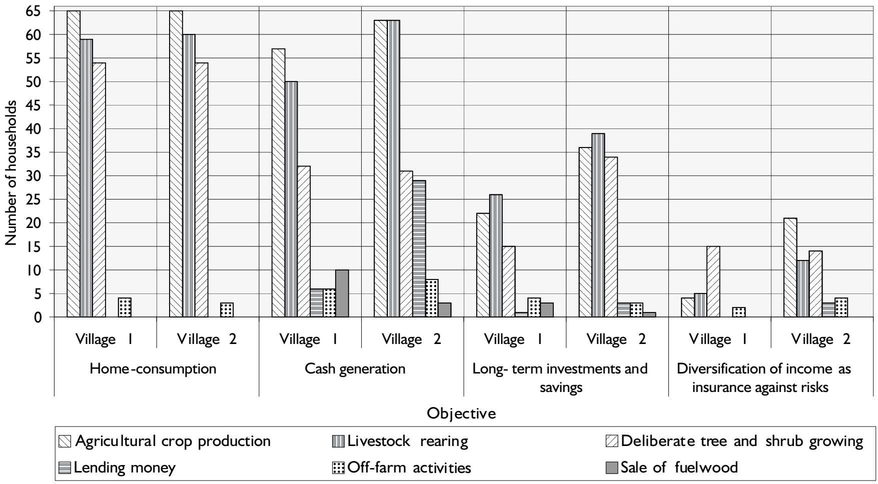
Deliberate tree and shrub growing is perceived as the third-important activity for income generation (79 per cent in PA 1, and 78 per cent in PA 2) after agriculture and livestock rearing. The predominant functions to the farmers are the availability of a stock of trees for fuel and construction purposes, the demarcation of the homestead, the provision of shelter from wind and frost as well as the availability of non-cash savings for immediate

Table 1: Selected bio-physical conditions and access to infrastructure in the two villages

Criteria	*PA 1*	*PA 2*
	Climate	
AEZ (MOA 2000)	M 2-5 "Tepid to cool moist mountains and plateau"	M 3-7 "Cold to very cold moist mountains"
Annual temperatures [°C] (MSH and MSG 2004)	Mean: 14.2 Max: 22.7 Min: 4.7	Mean: 11.9 Max: 20.7 Min: 0.8
Annual rainfall* [mm] (MSH and MSG 2004)	Mean: 992 Max: 1227 Min: 834	Mean: 1095 Max: 1418 Min: 813
	Bio-physical conditions	
Altitude [m.a.s.l.]	Mean: ∼2350 Range: ∼2200-2600	Mean: ∼2950 Range: ∼2800-3050
Topography	Flat to moderately sloping plateau, dissected by deep gullies, bordered by river valleys; rough, steep hilly territory	Temporarily flooded plains; topography similar to PA 1
Soil types by farmers	Black soil; Brown soil; Red soil+sand	Reddish-brown soil; Brown soil; Dark brown soil; Grey soil
Current vegetation	Solitary remnants/ pioneer indigenous trees/ shrubs on wood-land, agricultural ∼, degraded ∼; Eucalypts, Cupressus ssp. on-farm; Degraded natural forest patches	Solitary remnants of indigenous trees/ shrubs on grassland, agricultural ∼; Eucalypts, Cupressus ssp., etc. on-farm; Exploited Chilimo natural forest nearby
	Infrastructure	
Road access to and in village	No asphalt or paved road to urban centres; 3 km dry-weather track to main road; ∼2km step walk (30-45min) from Addis Alem town; Footpaths in village	Paved, all-weather road connection to ∼22km distant Ginchi town (no asphalt);/newline 4 dry-weather roads to Bicho, Danissa, Chobi, etc.; Footpaths in village
Water supply	Several rivers and brooks to fetch water, shared with animals, wells non-existent	
Education facilities	Primary school (1-4)	Primary and Junior sec. school (1-8)
Credits	No commercial bank access; Informal small-scale credits by neighbours	
Extension/ Research	EDBA: agricultural, livestock extension packages; EDBA: initial agroforestry extension programme in 2003	DDBA: agricultural, livestock extension packages; HARC: on-farm research in agroforestry
Markets Regional: Local:	Addis Alem: 3km step footpaths (>1h), Ihnde Gabayee: ∼8km (3h), etc., Gullet PA: ∼4km (2h), Mattala in Gaba Jimmatta PA: ∼3km (3h), Kimmoyye: 3-4km on paths (1.5h)	Ginchi town: ∼18km (∼3h walk, ∼45min by car), Geldu town: ∼15km (3.5h walk), Geba Senbeta (Geldu district): 4km (1h), Qidame gebaa, Boni market (Geldu district): 10km (2.5h walk), etc.
Off-farm employment	Wage labour; Government (PA administration, school); Craftsman business; Trade on regional markets	

*Data sets comprise an 11-year-intervall for PA 1 and a 21-year-intervall for PA 2
Source: RRA (2004)

Figure 4: Most important objectives in livelihood activities in the two villages



liquidation if needed. Woody plants are also marketed which constitutes a considerable immediate source for cash especially in PA 2 based on the road access to markets. Eucalypt trees are widely accepted for this purpose. The equal number of responses in regard to the cash generation function contrasts with the focus of PA 2 inhabitants on cash generation through farm woodlots which implies a relative stronger focus on homegarden growing in PA 1. The home consumption as crucial objective for growing woody plants in the homegarden is thus employed in decision modelling.

4.2 Decision modelling component II: Perceived utility of tree and shrub species

The utility of woody species is part of the consequences of the decision to grow trees and shrubs. It presupposes that farmers arrange their production factors in a way that enables them to achieve the identified utility. The assumption was that farmers do not grow species which are not perceived suitable. This was underlying to compile woody species which had been rated by at least ten and positively assessed by at least 50 per cent of the respondents to be good or very good for a particular utility in order to delineate trends in farmers' perception (Table 2).

Concerning the rating of species for construction purposes eucalypts appeared to be the answer to all demand although farmers' statements were influenced by the tradition of use and increasing disappearance of local knowledge regarding alternative indigenous species. Fuelwood rating values were attributed to woody species grown independently from the type of land use, which underpins the contribution of on-farm fuelwood supply to complement the exploitation of natural forests. Thus, the decision-making and subsequent behaviour of growing woody plants in homegardens is strongly directed by this particular utility. Integrated woody plants in other land use types attained worse results in either the villages which indicates that respondents did not prioritise growing woody plants merely because of fodder produce.

Table 2: Deliberately grown woody species perceived to be suitable for respective utilities

Woody species	*Village*	n_{hhGes}	n_{hhhg}	*Utility (rated being good or very good)*									
				1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Eucalyptus spp.	1	52	45	* * *	* * *	**	**			*	**	*	**
	2	58	43	* * *	**		**				*		**
Croton spp.	1	40	21	*					**	*	**	**	*
Juniperus spp.	1	34	22	* * *	* * *		**			**	**	**	* * *
Rhamnus spp.	1	33	33						*	*			* * *
	2	37	37										*
Cupressus spp.	1	16	16	* * *	* * *	**	**			*	*	*	**
	2	33	33	* * *	**		**				*		**
Hagenia spp.	2	20	10	**		**		**	**	*		*	**
Dombeya spp.	2	25	20	*			*	**	*		*	**	
Arundinaria spp	2	13	13				**						

Utility: 1=Fuelwood, 2=Construction wood, 3=House/farm utensils, 4=Fencing, 5=Fodder, 6=Soil improvement, 7=Ornamental purpose, 8=Windbreak, 9=Shade, 10=Cash generation,
* rated by 50 per cent, ** rated by 75 per cent, * * * rated by 100 per cent of respondents

The difference in perception of species between the villages has to be linked to the occurrence and non-occurrence of distinct woody species. Regarding the cash criterion, tree growing in PA 2 was more differentiated than in PA 1 explained by the perception of suitable species which concentrated on a few cash crops like eucalypts, and Cupressus lusitanica. The suitability of *Podocarpus falcatus, Olea africana, Acacia spp., Carissa edulis, Hagenia abyssinica* for cash generation was continuously mentioned in PA 1 though by a limited number of respondents (less than ten). *Rhamnus prinoides* helps to generate cash by the sale of leaves for the production of Tala, a local light brew, and was already positively tested in another study (NEGUSSIE, 2003).

4.3 Decision modelling component III: Decision determinants in growing woody species

The behaviour of respondents to grow tree and shrub species is influenced by the perceived severeness of constraining factors. Therefore, constraints were extracted from ratings which are 'likely' or 'for sure' to influence the decision to grow the referring species by respondents. The constraint arising from rodents is separately listed from other pests due to explicit emphasis by farmers. The shortage of natural resources has to be understood as the result of underlying chance events, e.g. small land holdings, poor rainfall, etc. To warrant a minimum level of prediction power woody species were exhibited in Table 3, if stated by at least ten respondents and assessed by at least 50 per cent of the respondents.

Most obviously the farmers' perception on what constraint could explicitly be attributed to what species cannot that easily be differentiated for the considerable range of woody species. An explanation is that only few species were perceived by farmers to have

Table 3: Decision determinants perceived to influence the decision to grow woody species

Woody species	*Village*	n_{hhGes}	n_{hhhg}	*Decision determinant (rated being likely or for sure)*						
				1	*2*	*3*	*4*	*5*	*6*	*7*
Eucalyptus spp.	1	52	45		*			**		
	2	58	43					**		
Croton spp.	1	40	21		*					
Juniperus spp.	1	34	22	*	*		**			
Rhamnus spp.	1	33	33		*					
	2	37	37							
Cupressus spp.	1	16	16		*		*	**		
	2	33	33							
Hagenia spp.	2	20	10	*						
Dombeya spp.	2	25	20							
Arundinaria spp	2	13	13		*					

Decision determinant: 1=Shortage of seedlings, 2=Shortage of land, 3=Shortage of water, 4=Poor growth performance, 5=Competition with crops, 6=Pest and diseases, 7=Rodents,
* rated by 50 per cent, ** rated by 75 per cent, * * * rated by 100 per cent of respondents

a strong negative influence on non-tree plant components. Moreover, the capability of households to shoulder the risk of income loss from non-tree plant components in homegardens was much different primarily based on the resources endowment available - a fact resulting in non-linear livelihood strategies pursued by farmers. An emerging determinant was the perceived shortage of land holding albeit being more influential in PA 1 than in PA 2. The finding coincides with the higher total number of integrated eucalypt and *Cupressus* plants in PA 2 in spite of similar holding size. The dissimilarity expresses that respondents in PA 1 realised fierce competition for land between on-farm activities and gave higher priority to other production components in intra-household land resource allocation with the exception of homegardens.

Respondents bear in mind the aggressive competition of eucalypts with agricultural crops, which could be regarded as a decisive factor to refuse growing them in the homegarden in correlation with the perceived shortage of land on the one hand. On the other hand the constraint was outweighed by the ease of protection of tree cash crops and, connected to this, the opportunity to cope with potential income loss from other land use types via liquidation. Therefore eucalypts have finally been accepted for being grown in the homegarden by the majority of respondents particularly in PA 2.

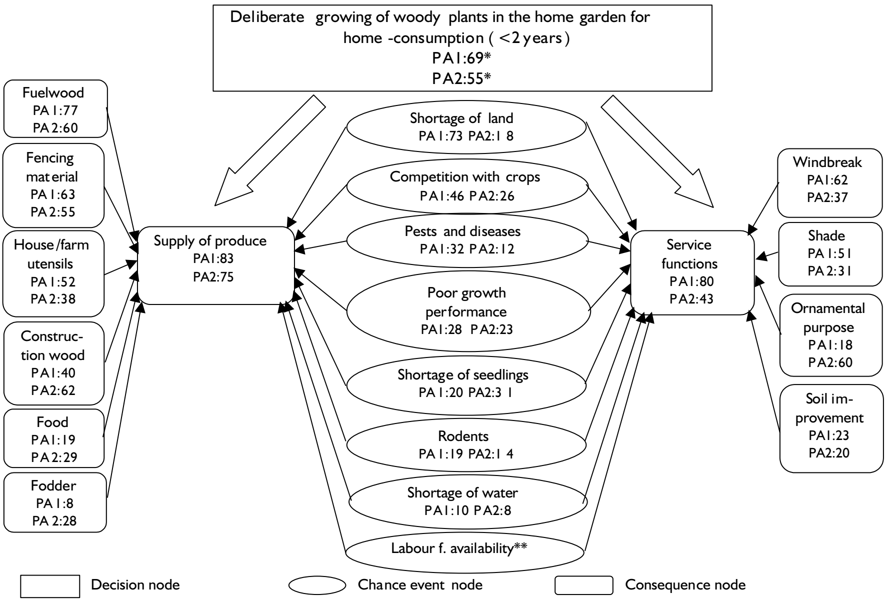
Only a minor proportion of respondents in both of the villages perceived the shortage of seedlings for eucalypts as constraining factor largely due to availability in markets. On the contrary, the short stock on seedlings for *Juniperus procera* in PA 1 was a key factor constraining the deliberate growing. Herein, it has to be taken into account that wildlings from natural forest remnants are sources of seedlings for *Juniperus* trees to a large extent.

4.4 Synthesis of decision modelling components: Growing woody plants for home consumption in the homegarden

Decision alternatives base on the respondents' involvement in tree and shrub growing. Accordingly, 45 (69 per cent) and 36 (55 per cent) of the total respondents were assigned to the grower category in PA 1 and 2 in compliance with the objective of home consumption of woody plants due to its high pertinence in farm households.

The relationships between (1) Decision alternatives, (2) Chance events incorporating decision determinants (being likely and for sure), and (3) Consequences incorporating utilities of woody species (being good and very good) are subject to the decision modelling (Figure 5).

Figure 5: Growing woody plants in homegardens for home consumption in the two villages



Statements in % of positive choice based on the number of woody species grown by the respective number of households
*Share of growers (Occurence: PA1:178, PA2:190)
**Not rated

The most important finding is that respondents' concerns for tree and shrub growing in PA 2 are much less regarding the shortage of land than in PA 1 (18 per cent and 73 per cent respectively). This result is explained by the informal subdivision of land holdings among household descendents in PA 1. Furthermore, the influence of the perceived shortage of land on tree and shrub growing coincides with the fact that the respondents' availability of fuel material in PA 2 is different than in PA 1. The majority of households in PA 2 (60 per cent) dispose over eucalypts in farm woodlots for obtaining various produce which influences the tree integration decisions in homegardens especially for fuelwood and posts for fencing.

The above utility and determinants necessitate the consideration of Multi-Purpose Tree Species (MPTS) in multi-storey arrangements like fuelwood/timber trees and small fuelwood/fencing trees at contours of homegardens particularly in PA 1. The exposure to more variable weather conditions like wind, frost, and high temperatures in PA 2 contributes to the significantly different perception of trees for shading and windbreak purposes by respondents than in PA 1.

4.5 Modelling of farmers' behaviour I: Descriptive depiction of external and internal factors influencing tree and shrub growing

There was a multitude of variables which passed in descriptive statistics at the first stage of analysis (p=0.10). Therefore, groups of relevant (1) external and (2) internal factors included in DAA are presented in brief.

(1) A range of external factors in PA 1 and PA 2 referred to the use of seedlings from various sources which indicates the respective variables to be very suitable for the intended discrimination of tree growers and non-growers. Variables pertaining to the access to fuelwood were partly significant in particular referring to the allocated household's and neighbour's land and natural forests. In contrast to PA 2 univariate statistics revealed for PA 1 that communication factors (social participation, access to extension, urban market access) are significant contributors to the discrimination in DAA. The tenure status of farm land is significant only in PA 1 which is caused by the activities regarding informal land rents. The majority of variables pertaining to inclination and soil quality in land use types possess negligible potential for the discrimination of tree growers and non-growers.

(2) The bulk of internal factors entering the second stage in analysis comes from the endowment with land and labour force, income from agricultural production, and returns from sale of produce in either the villages. Major variables linked to livestock assets were only significant in PA 2 indicating the better discrimination potential of livestock in possession. Proxies for the personal characteristics of household heads (gender, age, etc.) passed the first stage of analysis in PA 2 but stayed of minor relevance for the discrimination of the respondents in PA 1. Apparently, these factors did not possess a high explanation power as already compiled for other studies on the adoption of trees on-farm (MERCER, 2004; PATTANAYAK *et al.*, 2002).

4.6 Modelling of farmers' behaviour II: Discriminant analysis and classification

After pre-selection the above-delineated variables entered the DAA in arbitrary order and were step-wise tested according to their contribution to minimise the test value Wilk's λ. Noise variables were removed (Table 4).

In PA 1 the most important variable in discrimination of tree growers from non-growers was the use of wildlings from allocated land (standardised canonical discriminant coefficient of 0.730). It appeared that for those households, who have tree and shrub resources already available from naturally grown trees and shrubs on agricultural or pasture plots, the threshold to transplant woody plants into homegardens is lower than for households who are not endowed with these prerequisites.

Table 4: Analysis and classification results from DAA

Variables	*PA 1*	*PA 2*
Group centroid, canonical discriminant eigenvalues and Wilk's λ		
Grower	0.568	1.373
Non-grower	-1.278	-1.704
Eigenvalue	0.715	2.414
Canonical correlation	0.646	0.841
Wilk's Lambda	0.583	0.293
Level of significance	0.001	0.001
Standardised canonical discriminant coefficients		
Access to extension	0.487	
Access to credits	0.508	
Use of seedlings from farm nursery		0.446
Use of wildlings from allocated land	0.730	0.750
Use of wildlings from natural forest	0.384	
Use of seedlings from market	0.481	0.856
Cash generated from SEU*capita*a		0.464
Discrimination power (% of correctly classified households)		
Grower	70	94.4
Non-grower	91.1	86.2
Total	84.6	90.8

The access to extension by growers in PA 1 revealed that these respondents have access to communication with the development agent who may raise the farmers' awareness towards woody plants on-farm. However, the implementation of extension programs incorporating woody plant components into production in various land use types was still in its infants (in PA 1) or missing at all (in PA 2) .

The risk-averting behaviour and diversification of cash-generating activities is investigated by Senkondo (2000). Similar to homegarden growers, respondents adopting trees and shrubs also made use of natural regeneration from farm land. In PA 2, tree growers were characterised by the use of wildlings from allocated land, seedlings from farm nurseries and the purchase from markets. In addition to this, growers generated a higher amount of cash per capita from the sale of sheep within the last two years which indicates the focus on livestock production for cash generation and suggests to make use of woody plants to support this activity by complementary fodder.

The discriminating variables for tree and shrub growers and non-growers contribute to a high percentage of correctly classified households (84.6 and 90.8 per cent). This indicates the discrimination power of the variables and the prediction of other households to belong to one of the two groups according to the selected variables.

5 Conclusion

The respondents represent the total population in the villages and therefore conclusions apply for the villages. Pertinent components in the modelling of decisions are (1) the objectives of growing woody plants, (2) the utility of woody species, and (3) the decision determinants of growing woody species in the homegarden. Farmers' behaviour on tree integration in the homegarden is influenced by (4) external and internal factors related to the farm system. The following conclusions were drawn.

- The farmers' objective to grow woody plants, particularly in the homegarden, is determined by means of how woody plants primarily contribute to home consumption and, secondary, whether they warrant immediate cash generation and are appropriate for saving purposes or not.
- The road access to markets favours the farmers' perception of land use types other than the homegarden to be suitable for integrating woody plants for cash generation.
- Tree and shrub growing decisions are driven by the subjectively perceived utility of woody species for primarily fuelwood, timber-based produce, and cash generation. The use of woody species for fodder purposes is negligible and does not drive farmers to grow them in the homegarden.
- The perceived shortage of land resources and seedlings are chief decision determinants that continue to hinder farmers from growing woody plants in the homegarden. The perceived shortage of seedlings is connected to the range of sources used.
- Farmers who deliberately grow woody plants in the presence of road access to the market are characterised by a higher risk-taking capability than non-growers and thus continue to afford means of increasing the total utility from farm components by taking crop yield reduction in the homegarden into account.
- Accessible markets influence the establishment of farm nurseries and enable the purchase of seedlings by farmers which outweighs the use of wildlings from natural forests and partly overcomes missing agroforestry-related extension work depending on the household's cash capital endowment.

These conclusions can be understood as a hint to further qualify extension regarding integration of woody plants with other on-farm activities, expansion of seedlings supply particularly of multi-purpose indigenous species, and further improvement of the all-weather road network.

Acknowledgement
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Threatened and Rare Ornamental Plants

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Abstract

The application of IUCN criteria and Red List Categories was done for ornamental plants. Main sources of the study were Glen's book, Cultivated Plants of Southern Africa (Glen, 2002) and the Red List of Threatened Plants, IUCN (2001). About 500 threatened ornamental plants could be found and presented in respective lists. Rare ornamental plants with 209 species is the largest group followed by Vulnerable (147), Endangered (92), Indeterminate (37), Extinct (6) and finally Extinct/Endangered groups with 2 species. A weak positive correlation (r = +0.36) was found between the number of threatened species and the number of threatened ornamental species within the families.

Keywords: ornamental plants, IUCN criteria, red list

1 Introduction

Whereas red lists of threatened plants are being highly developed for wild plants and even replaced by green lists (Imboden, 1989) and blue lists (Gigon *et al.*, 2000), ornamental plants still lack similar lists. A statistical summary of threatened crop plant species was published by Hammer (1999) showing that roughly 1000 species of cultivated plants (excluding ornamentals) are threatened (see also Lucas and Synge (1996). An attempt was recently made towards a red list for crop plant species, which presents about 200 threatened cultivated (excluding ornamentals) plants in the IUCN categories (Hammer and Khoshbakht, 2005b). Now an effort is made to include ornamentals.

IUCN has defined six categories for threatened plants – Extinct, Extinct/Endangered, Endangered, Vulnerable, Rare and Indeterminate (see IUCN (2001) for definitions).

2 Materials and Methods

To obtain a list of threatened ornamental plants at the species level, the book of Glen (2002) was compared with the Red List of Threatened Plants, IUCN (2001). Glen (2002) contains about 9.000 species. Most of them are ornamental plants. They are based on observations of about 37.000 specimens of cultivated plants in Southern Africa.

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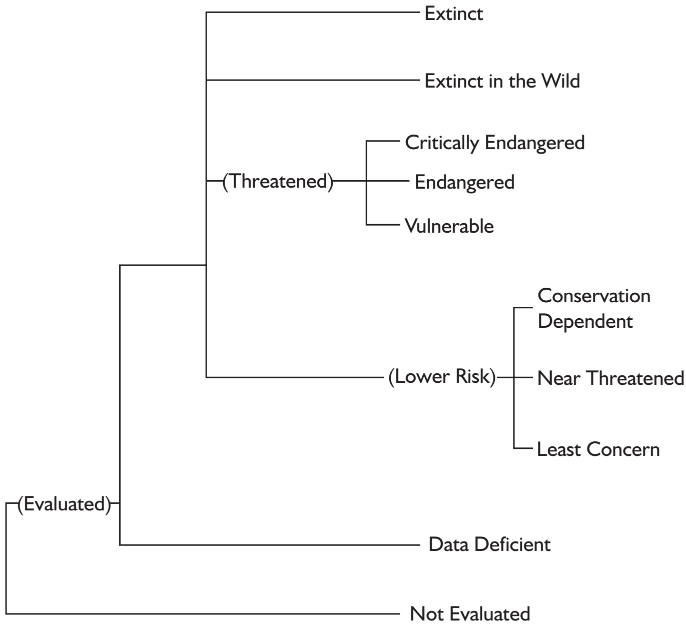
The aim of the list is a Prodromus of a Southern Africa garden flora similar to that of WALTERS *et al.* (1986-2000, 6 volumes) for Europe.
Species available in GLEN (2002) matching with the Red List of Threatened Plants (IUCN, 2001) were arranged alphabetically in tables, according to the following IUCN (2001) categories, see also Fig 1.

Figure 1: Structure of IUCN Red List Categories (from Species Survival Commission; IUCN 1994)



(1) Extinct (Ex): Taxa that are no longer known to exist in the wild after repeated searches of the type localities and other known or likely places.

(2) Extinct/Endangered (Ex/E): Taxa possibly considered to be extinct in the wild.

(3) Endangered (E): Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction.

(4) Vulnerable (V): Taxa believed likely to move into the Endangered category in the near future if the causal factors continue operating. Included are taxa of which most or all the populations are decreasing because of over-exploitation, extensive destruction of habitat or other environmental disturbance; taxa with populations that have been seriously depleted and whose ultimate security is not yet assured; and taxa with populations that are still abundant but are under threat from serious adverse factors throughout their range.

(5) Rare (R): Taxa with small world populations that are not at present Endangered or Vulnerable, but are at risk. These taxa are usually localized within restricted geographic areas or habitats or are thinly scattered over a more extensive range.

(6) Indeterminate (I): Taxa known to be Extinct, Endangered, Vulnerable, or Rare but where there is not enough information to say which of these four categories is appropriate.

For each of these categories, the ornamental plants are arranged alphabetically by genus names (Tables 1-6). The number of plant species in the different families and the percentage of threatened plants was added for each family from the Red List of Threatened Plants IUCN (2001), and per thousands of threatened ornamental plants was calculated (Table 7).

3 Results

The result of this study is presented in tables 1-6. The species in the category of Extinct (Ex.) (Table 1) have to be considered as extinct in the wild (see fig.1). They still exist under cultivation in South Africa. Some of them are not rare in collections, e.g. in Europe, as *Tacitus bellus*, *Holarrhena pubescens* (Alexander and Watson, 2000) and *Franklinia alatamaha* (Whitefoard, 1995), (see table 2) appear in the European Garden Flora.

Table 1: Extinct (Ex) ornamental plants

Taxa	*Family*
Astragalus robbinsii (Oakes) A.Gray var. *robbinsii*	Leguminosae
Encephalartos woodii Sander	Zamiaceae
Erica verticillata P.J.Bergius	Ericaceae
Holarrhena pubescens (Buch.-Ham.) Wall. ex G. Don	Apocynaceae
Pitcairnia undulata Scheidw.	Bromeliaceae
Tacitus bellus Moran & J.Meyrán	Crassulaceae

Table 2: Extinct/Endangered (Ex/E) ornamental plants

Taxa	*Family*
Franklinia alatamaha Bartr. ex Marsh.	Theaceae
Pritchardia affinis Becc.	Palmae

Compared with the results on crop plant species overlapping of both lists, ornamental plants are sometimes used for other purposes, crop plants become ornamental ones after giving up crop production. Several multi-purpose plants can be found in different categories. As an example *Juglans hindsii*, from the Endangered group (see table 3) might be considered. It is planted in North America as road and shade tree. It is used as a rootstock for *J. regia* because of its disease resistance and vigour. The edible nuts are produced on a small-scale commercial basis in Missouri and Indiana and are traded occasionally on the American markets (Keller, 2001). In this category Zamiaceae (14), Palmae (21) and Bromeliaceae (16) are frequent. Bromeliaceae are typical objects for collection similar to Orchidaceae and succulents (Agavaceae, Aloaceae, Cactaceae, Aizoaceae).

