Creating awareness among decision makers on land degradation and sustainable land management – *a Farm System Analysis for the development of a computer game, in the Usambara Mountains of Tanzania*

M. A. Schoolenberg[1]

[1]YPARD Europe, part of the YPARD Global coordination unit; hosted by GFAR Secretariat, c/o FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy; machteld.schoolenberg@gmail.com

ABSTRACT

Land degradation is an increasing problem for smallholder farmers in the Usambara Mountains of Tanzania. A lot of research has already been done, but there lacks communication with district level policy makers. With the results of this study a computer game was developed in order to create awareness among policy makers. The game should explain farmers' main issues in a fast and comprehensible manner. For this, the local farming system and farmers' critical decision moments and investment behaviour were examined. Also, a farming system analysis was conducted, based on case-study research.

Results indicate, firstly that most farmers keep savings, - e.g. stocked goods, livestock – increasing their coping capacity for low market prices. Secondly, in case of conflict, illness or death, farmers' social relations play a crucial role. And thirdly, as they cultivate both staple and cash crops, they are relatively resilient to natural disasters, pests and diseases. It also became clear, however, that the implementation of soil conservation techniques was highly variable. Farmers seem unconvinced of the possible benefits of these measures. The influence of policy makers on this proved to be limited: incentives and regulations do not extent beyond the main market points, are not well enough adapted to farmers' capital and meet little acceptance. Therefore, the game needed to show farmers' resilience as well as their limitations in order to give a clear message to policy makers. A policy maker workshop should give room for discussion on the topics addressed in this computer game.

INTRODUCTION

The degradation of arable land has been an increasing problem on smallholder farmer communities such as can be found in the Lushoto District, Usambara Mountains in Tanzania. Here, soil erosion by runoff water is the main cause of the degradation of upslope fields that are often characterised by steep slopes. Although many soil conservation techniques have been introduced in the area, the acceptation and wide implementation of these techniques by local communities is limited and land degradation (LD) is increasingly destructive regarding agricultural production. Therefore, more attention for the problem is needed (Wickama & Nyanga, 2009; García Herrero, 2010).

A lot of research on LD and sustainable land management (SLM) has been done, trying to involve institutes and NGOs to improve the situation in the area. Even so, there lacks communication between these scientific studies and policy makers, especially on district level (pers. comm. Dr Aad Kessler, September 2010). The latter is an important group to involve in the land management issues of the Usambara Mountains as they can influence land conservation policies and represent for instance the governmental, international or environmental institutes among the involved stakeholders.

Part of the communication gap comes forth from the working schedule of these policy makers that leaves little room studying research reports (pers. comm. AW Nyanga, 03-12-2010). Therefore, a research project of the Land Degradation and Development group of Wageningen University pitched the idea of using innovative communication tools [among which a computer game] in a policy maker workshop to bridge this communication gap. This project, of which this study is part of, consists of four PhDs who work on physical, sociological and economical aspects of SLM in the East African Highlands, and a post-doc researcher who works on the possibilities of implementation and policy adaptations regarding SLM. WOTRO supported their idea, thus giving me the opportunity to make this game. To get clarify the following paper; the main purpose of the project's workshop will be to trigger discussion and brainstorm sessions with policy makers on sustainable land management policy. Thus, the game should serve this purpose. As this study was done to deliver input for the game, the study objective was to analyse farmer's livelihoods in the Usambara Mountains and get insight in their decision moments. This information will provide the input needed to develop a game that delivers a good overview of farmers' constraints and options regarding agriculture in the region. In the context of the workshop the idea is that this will thus trigger the discussion that was aimed for.

The workshop and the game

During the policy maker workshop, research partners, e.g. the African Highlands Initiative and Wageningen University, will attempt to make policy makers aware of the problems in the Usambara Mountains. The communication tools used in this workshop have to be chosen carefully: they should be able to catch the attention quickly and clearly explain the main issues faced by farmers in a short but powerful manner. One of the

potential tools that incorporate these possibilities would be a short computer game.

Both statistical research and literature reviews have shown over the last decades that gaming not only has significant learning potential, but also increases the efficiency in instruction time (van Eck, 2006). Some aspects of game based learning were found to give an added value to learning, such as (van Eck, 2006): *situated cognition* (learning is already applied within a certain context) and *cognitive disequilibrium* (learning through the assimilation of new information into existing categories, and through the accommodation of new information, by adapting these existing categories). Furthermore, policy makers are adults, who learn best by doing. The computer game made according to this thesis provides this (inter) active learning environment.

It is important to keep in mind, though, that although games have the potential to provide a highly effective learning environment, their implantation is crucial in the actualisation of this promise! Offering the player an engaging 'world', while being able to effectively send out a certain message or information, is the real challenge: neither the game itself, nor the educational value should be neglected (van Eck, 2006; Graesser et al. 2008).