Table 3: Endangered (E) ornamental plants

Taxa	*Family*
Agave wercklei Weber ex Werckle	Agavaceae
Aloe albiflora Guillaumin	Aloaceae
Aloe ballii Reynolds	Aloaceae
Aloe bellatula G. Reynolds	Aloaceae
Araucaria rulei F. Muell.	Araucariaceae
Areca concinna Thwaites	Palmae
Astrophytum asterias (Zucc.) Lem.	Cactaceae
Atriplex canescens (Pursh)Nutt. var. *gigantea* Welsh & Stutz	Chenopodiaceae
Balfourodendron riedelianum Engl.	Rutaceae
Beccariophoenix madagascariensis Jum. & H. Perrier	Palmae
Brahea edulis S.Watson	Palmae
Brighamia insignis Gray	Campanulaceae
Butia campicola Barb. Rodr.	Palmae
Ceratozamia hildae Landry & M. Wilson	Zamiaceae
Chamaedorea brachypoda Standley & Steyerm.	Palmae
Coccothrinax crinita Becc. ssp. *crinita*	Palmae
Columnea allenii Mort.	Gesneriaceae
Cupressus goveniana Gord.	Cupressaceae
Cypella herberti (Lindley) Herbert	Iridaceae
Dypsis decipiens (Becc.) Beentje & J. Dransf.	Palmae
Encephalartos arenarius R.A.Dyer	Zamiaceae
Encephalartos cerinus Lavranos & D.L.Goode	Zamiaceae
Encephalartos chimanimaniensis R.A.Dyer & I.Verd.	Zamiaceae
Encephalartos concinnus R.A.Dyer & I.Verd.	Zamiaceae
Encephalartos cupidus R.A.Dyer	Zamiaceae
Encephalartos dolomiticus Lavranos & D.L.Goode	Zamiaceae
Encephalartos dyerianus Lavranos & D.L.Goode	Zamiaceae
Encephalartos inopinus R.A.Dyer	Zamiaceae
Encephalartos laevifolius Stapf & Burtt Davy	Zamiaceae
Encephalartos latifrons Lehm.	Zamiaceae
Encephalartos munchii R.A.Dyer & I.Verd.	Zamiaceae
Encephalartos pterogonus R.A.Dyer & I.Verd.	Zamiaceae
Gaussia attenuata (O.F. Cook) Becc.	Palmae
Geranium maderense Yeo	Geraniaceae
Gigasiphon macrosiphon (Harms) Brenan	Leguminosae
Grevillea caleyi R.Br.	Proteaceae
Haemanthus pumilio Jacq.	Amaryllidaceae
Hyophorbe lagenicaulis (L. Bailey) H.E. Moore	Palmae

(Table 3 continuation)

Taxa	*Family*
Hyophorbe vaughanii L. Bailey	Palmae
Hyophorbe verschaffeltii H.A. Wendl.	Palmae
Juglans hindsii (Jepson) Jepson ex R.E. Sm.	Juglandaceae
Juniperus barbadensis L.	Cupressaceae
Juniperus bermudiana L.	Cupressaceae
Juniperus cedrus Webb & Berthel.	Cupressaceae
Latania loddigesii Martius	Palmae
Latania lontaroides (Gaertner) H.E. Moore	Palmae
Lavatera phoenicea Vent.	Malvaceae
Limonium dufourei (Girard) Kuntze	Plumbaginaceae
Livistona carinensis (Chiov.) Dransf. & Uhl	Palmae
Lotus berthelotii Masf	Leguminosae
Lotus maculatus Breitfeld	Leguminosae
Malus hupehensis (Pamp.) Rehd.	Rosaceae
Malvaviscus arboreus Cav. var. *lobatus* A. Robyns	Malvaceae
Mammillaria carmenae Castaneda & Nunez	Cactaceae
Marojejya darianii J. Dransf. & N. Uhl	Palmae
Melocactus matanzanus Leon	Cactaceae
Metasequoia glyptostroboides Hu & Cheng	Taxodiaceae
Neoveitchia storckii (H.A. Wendl.) Becc.	Palmae
Nepenthes gracillima Ridley	Nepenthaceae
Orania trispatha (J. Dransf. & N.W. Uhl) Beentje & J. Dransf.	Palmae
Paphiopedilum armeniacum S.C. Chen & F.Y. Liu	Orchidaceae
Paphiopedilum micranthum Tang & Wang	Orchidaceae
Pinanga javana Blume	Palmae
Pinus maximartinezii Rzedowski	Pinaceae
Pinus muricata D. Don var. *muricata*	Pinaceae
Pinus radiata D. Don var. *radiata*	Pinaceae
Pinus torreyana Parry ex Carr.	Pinaceae
Pleiospilos simulans (Marloth) N.E.Br.	Aizoaceae
Pritchardia remota Becc.	Palmae
Puya laxa L.B. Smith	Bromeliaceae
Puya macrura Mez	Bromeliaceae
Sabal bermudana L.H. Bailey	Palmae
Sedum obtusatum A. Gray ssp. *paradisum* Denton	Crassulaceae
Teline nervosa A. Hansen & Sunding	Leguminosae
Tillandsia balsasensis Rauh	Bromeliaceae
Tillandsia califanii Rauh	Bromeliaceae
Tillandsia hildae Rauh	Bromeliaceae
Tillandsia hondurensis Rauh	Bromeliaceae
Tillandsia ignesiae Mez	Bromeliaceae
Tillandsia ixioides Grisebach	Bromeliaceae
Tillandsia kammii Rauh	Bromeliaceae
Tillandsia lindenii Regel var. *lindenii*	Bromeliaceae
Tillandsia magnusiana Wittmack	Bromeliaceae
Tillandsia matudae Lyman B. Smith	Bromeliaceae
Tillandsia nuptialis Braga & Sucre	Bromeliaceae
Tillandsia plumosa Baker	Bromeliaceae
Tillandsia reuteri Rauh	Bromeliaceae
Veitchia montgomeryana H.E. Moore	Palmae

(Table 3 continuation)

Taxa	*Family*
Vriesea harmsiana (Lyman B. Smith) Lyman B. Smith	Bromeliaceae
Widdringtonia cedarbergensis Marsh	Cupressaceae
Widdringtonia schwarzii (Marloth) Mast.	Cupressaceae
Zamia vasquezii D. Stevenson	Zamiaceae

The Vulnerable category (Table 4) is the second large group in the threatened ornamentals. Some important multi-purpose plants in this group are *Dimocarpus longan*, *Jubaea chilensis*, *Lodoicea maldivica*, *Macadamia ternifolia*, *M. tetraphylla*, *Origanum dictamnus*, *Syzygium paniculatum*, *Warburgia salutaris*. In this category Palmae (26) and Zamiaceae (17) are rather frequent.

Table 4: Vulnerable (V) ornamental plants

Taxa	*Family*
Acacia flocktoniae Maiden	Leguminosae
Acacia koaia Hbd.	Leguminosae
Acanthophoenix rubra (Bory) H.A. Wendl.	Palmae
Aeonium sedifolium (Webb ex Bolle) Pit. & Proust	Crassulaceae
Allagoptera arenaria (Gomes) Kuntze	Palmae
Araucaria heterophylla (Salisb.) Franco	Araucariaceae
Argyranthemum broussonetii (Pers.) Humphries ssp. *broussonetii*	Compositae
Ariocarpus fissuratus (Engelm.) Britton & Rose var. *lloydii* (Rose) W.T. Marsh	Cactaceae
Armeria welwitschii Boiss.	Plumbaginaceae
Astrophytum capricorne (A. Dietr.) Britton & Rose var. *capricorne*	Cactaceae
Azorina vidalii (H.C.Watson) Feer	Campanulaceae
Begonia cubensis Hassk.	Begoniaceae
Bentinckia nicobarica (Kurz) Becc.	Palmae
Caesalpinia echinata Lam.	Leguminosae
Callitris oblonga A.Rich. & Rich.	Cupressaceae
Calophyllum calaba L. var. calaba	Guttiferae
Carpenteria californica Torr.	Hydrangeaceae
Ceanothus cyaneus Eastw.	Rhamnaceae
Ceanothus dentatus Torr. & Gray	Rhamnaceae
Cedrus brevifolia (Hook.f.) Henry	Pinaceae
Cephalocereus senilis (Haw.) Pfeiffer	Cactaceae
Cephalotaxus hainanensis Li	Cephalotaxaceae
Ceratozamia kuesteriana Regel	Zamiaceae
Ceratozamia norstogii D. Stevenson	Zamiaceae
Chamaedorea graminifolia H. Wendl.	Palmae
Chamaedorea microspadix Burret	Palmae
Chamaedorea radicalis C. Martius	Palmae
Cheiridopsis peculiaris N.E.Br.	Aizoaceae
Chorizema varium Benth.	Leguminosae
Cupressus bakeri Jepson	Cupressaceae
Cupressus cashmeriana Royle ex Carrière	Cupressaceae
Cycas ophiolitica K.Hill	Cycadaceae

(Table 4 continuation)

Taxa	*Family*
Cycas taiwaniana Carruth.	Cycadaceae
Cyrtanthus brachysiphon Hilliard & B.L.Burtt	Amaryllidaceae
Deckenia nobilis H.A. Wendl.	Palmae
Dianthus serotinus Waldst. & Kit.	Caryophyllaceae
Dierama pulcherrimum (Hook.f.) Baker	Iridaceae
Dimocarpus longan Lour.	Sapindaceae
Dioon mejiae Standley & L.O. Williams	Zamiaceae
Dioscorea elephantipes (L'Hér.) Engl.	Dioscoreaceae
Dodonaea rupicola C.White	Sapindaceae
Drosera adelae F.Muell.	Droseraceae
Dypsis decaryi (Jum.) Beentje & J. Dransf.	Palmae
Dypsis hildebrandtii Becc.	Palmae
Dypsis jumelleana Beentje & J. Dransf.	Palmae
Dypsis louvelii Jum. & H. Perrier	Palmae
Dypsis rivularis (Jum. & H. Perrier) Beentje & J. Dransf.	Palmae
Echium pininana Webb & Berthel.	Boraginaceae
Encephalartos altensteinii Lehm.	Zamiaceae
Encephalartos caffer (Thunb.) Lehm.	Zamiaceae
Encephalartos cycadifolius (Jacq.) Lehm.	Zamiaceae
Encephalartos eugene-maraisii I.Verd.	Zamiaceae
Encephalartos friderici-guilielmi Lehm.	Zamiaceae
Encephalartos ghellinckii Lem.	Zamiaceae
Encephalartos gratus Prain	Zamiaceae
Encephalartos horridus (Jacq.) Lehm.	Zamiaceae
Encephalartos humilis I.Verd.	Zamiaceae
Encephalartos longifolius (Jacq.) Lehm.	Zamiaceae
Encephalartos ngoyanus I.Verd.	Zamiaceae
Encephalartos paucidentatus Stapf & Burtt Davy	Zamiaceae
Encephalartos princeps R.A.Dyer	Zamiaceae
Encephalartos trispinosus (Hook.) R.A.Dyer	Zamiaceae
Encephalartos umbeluziensis R.A.Dyer	Zamiaceae
Erica bauera Andrews	Ericaceae
Erythronium tuolumnense Applegate	Liliaceae
Eucalyptus argophloia Blakely	Myrtaceae
Eucalyptus burdettiana Blakely & Steedman	Myrtaceae
Eucalyptus nicholii Maiden & Blakely	Myrtaceae
Eucalyptus pulverulenta Sims	Myrtaceae
Eucalyptus scoparia Maiden	Myrtaceae
Furcraea bedinghausii K. Koch	Agavaceae
Gastrochilus japonicus (Makino) Schltr.	Orchidaceae
Gaussia maya (Cook) Quero & R. W. Read	Palmae
Genista tinctoria L. ssp. *prostrata* Corillion, Figureau, Godeau	Leguminosae
Haemanthus amarylloides Jacq. ssp. *amarylloides*	Amaryllidaceae
Hedyscepe canterburyana (C. Moore & F. Muell.) H. Wendl.	Palmae
Heliconia angusta Vell.	Heliconiaceae
Hyophorbe indica Gaertner	Palmae
Jasminum azoricum L.	Oleaceae
Jubaea chilensis (Mol.) Baillon	Palmae
Jubaeopsis caffra Becc.	Palmae
Juniperus recurva Buch-Ham. ex D. Don var. *coxii* (Jacks.) Melville	Cupressaceae

(Table 4 continuation)

Taxa	*Family*
Kennedia macrophylla (Meisner) Benth.	Leguminosae
Laelia furfuracea Lindley	Orchidaceae
Latania verschaffeltii Lemaire	Palmae
Leucadendron daphnoides (Thunb.) Meisn.	Proteaceae
Leucadendron galpinii E.Phillips & Hutch.	Proteaceae
Leucospermum formosum (Andrews) Sweet	Proteaceae
Leucospermum fulgens Rourke	Proteaceae
Leucospermum grandiflorum (Salisb.) R.Br.	Proteaceae
Leucospermum parile (Salisb. ex Knight) Sweet	Proteaceae
Libocedrus plumosa (D. Don) Sarg.	Cupressaceae
Limonium perezii (Stapf) Hubbard	Plumbaginaceae
Livistona drudei F.Muell. ex W.Watson	Palmae
Lodoicea maldivica (J. Gmelin) Pers.	Palmae
Lyonothamnus floribundus A.Gray ssp. *aspleniifolius* (Greene) Raven	Rosaceae
Lythrum flexuosum Lag.	Lythraceae
Macadamia integrifolia Maiden & Betche	Proteaceae
Macadamia ternifolia F.Muell.	Proteaceae
Macadamia tetraphylla L.A.S.Johnson	Proteaceae
Mammillaria bocasana Poselger	Cactaceae
Marojejya insignis Humbert	Palmae
Masdevallia instar Luer & Andreetta	Orchidaceae
Mimetes hirtus (L.) Salisb. ex Knight	Proteaceae
Nephrosperma vanhoutteanum (Wendl. ex Van Houtte) Balf. f.	Palmae
Normanbya normanbyi (A.W.Hill) L.H.Bailey	Palmae
Ocotea porosa (Nees & Martius) Barroso	Lauraceae
Oncidium phalaenopsis Lindley	Orchidaceae
Opuntia whipplei Engelm. & Bigelow	Cactaceae
Origanum dictamnus L.	Labiatae
Paranomus reflexus (E.Phillips & Hutch.) N.E.Br.	Proteaceae
Phalaenopsis schilleriana Reichb.f.	Orchidaceae
Phoenicophorium borsigianum (K. Koch) Stuntz	Palmae
Phoenix rupicola T. Anders.	Palmae
Phoenix theophrasti Greuter	Palmae
Picea omorika (Pancic) Purk.	Pinaceae
Pinus muricata D. Don	Pinaceae
Pinus occidentalis Sw.	Pinaceae
Prosopis tamarugo Philippi	Leguminosae
Psoralea arborea Sims	Leguminosae
Reutealis trisperma (Blanco) Airy Shaw	Euphorbiaceae
Roystonea elata (Bartr.) F. Harper	Palmae
Salix magnifica Hemsl.	Salicaceae
Sciadopitys verticillata (Thunb. ex J.A. Murray) Sieb. & Zucc.	Taxodiaceae
Sequoiadendron giganteum (Lindl.) Buchh.	Taxodiaceae
Sequoia wellingtonia Seem.	Taxodiaceae
Serruria florida (Thunb.) Salisb. ex Knight	Proteaceae
Sparaxis elegans (Sweet) Goldblatt	Iridaceae
Sparaxis tricolor (Schneev.) Ker Gawl.	Iridaceae
Stanhopea hernandezii (Kunth) Schltr.	Orchidaceae
Stanhopea tigrina Bateman ex Lindley	Orchidaceae
Strongylodon macrobotrys A.Gray	Leguminosae

(Table 4 continuation)

Taxa	*Family*
Syzygium paniculatum Gaertner	Myrtaceae
Tanacetum ptarmiciflorum (Webb) Schultz Bip.	Compositae
Tillandsia baileyi Rose ex Small	Bromeliaceae
Tillandsia butzii Mez	Bromeliaceae
Tillandsia caput-medusae E. Morren	Bromeliaceae
Tillandsia heterophylla E. Morren	Bromeliaceae
Tillandsia ionantha Planchon	Bromeliaceae
Tillandsia pueblensis Lyman B. Smith var. *pueblensis*	Bromeliaceae
Tillandsia selleana Harms	Bromeliaceae
Tillandsia streptophylla Scheidw. ex Morren	Bromeliaceae
Tillandsia superba Mez & Sodiro	Bromeliaceae
Verschaffeltia splendida H.A. Wendl.	Palmae
Warburgia salutaris (Bertol.f.) Chiov.	Canellaceae
Zamia fischeri Miq.	Zamiaceae
Zamia splendens Schutzman	Zamiaceae

The largest group in our study is the Rare category (see table 5). In this category are many multipurpose species such as *Dioon edule, Eucalyptus macarthurii, Euterpe edulis, Pimpinella anisetum and Rheum rhaponticum*.
Corypha umbraculifera is a multi-purpose ornamental palm tree. The leaves serve for the production of fans, mats, umbrellas, and baskets or are used (especially formerly) as writing materials. The leaf stalks are made into paper. The pith of the stems is the source of a sago-like product. The hard seeds are manufactured into buttons and jewellery (Kruse, 2001).

Table 5: Rare (R) ornamental plants

Taxa	*Family*
Abies pinsapo Boiss. var. *pinsapo*	Pinaceae
Abromeitiella brevifolia (Grisebach) Castellanos	Bromeliaceae
Acacia howittii F.Muell.	Leguminosae
Acacia iteaphylla Benth.	Leguminosae
Acacia jonesii F.Muell. & Maiden	Leguminosae
Acacia quornensis J.Black	Leguminosae
Acacia robynsiana Merxm. & A.Schreib.	Leguminosae
Acaena novae-zelandiae Kirk	Rosaceae
Adansonia za Baillon	Bombaceae
Aechmea blumenavii Reitz	Bromeliaceae
Aechmea kleinii Reitz	Bromeliaceae
Agathis atropurpurea B.Hyland	Araucariaceae
Agathis microstachya J.F.Bailey & C.White	Araucariaceae
Agathosma pulchella (L.) Link	Rutaceae
Alberta magna E.Mey.	Rubiaceae
Alloxylon pinnatum (Maiden & Betche) P.Weston & Crisp	Proteaceae
Aloe forbesii Balf. f.	Aloaceae
Alyssum wulfenianum Bernh.	Cruciferae
Anacampseros filamentosa (Haw.) Sims ssp. *filamentosa*	Portulacaceae
Anthemis sancti-johannis Stoj., Stef. & Turrill	Compositae
Aporocactus flagelliformis (L.) Lemaire	Cactaceae

(Table 5 continuation)

Taxa	*Family*
Aquilegia eximia Van Houtte ex Planch.	Ranunculaceae
Aquilegia longissima Gray	Ranunculaceae
Arabis ferdinandi-coburgi Kellerer & Sünd.	Cruciferae
Araucaria angustifolia (Bertol.) Kuntze	Araucariaceae
Araucaria araucana (Mol.) K. Koch	Araucariaceae
Areca guppyana Becc.	Palmae
Argyranthemum webbii Schultz Bip.	Compositae
Aruncus dioicus Fern. var. *subrotundus* Hara	Rosaceae
Aztekium ritteri (Boed.) Boed.	Cactaceae
Ballota pseudodictamnus (L.) Benth.	Labiatae
Bauhinia bowkeri Harv.	Leguminosae
Begonia dregei Otto & A.Dietr.	Begoniaceae
Bolusiella maudiae (Bolus) Schltr.	Orchidaceae
Bowkeria citrina Thode	Scrophulariaceae
Brunfelsia undulata Sw.	Solanaceae
Burretiokentia vieillardii (Brongn. & Gris) Pichi-Serm.	Palmae
Calothamnus rupestris Schauer	Myrtaceae
Calycanthus occidentalis Hook. & Arn.	Calycanthaceae
Calyptronoma occidentalis (Sw.) H.E. Moore	Palmae
Campanula davisii Turrill	Campanulaceae
Campanula elatinoides Moretti	Campanulaceae
Campanula incurva Aucher ex A.DC.	Campanulaceae
Campanula portenschlagiana Schult.	Campanulaceae
Campanula poscharskyana Degen	Campanulaceae
Carex oshimensis Nakai	Cyperaceae
Cassia splendida Vog.	Leguminosae
Ceanothus arboreus Greene	Rhamnaceae
Ceanothus lemmonii Parry	Rhamnaceae
Ceanothus papillosus Torr. & Gray	Rhamnaceae
Ceratozamia robusta Miq.	Zamiaceae
Chamaecyparis formosensis Matsum.	Cupressaceae
Chamaecyparis lawsoniana (A. Murr.) Parl.	Cupressaceae
Chamaedorea klotzschiana H. Wendl.	Palmae
Chambeyronia macrocarpa Vieill. ex Becc.	Palmae
Clarkia purpurea (W. Curtis) A. Nels. & J.F. Macbr.	Onagraceae
Coelogyne cristata Lindley	Orchidaceae
Coreopsis maritima (Nutt.) Hook. f.	Compositae
Corypha umbraculifera L.	Palmae
Crinodendron hookeranum Gay	Elaeocarpaceae
Crinum campanulatum Herb.	Amaryllidaceae
Cryptomeria japonica (L. f.) D. Don var. *japonica*	Taxodiaceae
Cupressus lusitanica Mill. var. *benthamii* (Endl.) Carrière	Cupressaceae
Cupressus sargentii Jepson	Cupressaceae
Cycas seemannii A. Br.	Cycadaceae
Cyphophoenix nucele H.E. Moore	Palmae
Davidia involucrata Baillon var. *involucrata*	Cornaceae
Dendrobium wassellii S.T.Blake	Orchidaceae
Dianthus gallicus Pers.	Caryophyllaceae
Dianthus knappii (Pant.) Asch. & Kanitz ex Borbás	Caryophyllaceae
Dianthus spiculifolius Schur	Caryophyllaceae
Dietes bicolor (Steud.) Sweet ex Klatt	Iridaceae

(Table 5 continuation)

Taxa	*Family*
Dionaea muscipula Ellis	Droseraceae
Dioon edule Lindley	Zamiaceae
Dioon spinulosum Dyer	Zamiaceae
Drosera capillaris Poir.	Droseraceae
Drymophloeus pachycladus (Burret) H.E. Moore	Palmae
Drymophloeus subdistichus (H.E. Moore) H.E. Moore	Palmae
Dypsis madagascariensis (Becc.) Beentje & J. Dransf.	Palmae
Echium wildpretii H. Pearson ex Hook.f.	Boraginaceae
Encephalartos ferox Bertol.f.	Zamiaceae
Encephalartos lanatus Stapf & Burtt Davy	Zamiaceae
Encephalartos lehmannii Lehm.	Zamiaceae
Encephalartos manikensis (Gilliland) Gilliland	Zamiaceae
Encephalartos natalensis R.A.Dyer & I.Verd.	Zamiaceae
Encephalartos tegulaneus Melville	Zamiaceae
Encephalartos transvenosus Stapf & Burtt Davy	Zamiaceae
Episcia punctata (Lindley) Hanst.	Gesneriaceae
Erica propendens Andrews	Ericaceae
Erodium manescavi Coss.	Geraniaceae
Erodium pelargoniiflorum Boiss. & Heldr.	Geraniaceae
Eucalyptus caesia Benth. ssp. *caesia*	Myrtaceae
Eucalyptus caesia Benth. ssp. *magna* Brooker & Hopper	Myrtaceae
Eucalyptus dunnii Maiden	Myrtaceae
Eucalyptus lansdowneana F.Muell. & J.E.Brown ssp. *lansdowneana*	Myrtaceae
Eucalyptus leptoloma Brooker & A.R.Bean	Myrtaceae
Eucalyptus luehmanniana F.Muell.	Myrtaceae
Eucalyptus macarthurii Deane & Maiden	Myrtaceae
Eucalyptus neglecta Maiden	Myrtaceae
Eucalyptus risdonii Hook.f.	Myrtaceae
Eucalyptus rudderi Maiden	Myrtaceae
Eucalyptus rummeryi Maiden	Myrtaceae
Eucalyptus stoatei C.Gardner	Myrtaceae
Eucalyptus yarraensis Maiden & Cambage	Myrtaceae
Eucalyptus youmanii Blakely & McKie	Myrtaceae
Eugenia zeyheri Harv.	Myrtaceae
Euterpe edulis Mart.	Palmae
Fosterella penduliflora (C.H. Wright) L.B. Smith	Bromeliaceae
Fothergilla major (Sims) Lodd.	Hamamelidaceae
Fremontodendron mexicanum A. Davids	Sterculiaceae
Geranium canariense Reuter	Geraniaceae
Ginkgo biloba L.	Ginkgoaceae
Gladiolus oppositiflorus Herbert ssp. *oppositiflorus*	Iridaceae
Gladiolus varius Bolus f. var. *varius*	Iridaceae
Greyia flanaganii Bolus	Greyiaceae
Guzmania erythrolepis Brongn. ex Planch.	Bromeliaceae
Heuchera hallii Gray	Saxifragaceae
Horkelia frondosa (Greene) Rydb.	Rosaceae
Howea belmoreana (C. Moore & F. Muell.) Becc.	Palmae
Howea forsteriana (C. Moore & F. Muell.) Becc.	Palmae
Hypericum polyphyllum Boiss. & Bal. ssp. *polyphyllum*	Guttiferae
Impatiens flanaganiae Hemsl.	Balsaminaceae
Isoplexis canariensis (L.) Loud.	Scrophulariaceae

(Table 5 continuation)

Taxa	*Family*
Jacaranda mimosifolia D. Don	Bignoniaceae
Kniphofia ensifolia Baker ssp. *autumnalis* Codd	Asphodelaceae
Kolkwitzia amabilis Graebner	Caprifoliaceae
Lafoensia pacari St.-Hil.	Lythraceae
Lavatera acerifolia Cav.	Malvaceae
Lecythis lanceolata Poiret	Lecythidaceae
Leucadendron argenteum (L.) R.Br.	Proteaceae
Leucadendron nobile I.Williams	Proteaceae
Leuchtenbergia principis Hooker	Cactaceae
Leucospermum muirii E.Phillips	Proteaceae
Leucospermum saxosum S.Moore	Proteaceae
Liquidambar orientalis Miller var. *orientalis*	Hamamelidaceae
Liriodendron chinense (Hemsley) Sarg.	Magnoliaceae
Lithops lesliei (N.E.Br.) N.E.Br. ssp. *burchellii* D.T.Cole	Aizoaceae
Livistona alfredii F.Muell.	Palmae
Mammillaria matudae H. Bravo-Holl.	Cactaceae
Manihot leptopoda (Mueller von Argau) Rogers & Appan	Euphorbiaceae
Merremia dissecta (Jacq.) Hallier f.	Convolvulaceae
Meryta sinclairii (Hook. f.) Seem.	Araliaceae
Monadenium coccineum Pax	Euphorbiaceae
Moringa drouhardii Jum.	Moringaceae
Musschia aurea (L.f.) DC.	Campanulaceae
Myosotidium hortensia (Decne.) Baillon	Boraginaceae
Nemesia strumosa Benth.	Scrophulariaceae
Nepenthes burkei Masters var. *burkei*	Nepenthaceae
Nerine pudica Hook.f.	Amaryllidaceae
Ocotea foetens (Aiton) Benth. & Hook.f.	Lauraceae
Orania longisquama (Jum.) J. Dransf. & N. Uhl.	Palmae
Pancratium canariense Ker-Gawl.	Amaryllidaceae
Paphiopedilum hirsutissimum (Lindley & Hook.) Stein	Orchidaceae
Paphiopedilum philippinense (Reichb. f.) Stein var. *roebelenii* (Veitch) Cribb	Orchidaceae
Paranomus spicatus (P.J.Bergius) Kuntze	Proteaceae
Parmentiera cereifera Seem.	Bignoniaceae
Pereskia bahiensis Gürke	Cactaceae
Physokentia dennisii H.E. Moore	Palmae
Pimpinella anisetum Boiss. & Bal.	Umbelliferae
Pinus canariensis Sweet ex Spreng.	Pinaceae
Pinus chihuahuana Engelm.	Pinaceae
Pinus greggii Engelm.	Pinaceae
Pinus lawsonii Roezl ex Gordon & Glend.	Pinaceae
Pinus luchuensis Mayr	Pinaceae
Pinus lumholtzii Robinson & Fernald	Pinaceae
Pinus oocarpa Mart. var. *trifoliata* Mart.	Pinaceae
Pitcairnia andreana Linden	Bromeliaceae
Pitcairnia punicea Scheidweiler	Bromeliaceae
Platycladus orientalis (L.f.) Franco	Cupressaceae
Plectranthus elegans Britten	Labiatae
Plectranthus oertendahlii T.C.E.Fr.	Labiatae
Polygala hispida (Burch.) DC.	Polygalaceae
Pritchardia thurstonii F. Muell. & Drude	Palmae

(Table 5 continuation)

Taxa	*Family*
Pseudotsuga macrocarpa (Vasey) Mayr	Pinaceae
Ptychosperma gracile Labill.	Palmae
Raphia australis Oberm. & Strey	Palmae
Ravenea robustior Jumelle & H. Perrier	Palmae
Rheum rhaponticum L.	Polygonaceae
Rhopaloblaste elegans H.E. Moore	Palmae
Rhopalostylis baueri (Hook.f.) H.A. Wendl. & Drude var. *baueri*	Palmae
Rhus batophylla Codd	Anacardiaceae
Romneya coulteri Harvey	Papaveraceae
Roystonea borinquena O.F. Cook	Palmae
Sabal uresana Trel.	Palmae
Sarracenia leucophylla Raf.	Sarraceniaceae
Sarracenia rubra Walt.	Sarraceniaceae
Schinus terebinthifolius Raddi	Anacardiaceae
Sedum hispanicum L. var. *planifolium* Chamb.	Crassulaceae
Serruria candicans R.Br.	Proteaceae
Sideritis candicans Aiton	Labiatae
Sonchus acaulis Dum. Cours.	Compositae
Sparaxis grandiflora (D.Delaroche) Ker Gawl ssp. *grandiflora*	Iridaceae
Stangeria eriopus (Kunze) Baill.	Stangeriaceae
Sterculia alexandri Harv.	Sterculiaceae
Strelitzia juncea Link	Strelitziaceae
Swartzia langsdorffii Raddi	Leguminosae
Tanacetum ferulaceum (Webb) Schultz Bip.	Compositae
Taxodium mucronatum Ten.	Taxodiaceae
Tecoma guarume A. de Candolle	Bignoniaceae
Terminalia bentzoë (L.) L. f. ssp. *bentzoë*	Combretaceae
Tetraclinis articulata (Vahl) Mast.	Cupressaceae
Thrinax excelsa Lodd.	Palmae
Tillandsia heteromorpha Rauh	Bromeliaceae
Tylecodon decipiens Toelken	Crassulaceae
Umtiza listeriana Sim	Leguminosae
Veitchia joannis H.A. Wendl.	Palmae
Washingtonia filifera (L. Linden) H. Wendl.	Palmae
Zamia amplifolia Hort. ex Masters	Zamiaceae
Zamia paucijuga Wieland	Zamiaceae
Zantedeschia pentlandii (Watson) Wittm.	Araceae

The Indeterminate category (see table 6) also presents some multi-purpose plants such as *Ageratum houstonianum* that is widely cultivated as an ornamental and with *Centrosema* sp. as a ground cover plant in rubber plantations in Indonesia. *Cinnamomum glanduliferum* is planted as shade tree in tea plantations as well as medicine and spice. The wood, smelling like sassafras, is utilized in carpentry, shipbuilding and for tools. *Delonix regia* in the tropics widely planted as an ornamental plant as well as support for *Piper nigrum* and shade tree (Kruse, 2001). The largest families in this category are Orchidaceae (7), Palmae (10), and Cactaceae (5).

Table 6: Indeterminate (I) ornamental plants

Taxa	*Family*
Aechmea orlandiana Lyman B. Smith var. *orlandiana*	Bromeliaceae
Aerides vandara Reichb.	Orchidaceae
Ageratum houstonianum Mill.	Compositae
Amherstia nobilis Wallich	Leguminosae
Aristolochia brevilabris Bornm.	Aristolochiaceae
Astrophytum ornatum (DC.) A. Weber	Cactaceae
Babiana hypogaea Burch. var. *longituba* G.J.Lewis	Iridaceae
Butia eriospatha (Mart. ex Drude) Becc.	Palmae
Caryota no Becc.	Palmae
Cattleya trianae Linden & Reichb.f.	Orchidaceae
Ceiba insignis (Kunth) Gibbs & Semir	Bombacaceae
Ceratozamia mexicana Brongn.	Zamiaceae
Chamaedorea geonomiformis H. Wendl.	Palmae
Cinnamomum glanduliferum Meiss.	Lauraceae
Coccothrinax miraguama (Kunth) Leon	Palmae
Cotoneaster simonsii Baker	Rosaceae
Crocosmia masonorum (L.Bolus) N.E.Br.	Iridaceae
Delonix regia (Bojer ex Hook.) Raf.	Leguminosae
Embreea rodigasiana (Claes. ex Cogn.) Dodson	Orchidaceae
Epithelantha micromeris Britton & Rose var. *greggii* (Engelm.) Borg	Cactaceae
Hatiora gaertneri (Reg.) Barthlott	Cactaceae
Hatiora rosea (Lagerh.) Barthlott	Cactaceae
Lobelia valida L.Bolus	Campanulaceae
Oncidium papilio Lindley	Orchidaceae
Orania sylvicola (Griff.) H.E. Moore	Palmae
Paphiopedilum philippinense (Reichb. f.) Stein	Orchidaceae
Paphiopedilum randsii Fowlie	Orchidaceae
Paphiopedilum sukhakulii Schoser & Senghas	Orchidaceae
Philodendron aff. scandens C. Koch & H. Sello	Araceae
Pinanga maculata Porte ex Lem.	Palmae
Pseudophoenix sargentii H.A. Wendl. ex Sarg. ssp. *sargentii*	Palmae
Reinhardtia simplex (H. Wendl.) Drude ex Dammer	Palmae
Renanthera imschootiana Rolfe	Orchidaceae
Rhipsalis pilocarpa Loefgr.	Cactaceae
Rhopalostylis sapida H. Wendl. & Drude	Palmae
Siphonochilus aethiopicus (Schweinf.) B.L.Burtt	Zingiberaceae
Veitchia merrillii (Becc.) Moore	Palmae

4 Summarized Results

The summarized results of our studies are shown in table 7. Highest percentages of threatened ornamental plants are found in the smallest families. Large families ($\geq$ 100-1000 species) rarely exceed 5 ‰; Agavaceae 5.3 ‰, Aloaceae 5.7 ‰, Amaryllidaceae 6.7 ‰, Cornaceae 10 ‰, Crassulaceae 5.6 ‰, Droseraceae 30 ‰, Geraniaceae 5.7 ‰, Hamamelidaceae 20 ‰, Myrtaceae 7 ‰, Pinaceae 68 ‰, Plumbaginaceae 10 ‰, Proteaceae 20 ‰, Ranunculaceae 5.6 ‰. Very large families with more than 1000 species have usually lower numbers of threatened species. Exceptions are Bromeliaceae – 17.5 ‰, Cactaceae – 12.7 ‰ and Palmae – 29.30 ‰. There is a weak positive correlation ($r = +0.36$) between the number of threatened species and the number of threatened ornamental species within the families.

Table 7: Number of threatened plant species in different categories, threatened crop species per thousands, number of all species and percent of threatened species in each families.

Family	*Ex.*	*Ex./E.*	*E.*	*V.*	*R.*	*I.*	*No. of threatened species*	*‰ threatened ornamentals*	*No. of all species*
Agavaceae	-	-	1	1	-	-	2	5.3	380
Aizoaceae	-	-	1	1	1	-	3	1.2	2,500
Aloaceae	-	-	3	-	1	-	4	5.7	700
Amaryllidaceae	-	-	1	2	3	-	6	6.7	900
Anacardiaceae	-	-	-	-	2	-	2	3.3	600
Apocynaceae	1	-	-	-	-	-	1	0.5	2,000
Araceae	-	-	-	-	1	1	2	1.1	1,800
Araliaceae	-	-	-	-	1	-	1	1.4	700
Araucariaceae	-	-	1	1	4	-	6	158	38
Aristolochiaceae	-	-	-	-	-	1	1	1.7	600
Asphodelaceae	-	-	-	-	1	-	1	3.1	319
Balsaminaceae	-	-	-	-	1	-	1	2.2	450
Begoniaceae	-	-	-	1	1	-	2	1.97	1,020
Bignoniaceae	-	-	-	-	3	-	3	3.8	800
Bombaceae	-	-	-	-	-	1	1	5	200
Boraginaceae	-	-	-	1	2	-	3	1.5	2,000
Bromeliaceae	1	-	16	9	8	1	35	17.5	2,000
Cactaceae	-	-	3	6	5	5	19	12.7	1,500
Calycanthaceae	-	-	-	-	1	-	1	200	5
Campanulaceae	-	-	1	1	6	1	9	4.5	2,000
Canellaceae	-	-	-	1	-	-	1	50	20
Caprifoliaceae	-	-	-	-	1	-	1	2.5	400
Caryophyllaceae	-	-	-	1	3	-	4	2	2,000
Cephalotaxaceae	-	-	-	1	-	-	1	143	7
Chenopodiaceae	-	-	1	-	-	-	1	0.7	1,500
Combretaceae	-	-	-	-	1	-	1	2.5	400
Compositae	-	-	-	2	5	1	8	0.4	20,000
Convolvulaceae	-	-	-	-	1	-	1	0.7	1,500
Cornaceae	-	-	-	-	1	-	1	10	100
Crassulaceae	1	-	1	1	2	-	5	5.6	900
Cruciferae	-	-	-	-	2	-	2	0.7	3,000
Cupressaceae	-	-	6	5	6	-	17	130.8	130
Cycadaceae	-	-	-	2	1	-	3	85.7	35
Dioscoreaceae	-	-	-	1	-	-	1	1.6	630
Droseraceae	-	-	-	1	2	-	3	30	100
Elaeocarpaceae	-	-	-	-	1	-	1	2.5	400
Ericaceae	1	-	-	1	1	-	3	0.86	3,500
Euphorbiaceae	-	-	-	1	2	-	3	0.4	7,500
Geraniaceae	-	-	1	-	3	-	4	5.7	700
Gesneriaceae	-	-	1	-	1	-	2	0.8	2,500
Ginkgoaceae	-	-	-	-	1	-	1	1000	1
Greyiaceae	-	-	-	-	1	-	1	333	3
Guttiferae	-	-	-	1	1	-	2	1.7	1,200
Hamamelidaceae	-	-	-	-	2	-	2	20	100
Heliconiaceae	-	-	-	1	-	-	1	10	100
Hydrangeaceae	-	-	-	1	-	-	1	5.9	170
Iridaceae	-	-	1	3	4	2	10	0.7	1,500

(Table 7 continuation)

Family	*Ex.*	*Ex./E.*	*E.*	*V.*	*R.*	*I.*	*No. of threatened species*	*‰ threatened ornamentals*	*No. of all species*
Juglandaceae	-	-	1	-	-	-	1	16.7	60
Labiatae	-	-	-	1	4	-	5	1.6	3,200
Lauraceae	-	-	-	1	1	1	3	1.5	2,000
Lecythidaceae	-	-	-	-	1	-	1	2.5	400
Leguminosae	1	-	4	9	9	2	25	1.9	13,100
Liliaceae	-	-	-	1	-	-	1	2.2	460
Lythraceae	-	-	-	1	1	-	2	4	500
Magnoliaceae	-	-	-	-	1	-	1	4.5	220
Malvaceae	-	-	1	-	1	-	2	1.6	1,250
Moringaceae	-	-	-	-	1	-	1	100	10
Myrtaceae	-	-	-	6	16	-	21	7	3,000
Nepenthaceae	-	-	1	-	1	-	2	26.7	75
Oleaceae	-	-	-	1	-	-	1	1.7	600
Onagraceae	-	-	-	-	1	-	1	1.5	675
Orchidaceae	-	-	2	7	5	8	22	0.7	30,000
Palmae	-	1	21	29	27	10	88	29.3	3,000
Papaveraceae	-	-	-	-	1	-	1	5	200
Pinaceae	-	-	4	4	9	-	17	68	250
Plumbaginaceae	-	1	1	2	-	-	4	10	400
Polygalaceae	-	-	-	-	1	-	1	1.3	750
Polygonaceae	-	-	-	-	1	-	1	1	1,000
Portulacaceae	-	-	-	-	1	-	1	2	500
Proteaceae	-	-	1	12	7	-	20	20	1,000
Ranunculaceae	-	-	-	-	3	-	3	1.5	2,000
Rhamnaceae	-	-	-	2	3	-	5	5.6	900
Rosaceae	-	-	1	1	3	1	6	2	3,000
Rubiaceae	-	-	-	-	1	-	1	0.15	6,500
Rutaceae	-	-	1	-	1	-	2	2	1,500
Salicaceae	-	-	-	1	-	-	1	2.9	340
Sapindaceae	-	-	-	2	-	-	2	1.3	1,500
Sarraceniaceae	-	-	-	-	2	-	2	133	15
Saxifragaceae	-	-	-	-	1	-	1	1.7	588
Scrophulariaceae	-	-	-	-	3	-	3	0.75	4,000
Solanaceae	-	-	-	-	1	-	1	0.36	2,800
Stangeriaceae	-	-	-	-	1	-	1	1000	1
Sterculiaceae	-	-	-	-	2	-	2	2	1,000
Strelitziaceae	-	-	-	-	1	-	1	142.9	7
Taxodiaceae	-	-	1	3	2	-	6	375	16
Theaceae	-	1	-	-	-	-	1	1.7	600
Umbelliferae	-	-	-	-	1	-	1	0.3	3,000
Zamiaceae	1	-	14	19	12	1	47	326.4	144
Zingiberaceae	-	-	-	-	-	1	1	1	1,000
Total	2	6	91	148	210	37	491	-	-

Ex, Extinct; Ex/En, Extinct/Endangered; E, Endangered; V, Vulnerable; R, Rare; I, Indeterminate

5 Discussion

After finishing the first comprehensive work on threatened crop plants (Hammer and Khoshbakht, 2005b) the question arose concerning threatened ornamental plants. Ornamental plants are not included in Mansfeld's Encyclopedia of Agricultural and Horticultural Crops (Hanelt and IPK, 2001), which has been used as the world-wide basis for crop plants (excluding ornamentals). Mansfeld's Encyclopedia was checked against the Red List of Threatened Plants (IUCN, 2001). In principal, the same procedure was planned for the ornamental plants but for them no world-wide Encyclopedia is available. Therefore, a special calculation was necessary, taking into account different sources as Hortus Third (1976), The European Garden Flora (Walters *et al.*, 1986-2000), Bañares *et al.* (2004); Cullen *et al.* (2000) and others.

The plant finder by Erhardt and Erhardt (2000) contains 50.000 species and cultivars all over Europe and the newest plant finder (Dorling Kindersley, 2006) reports more than 70.000 species and cultivars. Plant finders provide the possibility to summarize all information from commercial plants and seeds lists. But there is still the question to differentiate between species and cultivars. The decision is not easy and there are only few publications that report separated or alone about the species number in ornamental plants of an area. For crop plants some data are available, e.g. from the work with checklists in Cuba (Hammer *et al.*, 1992-1994), Italy (Hammer, 1999) and Korea (Hoang *et al.*, 1997). This work helped to push the overall number of crop plant species in the world to more than 6.000 and supported the compilation in Mansfeld's Encyclopedia (Hanelt and IPK, 2001).

A similar approach has been made by Glen (2002) in Southern Africa. He started from 37.000 specimens he has seen of cultivated plants in this area. Therefore, the basis is much more similar to the results obtained from checklists and eventually different from figures obtained from seed catalogues and plant lists (e.g. Walters *et al.* (1986-2000)). The specimens of Glen (2002) are mostly archived in the National Herbarium of South Africa, Pretoria, and thus available for scientific work.

This is the reason for taking the data as a solid basis for a first survey of threatened ornamental plants and at the same time for supporting the calculation of the total number of ornamental plants in the world. This number appears to be relatively high as can be seen from table 8.

The way to calculate the total number of cultivated ornamentals will be presented elsewhere (Hammer and Khoshbakht, in prep.). As can be seen from table 8 the total number of cultivated plant species amounts for about 35.000 species. Tree species of forest cultivation are less frequent. A compilation about cultivated forest trees was published by Schultze-Motel (1966). New data can be found in different sources. As many of the included trees are multi-purpose trees they can be found, often in connection with agro-forestry, also in Mansfeld's Encyclopedia (Hanelt and IPK, 2001).

From our work in Cuba (Hammer *et al.*, 1992-1994) we know that crop plants are often considered also as ornamentals. When they are no longer used in their respective group of commodity, e.g. as vegetables or medicinal plants, they may still persist in the

Table 8: Number of existing (Exi.) / threatened (Thr.) higher plant species, ornamentals and cultivated plant species worldwide (after Hammer 1998, see also HAMMER (1999).

Higher plant species			*Ornamental plant species*			*Crop plant species* *		
Exi.	*Thr.*	*%Thr.*	*Exi.*	*Thr.*	*%Thr.*	*Exi.*	*Thr.*	*%Thr.*
250,000	33,730 †	13.5	28,000	3,900	13.9	7,000	940 ‡	13.4

* In the definition of Mansfeld's Encyclopedia; † Calculated after LUCAS and SYNGE (1996) ‡ From LUCAS and SYNGE (1996)

gardens as ornamentals. There is a certain overlap between crop plants and ornamentals, which should be considered when calculating the total number of these two major groups (Table 8).

Similar to the crop plants, ornamental plants show some general tendencies as explained by HAMMER and KHOSHBAKHT (2005b). Even very rare ornamental plants are presented in collections as can be seen from the tables of the first red list categories. In some cases plants already extinct in the wild get well establish in collections and many are later transfered back to the nature. These groups are shown in table 7 with a high number of threatened species (Bromeliaceae – 35, Cactaceae – 19, Orchidaceae – 22, Palmae – 88, Zamiaceae – 47).
On the other hand, extensive collection of these ornamental species was, at least in some cases, the cause of their rarity.

Successful cultivation may provide the necessary materials for human use and also for reintroduction into the wild (HAMMER and KHOSHBAKHT, 2005a). Here the practical experiences of botanical gardens can be used (MAUNDER, 1992; AKEROYD and WYSE JACKSON, 1995). Of course, this way can be followed easily for plants with absent or on the lower levels of domestication.

Modern biotechnology has helped in the propagation of difficult ornamentals. The best-known examples are the Orchidaceae.
Contrary to the crop plants where there is a certain tendency to reduce the number of species in present use, we find the reverse trend in ornamental plants. A steadily increasing number of species is taken into cultivation to serve the growing curiosity of mankind, in making use of modern technology. An interesting example from table 3 (endangered ornamental plants) is *Brighamia insignis* Gray (Campanulaceae) from the Hawaii archipelago, a pachycaul treelet that underwent successful micropropagation within a programme of IUCN and is sold as a curiosity in many parts of world and accordingly was reported also by GLEN (2002). Another good example provide carnivorous plants, which can be easily propagated with modern technology (see families

Droseraceae, Nepenthaceae, Sarraceniaceae in our lists). Rarity and curiosity become strong incentives for the hunters/gathers of our days.

Our result provides the basis for a first list of threatened ornamental plants and, at the same time, for supporting the calculation of the total number of ornamental plants in the world.

6 Conclusion

About 500 threatened ornamental plant species have been listed using the book of GLEN (2002) and the method indicated above. But there is good reason to predict a higher number (see table 8), as can be seen from our preliminary calculation.

Many efforts have been done to find effective methods for the protection of rare ornamental plants. In Great Britain "The Pink Sheet" (ANONYMOUS, 2000) is published for rare and endangered garden plants (see also HAMMER and KHOSHBAKHT (2005b)). As already stated, the numbers of garden plants comprises mostly ornamentals. Ornamental plants are often taken in the gardens and are protected there.

Sources from cultivated material can be eventually taken for the reintroduction to the wild. But also the destruction of rare material in the wild is connected with the collecting of ornamental plants. Those activities are today coined as "biopiratry". Of course, the plants are changed genetically under domestication influences and there may be problems with their reintroduction to the wild. Whereas there is a certain tendency to reduce the number of crop plant species (HAMMER, 2004), the number of ornamentals under cultivation is steadily increasing. This is not only the result of plant breeding but also of direct introduction, so that plant collecting for ornamental plant use will remain a certain problem.

The number of ornamental species has been often discussed. The plant finder (ERHARDT and ERHARDT, 2000) contains 50.000 species and cultivars which are traded all over Europe and the newest plant finder (DORLING KINDERSLEY, 2006) reports more than 70.000 species and cultivars.

From the roughly 200 species of threatened crop plants listed by HAMMER and KHOSHBAKHT (2005b), 28 also appear in the present lists (ca. 14%). This gives a first idea about the overlap of calculations between the groups of ornamental and crop plants.

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Assessment of Structural Traits and Management Related to Dairy Herds in the Peri-urban Area of Bobo Dioulasso (South West of Burkina Faso)

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Abstract

To define mean herd size, structural traits, animal sourcing and use, management and aspects related to the milk production, 118 dairy herds, involved in a FAO dairy development project were studied. The mean herd size after allocation to clusters: Small (≤ 38 heads), Medium (> 38, ≤ 61 heads) and Large (> 61 heads) was 52.8±25.8, ranging from 7 to 134 heads of cattle. The following genotypes: Cross bred (CR) 58.8%, Zebu (ZB) 23.2% and Taurine cattle (TA) 18.0% which were not uniformly distributed neither across nor within herds were identified. Sex ratio was two thirds of females (70.6%), one third of males (28.1%) and a low proportion (1.3%) of castrated males. No mature TA males compared to 53.3% of the male ZB and 31.4% of the male CR, were indicated as potential sires. Investments in purchase of animals were higher in Small than in Medium and Large herds; of all purchased sires 53.8% were found in Small herds vs. 28.2% and 18.0% in Medium and Large. Herd property was equally distributed between single (56.8%) and multi property (43.2%). There was more manpower available per 100 cows in Small, being almost double and triple than in Medium and Large herds. Although milk extracted, was similar in all clusters averaging 2.4±0.5 litres/day/cow, milk off take rate, due to higher proportion of lactating cows, appeared higher in Small herds.

Keywords: Africa, cattle, dairy herds, structural traits, management, peri-urban

1 Introduction

Milk production in sub Saharan Africa is a sensitive issue. Relevant studies point out that in this part of the continent milk production has continuously increased from the early 1960s until the late 1980s, underlining however that to fulfil the enhancing demand, production should increase by about 4% per year until 2025. By that date, human population in sub Saharan Africa will increase by nearly 800 million, of which 55% will live in towns (Winrock, 1992). Based on this assumption to meet the demand, milk

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production should reach 45 million tons per year, and this growth should be stronger in peri urban areas (TACHER *et al.*, 2000). Unfortunately throughout sub Saharan Africa, although with regional differences, farmers still look at dairying in broad terms (UDO and CORNELISSEN, 1998). In general cattle are raised with several output objectives: milk production for selling and self consumption, social status, risk diversification, exploitation of manure for fertilization and draught power for cash crop and cereal cultivation (SLINGERLAND and SAVADOGO, 2001). Since Africa is marked by deep regional differences, a clear understanding of the constraints and opportunities characterising the local production systems (available livestock, management etc.) would help to design and implement, sustainable policies and strategies (BEBE *et al.*, 2002). The study was carried out in the peri urban area of Bobo Dioulasso, sub humid zone of south western Burkina Faso, considered as one the most potential zones to enhance milk production through the integration of crops and livestock farming system (TOURÉ, 1992).