In order to reach this goal, the ambition is to provide a game that does justice to both the research that has been done in the area and to the reality of farmers' daily lives. On the other hand, the game cannot be too complex, as to deliver a strong message, should be inviting to busy, inexperienced players.

METHODS

To gather input data for the game, a farming system analysis was done in order to understand the choices a farmer faces regarding his land management. The analysis was based on case-study research, which focuses on the different aspects of Farming System Research (FSR). The FSR approach focuses on the farming system as a whole, and takes into account various aspects such as cultivation characteristics, livestock and labour availability (Nyanga, 1998, Gomiero et al., 2006). Additionally, the case studies addressed farmers' investment and spending behaviour and their coping strategies at critical decision moments (Willock et al. 1999; Risbey et al. 1999). The case studies consisted of interviews with farmers, shop owners and market employees, and field observations.

The case study results were interlinked with information on farmers' livelihoods, and the overview was translated as input for the computer game. Following is an overview of specific methods for different study objectives.

To gain insight into farmers' choices in land management

First, a general overview on the farming practices was made, which formed the basis for the development of a questionnaire in which farmers' choices in land management were specifically addressed. Literature and expert communications were used to form this general impression. The questionnaire was based on a series of positive hypotheses, addressing farming system and household characteristics.

The questionnaires were first pre-tested in Soni, Soni ward, and subsequently improved and conducted with farmers in the village Shashui, Soni ward.

Insight in the critical decision moments that farmers face for socio-economic issues and physical phenomena

Literature and expert communications were used to select the 'events' occurring in the game. The focus was on physical phenomena and socio-economic contexts that have significant impact on the agricultural practices of farmers, i.e. forced them to adjust their land management practices or caused severe damage to their existing farming system.

Insight in the coping strategies and investment behaviour of farmers at critical decision moments

Case study research was done with farmers in the village Shashui, in Soni ward. By interviewing and field observation, detailed information was gathered on the critical decision moments they face in their daily, agricultural life: how they cope with these moments and how it influences their agricultural practices and/or investment behaviour.

The analysis was based on case study research. A set of eight selected case study farmer households were interviewed to guarantee sufficient data for analysis. The farmers selected themselves, based on a combination of both this research and their own criteria. The selection criteria of this research were explained in a village meeting, after which the Village Executive Officer (VEO) coordinated the villagers to select among themselves the most suitable farmers, motivated to cooperate in this study.

Translation of results into rules and input data for the game

According to Joram Rafalowicz (2011) designing a game can be divided in different phases. Phase I is to define the general approach of the game, starting with 1) describing the game concept, in which the target group and general goal is explained, and 2) stating the specific requirements, regarding both the technical and graphical demands, and the general requirements, e.g. game length, manual and scores. Phase I should be completed before the actual data collection in the field.

Phase II is to develop a functional design describing what the user should be able to do in the game and what the results are of these actions.

In Phase III a flowchart is made showing all the screens that appear in the game. This flowchart is extrapolated into wireframes showing detailed information on its content. With these products as basis of the game, a list can be created of all detailed information that needs to be collected. Literature research was done to gather information that was not obtained during the field work. In addition, a second questionnaire with the farmers was done to collect in-depth information. Shop owners and the market facilitation manager of Soni market were interviewed to gather detailed information on crop and seed prices.

To complete this last objective, all data was combined and used to select the ultimate features and rules of the game.

Crop	Seed/ha	Unit	Price (Tsh) / unit	Price / ha (Tsh)	Price / grid
Tomato	500	gr	100	50000	5000
Maize	15	kg	3500	52500	5250
Beans	100	kg	1200	120000	12000
Coffee	1900	plant	300	570000	57000
Sweet pepper	300	gr	140	42000	4200

Table 1 - Summary of average crop input values (seed prices and net values per hectare; grid = 0.1 ha)

RESULTS

The results presented here are the combined results of the first three objectives of this study [with data collected in the field and from literature] and the translation afterwards into input characteristics for the computer game. Although this representation of results might seem less academic than usually the case, that is exactly the point of this study: as the final purpose was to make a realistic computer game, data collected has merely the point of giving insight in the situation in a qualitative manner. Exact figures sometimes had to be altered [within realistic boundaries] to create a game which represents the reality of the study area.