2 Material and Methods

The study area was located at a longitude of 11° 8' N and at a latitude of 4° 11' W with mean minimum and maximum temperature ranging from 17°/23°C to 33°/37°C respectively. Four distinct seasons are acknowledgeable, dry cool, dry hot, wet cool and wet hot. Average annual rainfall is about 1100 mm, falling from June until October. The animals considered in this study were included in a FAO dairy development project (Faso Kossam) and amounted to 4834 heads of cattle. The survey, carried out from May to July 2003, intended to characterise herd distinctive traits through direct data collection on the animals: number of heads, genotype, age, sex, age at first calving, and milk individually produced at the day of the interview. Questions asked to the herdsman referred to age, origin, and the foreseen or actual use of each individual animal at the time of interview. Moreover, social and management aspects were investigated: status of the herdsman (proprietor, non proprietor), nature of ownership (single, multiple), availability of aid herdsman (none, at least one), their salary (none, cash, goods), feed complementation (yes, no, why), watering and estimated distance to water the animals, grazing and milking regimes, transhumance. The herds included in the study were spread in a radius of 50 km around Bobo Dioulasso, commonly considered the peri urban milk production basin of the town. Animals were assigned to specific genotypes according to phenotypic characters: Zebu (ZB), Taurine (TA) and intermediate Crossbred type (CR). Direct observations as well as interviews were carried out by qualified "ingénieurs d'élevage", fluent in both local languages, Fulani and Dioulà. To run statistical analysis on herd structure, the whole lot of herds was split into three clusters scored as Small (≤ 38 heads), Medium (> 38, ≤ 61 heads) and Large ones (> 61 heads) each including about 30% of the animals: 32% (1547) animals were included into Small herds, 33.9% (1642) animals in Medium and the remaining 34.1% (1645) animals in Large herds. The analysis was carried out with SPSS 5.1 ®, by one way ANOVA, non parametric Kruskal Wallis test to compare herds composition for not normally distributed samples and Chi Square test to compare frequencies and proportions. Means are always reported $\pm$ standard deviation.

3 Results

3.1 Herd size and sex ratio

The overall mean herd size was 52.8±25.8 ranging from 7 to 134 heads of cattle. As result of the clustering Small herds (62) averaged 28.2±7.1, Medium (35) 46.5±6.4 and Large ones (21) 82.7±20.5 heads of cattle. Out of 4834 heads the majority of cattle (58.8%; 2840 heads) were scored as CR type whereas ZB represented 23.2 % (1125 heads) and only 18.0 % (869 heads) were classified as TA (P<0.001). The distribution of ZB cattle was similar in Small (37.6%) and Medium herds (34.4%), and statistically different from the two other in Large (28.0%) (P<0.05). The allocation of TA animals differed between the clusters (P<0.001), being 18.4%, 45.2%, and 36.4% in Small, Medium and Large herds. Concerning CR, their proportion across herds did not differ between Small and Large herds (34.1% vs. 35.6%) but was different between Medium (30.3%) and Small (P<0.05) and between Medium and Large herds (P<0.001). The details of genotypes distribution within each cluster are outlined in Table 1.

Table 1: Genotypes of cattle in 118 dairy herds of the peri-urban area of Bobo Dioulasso, Burkina Faso

	Clusters		
Genotype	*Small (%)*	*Medium (%)*	*Large (%)*
Zebu	27.1 ^{a}	23.7 ^{a}	19.2 ^{a}
Taurine	10.4 ^{b}	23.9 ^{a}	19.2 ^{a}
Crossbred	62.5 ^{c}	52.4 ^{b}	61.6 ^{b}
(n)	(1547)	(1642)	(1645)

(n) = Number of animals; values in the same column, with different superscripts (^{a}, ^{b}, ^{c}), differ by P<0.05.

The analysis of the overall sex ratio revealed that over two thirds of the animals were females (70.6%, 3411), about one third males (28.1%, 1357) and a very low proportion (1.3%, 66) castrated males. The analysis of the sex ratio by clusters considering only productive animals >3 years (2143) is presented in Table 2. The analysis of the overall sex ratio revealed that over two thirds of the animals were females (70.6%, 3411), about one third males (28.1%, 1357) and a very low proportion (1.3%, 66) castrated males. The analysis of the sex ratio by clusters considering only productive animals >3 years (2143) is presented in Table 2.

As outlined in the table more pubertal ZB females (P<0.05) were encountered in Small than in Medium and Large herds, in which conversely the proportion of TA was higher (P<0.001). In all herds CR cows represented the majority of females although the fraction they represented differed (P<0.05) across clusters of herds. Concerning adult

Table 2: Proportions of productive females and males (>3 years) available in 118 peri-urban dairy herds of Bobo Dioulasso within clusters and according to genotype.

	Clusters					
	Small	*Medium*	*Large*	*Small*	*Medium*	*Large*
Genotype	*F (%)*	*F (%)*	*F (%)*	*M (%)*	*M (%)*	*M (%)*
ZB	23.3 [a]	19.4 [a]	15.4 [b]	44.8 [a]	47.8 [a]	38.0 [a]
TA	12.7 [a]	32.3 [b]	26.8 [c]	6.0 [a]	16.4 [b]	5.0 [a]
CR	64.0 [a]	48.3 [b]	57.8 [c]	49.2 [a]	35.8 [b]	57.0 [c]
(n)	(631)	(624)	(676)	(66)	(67)	(79)

(n) = Number of animals; F = females, M = males; values in the same column, with different superscripts ([a], [b], [c]), differ by P<0.05.

males a statistical difference was observed between the three clusters (P<0.001) for CR and TA but not for ZB (Table 2).

3.2 Use of the animals

Table 3 summarises the indications of use for males, outlined by genotype. For animals <3 years more ZB (P<0.001) were not yet allocated to a specific use compared to TA and CR; whereas a smaller proportion (P<0.001) was pointed out for cash earning. The picture radically changed for animals >3 years, statistically more ZB were perceived as suitable for breeding than CR and TA (Table 3).

Particularly TA were clearly indicated as source of cash or traction but not considered appropriate as sires in both <3 and >3 years class of age. Conversely, for ZB and CR very few animals were indicated as potential sires within the class of age <3 years, while their proportion increased tremendously for animals >3 years. Table 3 are also shows that significantly more ZB (P<0.05) were designated for breeding than CR, the opposite occurred for draught animals. Females were essentially foreseen for milk production irrespective of the class of age.

3.3 Animal origin, herding, property

The analysis on animals' origin indicated that, up to 86.3% (4170) of the animals were inborn, 4.3% were purchased (210), 9.0% (436) entrusted to the herds, and a very low proportion represented gifts (0,4%). The overall sex ratio of purchased animals was 80.0% females, 18.6% males and 1.4% castrated. Purchasing and entrusting of animals was related to the herd size. Of the purchased animals, 46.7%, were acquired by Small herds, 20.0% by Medium, and 33.3% by Large ones (P<0.001), while up to 42.4% (185/436) of entrusted animals were in Large herds, 37.4% (163/436) in Medium and 20.2% (88/436) in Small ones. In Small herds, proportions of purchased and

Table 3: Proportions for entire males available in the 118 peri-urban dairy herds of Bobo Dioulasso by classes of age and genotype according to indication of use

	Classes of age and Genotypes					
	<3 years			*>3 years*		
Indication of use	*ZB*	*TA*	*CR*	*ZB*	*TA*	*CR*
Undecided	58.8 [a]	34.3 [b]	36.8 [b]	2.2 [a]	5.3 [a]	9.8 [c]
Sale	27.8 [a]	43.2 [b]	38.6 [c]	5.4 [a]	26.3 [b]	5.9 [a]
Mating	6.2 [a]	—	3.6 [b]	53.3 [a]	—	31.4 [b]
Traction	7.2 [a]	22.5 [b]	21.0 [b]	39.1 [a]	68.4 [b]	52.9 [c]
(n)	(291)	(102)	(604)	(92)	(19)	(101)

(n) = number of animals; values in the same row for the same class of age with different superscripts ([a], [b], [c]), differ by $P<0.05$

entrusted animals were 48.3% and 43.3% (8.4% gifts); in Medium and Large herds these proportions were 20.4% purchased 79.1% entrusted (0,5% gift) 27.5%, purchased 72.5% entrusted (0% gift) respectively ($P<0.001$). Of the 118 herds involved in the study, 83 were managed by their proprietor, while 35 (29.6%), were run by hired herdsmen. Of the hired herdsmen, 68.6% (24) were remunerated in cash and goods, and 31.4% (11) compensated in kind. The large majority (82.8%) of the salaried herdsmen managed single property herds, while the totality of those compensated managed multi property herds. The proportion of herds belonging to one 56.8% (67) or more owners 43.3% (51) was similar ($P>0.05$), with no difference ($P>0.05$) in the mean herd size, although single property herds were smaller (37.7±21.2) than multi property ones (44.3±22.8). About half of the Medium (51.4%) and Large (47.6%) herds were multi property vs. only 37.1% of the Small herds ($P<0.05$). The availability workers unit per hypothetical 100 cows differed ($P<0.001$) in the three clusters, being 9.7±3.2, 5.0±2.7, 2.9±1.0 in Small, Medium and Large herds.

3.4 Feeding and milking regimes

A high proportion of herds, 83.9% (99), were complemented with no statistical difference ($P>0.05$) in the mean herd size, 37.9±18.1 for complemented herds and 56.5±33.8, for those non complemented; even though the proportion, of complemented herds decreased as the size of the herd increased (Table 4). Table 4 also reports the proportion of herds carrying out transhumance per each cluster; for all herds the reason for transhumance was difficult access to grazing areas due to intense cropping in the rainy season.

The length of transhumance averaging 3.9±1.3 months was not influenced by herds size. Daily grazing was an ordinary practice, 95.8% of the herdsmen guided the herds, and only 4.2% of the farmers owing very small herds, averaging 15.2±3.4 heads, grazed

Table 4: Proportion of complemented 118 dairy herds carrying out transhumance and season of transhumance outlined by clusters

	Complemented	*Transhumant*	*Season of transhumance*	
Cluster (n)	*Yes (%) (n)*	*Yes (%) (n)*	*Dry (%) (n)*	*Rainy (%) (n)*
Small (62)	93.6 [a] (58)	12.9 (8)	0.0 (0)	0.0 (8)
Medium (35)	80.0 [b] (28)	48.5 (17)	0.0 (0)	100.0 (17)
Large (21)	61.9 [c] (13)	80.9 (17)	0.0 (0)	100.0 (17)

(n) = number of herds; figures in the same column with different superscripts ([a], [b], [c]), differ by $P<0.05$

their animals close to the settlement. The average daily grazing time was 9.8±1.2 hours, ranging from 9 to 12 hours, with no statistical difference ($P>0.05$) referring to both mean herds size and clusters. Watering was assured once a day for all herds. During the rainy season 42.4% of the herds walked an average distance of 7.2±2.2 km (back and forth) for watering, the remaining 57.6% got water close to the settlement (< 1 km), this proportion decreased in the dry season to 6.7% whereas 93.3% walked an average daily distance of 12.3±4.2 km. Among females from 3 to 4 years, 35.3% had calved at least once. The analysis by cluster indicated that this proportion was higher ($P<0.05$) in Small 40.1% (67/167) than in Medium 33.4% (84/251) and Large herds 34.0% (84/247). In all herds milk produced was channelled to both selling and home consumption. More herds ($P<0.001$), were milked once a day 75.4% (89) than twice a day 24.6% (29). Although the herds milked once a day appeared larger (44.0±23.4) than those milked twice (30.9±13.5) there was no statistical difference in the mean herd size ($P>0.05$). Of the herds milked twice a day 72.4% (21) were Small, 24.1% (7) Medium and 3.5% (1) Large, the same herds represented 33.8%, 20.0%, and 4.7% of Small, Medium and Large herds ($P<0.001$). Of the 29 herds milked twice 26 (89.6%) were managed by their proprietors and 3 were not. The average daily milk production was 2.4±0.5 litres/cow with no statistical difference between Small (2.5±0.7), Medium (2.3±0.4) and Large (2.1±0.6) herds and cows milked once or twice a day. The proportion of milking cows, on the totality the herd was similar ($P>0.05$) between Medium (22.7%) and Large herds (20.6%) but higher ($P<0.001$) in Small herds (34.1%).

4 Discussion

Herd size presented a great variation ranging from herds with few heads of cattle (< 10) to very large ones (>130). The overall herd composition generally fits with herds of Type A recently described for the area by Hamadou *et al.* (2003) and other authors (Sidibe *et al.*, 2004), characterised by the predominance of CR followed by ZB and then TA. This indicates the low degree of specialization of the dairy sub sector. Moreover, within the herds of the FAO project, we could identify productive units similar to the herds scored as Type B (Hamadou *et al.*, 2003), characterised by specific tropical dairy breeds. Dissimilarly to what is reported in related studies (Sidibe *et al.*, 2004) our data show that Small herds (52.6%) largely above Medium (29.6%) and Large (17.8%). Unfortunately the authors do not report the mean heard size making any comparison impossible, although the difference might be due to a different clustering system. Our results indicate that there is a relationship between the herd size and the proportion of genotypes building up the herd. The presence of ZB cattle decreases as the size of the herd increases, in Small herds their proportion is higher than TA whereas in both Medium and Large herds, ZB and TA are equally represented. More specifically in Small herds ZB females account for 23% of females, 19% and 15% in Medium and Large herds. The proportion of milking cows also varies according to the herd size; it is higher in Small herds (34%) which in line with the findings of Adu *et al.* (1998), than in Medium (24%) and Large herds (16%). This suggests that smaller herds are build up with a more specific milk orientation towards milk production obtained by a high percentage of Zebu females considered better dairy cows (Hamadou and Kamuanga, 2004) whereas the proportion of CR cows is explained by the need to raise trypanotolerant animals (Tano *et al.*, 2001). This relationship between the size of the herd and a more milk oriented output mirror what reported for to the eastern part of the continent (Bebe *et al.*, 2002). Livestock keepers strategy to keep more dairy and/or more trypanotolerant animals (Touré, 1992) also suitable for traction (Kamuanga *et al.*, 2001), is achieved through the use of ZB or CR sires since no TA males are ever indicated as potential breeding bulls, but rather indicated instead as source of cash or had an uncertain destination. It is significant that the overall sex ratio (30% of males) is still in line with studies conducted in West Africa over the last thirty years (Pullan, 1979; Landais and Cissoko, 1986; Njoia *et al.*, 1997), indicating that very little has changed in the management system: still based on plethoric and unspecialised herds. The proportion of animals representing a real investment (purchased) is in general very low, it is just 4.3% of the totality of the animals introduced (14%), and just one out of five is a male, suggesting that no specific importance is attached to genetic upgrading through male outsourcing. This conflicts with what was reported for smallholder dairy system in the Kenya highlands (Bebe *et al.*, 2002) but matches perfectly with the work of Hamadou *et al.* (2003) carried out in the same area, which [defining these herds as "troupeau naisseur"] emphasizes that on a continental basis milk production is dissimilarly perceived and developed. Anyhow within this system, the equivalent proportion between purchased and entrusted animals, points towards a higher level of investment in Small herds compared to Medium and Large herds in which entrusted animals are were the majority. Additionally over 50% of the animals purchased, were found in Small herds, reinforcing the idea of a more focused management. The level of investments in herding appear higher in single property herds where 83.3% of the herdsmen (non proprietors) were remunerated whereas under multi property conditions 100% of hired herdsmen were compensated in goods. In the study area single or multiple property herds were equally distributed conversely to what is reported for The Gambia (Jaitner *et al.*, 2003) where only about 8% of the herds were of single property. The same work indicates that single property herds were larger than those multi property, dissimilarly to our findings. Although the difference was not statistically significant, single property herds were smaller (37.7±21.2) than multi property ones (44.3±22.8). This is in relation with the widespread tradition to entrust animals of different ownership to one single herdsman constituting large herds (Itty, 1992). In Small herds the proportion of entrusted livestock remained low (40%) compared to over 70% in Medium and Large ones because of the relatively low percentage (37.1%) of Small herds in multi property. The production of milk as double purpose activity, for self consumption and cash income, was also shown in previous studies conducted in eastern and western Africa (Adu *et al.*, 1998; Bebe *et al.*, 2003) and confirms that in the sub humid zone, in spite of its potential (Touré, 1992; Kameni *et al.*, 1999; Dieye *et al.*, 2002) there is still a lack of proper market-oriented milk production sub sector. Although mean daily milk production (2.4±0.5) was similar for the three clusters and comparable to the reported yield (Coulibaly and Nyalibouly, 1998; Bayemi *et al.*, 2005), milk off take appeared higher in Small herds than in Medium and Large ones, because of the higher rate of lactating cows in Small herds and the higher proportion of cows that had calved within the fourth year; both likely due to a better feeding regime. Only 6.4% of Small herds were not complemented compared to 20.0% and 38.1% of Medium and Large herds, which in turn played an important role on transhumance since only 12.9% of Small herds, practiced transhumance against respectively 48.5% and 80.9% of Medium and Large ones. It appears evident that under peri urban conditions availability of grazing land during the growing season is a striking problem although less acute for smaller herds which can more easily meet their nutritional requirements. This goes along with the statement that under peri urban conditions smaller units are easier to manage and perform better (Bebe *et al.*, 2002; Hamadou *et al.*, 2003). Lower complementation rates in Medium and Large herds might be also due both multiple ownerships generating conflicts in the management decision process and owners forced to accept essential expenditures (herdsman charges) but keeping complementation costs at low level. On this matter Bennison *et al.* (1997) suggested that conflicts arise in the decision process, between the owner/s and the hired managers as well as between different owners on the choice of management procedures.

Concerning the option of milking once or twice a day we couldn't come to a definite conclusion. It is likely a multi factorial choice driven by; (i) the size of the herd: in smaller herds the lower amount of labour required for management and the higher number of available active workers per cow might increase time for milking; (ii) the status of the herdsman: double milking was preponderantly encountered in herds managed by an herdsman-owner with an evident choice to maximise milk off take, (iii) a labour conflict: it is possible that in herds managed by hired, compensated herdsmen, labour conflicts on milking arise on the basis of a non specific contract (Jaitner *et al.*, 2003).

We can conclude that in the study area, the peri urban milk production sub sector suffers from low specialization, and is hindered by several factors: (i) scarce presence of specialized tropical dairy breeds, (ii) insufficient watering facilities and grazing land, forcing farmers into long displacement and transhumance in the rainy season, (iii) low proportion of milking cows, and (iv) multiple property which preclude focused management.

Among the productive units, smaller herds seems to answer better to a sustainable peri urban dairy production. They are characterised by (i) higher and more focused management and investments on dairy animals (ZB), (ii) lower nutritional constraints, (iii) higher proportion of milking cows, and (iv) a lower proportion of herds in multi property management.

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Economic Viability of Small Scale Organic Production of Rice, Common Bean and Maize in Goias State, Brazil

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Abstract
This study was conducted to assess the economic feasibility of small scale organic production of rice, common bean and maize in Goias State, Brazil. During 2004/05 and 2005/06 growing seasons, rice, common bean and maize were produced at the organic farm of Embrapa Rice and Beans in five mulching systems (fallow, *Crotalaria juncea, Cajanus cajan, Mucuna aterrima* and *Sorghum bicolor*), with and without tillage. Soil tillage consisted of heavy disc harrowing followed by light disc harrowing. All operations and used inputs were recorded. Based on those records, the production costs for each crop were estimated for each cropping season. The costs included operations like sowing, ploughing, harrowing, spraying, fertilizer broadcasting and harvesting, as well as inputs like seeds, inoculant strains of Rhizobium, neem oil and organic fertilizers. The benefits include the gross revenue obtained by multiplying the production amount with the market price for non-organic products. For the purpose of analysis of competitiveness of organic production in comparison to conventional farming the market prices assumed were those of conventional production. In the analysis, the costs of certification were not considered yet due to lack of certifiers in the region. For comparison between traits, net revenue, the benefit-cost-ratio (BCR) and the break even point were used. In 2004/05 growing season the BCR varied from 0.27 for common bean on *S. bicolor* mulch system with tillage up to 4.05 for green harvested maize produced after *C. juncea* in no tillage system. Common bean and rice were not economically viable in this growing season. In 2005/06 growing season the BCR varied between 0.75 for common bean after *S. bicolor* in tillage system and 4.50 for green harvested maize produced after fallow in no tillage system. In this season common bean was economically viable in leguminous

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mulching systems and green harvested maize was viable in all mulching systems.

Keywords: economic feasibility, organic farming, organic rice production, organic common bean production, organic maize production

1 Background and Objective of the Study

The increasing demand for healthy food and the need for environmental and economic sustainability of agricultural production organic farming is being promoted worldwide. Some studies carried out in Brazil pointed out a growing market for those products (Moreira *et al.*, 2005) and the need for additional production (Lacerda *et al.*, 2005).

Therefore, agricultural researchers are challenged to develop such systems together with farmers. In Brazil, scientists are testing different farming systems to produce organic food. However, the economic feasibility, which is a key factor for technology adoption and sustainable production, was not analysed yet.

Therefore, the main objective of this study was to assess the economic viability of small scale organic production of rice, common bean and maize in Goias State, Brazil.

2 Methods

The study was conducted in Santo Antonio de Goias, Goias State, Brazil. The soil type is a Typic Haplustox with 473 g/kg of clay, 190 g/kg of silt and 336 g/kg of sand in the top 30 cm. According to classification of Köppen, the research area is characterized by an Aw climate (tropical seasonal savannah). The annual average of pluvial precipitation is of 1,461.8 millimetres. The rainy season lasts from October to April, and the dry season from May to September. The annual average air temperature is 22.6 °C. The monthly average temperature varies from 14.2 °C in June to 31.3 °C in September.

During 2004/05 and 2005/06 growing seasons, upland rice, common bean and maize were produced at the organic farm (MAPA-Brasil, 2004) of Embrapa Rice and Beans under five mulching systems (fallow, sunn hemp [*Crotalaria juncea*], pigeon pea [*Cajanus cajan* (L.) Millsp], velvet bean [*Mucuna aterrima* (Piper et Tracy) Holland] and sorghum [*Sorghum bicolor* (L.) Moench]), with and without tillage. All carried out operations and used inputs were recorded. Based on those records, the production costs for each crop were estimated in each cropping season. The costs include operations like sowing, ploughing, harrowing, weeding, spraying and harvesting, as well as inputs like seeds, inoculant strains of Rhizobium, neem oil and organic fertilizers. The benefits include the gross revenue obtained by multiplying the production amount with the market price for non-organic products, as there are no established certification procedures for organic production in the study region. Thus, for the purpose of analysis of competitiveness of organic production in comparison to conventional farming, the market prices assumed were those of conventional production. In the analysis, the costs of certification were not considered yet due to lack of certifiers in the region. For comparison between treatments, the net revenue (NR), the benefit-cost-ratio (BCR) and the break even point (BEP) were used.

NR is the difference obtained when subtracting the total cost from the gross revenue (Gittinger, 1982) and can be obtained as follows:

$$NR = \left(\sum_{t=0}^{n} R_t/q^t \right) - \left(\sum_{t=0}^{n} C_t/q^t \right) \tag{1}$$

where R is the gross revenue, C is the total cost, i is the interest rate, and n is the number of years, and $q^t = (1+i)^t$. If $NR > 0$, then the gross revenue is greater than the total cost, if $NR = 0$, than the gross revenue is equal to the total cost, and if the $NR < 0$, than the gross revenue is less than the total cost. In this study, NR is measured in Brazilian Reais (R$) and is based on one hectare.

BCR is the ratio obtained when the present worth of the benefit stream is divided by the present worth of the cost stream (Gittinger, 1982; Noronha, 1987) and can be obtained as follows:

$$BCR = \frac{\sum_{t=0}^{n} R_t/q^t}{\sum_{t=0}^{n} C_t/q^t} \tag{2}$$

where R is the gross revenue, C is the total cost, i is the interest rate, and n is the number of years, and $q^t = (1+i)^t$. If $BCR > 1$, then the gross revenue is greater than the total cost, if $BCR = 1$, than the gross revenue is equal to the total cost, and if the $BCR < 1$, than the gross revenue is less than the total cost.

BEP is the level where the gross revenue is equal to the total cost and can be obtained as follows:

$$GR_{cr} = C_{cr} \tag{3}$$

where GR is the gross revenue obtained with crop cr, calculated by multiplying its yield y_{cr} by its market price p_{cr}, and the C is the total cost obtained by multiplying the amount of used inputs by its prices. In this study, the BEP for yield and for product price are considered.

3 Results and Discussion

3.1 The Gross Revenue

In Table 1 the gross revenues obtained per hectare for different treatments are presented. Gross revenue is one important input for the further analysis and can not be used alone for discussion.

3.2 The Production Costs

Table 2 shows the total production costs per hectare for each different treatment. The total production costs represent another important input for the further analysis and can not be used alone for discussion.

3.3 The Net Revenue

Table 3 shows the net revenue (NR) per hectare for each different treatment. The net revenue per hectare is one of the indicators used for analysis. Considering the net revenue per hectare, green maize and maize grain achieved the highest performance. Common

Table 1: Gross revenue (R$/ha) of organic production of common bean (*Phaseolus vulgaris*), upland rice (*Oryza sativa*) and maize (*Zea mays*) under five mulching systems with and without tillage in cropping seasons 2004/2005 and 2005/2006.

Crop	*Tillage*	*Season*	*Gross revenue (R$/ha) in different mulching systems*				
			Fallow	*C.juncea*	*C.cajan*	*M.aterrima*	*S.bicolor*
Common beans	With	2004/2005	719.76	1,201.74	982.33	859.94	760.20
		2005/2006	2,286.00	2,183.00	2,295.50	2,225.85	1,623.60
	Without	2004/2005	1,034.28	1,643.97	1,386.75	1,506.23	1,110.12
		2005/2006	1,306.80	1,892.85	2,063.85	2,103.35	1,571.10
Upland rice	With	2004/2005	605.20	1,104.50	874.01	547.42	304.80
		2005/2006*	–	–	–	–	–
	Without	2004/2005*	–	–	–	–	–
		2005/2006*	–	–	–	–	–
Green maize	With	2004/2005	5,424.76	6,317.21	7,703.45	7,265.35	4,401.65
		2005/2006	5,754.00	5,495.75	6,361.75	6,836.50	4,122.50
	Without	2004/2005	4,161.01	6,465.27	4,126.42	6,779.34	3,231.32
		2005/2006	5,261.00	5,330.25	5,363.00	6,122.50	3,813.50
Maize grain	With	2004/2005	1,987.95	2,274.06	2,329.13	2,151.03	867.10
		2005/2006	1,408.55	2,180.88	2,463.22	2,760.99	807.02
	Without	2004/2005	1,055.84	2,004.01	1,874.16	2,399.21	887.57
		2005/2006	1,480.16	1,679.40	1,925.39	2,902.15	1,011.47

Table 2: Production costs (R$/ha) of organic production of common bean (Phaseolus vulgaris), upland rice (*Oryza sativa*) and maize (*Zea mays*) under five mulching systems with and without tillage in cropping seasons 2004/2005 and 2005/2006.

Crop	*Tillage*	*Season*	*Production costs (R$/ha) in diff. mulching systems*				
			Fallow	*C.juncea*	*C.cajan*	*M.aterrima*	*S.bicolor*
Common beans	With	2004/2005	2,226.89	2,522.89	2,522.89	2,562.89	2,766.89
		2005/2006	1,638.11	1,934.11	1,934.11	1,974.11	2,178.11
	Without	2004/2005	1,909.59	2,205.59	2,205.59	2,245.59	2,449.59
		2005/2006	1,320.81	1,616.81	1,616.81	1,656.81	1,860.81
Upland rice	With	2004/2005	1,671.50	1,967.50	1,967.50	2,007.50	2,211.50
		2005/2006*	–	–	–	–	–
	Without	2004/2005*	–	–	–	–	–
		2005/2006*	–	–	–	–	–
Green maize	With	2004/2005	1,607.40	1,903.40	1,903.40	1,943.40	2,147.40
		2005/2006	1,485.60	1,781.60	1,781.60	1,821.60	2,025.60
	Without	2004/2005	1,290.10	1,586.10	1,586.10	1,626.10	1,830.10
		2005/2006	1,168.30	1,464.30	1,464.30	1,504.30	1,708.30
Maize grain	With	2004/2005	1,527.40	1,823.40	1,823.40	1,863.40	2,067.40
		2005/2006	1,485.60	1,781.60	1,781.60	1,821.60	2,025.60
	Without	2004/2005	1,210.10	1,506.10	1,506.10	1,546.10	1,750.10
		2005/2006	1,168.30	1,464.30	1,464.30	1,504.30	1,708.30

* Yields were to low to justify harvesting.

beans where only economically viable in season 2005/2006, but not on sorghum mulch, with or without tillage, and on fallow mulch without tillage. Rice was not viable. Green maize instead had quite high net revenues, up to R$ 5,800 per hectare and was viable on all mulching systems, with or without tillage. Maize grain was viable on leguminous mulches in both years, with or without tillage.

Table 3: Net revenue (R$/ha) of organic production of common bean (*Phaseolus vulgaris*), upland rice (*Oryza sativa*) and maize (*Zea mays*) under five mulching systems with and without tillage in cropping seasons 2004/2005 and 2005/2006.

			Net revenue (R$/ha) in different mulching systems				
Crop	*Tillage*	*Season*	*Fallow*	*C.juncea*	*C.cajan*	*M.aterrima*	*S.bicolor*
Common beans	With	2004/2005	(1,507.13)	(1,321.15)	(1,540.56)	(1,702.95)	(2,006.69)
		2005/2006	647.89	248.89	361.39	251.74	(554.51)
	Without	2004/2005	(875.31)	(561.62)	(818.84)	(739.36)	(1,339.47)
		2005/2006	(14.01)	276.04	447.04	446.54	(290.71)
Upland rice	With	2004/2005	(1,066.30)	(863.00)	(1,093.49)	(1,460.08)	(1,906.70)
		2005/2006*	–	–	–	–	–
	Without	2004/2005*	–	–	–	–	–
		2005/2006*	–	–	–	–	–
Green maize	With	2004/2005	3,817.36	4,413.81	5,800.05	5,321.95	2,254.25
		2005/2006	4,268.40	3,714.15	4,580.15	5,014.90	2,096.90
	Without	2004/2005	2,870.91	4,879.17	2,540.32	5,153.24	1,401.22
		2005/2006	4,092.70	3,865.95	3,898.70	4,618.20	2,105.20
Maize grain	With	2004/2005	460.55	450.66	505.73	287.63	(1,200.30)
		2005/2006	(77.05)	399.28	681.62	939.39	(1,218.58)
	Without	2004/2005	(154.26)	497.91	368.06	853.11	(862.53)
		2005/2006	311.86	215.10	461.09	1,397.85	(696.83)

* Yields were to low to justify harvesting.

3.4 The Benefit-Cost-Ratio

The benefit-cost-ratios are presented in Table 4. Common bean's economic performance in cropping season 2005/2006 was superior to 2004/2005. While in 2004/2005 none of the common bean treatments achieved $BCR > 1$, in 2005/2006 all treatments under leguminous mulching (*C. juncea, C. cajan* and *M. aterrima*) reached $BCR \geq 1.13$. In 2005/2006 also on fallow area with tillage the BCR was 1.4. Sorghum as mulch for common bean production was not a viable option in none of the two years considered (Table 4).
The upland rice production had the worst economic performance in organic farming. In 2004/2005 only in tillage systems its harvest was justified by yields and the BCR were all below 0.57. The low yields achieved under the considered conditions were the cause of insufficient economic performance (Table 4).
The green maize production achieved the highest BCR, varying from 1.77 on *S. bicolor* mulch in season 2004/2005 up to 4.50 on fallow mulch in season 2005/2006. Thus, green maize production was viable under all considered systems (Table 4).

Table 4: Benefit-Cost-Ratio of organic production of common bean (*Phaseolus vulgaris*), upland rice (*Oryza sativa*) and maize (*Zea mays*) under five mulching systems with and without tillage in cropping seasons 2004/2005 and 2005/2006.

			Benefit-Cost-Ratio in different mulching systems				
Crop	*Tillage*	*Season*	*Fallow*	*C.juncea*	*C.cajan*	*M.aterrima*	*S.bicolor*
Common beans	With	2004/2005	0.32	0.48	0.39	0.34	0.27
		2005/2006	1.40	1.13	1.19	1.13	0.75
	Without	2004/2005	0.54	0.75	0.63	0.67	0.45
		2005/2006	0.99	1.17	1.28	1.27	0.84
Upland rice	With	2004/2005	0.36	0.56	0.44	0.27	0.14
		2005/2006*	–	–	–	–	–
	Without	2004/2005*	–	–	–	–	–
		2005/2006*	–	–	–	–	–
Green maize	With	2004/2005	3.37	3.32	4.05	3.74	2.05
		2005/2006	3.87	3.08	3.57	3.75	2.04
	Without	2004/2005	3.23	4.08	2.60	4.17	1.77
		2005/2006	4.50	3.64	3.66	4.07	2.23
Maize grain	With	2004/2005	1.30	1.25	1.28	1.15	0.42
		2005/2006	0.95	1.22	1.38	1.52	0.40
	Without	2004/2005	0.87	1.33	1.24	1.55	0.51
		2005/2006	1.27	1.15	1.31	1.93	0.59

* Yields were to low to justify harvesting.

When harvesting maize as grain, all systems under leguminous mulching, with or without tillage, were economically viable, with BCR varying from 1.15 to 1.93. The fallow system was only viable with tillage in 2004/2005 and without tillage in 2005/2006. Sorghum was not economically viable as mulch for maize grain production (Table 4). The differences in economic performance between green and maize grain are revenue based, considering the higher yields and the market prices for green maize, as the production costs are similar to maize grain.
Obviously the economic performance of each crop would be increased if consumers were willing to pay more for organic products. In this case the costs of certification would also increase the production costs.

3.5 The Break Even Point

Table 5 shows the break even point of yield for each treatment. Green and maize grain are again those crops with best performance as their break even points for yield are far below the obtained yields.

The market prices for common beans were R$ 1.20/kg in 2004/2005 and R$ 1.50/kg in 2005/2006. For rice, the prices were R$ 0.40/kg in 2004/2005 and R$ 0.33/kg in 2005/2006. For maize, the prices were R$ 0.34/kg for maize grain in both years and R$ 0.50/kg for green maize also in both years.

The break even points for product price are presented in Table 6. It can be seen, again, that green maize shows the break even point for price far below the market price.

Table 5: Break even point (kg/ha) of organic production of common bean (*Phaseolus vulgaris*), upland rice (*Oryza sativa*) and maize (*Zea mays*) under five mulching systems with and without tillage in cropping seasons 2004/2005 and 2005/2006.

			Break even point (kg/ha) in diff. mulching systems				
Crop	*Tillage*	*Season*	*Fallow*	*C.juncea*	*C.cajan*	*M.aterrima*	*S.bicolor*
Common beans	With	2004/2005	1,855.7	2,102.4	2,102.4	2,135.7	2,305.7
		2005/2006	1,092.1	1,289.4	1,289.4	1,316.1	1,452.1
	Without	2004/2005	1,591.3	1,838.0	1,838.0	1,871.3	2,041.3
		2005/2006	880.5	1,077.9	1,077.9	1,104.5	1,240.5
Upland rice	With	2004/2005	4,178.8	4,918.8	4,918.8	5,018.8	5,528.8
		2005/2006*	–	–	–	–	–
	Without	2004/2005*	–	–	–	–	–
		2005/2006*	–	–	–	–	–
Green maize	With	2004/2005	3,214.8	3,806.8	3,806.8	3,886.8	4,294.8
		2005/2006	2,971.2	3,563.2	3,563.2	3,643.2	4,051.2
	Without	2004/2005	2,580.2	3,172.2	3,172.2	3,252.2	3,660.2
		2005/2006	2,336.6	2,928.6	2,928.6	3,008.6	3,416.6
Maize grain	With	2004/2005	4,492.4	5,362.9	5,362.9	5,480.6	6,080.6
		2005/2006	4,369.4	5,240.0	5,240.0	5,357.7	5,957.7
	Without	2004/2005	3,559.1	4,429.7	4,429.7	4,547.4	5,147.4
		2005/2006	3,436.2	4,306.8	4,306.8	4,424.4	5,024.4

Table 6: Break even point (R$/ha) of organic production of common bean (*Phaseolus vulgaris*), upland rice (*Oryza sativa*) and maize (*Zea mays*) under five mulching systems with and without tillage in cropping seasons 2004/2005 and 2005/2006.

			Break even point (k$/ha) in diff. mulching systems				
Crop	*Tillage*	*Season*	*Fallow*	*C.juncea*	*C.cajan*	*M.aterrima*	*S.bicolor*
Common beans	With	2004/2005	3.71	3.39	4.13	4.13	4.37
		2005/2006	1.07	1.46	1.58	1.71	2.01
	Without	2004/2005	2.22	1.95	2.40	2.23	2.65
		2005/2006	1.52	1.47	1.59	1.51	1.78
Upland rice	With	2004/2005	1.10	0.99	1.26	1.85	2.90
		2005/2006*	–	–	–	–	–
	Without	2004/2005*	–	–	–	–	–
		2005/2006*	–	–	–	–	–
Green maize	With	2004/2005	0.15	0.16	0.13	0.14	0.24
		2005/2006	0.13	0.17	0.15	0.14	0.25
	Without	2004/2005	0.16	0.13	0.21	0.13	0.28
		2005/2006	0.11	0.14	0.15	0.13	0.22
Maize grain	With	2004/2005	0.26	0.32	0.30	0.31	0.81
		2005/2006	0.36	0.31	0.30	0.27	0.85
	Without	2004/2005	0.39	0.30	0.32	0.25	0.67
		2005/2006	0.27	0.35	0.36	0.21	0.57

* Yields were to low to justify harvesting.

4 Conclusions and Policy Implications

Organic farming can be a viable option even if the producer prices are the same than those of conventional food.

Upland rice was not economically viable under the considered conditions. Organic common bean production was economically feasible only in the second of the two years considered and mainly in leguminous mulching systems. Maize had the best economic performance under all considered options and cultivation systems. The best results were obtained with green maize cultivated in leguminous mulching systems.

As rice and beans are staple food for Brazilian population, there should be established incentives in order to enable its viable organic production. There may be a demand for certification in the region. In this case, additional studies should be carried out considering the situation where certification is being carried out, with higher costs and product prices.

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The Profitability of Animal Husbandry Activities on Farms in Dry Farming Areas and the Interaction between Crop Production and Animal Husbandry: The Case of Ankara Province in Turkey

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Abstract

This paper examines the linkages between livestock and crop farming activities and provides a comparative analysis of the profitability of different livestock activities in the highlands of Ankara. The data was collected from 52 sample farms in the Nallıhan, Ayaş, Güdül and Beypazarı districts of Ankara by way of a questionnaire, where the farms have, on average, 20.7 ha of land and are thus regarded as small family farms. Insufficient irrigated land and working capital, weak market relations and the pressure of high population brings about a requirement to strengthen crop-livestock interaction. Production on the farms is generally carried out in extensive conditions, with goat, sheep and cattle husbandry in addition to crop production. Crop production makes up for 20.8% of the total gross production value on the farms. Of this figure, the entire yields of wheat, barley, pulses, straw and fodder crops are used for own consumption by the households, along with 74% of the wheat and 77% of the barley produced. The research results indicate that the current management systems may be defined as mixed farms in terms of crop–livestock linkages. The average total income of the households surveyed is 9,412.0 USD, of which 63.4% comes from farming activities. Every 1 USD invested in animal husbandry provides an income of 1.12 USD from dairy cattle breeding, 1.13 USD from Angora goat breeding, 1.16 USD from sheep breeding and 1.27 USD from ordinary goat breeding. It has been found that ordinary goat breeding, which provides the greatest relative profitability for the farms, offers many advantages, and that the transition from Angora goat breeding to ordinary goat breeding through the breeding of ordinary male goats into the Angora herd has occurred in recent years. The results of the survey indicate that supporting crop production with animal husbandry is considered a requirement in order to maintain economic and social sustainability in the farms and to support rural development.

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1 Introduction

The insufficient and unbalanced nutrition in rural areas is emerging as an increasingly important problem in developing countries (FAO, 2006; İNAN, 1998). The most obvious solution to these problems in rural areas would seem to be engaging in both livestock and crop production, utilizing the interaction between the two, which has been suggested as a means to raise the income and improve the living standards of those people, and also increasing employment (AÇIL and DEMIRCI, 1984). Livestock provides meat and milk for the households, as well as cash income that can be invested in crop production technologies. In many regions, livestock is also a means of storing capital to buffer food shortages in years of poor crop production (POWELL *et al.*, 2004). The dependence of animal husbandry activities on land in the farms is related to the input demands of the activities and the means of meeting these from within the farm. While some livestock activities are highly dependant on land, others, such as poultry farming, are not. In cases where there are sufficient pastures and meadows, goat and sheep breeding emerge as an important main or complementary income and employment source for rural households. In the farms located in villages distant from the markets, where there is little opportunity to sell produce, dairy cattle breeding is oriented to meeting the needs of the individual households, with any milk over and above that used by the household being refined into milk products. Goat and sheep breeding are activities that are highly dependant on land and require intensive labor. These activities are performed particularly in the highlands of developing countries, where labor is abundant and unemployment is a common problem, enabling people to consume animal products at low cost (DEVENDRA, 1981; PETERS *et al.*, 1981; FAO, 2006).

In Turkey there are 4.2 million households in rural areas, 76.2% of which are engaged in crop and animal production activities. The farms engaged in both animal and crop production activities are generally located in dry farmlands, in the highlands and in mountainous areas, but are generally engaged in animal husbandry on a small scale. On average, farms keep an average of four head of cattle or buffalo, and nine head of sheep or goats. On farms carrying out only animal husbandry activities, the average livestock per farm is five head of cattle or buffalo and 35 head of sheep or goats (SIS, 2004b,a). The low average of livestock population, even on specialized livestock farms, has a substantial negative affect in utilizing economics of scale. The income sources of rural households vary depending on the natural, economic and social conditions of the settlements. On the farms settled on higher ground, the amount of farmland, particularly meadows and pastures, is low; the rate of idle labor is high; the capital is insufficient; income and saving levels are restricted; and living conditions are very arduous.

Dry farmlands integrate crop and livestock activities in the Central Anatolian Region of Turkey, in line with the trend in the rest of the country. Located in the northern part of the Central Anatolian region, Ankara has a dry climate; it receives limited rainfall (average 367-480 mm year^{-1}) and is suitable for small ruminant breeding. The total number of farms in Ankara is 43,400, 31.0% of which deal with crop production and 6.0% with animal husbandry, while 63.0% are involved in the production of both crop and animal products. The province of Ankara contains a total of 1.3 million ha of farmland, of which 62.9% is allocated for cereal production. Although 15.3% of this is appropriate for irrigation, only 7.4% is actually irrigated. There are 219,792 head of cattle, 535,621 head of sheep, 34,572 head of ordinary goats and 88,308 head of Angora goats in the province. Goat and sheep breeding is one of the major sources of income and employment on the farms located in the mountainous regions of Ankara, and along with cattle breeding provides multiple products, such as milk, mohair, hair, wool, increase in stock (live weight gain), leather and manure. In the Ayaş, Güdül, Nallıhan, and Beypazarı districts of Ankara the farms are involved in sheep, goat and cattle breeding as well as crop production, and in the villages settled in or around forests, where the land resources are sloped, the rearing of goat and sheep is a traditional activity. However, after the 1980s the livestock populations in farms have significantly reduced in parallel to the changing economic conditions. It has been observed that changes in socio-economic factors are rapidly transforming traditional and extensive crop and livestock management practices.

The main problems in the crop and livestock management systems include inadequate working capital and feed resources, limited farmland and irrigated land resources, shortages of productive pasture and meadows, lack of access to nutrient inputs, labor shortages during the planting season and inadequate access to markets. A principal challenge facing agriculture in dry farming is how to achieve sustainable increases in crop and livestock production with limited use of fertilizers, pesticides, feed supplements, certified seeds, fuels, water, and so on. Low household incomes and the high cost of fertilizer and feed supplements, among other factors, prevent the widespread use of external nutrient sources, which are generally limited to small farms devoted to cash crops. Diet supplements for livestock are used rarely in livestock activities around the highland and mountain areas due to limited working capital, insufficient farmland and weak market access. As long as fertilizers and feed supplements are unavailable, the fertility of cropland will continue to depend on the nutrients supplied from animal manure (POWELL *et al.*, 2004). On the farms in the highlands at an altitude of over 800 meters in Ankara Province, in order to utilize the products obtained from crop production in animal husbandry and to improve the productivity of crop production and maintain soil productivity, it is necessary to improve the income sources and living standards of households by utilizing manure, and thus strengthen the transfer between activities.

Although there are many scientific researches analyzing the economic results of animal breeding at a farm level in Turkey (ERKUŞ and DEMIRCI, 1983; KIRAL *et al.*, 1996), the issue of livestock-crop interaction in farms remains understudied. It is necessary to develop appropriate policies for the higher regions by evaluating the profitability and competitive strengths of livestock activities, and the impacts of the livestock-crop interaction on the economic performances of the activities. Crops and livestock are enterprises that have been operationally and functionally linked for years (MCCOWN *et al.*, 1979) and the linkages between animal breeding and planting activities are evaluated from the viewpoint of food, investment, manure, feeds and employment (Powell and Waters-Bayer, 1985). In the evaluation of crop–livestock systems, the ratios of input provided from farms (at least 10% of the feed) or share production value obtained from non-livestock farming activities in all farms (Seré and Steinfeld, 1996; Powell *et al.*, 2004) are assessed in general. In this research, the usage of land and labor forces in the farms located in the high regions of Ankara, livestock-crop interaction, the gross production value of the crop and animal production activities, costs, farm and total incomes of the households and their sources, production volume of the animal husbandry activities, production costs, gross and net margin (profit) per herd or large animal unit (LAU) are examined. Based on the research results, improvements of livestock-crop interaction in dry farming areas and opportunities for increasing the income contribution obtained from these interactions have been discussed.

2 Materials and Method

In this study, the economic efficiency of the production activities and livestock-crop interaction taking place in the high regions of Ankara have been evaluated using the questionnaire data obtained from the farms situated in the districts of Ayaş, Güdül, Beypazarı and Nallıhan, where alongside crop production the focus is on the breeding of Angora goat, ordinary goat, sheep and dairy cattle. The data was collected by administrating a questionnaire to farms involved in market-oriented production with 20 or more head of goat and sheep and four or more head of dairy cattle in the 16 villages with the highest livestock population and the most breeders in the four districts. The survey was implemented between May and July 2006, and included input-output figures related to the production activities of the 52 farms that agreed to participate in the survey. The monetary results of the study were measured initially with the national currency, and then converted into USD, based on the average exchange rate of the Central Bank of the Republic of Turkey.

Production factors, income from farming and other sources, head of livestock, productivity, production costs, profitability levels, and the tendencies and expectations of the producers were examined in the evaluation of the structural properties of the farms. Production costs were measured by taking the actual inputs and the prices paid by the producers as a basis. The gross production value was calculated by multiplying the average production figures obtained from the farm by the farmers' received prices. Variable (fertilizers, pesticides, feeds, veterinary, shearing, hired labor, shepherding, transportation, sales and working capital interest) and fixed costs in crop production and livestock activities were analyzed. Fixed assets and the economic life of breeding animals were taken as a basis for the amortization calculation, and real interest rates (5%) were used in the identification of the interest of the fixed assets. The interest of working capital was determined through short-term loan interest rates (average 18%). The herd composition in the farms and annual livestock inventory were examined. The change in inventory (real increase in inventory value) was found by subtracting the value of the stock, the sold value and the animals slaughtered in the households at the end of the year from the value of the animal stock at the start of the year and purchase price by using a livestock inventory chart (Açıl, 1976; Turner and Taylor, 1998). After determining the annual livestock numbers for each enterprise, animal populations are transformed to a standard figure, known as the large animal unit (LAU), based on species and age (Açıl and Demirci, 1984; İnan, 1998).

A partial budget or production activity analysis was implemented for the analysis of contributions of animal husbandry to the welfare of the producers (Turner and Taylor, 1998). During the production activity analysis, net profits from the activity were determined by subtracting the production costs of the activities from the gross production value; and gross profits of the activity were determined by subtracting variable costs of production activities from the gross production values (Gittinger, 1984; Açıl and Demirci, 1984; Erkuş *et al.*, 1995). In the research area, crop and animal production activities have been operationally and functionally linked for years (McCown *et al.*, 1979) and the evaluation of linkages between these activities can be used to draw up policies to enhance sustainable rural development. The livestock-crop interaction in the farms was evaluated taking into account factors such as usage of lands, capital demand, own consumption rates of the crop and animal produce, usage of manure, distribution of gross production value according to activity and the impact of livestock-crop interaction on living standards of producers. In the evaluation of the crop–livestock systems, farms on which at least 10% of the feed comes from crops and/or crop by-products or on which more than 10% of the total agricultural production value comes from non-livestock farming activities are termed as mixed farms (Steinfeld, 1998; Seré and Steinfeld, 1996; Powell *et al.*, 2004).

3 Research Results and Discussion

3.1 Farmland of Households, Climate Conditions and Land Use

While Ankara's dominant climatic characteristic is the continental climate, the mild and rainy Black Sea climate can also be observed in the northern regions of the province. While the city has an average annual rainfall of 367 mm, in the districts of Beypazarı, Ayaş, Güdül, and Nallıhan this figure increases to 440-480 mm. 78% of the average annual rainfall in Ankara is concentrated between the months of October and April. 80.6% to 88.2% of farmlands are within the 1^{st} – 4^{th} soil classes and the rest of these lands fall in the 6^{th} – 7^{th} classes. Dry lands, constituting 90% to 95% of the total land in the region, fall within the range of 1^{st} – 7^{th} classes. 48.9% to 71.4% of the lands in the districts are located in mountainous areas on a gradient of more than 12%. Since the lands are sloped, the productive soil depth is not sufficient. In the four districts, 73.7% to 81.9% of the lands have very low (less than 50 cm) topsoil cover (KHGM, 1992). In sloped areas, topsoil is generally shallow, high in acidity, low in fertility and vulnerable to erosion. In the districts surveyed, 13.4% to 20.7% of the lands are subject to very severe water erosion and 42.1% to 60.7% are subject to severe water erosion. No serious drainage or barrenness problems, which can negatively impact productivity, are observed (KHGM, 1992). In the districts, the share of the lands not affected by these problems is very low, which has a detrimental affect on the rate of obtainable income.

The average operating and of the farms is 20.71 ha, almost all of which is owned land (91%), and self-entrepreneurship is dominant. Entrepreneurs state that the lands cannot provide a satisfactory level of income and it has been found that the amount of the lands cultivated through rental and partnering is at low levels. Other factors, such as the lack of labor in the farms (due to the aged and unhealthy population), the location of some parcels remote from the villages, and land cultivation not being economically advantageous have led some households to open some parcels of their own lands for utilization under rental or crop-sharing. The households are generally regarded as small family farms in terms of land, although operating farmland is 3.4 times greater than the national average (6.1 ha).

Table 1: Land assets and land tenure in the farms.

Land Tenure Forms	*Types of Land (ha)*			*Total Land (ha)*
	Irrigated Land	*Dry Land*	*Orchards & Vineyards*	
Owned Land	0.55	17.65	0.55	18.75
Land Used Under Rental and/or Crop-sharing	1.81	1.34	–	3.15
Land Allocated to Rent and/or Crop-sharing	–	1.19	–	1.19
Total Operating Land	2.36	17.80	0.55	20.71

On the farms, 85.9% of the lands are comprised of dry lands, generally allocated to cereal, pulses, and fodder crop production. 11.4% of the farmlands are irrigated and 2.7% of fruit plantations and vineyards. 14.1% of the lands cultivated by the farms are irrigated, and are used for the cultivation of sugar beet, alfalfa and tomatoes, as well as for vines and fruit orchards. 34.8% of the operating land is cultivated for wheat, 28.1% for barley, 3.2% for common vetch, 1.1% for alfalfa, 1.2% for chickpeas, 2.2% for sugar beet, 1.1% for vegetables and 2.7% for vines and fruit orchards, whereas 25.6% is left fallow. Since rainfall is scarce in the summer, the farms continue to rotate fallow dry lands. The approach of cultivating pulses and beans every year instead of allowing the land to remain fallow is observed only in one village. 4.3% of the farmlands are reserved for fodder crops, which falls short of the requirements for the animal husbandry activities. Under these conditions, pasture and forest lands are used for dry grass production and a significant amount of cereals are used as fodder.

3.2 Population and Labor Forces and their Use on Farms

The average household contains 5.11 persons, divided between sexes as 2.66 male and 2.45 female, resulting to 3.84 man work units. On average, 9.8% of the household residents are between the ages of 0 and 6, 14.7% between 7 to 14, 70.6% between 15 and 65, and 4.9% 66 and above. The 15 to 65 age group constitutes the economically active (productive) population in the households, and at 70.6% is higher than the national average.3 Due to the migration of the younger population to urban areas the average age in the villages has increased, leading to lower tendencies to invest in the businesses. While the population in the province and districts of the region is on the rise, the population in the rural areas is becoming lower. The decrease in the number of households in rural areas causes the barren lands with low productivity to be left idle as grassland.

It has been found that 100% of the male and female population in the households above the age of 7 is literate. The average schooling period of the population is 6 years, comprising primary (primary and secondary school) education. 40% of the family labor in farms cannot be utilized effectively throughout the year, however, as the production activities are not planned according to the labor requirement, these households employ permanent or temporary hired labor. While utilization of the idle labor force is expected with the improvement of animal husbandry activities on the farms, 48 of the surveyed households employ permanent shepherds, and all of the shepherding jobs are carried out by hired labor. In addition, the farms generally employ hired labor during maintenance and harvesting seasons. Since non-agricultural job opportunities of the household population are limited, crop and animal production are the main economic activities. 60% of the household heads are covered by social security, and most of this amount comprises of those who had worked in non-agricultural jobs in the cities before turning back to rural areas after retirement.

3.3 Capital Structure and Distribution in Farms

54.6% of the total assets of the farms are fixed capital (land, land improvements, building and crop assets) whereas 45.4% is working capital (livestock, tools and machinery, and other working capital items). The value of livestock, at 34.7%, has the highest share in total assets, followed by land (30.4%), buildings (22.3%) and tools and machinery (7.2%). On the farms, the share of crops and trees in the total assets is 1.1%, that of the land improvement investments 0.8%, and other working capital (input and output in stocks, cash, and so on) 3.5%. The average head of animals on the farms is 137.98 LAU, 35.1% of which is Angora goat, 33.9% ordinary goat, 27.4% sheep, 3.1% dairy cattle and 0.5% poultry and work animals. Considering the limited availability of cash on the farms, problems are experienced in meeting the requirements of animal husbandry in the winter season, which leads to the untimely slaughter of lambs and young goats.

Diversification into animal husbandry reduces risk by providing insurance in case of crop failure. In these systems, livestock is also a source of liquidity and investment capital in the absence of savings and credit institutions. Income obtained from the sale of livestock can provide the cash needed to finance crop farming and improve crop production by providing the investment capital needed to enhance productivity (Hopkins and Reardon, 1993). Crop farming meets the working capital requirements of animal husbandry activities, while the income obtained from sales of livestock meets the working capital demands of crop production (financing a product with another product within the farm). In the households, harvesting and marketing jobs of such crops as wheat and barley, for which 62.9% of the total lands are reserved, are carried out in the summer season, and the income obtained from sales of these products is used to meet the working capital demands of animal husbandry activities. Cash on the farms is limited, and the income obtained from the sales of crop products within the year is not sufficient to meet the demands of working capital and family requirements, leading to untimely lamb and goat sales.

3.4 Livestock-Crop Interactions on the Farms, Breeding Objectives and Gross Production Value

The historical development process of the farms of Ankara has witnessed three different periods with regard to livestock-crop interaction. In the first period, prior to 1950, animal power was used for land cultivation, processing and the transportation of products, and manure was the only fertilizer available. The second was the 1950-1880 period, when tractors and mechanical power replaced work animals, even in mountain villages; the usage of off-farm inputs such as chemical fertilizers, pesticides, certified seeds and concentrated feeds increased; and subsistence farming was replaced with market oriented production. However, serious population pressure on the farmlands and a significant decrease in the livestock population was observed within this period. The third period is post-1980, when the relatively more educated population migrated to urban regions, the elderly and retired individuals began participating in farming, and input transfers between crop production and animal husbandry became common in the mountainous regions. Since there are literally no producers with agricultural insurance, crop-livestock interaction significantly reduces risks and uncertainties in production and income, and also creates employment opportunities.

Animal production has been relatively common in the farms of the upland areas for several centuries. The decision to engage in crop-livestock farming on sloped land is closely related to the characteristics of land and water resources. Small-scale farmers used a wide range of produce, such as wheat, barley, vegetables, fruits, grapes and pulses, to meet the demand of the household and to feed their livestock. In recent decades, with the rapid economic growth, the number of animals per farm has increased or animal production has become localized in specific villages or farms. This has caused weak linkages between crop and livestock activities, which are vital for the intensive use of local resources and for the economic, social and environmental sustainability of small scale farming.

The crop-livestock farming systems for highlands are focused on dairy cattle, sheep and goat farming in particular. Farmers are still continuing to breed cross-bred dairy cattle that graze in pasture for 3 to 5 months a year and are fed in the barn for the rest of the year. Sheep and goats usually graze on natural pastures, meadows and forestlands for 7 to 9 months per year and stay in the pen during the December-April period. During the grazing season, in the months of April and May supplementary feeding is carried out. Agricultural by-products, such as straw, dried grass, grain and fodder crops, are used for feed, and thus it is possible to reduce production costs. Angora and ordinary goats are usually kept on the highlands, steep mountains or on forestland. Feed from common property resources provides a low-cost raising system, but not an efficient one. It destroys the plant cover, which, coupled with rainfall and sloped terrain, can cause serious soil erosion. However, higher economic benefits can be obtained when animals are able to graze, and their manure returned to the soil to enrich fertility.

The dry and low-precipitation climate of Ankara is suitable for goat and sheep breeding. As sheep and goat breeding is a meadow-based (extensive) activity, it is generally preferred to draw benefit from the meadowland, as long as the climate conditions are appropriate, in order to reduce costs, to ensure easy herd management and reduce the demand for working capital. Not all the examined villages have the opportunity to utilize meadows and plateau under common ownership of the village, an important factor considering the costs associated with renting meadows and plateau. Nine of the villages use common land owned jointly by the village, three use pasture rented from neighboring villages, and four use in-forest grazing areas, although this practice is illegal.

Farms are forced to graze their goat and sheep flocks inside the forests, as the amount of meadows, fallow land, pastures and tablelands in their villages is insufficient. In addition, grazing is performed on cereal stubble in the July to October period and on fallow land until September each year. Factors such as the barrenness, low fertility and insufficiency of the lands owned by the households, as well as the fact that some do not possess any land at all, makes goat and sheep breeding a very low cost per animal, and therefore advantageous, activity.

One of the most problematic issues in terms of crop production-animal husbandry interaction is encountered in animal-forest relations (Chang, 1989; Chen *et al.*, 1992; Gökçe and Engindeniz, 1994). Ordinary goats consume the leaves and young sprouts of the trees and damage the forests, which have the ideal plant coverage for low-cost feeds. However, it is thought that Angora goats and sheep cause no harm to the forests. The government has followed a policy of discouraging farmers from goat production in an attempt to conserve forestland. While the forestry authority seeks to ban goats and sheep from the forests as per the legal stipulations, the producers defend that Angora goats and sheep do not damage the forests to the same extent as ordinary goats.

Farmers select animal husbandry as a source of income and employment depending on factors such as land resources and topography (particularly the gradient of the land), soil fertility, availability of meadow and pasture, household labor force, price of feeds, value of produce, livestock accommodation, machinery assets of the farms, and in particular consumer demand, trends and traditions. Since a significant amount of the lands of the farms is barren, steep and of moderate or low fertility, the amount of meadows and pastures are limited, settlements are far away from markets, transportation is problematic especially in high lands, and the winter season and the time spend in shelters is relatively long, it would be advisable for these farms to focus on sheep and goat breeding.

Producers have animal husbandry experience that varies from between 5 to 72 years, with an average experience of 34.7 years. The 52 producers who participated in survey were queried about their reasons for engaging in animal husbandry. The reasons why farms prefer Angora goat, ordinary goat and sheep breeding include the high adaptation capabilities of these animals to barren lands, rapid increase in herd populations due to high birth rates, the ability to perform breeding activities even in primitive shelters and low maintenance costs as compare to intensive livestock activities, alongside other factors such as the traditional nature of the activity (especially for Yörüks) and it being the most convenient activity for increasing household income. On the other hand, farms engage in the breeding of dairy cattle for own produce consumption, low labor demand when compared to other activities, convenient opportunities the activity offers for utilizing the family labor force and to meet the cash requirement of the farm (Table 2).

Table 2: The reasons animal husbandry activities are preferred*.

Reasons (Objectives) of Breeders	*Mohair Goat*		*Ordinary Goat*		*Sheep Breeding*		*Milk Cattle Breeding*	
	No.	*Rate (%)*	*No.*	*Rate (%)*	*No.*	*Rate (%)*	*No.*	*Rate (%)*
Adaptation to barren land and ease of feeding	36	17.82	41	19.34	43	18.07	6	4.20
High fertility rates and ease of expanding the herd	32	15.84	38	17.92	40	16.81	3	2.10
Breeding possible even with primitive shelter	29	14.36	20	9.43	34	14.29	2	1.40
Low maintenance costs and a traditionalized activity	27	13.37	23	10.85	31	13.03	4	2.80
Increasing the household income	23	11.39	27	12.74	27	11.34	17	11.89
Herd management tasks are at a low level and easy	21	10.40	25	11.79	25	10.50	13	9.09
Labor force requirements are lower than other activities and the high potential to use family labor	17	8.42	20	9.43	19	7.98	32	22.38
Meeting cash requirements of the farm	13	6.44	11	5.19	14	5.88	22	15.38
Meat, milk, manure, wool, hair, and mohair to meet family requirements	4	1.98	7	3.30	5	2.10	44	30.77
Total	202	100.00	212	100.00	238	100.00	143	100.00

(*) Survey participants were allowed to give more than one reason.

All but 11 of the 52 producers surveyed stated that they were inclined to continue goat and sheep breeding in the future. The reasons given by the 11 that were inclined to abandon livestock breeding included the unsatisfactory prices for mohair, wool, goat hair and goat and sheep meat. In the examined villages and farms covered in the survey, the livestock populations have decreased by as much as 80%, while farms engaged in animal husbandry have decreased by two-thirds since the 1980s. The reasons for this include insufficient and/or unstable prices of animal products, the wish to transform the land from pasture to cultivation, the ban on grazing in forests, high feed costs, high wages of shepherds and insemination facilitators, the high cost of leasing pasture in villages with no common grazing areas and the decreasing demand for sheep and goat meat in parallel to increasing levels of social welfare. Goats and sheep can bring income that is double or treble their value annually thanks to mohair, wool, hair, milk, and lamb and kid sales; however, the breeding activity necessitates regular cash throughout a year and the working capital demands of the breeding activity is met only by cash assets obtained from other activities and funds. Most of the farms tend to continue their livestock breeding activities as it is the only source of income and is a traditionalized activity, and because they do not have sufficient land or capital for crop farming.

For the households that breed sheep and goats which do not have any privately owned lands it is very difficult for the crop and livestock activities to finance each other, and since animals can not be properly maintained and fed the mohair, hair, wool, milk, and live weight productivity remains low. The households commonly slaughter lambs and kids prematurely after 3 to 5 months, when the optimum live weight is not reach until 5 to 8 months, causing a decrease in profitability levels of the animal husbandry activities within the farm. The premature slaughter of lambs and kids is on one hand, an economic loss, an, on the other hand, a problem concerning animal welfare, as particularly defined by Cullen (1991) and Bartussek (1999).

Most part of dry land farming in Anatolia region of Turkey integrates crop and livestock production, in line with the rest of the country. In these systems, the productivities of livestock and croplands are inextricably linked. In the examination of the crop-livestock interaction, the own consumption of the crops in the farms and the marketing ratios of these produces and transfers between crop production and animal husbandry activities are primarily evaluated. Wheat and barley are the principal cereals, alfalfa and wild vetch are the main fodder crops, chickpeas are important in some areas, and sugar beet, vegetables, and fruits are cultivated along rivers and streams. Legumes and vegetables are used for subsistence, cereals are used both for subsistence and as cash crops. The straws from wheat, barley and pulses, as well as all of the fodder produced in the households, are used in animal husbandry and are not offered to the market. Similarly, 74.2% of the wheat and 76.7% of barley produced is utilized as feed in animal husbandry, and a certain amount of these crops is kept as seeds to be used in crop production. The remainder is consumed by the household. The farms produce vegetables, fruit and grapes at a low level for household consumption, while nearly all of the industrial plants, such as sugar beet, are produced in a particularly low number of farms and are offered to the market (Table 3).

Crop residues are vital livestock feeds during the 3 to 5-month winter season, and manure enhances soil fertility for crop production. Feed from pasture, meadows, forestland and fallow lands provide important livestock feeds, and manure is used for increasing cropland productivity. The households use 70.5% of milk produce, 3.2% of meat or live animals, 97.1% of eggs, 1.1% of wool produce, 13.7% of hair produce and 95.4% of manure is utilized on the farm, with the remaining offered to the market. A significant part of the animal products is used to meet the product requirements of the household members, shepherds and other agriculture workers. Since most of the animal products produced in the households is also consumed in the households, in cases when the households abandon animal production activities, sufficient and balanced nutrition of families and meeting the animal product requirements will become a significant problem. As noted by Minasyan and Mkrtchyan (2005), farming still helps to provide the minimum

Table 3: The utilization of products produced by farms in households and marketing ratios.

	Average Per Household				
		Production Amount (kg)		Marketing Rates (%)	
Crop Products	*Arable Land (ha)*	*Grains*	*Straw*	*Grains*	*Straw*
Wheat	7.21	14,650	8,445	25.81	0.00
Barley	5.81	14,319	6,625	23.33	0.00
Common Vetch	0.67	678	940	0.00	0.00
Alfalfa	0.23	3,450	–	0.00	–
Chickpeas	0.25	255	320	60.00	0.00
Sugar Beet	0.45	29.255	–	99.65	0.00
Vineyards	0.35	3,650	–	43.22	–
Vegetables	0.23	11.560	–	65.35	–
Fruit Plantation	0.20	5,550	–	45.51	–
Fallow Land	5.31	–	–	–	–

of food for consumption, keeping extreme poverty in rural areas lower as compared to urban areas. On the other hand, manure is used entirely for the fertilization of croplands and is generally obtained from either one's own livestock or from the livestock of other farmers on rare occasions. When intensive vegetable and fruit farming is uncommon in the region, the marketing ratio of manure is very low. Animal power was used for the production, harvesting, processing and marketing of crops before the 1950s, after which tractors replaced animal power. It is observed that there are no longer any farmers using animal power.

The average gross production value in farms is 65,626.02 USD, 20.8% of which comes from crop production and 78.2% from animal production. Since 20.9% of the gross production value is obtained from non-animal husbandry activities in the farms, in line with the general principles put forth by SERÉ and STEINFELD (1996); POWELL *et al.* (2004) (stating more than 10%), these business can be defined as mixed farms. In the crop farming, wheat production has the largest share (7.6%) in gross production value of the households, followed by barley production (5.7%). Dairy cattle breeding have very limited share in the households and is generally oriented to meet the milk and milk product demands of the households; none of the households engage in cattle fattening. Since farms are generally located in the villages situated around the forests, only producers living in four villages were found to supply the milk in excess of household requirements to the market. In mohair goat breeding, the income obtained from mohair production and the sale of goats has an important share, and milking is performed only to meet the requirements of own consumption, as Angora goat milk has no commercial value. In ordinary goat and sheep breeding, milking is performed for an average of 40 to 50 days annually, and the milk is generally used for household consumption and for refining into milk products, whereas kid, lamb, goat hair, mohair and wool is generally produced for the market. In animal production, the Angora goat has the largest share (30.1%) in the gross production value of the farms, followed by ordinary goats, sheep, dairy cattle, and other animal husbandry, which are 23.0%, 19.8%, 6.0% and 0.3% respectively (Table 4). Angora goats, ordinary goats, sheep and cattle skins can be sold for high prices, and thus the leather from the animals slaughtered for household consumption or that have died of natural causes are supplied to the market. There is a linear relation between the volume of the livestock activities or herd size and the gross production value of these activities and the gross production value of the activities increases parallel to the increase in herd sizes. However, an increase in the herd size may also yield an increase in costs, as well as dispatch and management problems.

Table 4: Gross production value and distribution in farms.

Production Activities	*Value (US $)*	*Rate (%)*	*Rate (%)*
Crop Production Activities			
Wheat	4,978.83	36.38	7.59
Barley	3,765.52	27.52	5.74
Alfalfa	1,189.54	8.69	1.81
Common Vetch and Sainfoin	1,076.47	7.87	1.64
Sugar Beet	1,762.93	12.88	2.69
Other Crop Products	911.98	6.66	1.39
Total Crop Production	13,685.27	100.00	20.85
Animal Husbandry Production Activities			
Cattle Breeding	3,948.80	7.60	6.02
Sheep Breeding	12,969.13	24.97	19.76
Ordinary Goat	15,058.66	28.99	22.95
Angora Goat	19,747.87	38.02	30.09
Poultry Farming	216.29	0.42	0.33
Total Animal Husbandry Production	51,940.75	100.00	79.15
Grand Total	65,626.02	–	100.00

3.5 Farm and Total Incomes of Households and Incomes Sources

The net return of the farms is 16,957.8 USD, of which the proportion to gross income is 25.8%. The farms earn positive interest revenue for the total assets they invest in agriculture. The farm income of the households is obtained in provisions of labor force of the entrepreneur and of his/her family who work in the enterprise without pay, the income of the equity capital and the entrepreneurship income. Farm income is an important indicator of the success of the entrepreneur. The average income of households from farming is 5,963.1 USD, and off-farm income is 3,448.9 USD equating to a total household income of 9,412.0 USD. The farm income of families is close to the sufficient farm income (5,543.31 USD) defined by Law, no. 3083 dated 1983. The per capita income is 1,841.9 USD, which is almost on the same level as the rural average, but below the national average.

The opinions of the producers concerning the income sources of the households and their priority were also evaluated. According to the 76.2% of the households, the primary income source comes from animal husbandry, 15.4% said crop production while 8.4% said pension salary, small business and trade incomes and direct income support payments. In order to check the declarations of the producers, the distribution of household incomes according to sources was examined. The share of farm income in total family income is 63.4%, whereas that of pensions, wages and fees is 17.7%, that of direct income support is 15.4%, and that of trade and other activities is 3.5%. It has been determined that the households saved 15.2% of their annual average income and that their average saving trend is below the average for rural areas. 67.1% of the households stated that they obtained sufficient income to meet the annual expenditures of the families, with the remaining 32.9% claimed that the average annual income was not sufficient, and that they have needed to borrow from their neighbors, relatives and organizations.

3.6 Comparative Analysis of Livestock Activities and Competitive Opportunities in Farms

The impact of production activities on the welfare of producers can be measured in terms of gross margin. This approach assumes that fixed costs are not affected by the production activities or the size of farm (Gittinger, 1984; Webster and Bowles, 1996; Bülbül and Tanrivermiş, 2002). The contribution of livestock activity to the standard of living of the producer can be measured with the increase in the profit obtained from the activity. The gross production value of animal husbandry activities comprises mohair, wool, hair, change in the inventory value, milk, leather from the dead and slaughtered animals and manure.

The average herd size in the farms and the production costs, gross production value, as well as gross and net profits per household and per LAU are calculated. The distribution of production costs in animal husbandry provides an insight into the production intensity level. Although the share of feed costs in total production costs varies from 22.2% to 24.2% in Angora goat, ordinary goat and sheep breeding, this ratio is around 60% in dairy cattle breeding, which are housed in barns for two-thirds of the year. The share of labor costs in total production costs varies between 45.8% to 48.2% in goat and sheep breeding, whereas this ratio is around 23.0% in dairy cattle breeding (Table 5). As goat and sheep breeding are mainly dependent on natural conditions and pastures, contrary to extensive livestock activities, the biggest share in the annual production costs is taken by temporary and permanent labor costs rather than the costs of feeds.

Table 5: The distribution of production cost items in animal husbandry activities.

Livestock Activities	*Feed Costs*	*Labor Costs (%)*		*Other Costs (%)*
		Temporary Labor	*Permanent Labor*	
Angora Goat	23.94	12.64	33.16	30.26
Ordinary Goat	22.17	13.11	35.13	29.59
Sheep Breeding	24.23	13.17	34.17	28.43
Dairy Cattle Breeding	59.77	10.42	12.61	17.20

As the breeds, numbers, and ages of the livestock in the farms are variable, gross and net profits per LAU are compared. The gross production value per LAU in the farms is highest in dairy cattle breeding (937.9 USD) followed by Angora goat, sheep and ordinary goat breeding. The gross profit per LAU is highest in dairy cattle breeding, 360.9 USD and lowest in sheep breeding, 183.5 USD. However, an investigation of the net profits per LAU shows that the highest net profit is obtained from dairy cattle breeding at 101.4 USD and the lowest from Angora goat breeding at 46.0 USD. For every 1 USD invested in animal husbandry in the farms the minimum income of 1.12 USD is obtained from dairy cattle breeding, which is followed by 1.13 USD from Angora goat breeding, by 1.16 USD from sheep breeding, and 1.27 USD from ordinary goat breeding (Table 6). As capital is a scarce factor in the farms, utilizing the capital in the areas where relative profitability is highest would be preferable.

One of the most significant indicators in examining goat, sheep and cattle breeding in the farms is net profit and an evaluation of its sufficiency. An advantageous result emerges in terms of gross and net profit based on the realized product yields, production costs and price relations. While the ratio of gross margin to gross production value is 58.0% in ordinary goat breeding, it is 53.5% in sheep breeding, 51.2% in Angora goat breeding and 38.5% in milk cattle breeding. On the other hand, the ratio of net profit to gross production value varies between 10.8% and 21.1% among animal husbandry activities, which is quite high. The average gross profits that the farms obtain from animal husbandry activities are at a rate that ranges between 38.5% and 58.0% of their gross income, and the ratio of the calculated net profit to the gross production value declines to the 10.8% to 21.1% range (Table 6). When the provisions of the capital invested in livestock activities in the farms are subtracted, it is seen that the producer obtains a positive net profit that is comparatively higher than the profitability indicators of agricultural activities in general, allowing utilization of the capital in alternative investment areas.

The gross production values obtained from animal husbandry activities, as well as gross and net profit levels, are fundamental factors that may influence the competitive edge of the animal husbandry activities within the farms. In all the animal husbandry activities in the farms, the positive gross and net profits are obtained per herd and LAU. Just as farms have surpassed the production threshold, they are surpassing the profit threshold and are meeting both the variable and fixed costs of production activities. As balances

Table 6: Profitability analysis of animal husbandry activities (Results per household and LAU)

Results of Activities	*Mohair Goat*		*Ordinary Goat*		*Sheep Breeding*		*Milk Cattle Breeding*	
	HH	*LAU*	*HH*	*LAU*	*HH*	*LAU*	*HH*	*LAU*
Variable Costs	9,637.35	199.16	6,330.99	138.99	6,026,70	159.31	2,429.34	577.04
Fixed Costs	7,886.12	162.97	5,553.00	121.91	5,158,50	136.36	1,092.41	259.48
Total Production Costs	17,523.47	362.13	11,884.00	260.90	11,185,20	295.67	3,521.75	836.52
Gross Production Value	19,747.96	408.10	15,058.83	330.60	12,969,26	342.83	3,948.81	937.96
Gross Profit	10,110.61	208.94	8,727.84	191.61	6,942,56	183.52	1,519.47	360.92
Net Profit	2,224.49	45.97	3,174.84	69.70	1,784,06	47.16	427.06	101.44
Gross Profit/ Gross Production Value	51.20		57.96		53.53		38.48	
Net Profit/ Gross Production Value	11.26		21.08		13.76		10.81	
Relative Profit (GPV/Production Costs)	1.13		1.27		1.16		1.12	
Livestock Population (LAU)	48.39		45.55		37.83		4.21	

HH: Hpusehold, LAU: large animal unit, GPV: Gross Production Value

are calculated and taken into consideration in cost analysis for the lands and buildings (such as domiciles, stables, pens and barns) owned by the manufacturers in the analysis of the production costs, it emerges that the producers gain other advantages in addition to the net profits. Under these circumstances, the maintenance of animal husbandry by the producers will be consistent in terms of management principles. However, it has been found that ordinary goat breeding, which provides the greatest relative profitability for the farms, offers many advantages, and that the transition from Angora goat breeding to ordinary goat breeding by breeding ordinary mail goats into the Angora herds in recent years bases on economic reasons. This finding of the study is quite a useful indicator, in that it shows the possible effects of agricultural policies on individual farms. Particularly in the villages of the district of Nallıhan, the tendency to replace Angora goat breeding with ordinary goat and sheep breeding is observed to be high. Although satisfactory margins are obtained from the ordinary goat production activities of the farms, it would be useful to support the producers with incentives within the framework of direct support income – as is the case with Angora goat breeding – in an effort to increase the net profit per animal or per average herd and to increase the productivity of breeder animals.

4 Conclusion

Crop and livestock activities on the farms in the higher lands of Ankara in the Central Anatolian region have existed side-by-side throughout their historical evolution. In the farms, along with crop production, Angora goat, ordinary goat, sheep and cattle breeding have been performed by households living in dry farming areas, around forest settlements, and in the mountains in the Central Anatolian region for a long time, and particularly Angora goat, ordinary goat and sheep breeding are all highly traditionalized activities.

Animal husbandry activities are an important source of income and employment for the farms, and contribute to the improvement of the productivity of soil resources and provide healthy and balanced nutrition for the population. However, it has been found that the farms in which the survey has been conducted, and the villages where these farms are located, have experienced a drop of 80%, particularly in their goat and sheep populations, over the last two to three decades. Factors such as unfavorable relations between production costs and prices for animal products, inadequate state incentives, transformation of pastures and meadows into farmlands, prohibition of grazing for goats and sheep in the forest villages, and the high costs of qualified shepherds has led to a drop in the goat and sheep population in the farms. In order to develop Angora goat, ordinary goat and sheep husbandry there is a need to increase the mohair, wool, hair and meat productivity of the current population, improve the maintenance and feeding conditions, and decrease production costs, as well as increase the profitability of the activity. The Central Anatolian region, and particularly Ankara, is characterized by Angora goat, ordinary goat and sheep breeding, and the study results prove that these activities are nearly traditionalized in farms. The farms perform production generally under extensive conditions and bear the characteristics of small family farms. An average of 40% of the labor forces in the households remains idle, however, the households employ imported labor for animal husbandry and for the maintenance and harvesting of crops. Elderly individuals living in rural areas work in agriculture, and it has been observed that their tendency to invest in agriculture and technology is very low. Of the total assets of farms, 54.6% is constituted by fixed assets and 41.34% by working capital. The general insufficiency of working capital poses significant problems, particularly in winter, when cash incomes are nearly zero. Of the total gross production value in the farms, 20.8% comes from crop production and 79.2% from animal husbandry related production. The average total income is 9,411.9 USD, 63.4% of which comes from farming activities. The savings tendency of the households is low, leading to slow and insufficient capital formation, low investment and slow technological change. The animal populations in the farms are raised under conditions appropriate for animal welfare, sufficient health measures are taken, and the animals are raised in shelters that match the natural settings to the highest extent possible. The producers raise kids and lambs for about 3 to 5 months before selling them; and although premature slaughter may contribute to meeting immediate cash demands of the farms, this process has serious drawbacks in terms of farm economics and animal welfare. However, it is not possible to halt this activity in the short term, as it is something that has continued for centuries.

The straws of wheat, barley and pulses, as well as the fodder produced in the households, are used in animal husbandry. The farms produce vegetables, fruit and grapes at a low level for household consumption and nearly all of the industrial crops, such as sugar beets, are offered to the market. The households use 70.5% of milk produce, 97.1% of eggs and 95.4% of manure within the farms, the remaining being offered to the market. The study results show that farms in the highlands may be defined as "mixed farms". As the majority of animal products produced in households are for own consumption, animal husbandry activities contribute to the balanced nutrition of households. Several natural, economic and social factors play parts in the selection of animal breeds to be raised by the farms. Income from the activities, costs and profitability are the main indicators among the economic factors. It has been found that ordinary goat breeding, which provides the greatest relative profit rates to the farms, offers great advantages, and that the transformation of Angora goats to ordinary goats through breeding with ordinary male goats is based on economic reasons. The implementation of policies targeted at improving the relative profitability of the sheep and Angora goat populations in the farms would enable the sustainability and competitive edge of these activities with ordinary goat breeding. The government must adjust its agricultural policies to help farmers reduce their costs and improve the quality of their produce, particularly in the highlands. Improvements in feed and grain crop production will help empower the linkages between crops and livestock in highlands. The integrated crop-livestock systems have been resilient, flexible and responsive to economic fluctuations and technical innovations, but should be evolved further to meet the certainty of further change and the challenges of sustainable agriculture.

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Economic Impact Assessment for Technology: The Case of Improved Soybean Varieties in Southwest Nigeria

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Abstract

The Study on economic impact assessment for the production of improved soybean varieties in Nigeria was carried out in Nigeria using the agronomic data on yield of the nationally coordinated soybean research from two major zones namely the southwest and the middle belt.

The study assesses the economic returns due to improved soybean varieties.

Primary data were collected with the use of structured and validated questionnaires. A sample of 288 respondents was drawn from four states namely Oyo, Ogun, Kwara and Niger State at 72 respondents per state.

Secondary data were collected from Agricultural Development Programme (ADP), International Institute for Tropical Agriculture (IITA), Institute of Agricultural Research and Training, (IAR & T), National Cereals Research Institute (NCRI), Central Bank of Nigeria CBN and Federal Office of Statistics (FOS).

An internal rate of return (IRR) of 38 percent was estimated from the stream of netted real social gains at 1985 constant.

The return to investment in soybean production technology is attractive and justifies the investments made on the technologies. The policy implication is that there is underinvestment in soybean production research.

Keywords: soybean, economic impact assessment, improved varieties, Nigeria

1 Introduction

Improvements in technology, driven by application of scientific research to practical problems are at the heart of economic growth and development. However, the economic value of public investment in research may not be obvious. It is particularly difficult to observe the impact of agricultural research, because the benefits are diffused over many years and to millions of dispersed producers and consumers.

Funds and resources allocated to agricultural research and development (R&D) are not available for use in other productive activities. Agricultural R&D therefore have a real cost to the society because of forgone alternatives. The economic aspect of the project evaluation requires a determination of the likelihood that the project contributes significantly to the development of the total economy and that its contribution significantly

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to the development of the total economy and that is contribution is great enough to justify the resources devoted. Economic studies are needed to measure those benefits, in order to compare them with cost of research and extension. This is with a view to come up with project cash flow on which investment appraisal method can be used to determine whether investment earns a rate of return which exceeds the interest rate or cost of borrowed funds. Soybean is a crop which has enjoyed investments in research and development in Nigeria because of the promise it has, being a highly proteins edible oil seed with the potential of reverting the protein-carbohydrate in balance in the diet of Nigerians. Further, is the importance of soybean utilization in live stock feed ration formulation because unlike groundnut cake, it does not pose the danger of aflatoxin. As far back as 1932, soybean has been in the cropping system in the area around Benue State. It is well adapted to the area because of the climate and edaphic factor of sandy soil. It was grown in mixture with other staple crops of sorghum, groundnut and maize. Maize is often grown in rotation with soybeans.

In 1947, an output of about 9 tonnes was produced on about 30 hectares of land in Benue area with an average yield of 300 kg per hectare. The variety planted was Malaya. By 1962, output has risen to 26,400 tones on about 70,212 hectare of land. What encourages increased hectare cultivation of the crop was the readily available external market for the commodity. The multinational companies of UAC and John Holt made the business to boom, and given the high demand output expansion was achieved through hectare expansion. With the outbreak of war in 1966, the export for soybean collapsed, and multinational companies' demand was dampened. The consequence of the war was that the output for the crop decreased over the years due to lack of marketing outlet. 1977 put the national soybean output, put at the low ebb of 258 tonnes on 686 hectares land. For a long time after the civil war, national output was on the decline and reached a mark of zero in 1978. In 1980, there was a turn around in the crop when at Mokwa, a Dutch scientist; Van Eighteen released a variety that was put into field trial in many locations. This resulted in the release of many lines. Many varieties of the crop were introduced to the farmers after the initial effort. With feed back from farmers to scientists, research was conducted into promising lines and increases in the yield of the crop on the field were observed. Researchers have released many improved varieties, which have higher yields than Malayan variety. Among these are TGx 344, SAMSOY2, TGx 306-036c, TGx 536- 02D, TGx 849-31, TGx 1019-2EN, TGx 923-2E 1448-2E, TGx 1440-IE, Tx1485-ID. Presently the Malayan variety no longer exists. Research effort on them however led to the release of other varieties, which have higher yield, better resistance to pests and better adaptability to location. This study proposes to undertake the economic impact of the research project that led to the production of the improved soybean varieties in Nigeria.

2 Analytical Technique

Economic impact assessment of research can be done through four approaches of

(1) indicator,

(2) econometric,

(3) programming and

(4) economic surplus

This study will adopt the economic surplus approach given its relative simplicity and lower demand for data. This impact assessment of soybean research proposed in this study is an expose assessment since the varieties are already on the field, at varying levels of adoption by the farmers.

3 Methodology

The data needed to calculate social gains fall into four broad categories namely:

(1) Market data on observed prices and quantities

(2) Agronomic evidence and costs of the technology being adopted

(3) Economic parameters on the market response to change (elasticity of supply and demand ϵ and e)

(4) Research and extension costs incurred in obtaining the new technology.

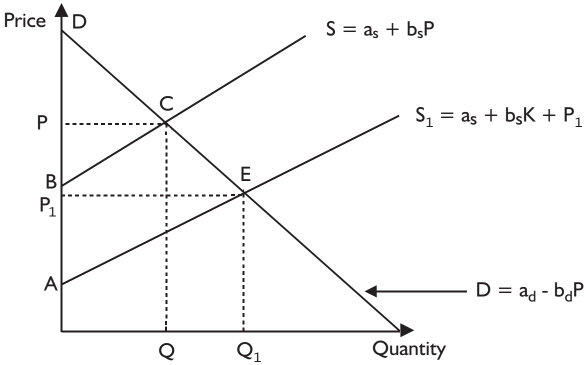
The most fundamental data required for the impact assessments are the Price (P) and quantity (Q) of the soybeans that is affected by technology change. Data for price were obtained from CBN publication. Data on quantity of soybean output over the years were source from the national statistics of CBN. For ex-post studies that use past prices, it is usually necessary to deflate them in order to remove the effects of inflation by dividing the observed prices by consumer price index (CPI). The base period used is 1985 with $CPI = 1.0$. Therefore all observed prices were transferred into real price at 1985 values. Agronomic data on yield gains and adoption costs were procured from field trials and farm surveys. The field trials were conducted at IAR&T, Moor Plantation and out stations. Information on adoption rates came from a combination of farm surveys and extension workers estimates.

Adoption rate (t) defined as the ratio of area on improved variety to total area to the crop in the area was found and it served as input in economic impact assessment determination. Information on adoption costs, which include value of labour, capital inputs provided by the respondent households as well as purchased inputs such as fertilizers, seeds and chemical required to obtain the yield increased associated with the new technology were procured from the surveyed households.

4 Theoretical Framework

An important step in economic impact assessment of technology development and promotion is the measurement of total social gain. In this study, this is done using economic surplus approach. The rational, are the technology adoption results in a rightward shift of supply curve from S to S_1. On the condition that a constant demand curve (D) prevails, this results in a new equilibrium with lower price P_1 and an increased quantity Q_1 demanded for the commodity (Figure 1). Without the technology, the surplus represented by area ABCE would not have arisen. Economic qualification of the area measures the social gain arising from the technology adoption. Economic impact assessment is based on estimating the magnitude of cost reductions given the observed

Figure 1: An ex-post economic impact assessment.



level of output and then making an adjustment for the change in quantity associated with the change in price.

The social gains (SG) as estimated by Ahmed *et al.* (1995) and Dalton (1997) is given by

$$SG = kPQ - \frac{1}{2}kP\Delta Q \tag{1}$$

where Q is the observed quantity produced of the commodity, ΔQ is the change in quantity caused by the technology and k is the vertical shift in supply.
Deduction of research and extension costs from social gains in a year would produce the net social gain for the year. Armed with suitable computer software programmes of spread sheet like Excel or Lotus 1-2-3, the internal rate of return (IRR) on investments in the technology can be estimated from the flow of net social gains over years.

From the equation of social gain (1), P and Q are observable through a census of agriculture or can be estimated from statistics published by the Central Bank of Nigeria (CBN) or Federal Office of Statistics (FOS). The unknown variables, which must be estimated, are K and ΔQ. In order to calculate K and ΔQ we need first to estimate the parameters J, I and k which represent:
J: the total increase of production caused by adopting the new technology (J),
I: the increase in per-unit input costs required to obtain the given production increase (J) and
k: the net reduction in production cost induced by the new technology (i.e. the vertical shift in the supply curve).
These are not directly observable but can be estimated in terms of research results of yield increases (ΔY), adoption costs (ΔC), adoption rates (t), total hectarage planted to the crop (A), total production (Q) and the overall average yield ($Y = Q/A$).

According to Ahmed *et al.* (1995), the J-parameter is the total increase in production that would be caused by adopting the new technology in the absence of any change costs or price and is given as

$$J = \Delta Y * t * A \tag{2}$$

Computing J-parameter in proportional terms, as the increase in quantity produced as a share of total quantity, we have

$$j = \frac{J}{Q} \tag{3}$$

This transformation permits us to estimate the supply shift parameter (j) in terms of the yield gains, adoption rates and the overall average yield level (Y) i.e.

$$j = \frac{\Delta Y * t}{Y} \tag{4}$$

It is important to note that this is valid only if Y is defined as the overall average yield $Y = Q/A$.

The I-parameter is the increase in per-unit input cost required obtaining the production increase J. It is therefore given as: $I = \Delta C * t/Y$.
Expressing I in proportional terms as a share of the product price P, the proportional cost increase parameter (c) is

$$c = \frac{I}{P} = \frac{\Delta C * t}{Y * P} \tag{5}$$

The K-parameter is the net reduction in production costs induced by the technology and can be obtained from combining the effects of increased productivity (J) and adoption costs (I). It corresponds to a vertical shift in the supply curve. Given J and I, it can be computed using the slope of the supply curve (b_s) as $K = (J * b_s) - I$
As the slopes of the suply curves (b_s) are associated with units of measurement, preference is for the use of the supply elasticity (ϵ) which is independent of units of measurement:

$$K = \frac{J}{\epsilon * Q/P} - I = \frac{J * P}{\epsilon * Q} - I \tag{6}$$

Using proportional terms i.e. the net-reduction in production cost as a proportion of the production price results in:

$$k = \frac{K}{P} = \frac{J * P}{\epsilon * Q * P} - \frac{I}{P} = \frac{j}{\epsilon} - c \tag{7}$$

The change in quantity (ΔQ) actually caused by technology depends on the shift in supply and the responsiveness of supply and demand. The equilibrium situation without technology would be that price and quantity, which satisfy both, demand and supply:

$$Q_d = Q_s \tag{8}$$

$$a_d + b_d P = a_s + b_s P$$

$$P = \frac{a_s - a_d}{b_d - b_s}$$

With the adoption of new technology, the equilibrium must be on a new supply curve, which is shifted in the direction of a price increase:

$$\begin{aligned} & Q_d = Q_s \\ & a_d + b_d P_1 = a_s + b_s K + b_s P_1 \\ & P_1 = \frac{a_s - a_d + b_s K}{b_d - b_s} \end{aligned} \tag{9}$$

The resulting change in price is:

$$\Delta P = \frac{-b_s * K}{b_d - b_s} = \frac{b_s * K}{b_s - b_d} \tag{10}$$

And hence change in quantity is

$$\Delta Q = b_d * \Delta P = \frac{b_d * b_s * K}{b_s - b_d} \tag{11}$$

To substitute elasticities for slopes, assume elasticity of demand is e, then

$$e = \frac{\% \Delta Q}{\% \Delta P} = \frac{\Delta Q / Q}{\Delta P / P} = \frac{\Delta Q}{\Delta P} \frac{P}{Q} = b_d \frac{P}{Q} \Rightarrow b_d = e \frac{Q}{P} \tag{12}$$

Thus

$$\begin{aligned} \Delta Q &= \frac{e * Q}{P} * \frac{\epsilon * Q}{P} * \frac{K}{(e * Q/P) + (\epsilon * Q/P)} \\ \Delta Q &= \frac{e * \epsilon * K \frac{Q^2}{P^2}}{(e + \epsilon) * \frac{Q}{P}} = \frac{e * \epsilon * K * Q}{(e + \epsilon) * P} \end{aligned} \tag{13}$$

In proportional terms, this simplifies to:

$$\Delta Q = \frac{Q * e * \epsilon * k}{e + \epsilon} \tag{14}$$

The social gain as given earlier (1): $SG = kPQ \pm \frac{1}{2} kP \Delta Q$
therefore becomes

$$SG = kPQ \pm \frac{1}{2} kP \frac{Qe\epsilon k}{e + \epsilon} = kPQ \pm \frac{1}{2} k^2 PQ \frac{e\epsilon}{e + \epsilon} \tag{15}$$

Since k, P, Q, e, and ϵ can be estimated or observed, the social gain from the technology adoption can be calculated. Deduction of research and extension costs from social gain over the years will produce the flow of net social gain, which should be expressed in constant value, and the internal rate of return can be estimated from cash flow.

5 Results [2]

The period under consideration for this study was from 1975 to 1999. Hectares cultivated to soybean varieties ranged between 4,080 and 195,000 hectares. The output in metric tonnes ranged between 1,544 and 304,600 – the soybean price was ₦66/tonne in 1975 and increased to ₦45,000/tonne in 1999.

The adoption rate of these varieties increased from 4 percent in 1990 to 14 percent in 1999.

Real adoption cost for the improved varieties ranged between ₦66 in 1975 and ₦45,000 in 1999.

The real social returns from the improved soybean varieties ranged between ₦230,791 in 1982 and ₦1,360 mio. in 1999 while the net real social gain was between ₦1,366,575 (m) in 1979 and ₦332 mio. in 1999. From the stream of the net gains, an internal rate of return (IRR) of 38% was estimated for the investment that produced the technology.

The pay off to investment that produced soybean varieties of 38% can be said to be attractive because the return is above the prevailing interest rate during the same period.

The policy implication of the finding is that there is under investment in soybean production (varieties) research, Invitation from donors to invest in soybean research in Nigeria.

6 Conclusion

Considering the result of internal rate of returns of 38 percent observed from the streams of net returns from research that produced soybean varieties in Nigeria between the year 1975 and 1999, the pay-off to soybean production investment is attractive during the period, it's well above the average interest rate of 15 percent during the periods. There is justification for the investment on soybean variety research.

The policy implication is that technology is a veritable tool for poverty avoidance and alleviation bearing in mind the vital role soybean plays in the economy. On the basis of field experience in this study such technology as the case of soybean varietal development should further be encouraged such that ecological settings of the beneficiaries are strongly taking into consideration.

It is therefore vital that more funds should be allocated to soybean research in Nigeria.

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Buchbesprechungen

J. Pohlan, L. Soto und J. Barrera (Hrsg.); 2006

El cafetal del futuro – realidades y visiones
Die Kaffeepflanzung der Zukunft – Wirklichkeit und Visionen

Herausgegeben von Prof. Dr. Jürgen Pohlan (Universität Bonn und ECOSUR, Tapachula, Mexico) und Dr. Lorena Soto und Dr. Juan Barrera ISBN 10: 3-8322-5052-2, Shaker Verlag - Aachen, 2006, 462 Seiten, Preis: € 26,–

Das derzeit leider nur in spanischer Sprache verfügbare Handbuch dokumentiert vor dem Hintergrund des mittel- und südamerikanischen Erfahrungsschatzes der überwiegend aus der angewandten Forschung- und Beratungspraxis kommenden Autoren in fünf klar strukturierten Kapiteln die vielfältigen Probleme des modernen Kaffeeanbaus. Ein Schwerpunkt des Werkes, das auch zahlreiche Fallbeispiele und einige sehr hilfreiche Bildtafeln enthält, liegt auf der Beziehung zwischen den pflanzenbaulichen und qualitätssichernden Anbaumassnahmen bei Kaffee und den sich ändernden Verbrauchererwartungen auf einem globalen Markt. Dieser stellt bei hohem Wettbewerbsdruck einerseits immer höhere Anforderungen an die Qualität des Produktes Kaffee, fordert andererseits aber auch zunehmend die Transparenz der Produktionsbedingungen und die Einhaltung immer wieder neu definierter Umweltstandards sowie die Berücksichtigung von sozialen Kriterien bei der Produktion.

Kennzeichnend für den in diesem Spannungsfeld erfolgreichen Kaffeeanbauer ist ein immer höheres Bildungsniveau, die Bereitschaft zu dauernder Innovation auf dem Betrieb, der naturgemäß durch lange Umtriebszeiten charakterisiert ist (Diversifikation des Anbausystems zur Abpufferung von Preisschwankungen) und eine optimale Beherrschung der Produktions- und Nacherntetechnik, um deren entscheidenden Einfluß auf die Qualität des Rohkaffees und damit einhergehende Preisvorteile nutzen zu können.

Insgesamt erfüllt das Buch eine zweifache Aufgabe. Zum einen ist es aufgrund seiner (bei Kenntnis der spanischen Sprache) leichten Lesbarkeit und übersichtlichen Darstellungsform in idealer Weise geeignet, das Wissen ökologisch orientierter Produzenten in Lateinamerika zu erweitern. Die zahlreich verwendeten und jeweils am Ende der einzelnen Kapitel angeführten Literaturhinweise, die insbesondere auch die recht schwer zugängliche „graue“ lateinamerikanische Literatur erschliessen, erleichtern Studierenden und interessierten Praktikern eine weiterführende Einarbeitung in die verschiedenen Themen. Durch seine zahlreichen Tabellen und Abbildungen sowie die durchgängig spürbare große Praxiserfahrung der Autoren erscheint das Buch deshalb auch in idealer Weise für die Lehre an Landwirtschaftsschulen und Fachhochschulen in Lateinamerika einsetzbar. Einem naturwissenschaftlich orientierten Leserkreis, der wegen der selten behandelten, komplexen Thematik ebenfalls Interesse an dem Buch haben sollte, mag dagegen fachliche Tiefe bei Einzelaspekten und ein übersichtliches Register fehlen. Eine Erfüllung auch dieser Erwartungen hätte jedoch dem eigentlichen Anliegen der Herausgeber und Autoren, ein gut lesbares Praxishandbuch für die Kaffebauern in Laterinamerika zu erstellen, zumindest teilweise widersprochen. Vor diesem Hintergrund ist eine Lektüre dieses Werkes in jedem Fall empfehlenswert.

Andreas Bürkert, Witzenhausen

Frank Bliss; 2006

Oasenleben: Die ägyptischen Oasen Bahriya und Farafra

Politischer Arbeitskreis Schulen (PAS), Bonn, ISBN: 3-921876-27-3, 496 Seiten, Preis: € 39,90 (broschiert)

Das spannend geschriebene, deutschsprachige Werk beschreibt aus einer ganzheitlichen, ethnologischen Sicht die materielle und immaterielle Lebenswirklichkeit zweier Oasengruppen in der Lybischen Wüste (Wüste westlich des Nils). Grundlage des Buches sind Feldforschungen in den Jahren 1979, 1981, 1982-1986 sowie 2000 und es ist gerade dieser Vergleich über zwei Jahrzehnte, der das Buch zu einem beeindruckenden Dokument des Wirkens moderner Transformationsprozesse im arabisch-afrikanischen Raum macht. Als solches stellt es sowohl für interessierte Laien, aber auch für die sozial- und agrarwissenschaftlich orientierte Fachwelt eine in jeder Hinsicht empfehlenswerte Lektüre dar.

In 13 Kapitel gegliedert wird ausgehend von der geographischen Lage der Oasengruppen, der physischen Grundlagen der Oasenwirtschaft und dem Verhältnis zur Außenwelt auch das Innenleben der Oasengesellschaften detailliert beschrieben. Das Werk schließt ab mit einer Beurteilung der Entwicklungsmöglichkeiten und -wirklichkeiten dieser auch heute noch relativ entlegenen Orte, die allerdings durch die modernen Kommunikationsanbindungen und den Massentourismus einem rasanten Wandel ausgesetzt sind.

Obwohl das Buch stilistisch in Berichtsform gehalten ist, wirkt es keineswegs langatmig oder allzu persönlich, wozu auch das 22 Seiten umfassende Literaturverzeichnis und das umfangreiche Glossar der verwendeten arabischen Fachbegriffe beiträgt. In diesem Zusammenhang wäre ein Stichwortverzeichnis hilfreich gewesen, dessen Fehlen aber dem Wert des Buches an sich keinen Abbruch tut.

Andreas Bürkert, Witzenhausen

Journal of Agriculture and Rural Development in the Tropics and Subtropics
Volume 108, No. 1, 2007, pages 89–95

Kurznachrichten

Gegen Hunger und Armut: Uni Kassel startet Forschungsvorhaben zur Verbesserung der Urbanen Landwirtschaft im westlichen Afrika

Kassel/Witzenhausen. Ackerbau und Viehzucht – in Europa typisch für das „platte Land" – sind in Afrikas rasch wachsenden Städten eine wichtige Einkommens- und Ernährungsquelle speziell für die arme Bevölkerung. Obwohl Afrika reich ist an natürlichen Ressourcen, prägen Hunger und Armut die gesellschaftliche Wirklichkeit vieler Länder südlich der Sahara. Mit einem 1,9 Millionen Euro umfassenden Förderprogramm will die Volkswagenstiftung dazu beitragen, die Effizienz und Nachhaltigkeit der Landwirtschaft in diesen Ländern zu verbessern. Den größten Betrag daraus erhält ein Projekt der Universität Kassel. Mehr als 450.000 Euro gehen an den Witzenhäuser Fachbereich Ökologische Agrarwissenschaften, an dem unter der Leitung von Prof. Dr. Eva Schlecht und Prof. Dr. Andreas Bürkert die Chancen und Möglichkeiten einer verbesserten Nahrungsmittelproduktion speziell in der städtischen Landwirtschaft untersucht werden sollen.

Mit Bürkert und Schlecht hat sich ein Team aus einem Pflanzenbauwissenschaftler und einer Spezialistin für Tierhaltung in tropischen und subtropischen Gebieten zusammengefunden und einen interdisziplinären Forschungsansatz formuliert. Wie können Tierhaltung und Pflanzenbau unter tropischen Bedingungen in einem städtischen Umfeld optimal so aufeinander abgestimmt werden, dass qualitativ hochwertige Produkte auf den Markt gebracht werden können? In drei Städten, nämlich in Kano (Nigeria), Bobo Dioulasso (Burkina Faso) und Sikasso (Mali) wird untersucht, wie Ressourcen in der städtischen Landwirtschaft effizienter genutzt werden können, in welcher Weise Tierhaltung und Pflanzenproduktion vernetzt sind, und welche Synergien, aber auch welche potentiellen Gefahren daraus erwachsen, etwa durch die Kontamination von Gemüse mit Fäkalkeimen.

Partner der Universität Kassel, von der auch das von Prof. Dr. Oliver Hensel geleitete Fachgebiet Agrartechnik am Projekt beteiligt ist, sind dabei Universitäten aus Belgien und den Niederlanden sowie Universitäten und Forschungszentren in Kenia, Nigeria, Burkina Faso und Mali. Sechs afrikanische Doktoranden werden aus dem Stiftungstopf bezahlt. Sie werden nicht nur die Forschungsarbeiten vor Ort durchführen, sondern dazu beitragen, dass „Know How" vor Ort entwickelt und verankert wird.

Die Aspekte der nachhaltigen Nutzung und die Verbindung ökonomischer mit ökologischen Fragestellungen standen für die Volkswagenstiftung bei dem Vorhaben im Vordergrund. Mit dem Fachbereich Ökologische Agrarwissenschaften hat sie dabei einen Partner gefunden, der auf diese Themen spezialisiert ist und gleichzeitig über langjährige Kenntnisse und Erfahrungen mit tropischer und subtropischer Landwirtschaft verfügt.

Pressemitteilung 198/06 – 20. Dezember 2006

Wissenschaftsrat sieht Chancen: Agrarfachbereich der Universität Kassel bleibt

Kassel/Witzenhausen. Als falsch hat die Universität Kassel eine Schlagzeile von AGRA-EUROPE, dem Pressedienst für die deutsche Landwirtschaft, zurück gewiesen, der zu Folge die Kasseler Agrarfakultät in Witzenhausen nach den Empfehlungen des Wissenschaftsrats zur Strukturreform der Agrarwissenschaften geschlossen werden soll. Im Gegenteil sei richtig: Der Wissenschaftsrat sehe sehr gute Chancen für die enge Kooperation der Agrarfakultäten in Göttingen und Kassel, die in einem Fakultäten-Verbund den Kern eines der sechs vom Wissenschaftsrat vorgesehenen Forschungszentren in der Bundesrepublik bilden könnten.

In der Überschrift über die Berichterstattung von AGRA-EUROPE war in der Ausgabe Nr. 47/2006 vom 20. November 2006 auf Seite 1 der Länderberichte und auf Seite 1 der Dokumentation behauptet worden, dass Kassel-Witzenhausen geschlossen werden solle. Im Bericht selbst wurde allerdings korrekt über die guten Perspektiven informiert, die der Wissenschaftsrat aber auch die Universität Kassel selbst ihrem Fachbereich Ökologische Agrarwissenschaften im Verbund mit der Agrar-Fakultät Göttingen einräumen. Schließlich haben beide Fakultäten bereits vor zwei Jahren einen Kooperationsvertrag darüber abgeschlossen, ihre jeweiligen Stärken in enger Zusammenarbeit weiter zu entwickeln und gemeinschaftlich auszubauen. So können beide Fakultäten wichtige Synergien entwickeln, wie sie der Wissenschaftsrat an verschiedenen Stellen z.B. für die tropisch-subtropisch orientierte Agrarforschung oder auch für die Bereiche Biodiversität, Umweltstandards und Qualitätssicherung und Lebensmittelqualität aufzeigt.

Der Verbund beider Fakultäten bringe, so das Gutachten des Wissenschaftsrates wörtlich, „für beide Seiten Vorteile“. Ausdrücklich würdigt der Wissenschaftsrat auch, dass „Kassel über den einzigen grundständig auf Ökologische Landwirtschaft ausgerichteten Fachbereich in Deutschland verfügt. Auch international ist er mit dieser Profilierung und dem umfassenden Angebot im Rahmen des Profilgebietes relativ einzigartig“.

Göttingen und Kassel hatten durch die gemeinsame Besetzung einer Professur für beide Fachbereiche erst vor kurzem ein beispielhaftes Signal für die vom Wissenschaftsrat empfohlenen neuen Kooperationsformen gesetzt, in diesem Fall erstmals sogar Ländergrenzen überschreitend. Nachdem der Wissenschaftsrat in seinem Gutachten die kritische Größe künftiger Agrarfakultäten in Deutschland auf 40 bis 50 Professuren festgesetzt hat, sei klar, dass Kassel-Witzenhausen allein nicht als Kern eines regionalen Clusters fungieren könne. Gemeinsam mit der Universität Göttingen sei es jedoch möglich, im Herzen Deutschlands einen schlagkräftigen Fakultäten-Verbund zu organisieren - ein Modell, an dem schon seit mehr als zwei Jahren von Göttingen und Witzenhausen gebaut werde.

Beide agrarwissenschaftlichen Fakultäten wissen dabei ihre Präsidenten und Ministerien hinter sich. Der Impuls zu dieser länderübergreifenden Zusammenarbeit war nicht zuletzt von den beiden Landesregierungen in Wiesbaden und Hannover ausgegangen. Eine andere Entwicklung für Witzenhausen als den agrarwissenschaftlichen Fakultäten-

Verbund mit Göttingen streben weder das Präsidium der Universität Kassel noch der Fachbereich selbst an.

Das europaweit einzigartige Profil des agrarwissenschaftlichen Fachbereichs Kassel-Witzenhausen bleiben dabei mit 19 einschlägig angesiedelten Professuren die Ökologische Agrarwissenschaften. Die rasant steigende Nachfrage nach Produkten ökologischer Landwirtschaft unterstreiche die Dringlichkeit dieses Forschungs- und Ausbildungsschwerpunkts, der nicht zuletzt durch drei privat finanzierte Stiftungsprofessuren der Wirtschaft unterstützt werde und im Wissenstransfer in die Praxis eine hervorragende Rolle spiele.

Mit inzwischen vier ökologisch ausgerichteten, zum Teil international orientierten Studiengängen zeigt sich der Fachbereich Kassel-Witzenhausen auch im Angebot für Studieninteressenten gut für die Zukunft gerüstet. Die Umstellung auf Bachelor- und Master-Abschlüsse im Rahmen des „Bologna-Prozesses“ wurde schon vor fast zwei Jahren erfolgreich abgeschlossen. Auch in der Einwerbung von Drittmitteln für die Forschung wisse sich der Fachbereich auf gutem Weg. Allein in diesem Jahr wird es dem Fachbereich gelingen, fünf Millionen Euro an Forschungsgeldern ein zu werben, darunter auch Mittel für ein DFG-Graduiertenkolleg.

Pressemitteilung 189/06 – 23. November 2006

Uni Kassel entwickelt mobile Wasseraufbereitungsanlage für Not- und Katastrophenfälle

Kassel. Eine Trinkwasseraufbereitungsanlage, die den Bedarf von bis zu 200 Personen deckt, hat die Universität Kassel heute als Prototyp vorgestellt. Die weltweit einzigartige Anlage ist betriebsfertig lagerbar, kann ohne Bedienungspersonal in Betrieb genommen werden und kommt ohne den Einsatz von Energie und Chemikalien aus. Sie kann so in allen Not- und Katastrophenfällen eine sofortige Trinkwasserversorgung sicherstellen, in denen eine aufwändigere Technik samt Personal nicht oder nicht schnell genug die Hilfsbedürftigen erreicht. Diese können mit der Anlage für eine Übergangszeit – bis eine geregelte Versorgung hergestellt ist – ihr Trinkwasser selbst aufbereiten.

Die Anlage wurde im Auftrag der Deutschen Bundesstiftung Umwelt von Prof. Dr.-Ing. Franz-Bernd Frechen und Dipl.-Ing. Axel Waldhoff im Fachgebiet Siedlungswasserwirtschaft, Fachbereich Bauingenieurwesen der UNIK entwickelt. „Naturkatastrophen der letzten Jahrzehnte haben gezeigt, dass in solchen Situationen die Erstversorgung mit genießbarem Wasser entscheidend ist“, sagte Fachgebietsleiter Frechen.

Die von Hubschraubern absetz- und von einem Mann transportierbare Anlage nutzt als verfahrenstechnischen Kern die Nano-Membranfiltration in Verbindung mit einer vorgeschalteten Grobstoffabtrennung. Wesentliche Anlagenmerkmale sind:

- Äußerst einfacher Aufbau
- Erreichen von i.d.R. Badegewässerqualität des Anlagenablaufes
- Bedienbar auch von Analphabeten durch Piktogrammbeschreibung
- Fehlbedienung konstruktiv ausgeschlossen
- Leichte, robuste Ausführung

– Keine Fremdenergie, keine Chemikalien nötig
– Betriebsfertig lagerbar, daher schnellste Verfügbarkeit
– Auf Standardpalette transportierbar
– Durch Hubschrauber (ggf.) Fallschirm) im Einsatzgebiet absetzbar
– Tragbar durch eine Person
– Wiederverwendung möglich

Aufbauend auf dieser Demonstrationsanlage kann nun die serienreife Anlage entwickelt werden.

Pressemitteilung 184/06 – 15. November 2006

Vorreiterrolle im Ökolandbau in Europa - eine Uni macht mobil:
Studierende auf Werbetour in Ungarn und Rumänien

Kassel/Witzenhausen. International die Trommel rühren für den Ökologischen Landbau wollen sechs Studierende und Mitarbeiter der Universität Kassel. Sie gehören dem in Witzenhausen ansässigen Fachbereich Ökologische Agrarwissenschaften an und starten am 1. April erstmals zu einer dreiwöchigen ORGANICagriculTOUR. Ziel dieser Reise ist Ungarn und Rumänien. Zusammen mit Studierenden vor Ort werden Projekttage zur Ökologischen Landwirtschaft veranstaltet. Christian Laing (22), Student aus Witzenhausen, fasst das Ziel der Tour zusammen: Wir wollen an den dortigen Agrarfakultäten bei den Studierenden Neugierde für den Ökologischen Landbau wecken, Partnerschaften knüpfen und ausbauen, sowie Interessierte für ein Studium in Witzenhausen gewinnen.

Der Fachbereich Ökologische Agrarwissenschaften in Witzenhausen ist mit seiner Ausrichtung auf die Ökologische Landwirtschaft einzigartig in Europa. In den internationalen Masterstudiengängen ist ein höherer Anteil an ausländischen Studierenden erwünscht. Die ORGANICagriculTOUR wird mit dazu beitragen, die Studienmöglichkeiten im Bereich Ökologische Agrarwissenschaften bekannter zu machen, sind die Organisatoren der Tour überzeugt.

Für Ungarn und Rumänien ist die Ökologische Landwirtschaft von großer Bedeutung. Beide Länder befinden sich in räumlicher Nähe zu dem europaweit größten Bio-Verbrauchermarkt Deutschland. In kaum einem anderen Land steigt die Nachfrage nach biologisch erzeugten Lebensmitteln stärker. Auch der Bio-Markt in den osteuropäischen Ländern kommt in Schwung, weiß das Team. Dort seien neue Kapazitäten in Erzeugung, Verarbeitung, Zertifizierung und Vermarktung erforderlich. Eine vergleichbare Hochschulausbildung in Ökologischer Landwirtschaft fehlt vor Ort.

Ungarn ist als Ziel ausgewählt worden, weil es als typisches traditionelles Agrarland auch die größte ökologisch bewirtschaftete Fläche vorzuweisen hat. 90 Prozent der ökologisch erzeugten Produkte gingen in den Export, der größte Teil landet auf deutschen Tellern. Auch in Rumänien wollen die Studierenden aus Hessen Unterstützung leisten. Dort fristet der Ökologische Landbau ebenfalls noch ein Nischen-Dasein. Gerade in den neuen EU-Mitgliedstaaten besteht Bedarf an qualifizierten Hochschulabsolventen im Bereich Ökolandbau.

Die ORGANICagricuITOUR wird mit Hilfe der Universität Kassel sowie Spenden von Bioverbänden wie Naturland, Bioland, und Demeter, aber auch dem Ökologischen Landbau nahe stehenden Stiftungen, Institutionen und Wirtschaftsunternehmen finanziert, und soll zweimal jährlich stattfinden. Daniela Schwarz, Koordinatorin für internationale Studienangelegenheiten in Witzenhausen und Initiatorin des Projektes: Die ORGANICagricuITOUR wird uns vorerst in die Länder zwischen Ostsee, Schwarzem Meer und Mittelmeer führen. Dabei kooperieren wir nicht nur mit Universitäten, sondern auch mit Verbänden, Institutionen und Einzelpersonen aus der Ökolandbaubranche in den jeweiligen Ländern. Dass das Projekt der Uni Kassel auch im außereuropäischen Ausland auf Interesse stößt, zeigen Anfragen aus Indien und China.

Die Internetadresse: www.organic-agricultour.de

Pressemitteilung 23/07 – 14. März 2007

Uni Kassel: Klimawandel verschärft die Unterschiede zwischen Nord- und Südeuropa massiv

Brüssel/Kassel. Vor einer Verschärfung der Unterschiede zwischen Nord- und Südeuropa warnt der Mitautor des UN-Klimaberichts zu den Folgen des Klimawandels, Prof. Dr. Joseph Alcamo, Direktor des „Center for Environmental Systems Research“ von der Universität Kassel. „Die Anzeichen des Klimawandels sind auch in Europa mittlerweile deutlich sichtbar“, so Prof. Alcamo. Der Weltklima-Rat hat am 6. April in Brüssel den zweiten Teil des UN-Klimaberichts vorgestellt, der die drohenden Folgen der Erderwärmung in verschiedenen Weltregionen darstellt. Prof. Alcamo ist einer der Hauptautoren des Kapitels zu den Folgen des Klimawandels in Europa und leitete ein Team von 22 Wissenschaftlern aus 16 Ländern. In dem insgesamt 1400-seitigen Expertenbericht wurde erstmals umfassend untersucht wie sich eine Änderung des Klimas auf Pflanzen, Tiere, den Meeresspiegel, Hochwässer, Trockenheiten und den Menschen auswirkt. Während sich die wissenschaftliche Auseinandersetzung mit dem Klimawandel bisher auf die zukünftigen Auswirkungen fokussiert habe, zeige der jetzt erarbeitete Bericht, dass bereits heute Auswirkungen des Klimawandels zu beobachten sind. „Die Zukunft hat bereits begonnen“, so Prof. Alcamo, „Europa wird nicht von den Folgen des Klimawandels verschont bleiben!“

Die Zukunft hat schon begonnen- auch Europa ist betroffen

Zwar schienen die meisten der beobachtbaren Veränderungen unspektakulär – etwa das Abschmelzen der Gletscher in den Alpen, die in höhere Regionen verschobene Baumgrenze in den Bergregionen Europas sowie Veränderungen in der Ausbreitung einiger Tier- und Pflanzenarten. Einige der Auswirkungen sind sehr viel unmittelbarer, wie etwa die Hitzewelle des Jahres 2003, die in Europa für 35.000 Todesopfer verantwortlich war und die der UN-Klimabericht als „ohne historisches Vorbild“ bezeichnet. Dem Bericht zufolge wird ohne eine Verlangsamung des Klimawandels Mitteleuropa letztlich die gleiche Zahl heißer Tage erwarten können, wie es sie bereits jetzt in Südeuropa gibt. Todesursachen in Folge der Hitzewellen werden sich somit wahrscheinlich in Süd- und

Mitteleuropa erhöhen. Prof. Alcamo warnt, dass die Auswirkungen des Klimawandels zudem die Unterschiede zwischen Nord- und Südeuropa verschärfen werden. Dem Bericht der IPCC zufolge wird der Klimawandel in Nordeuropa zwar das Wachstum des Waldes fördern, in Südeuropa aber gleichzeitig durch große Waldbrände Waldflächen vernichten. Dementsprechend wird die Getreideproduktion im Norden des Kontinents steigen, während sie im Süden generell abnehmen wird. Die hohen Temperaturen werden auch zu einem Wandel im sommerlichen Tourismusgeschäft führen, hin in den Norden. Südeuropa, ohnehin für Dürren anfällig, sei einer noch gesteigerten Gefahr von Dürren, Hitzewellen und Waldbränden ausgesetzt. Innerhalb der nächsten 70 Jahre könnte die jährlich verfügbare Menge Wasser im Süden um ein Drittel abnehmen, im Norden hingegen um ein Fünftel zunehmen. Aber auch Nordeuropa wird zunehmend von den negativen Auswirkungen des Klimawandels betroffen sein – etwa durch die Zunahme von Winterüberschwemmungen, die zunehmende Zahl gefährdeter Pflanzen- und Tierarten und generell ein höheres Risiko des Auftretens von Waldschäden. Letztlich, so der Bericht, werden auch in Nordeuropa die negativen Auswirkungen des klimatischen Wandels die positiven überwiegen.

Deutschland und der Rest Mitteleuropas wird ebenfalls von diesen negativen Folgen betroffen sein, zu denen steigende Zahlen von Überschwemmungen im Inland und an der Küste gehören sowie trockenere Sommer und erhöhter Beanspruchung der Wasserressourcen. Ganz Europa sieht sich einem erhöhtem Auftreten von Überschwemmungen und einer wachsenden Anzahl gefährdeter Pflanzen- und Tierarten gegenüber. Bis 2080 könnten zwischen einem Viertel bis zur Hälfte aller europäischen Pflanzenarten bedroht, stark gefährdet oder am Rande des Aussterbens stehen, verursacht durch klimabedingten durch Stress.

Prof. Alcamo: Nicht in Panik verfallen, sondern überlegt handeln

Der Bericht biete keinen Anlass zur Panik, wie Prof. Alcamo weiter ausführt. Er zeige aber, dass es Zeit sei für ernsthafte Anstrengungen, sich dem Klimawandel in allen Aspekten des täglichen Lebens anzupassen. „Jedesmal, wenn eine neue Brücke oder eine neue Straße gebaut wird, ein Bürogebäude errichtet oder die Bebauung eines Küstenstreifens geplant wird, müssen die Auswirkungen es Klimawandels (mit) einkalkuliert werden“, fordert der Umweltexperte aus Kassel.

Kohlendioxid-Reduktion würde mehr Zeit zum Handeln schaffen

Aus den Expertenergebnissen folgt erneut die Forderung nach einer drastischen Reduktion von Treibhausgasemissionen. „Wir müssen den Klimawandel soweit wie möglich verlangsamen, indem wir drastisch den Ausstoß von Kohlendioxid und anderen Treibgasen senken. Je weniger CO2 wir in die Atmosphäre freisetzen, desto mehr Zeit haben wir, uns an die unvermeidlich steigenden Temperaturen und das feuchtere oder trockenere Klima anzupassen“, führt Prof. Alcamo aus. Wie der IPCC-Bericht deutlich aufzeigt, werden es die ärmeren nicht-europäischen Staaten sein, welche nicht wie Europa über die Kapazitäten zur Anpassung an den Klimawandel verfügen, die am stärksten von häufiger auftretenden Küstenüberschwemmungen, Hitzewellen und anderen negativen Folgen des Klimawandels betroffen sein werden. „Ich glaube,“ so Prof. Alcamo „dass Europa als einer der Hauptverursacher von CO2 eine moralische Verpflichtung hat, den bedrohten ärmeren Ländern zu helfen, indem die europäischen Treibhausgasemissionen verringert werden und dadurch der Klimawandel verlangsamt wird. Zusätzlich müssen wir die Technologien und Finanzmittel bereitstellen, um den ärmeren Ländern zu helfen, sich an den Klimawandel anzupassen, der unvermeidlich ist."

Pressemitteilung 31/07 – 12. April 2007

Unis werfen digitales Auge auf den Ackerboden
DBU fördert Sensorenforschung mit 500.000 Euro

Osnabrück/Kiel/Kassel. Regelmäßiges Pflügen kann dazu führen, dass der Boden eines Ackers abgetragen und vom Regen ausgewaschen wird. Um das zu verhindern, setzen immer mehr Landwirte auf die "Mulchsaat". Dabei wird die Saat in die - nur oberflächlich in den Boden eingearbeiteten - Pflanzenreste der letzten Ernte (Mulch) eingestreut. Jetzt entwickeln die Universitäten Kassel und Kiel sowie die Fachhochschule Kiel zusammen mit der Firma "Bodenbearbeitungsgeräte Leipzig" ein Gerät, das auf dem Feld erkennt, wie gut die Reste eingearbeitet sind und die Arbeit der Landmaschinen dementsprechend anpasst. Gefördert wird die Forschung mit rund einer halben Million Euro von der Deutschen Bundesstiftung Umwelt (DBU). Insgesamt wird das Projekt 850 000 Euro kosten.

Das Gerät sorge dafür, dass Maschinen den Boden "intelligent" bearbeiten könnten, so Prof. Oliver Hensel von der Uni Kassel. „Über die Sensoren wird es einmal mit aktuellen Infos darüber versorgt, ob der Mulch gut verteilt ist. Außerdem hat es Daten, wie etwa die Bodenart oder die Wasserverfügbarkeit, gespeichert." Aus diesen Informationen errechne das Gerät, wie tief der Boden an den einzelnen Stellen bearbeitet werden müsse. Das schütze die oberen Bodenschichten und spare außerdem Treibstoff, da die Maschinen so viel wirkungsvoller arbeiten würden.

Hensel betont außerdem, dass durch eine so präzise Bodenbearbeitung auch ein bisheriger Nachteil der Mulchsaat wett gemacht werden könne. „Wenn die Pflanzenreste nicht optimal eingearbeitet sind, gehen häufig nicht so viele Samen auf wie beim normalen Einsäen. Das ist mit dem Sensorsystem nicht mehr so." Besonders vorteilhaft an dem Sensor sei auch, dass er für kein bestimmtes Bodenbearbeitungsgerät entworfen werde, sondern die Tiefenverstellung von Maschinen aller Fabrikate ansteuern könne.

Dieser Nutzen ist auch für die DBU bedeutend gewesen, die die verschiedenen Projektpartner zusammengeführt hat. DBU-Generalsekretär Dr. Fritz Brickwedde: „Das Sensorsystem macht es möglich, dass ganz neue Produktlinien für Landmaschinenhersteller möglich sind und so die bodenschonende Mulchsaat weiter verbreitet wird."

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Tropentag 2007

International Research on Food Security,
Natural Resource Management and Rural Development

Utilisation of diversity in land use systems: Sustainable and organic approaches to meet human needs

jointly organised by the Universities of Kassel-Witzenhausen and Göttingen
October 9 - 11, 2007 in Witzenhausen

General information
The annual Conference on Tropical and Subtropical Agricultural and Natural Resource Management (TROPENTAG) is jointly organised by the universities of Bonn, Göttingen, Hohenheim and Kassel-Witzenhausen as well as by the Council for Tropical and Subtropical Research (ATSAF e.V) in co-operation with the GTZ Advisory Service on Agricultural Research for Development (BEAF).Tropentag 2007 will be held in Witzenhausen. All students, Ph.D. students, scientists, extensionists, decision makers, politicians and practical farmers, interested and engaged in Agricultural Research and Rural Development in the Tropics and Subtropics are invited to participate and to contribute.

Target of the Conference
Meeting, exchange of knowledge and experience and interdisciplinary, scientific discussions on global challenges - to balance the production of sufficient, high quality food for an ever increasing world population.

Plenary Session
Tomorrow's world should not be worse than today's! Sustainability can only be achieved by situation-conform traditional and/or new technologies in agriculture and thorough and efficient utilisation of scarce resources. Crucial is also to include the political, social and economic environment.Invited international speakers will present their view, policy, philosophy and recommendations.

Special Session
On the occasion of this conference a special plenary session will be devoted to the presentation of the **"Hans H. Ruthenberg-Graduate-Award"** by the "Vater and Sohn Eiselen Stiftung", Ulm.

Oral and poster presentations
Six major topics have been formulated by the organisers of the Tropentag 2007 as focal points to be addressed in oral presentations and guided poster sessions:
- Diversity of land use and livelihood systems in the face of global change
- Towards the millennium development goals: Innovation and adoption in agriculture and forestry
- Resource use efficiency and diversity in agro-ecosystems
- Ecosystem services in forest and agrarian landscapes
- Current advances in analysis and modelling techniques
- Food production, food quality and food safety.

Tropentag 2007 will be organised in six parallel groups according to these topics. Each group consists of five sessions. Every topic will be introduced by an invited keynote lecture. Each session will consist of four original papers. Posters contributing to the different topics will be introduced in parallel guided poster sessions.

Further Information: http://www.tropentag.de, E-Mail: info@tropentag.de

Notes to authors

The Journal of Agriculture in the Tropics and Subtropics publishes papers and short communications dealing with original research in the fields of rural economy and farm management, plant production, soil science, animal nutrition and animal husbandry, veterinary hygiene and protection against epidemics, forestry and forest economy.
The sole responsibility for the contents rests with the author. The papers must not have been submitted elsewhere for publication. If accepted, they may not be published elsewhere without the permission of the editors.
Manuscripts are accepted in German, English, French, and Spanish. Papers may not be published in the order of receipt, those that require minor amendments, only are likely to appear earlier. Authors are advised to retain one copy of the manuscript themselves as the editors cannot accept any responsibility for damage or loss of manuscripts.

1. *Contents of the manuscripts*

Findings should be presented as brief as possible. Publication of a paper in consecutive parts will be considered in exceptional cases.
The following set-up is recommended:
The introduction should be as brief as possible and should concentrate on the main topics of the paper. Reference should be made to recent and important literature on the subject, only.
Materials used and methods applied should be explained briefly. Well-known or established methods and procedures should not be described. New or important methods should be explained. With all its brevity, this part should enable the reader to assess the findings adequately.
Tables and Figures should be used to effectively present the results. Explanations and other remarks on the results can be included in the text.
Discussion of results should also refer to relevant literature on the topic and lead to clear conclusions. Recommendations with respect to further research needed on the respective subject will increase the value of the paper.
The summary should concentrate on the main results and conclusions to highlight the author's contribution. It should be suitable for information storage and retrieval.

2. *Form of the manuscripts*

Manuscripts should be typed double-spaced with a wide margin, preferable on disk.
Documents should be submitted as standard word processing formats: OpenDocument Format (OpenOffice.org .odf), LaTeX or Microsoft Word (97-2003 .doc). Alternatively, the manuscript can be submitted as a simple text/rtf file together with a printed version or PDF file of the original format.

Please do not use automated or manual hyphenation.
Title, headings and references (names of authors) should not be in capitals.
Tables and figures should be attached at the end of the document or separately.
The preferred position for the insertion of tables and figures should be marked on the margin of the text.

The manuscript should not be longer than 15 typed pages including tables, figures and references.
The title of the paper is followed by the name(s) and address(es) of the author(s).
The abstract should be followed by a list of keywords (up to eight).
For each paper, a summary must be submitted in the same language (not more than 20 lines) and in English, if the paper is written in an other language.

Tables should not be prepared with blanks and should fit on a DIN A5 page
(max. width: 12cm (landscape: 18.5cm) with a minimum font-size of 7pt.).
All tables should have captions and should be numbered consecutively.

Figures should be black&white/greyscaled and suitable for reproduction (if possible, vector formats: svg or postscript). Photos should be high-gloss prints of good contrast, maximum size 13 by 18 cm, line drawings with Chinese ink on white or transparent paper. All figures should be numbered consecutively. A separate list of captions for illustrations has to be added.

S.I. (System International) units have to be used throughout.
References in the text should be made by the name of the author and the year.
Each paper should have an alphabetical list of references giving name and abbreviated first name of the author(s), title of the paper, name of the journal, number of the volume, year, page numbers; for books: title, place of publication, and year.
On publication, each author will receive two copy of the Journal

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