As there are always factors that had to be simplified in the game, the result was that other factors became relatively more important. Thus, following are the main features of the game:

- The player will have a field of 1 ha on which (s)he will be able to cultivate the following: staple crops [maize, beans], important vegetables [tomato, sweet potato] and coffee, similar to the high variety in crops cultivated in the area.
- Crops can be cultivated 0.1 ha, in order to allow multi-cropping as an option. For cultivation, seeds can be bought each year [except for coffee, being a perennial crop], for varying prices per year. In table 1, the average values from which the ranging prices were determined are shown. Note that these prices were used in the first game version, before testing, and might be altered in a later version.
- At the end of each playing turn, which represents one year, the yearly income will be calculated with the return rate of these cultivated crops.
- The player will be able to buy cows, goats and chicken as investment, but more importantly because their produce provides a source of income.
- The household size starts at 4, with possibility to grow to 7 household members. In that way the household size is representative according to the average household sizes from literate and field data. Household members consist of two parents and an additional amount of children.
- As for household expenses and daily living costs, it was assumed that parents consume twice as much as children (taken into account that older children leave home, and the only the very young ones eat at home instead of school).
- Treatment of Malaria will be an annual option in the game, as the disease proved to be common and a returning problem to families in the region.
- Small children can be send to primary school, which they have to attend for 7 years, as in reality. After finishing, they can attend secondary (boarding) school in which case they leave their homes. Although school fees are paid by the government in Tanzania, costs were taken in to account as in practice, parents are to pay for all kinds of additional costs, e.g. construction works, food, security, books. Secondary education can take up 4 years (Form 1 to 4), followed by a final exam at the end of Form 4. If passed with a certain level of high grades, students can continue with Form 5 and 6 for more advanced learners. In the game, the children of the starting situation already followed 2 years of primary education. After finishing secondary school the children leave the family forever send their family money as support.
- Different forms of labour were identified. To translate those into the game, the following types of labour will be used: 1) Off-farm labour; 2&3) On-farm (hired) labour: the option is either to work for someone else or hire someone to work for you; 4) Hire a field. About ½ ha per year, which will increase your production. Labour availability is also used as a limiting factor in the game. The aim was to create an index that could limit activities not only with money but also with the available labour within the household. A grown up adult accounts for 100% labour, a child (5 - 10 years) for 25% and an older child for 75% (10-20 years). The total amount of these percentages is added up for the household labour availability. For example, a household consisting of a couple with 2 young children has a labour availability of 250%. Children who attend primary or secondary school do not contribute labour. Labour percentages can be spend on the cultivation of crops, on- and off-farm jobs, keeping livestock and constructing and maintaining terraces and/or grass strips.

Figure 1 – The main playing field, 'African Highland Farmer'

- According to Tenge (2005), soil erosion causes a production decline in maize and beans of 2% and 1% per year respectively. As the game covers a period of 15 years a soil production decline of 4% was chosen to emphasize the effect of soil degradation on farmers' income within the time span of this game. Tenge also mentioned that maize and beans production rates increase with an average of 60% with bench terraces and 15% with grass strips. As terraces are highly effective on the slope category of the game and grass strips somewhat less, construction of these measures increases the soil productivity with 4% (terraces) and 2% (grass strips) per year. Taking into account the information from Tenge (2005), the maximum increase of productivity is 60% and 15% for terraces and grass strips respectively.

At the end of each year, the player will be presented with a summary of the costs and expenses, but an annual 'event' will also be taken into account in the calculations. These annual events, present the player with a situation resulting in a positive or negative impact on his/her farming system. The idea behind this is to give the player [the policy maker] more insight in the risks farmers' can face and the tools need and have [e.g. savings] to prepare for and cope with these situations. The impact of events is difficult to determine, yet necessary to quantify in order to show them in the game. In general farmers' coping strategies on these decision moments were to fall back on either saved goods/capital, spread risk [e.g. decreasing the impact of a single problem] and support from their social network. The following decision moments were found to be important in the region:

Bio-physical events:

- Little research has been done on yield losses by drought in comparable areas. Barron et al (2003) studied it for maize production in Same, Tanzania and based on their study, an average yield reduction of about 25% for maize was found, should a drought occur. This will be used for all crops in the first version of the game.
- For crop loss due to pests and diseases, a reduction in yield of 30% based will be used (Abate and Ampofo, 1996; Abate et al., 2000). All the crops have the option of being sprayed, which will cost 4500 Tshs/ha.
- Gully formation as result of intense rain storm results in a crop loss of 20%. This was based on the fact that farmers indicated that the effects of such events are negative, washing away part of their crops, but not as severe as crop diseases and droughts.

Socio-economic events:

- Conflicts with neighbours are normally resolved within the community. It is important for farmers to solve these issues fast, as neighbours, friends and family form a crucial social network that they can rely on in emergency situations.
  Conflicts are usually resolved but as this might take up some time, in the game it will not be possible to hire or get hired as on-farm labour force the year following the conflict.
- In situations when market prices for products are very low (i.e. less income), this has a negative impact on farmers' livelihoods. Farmers, however, proved to be resilient for these situations as they reduce their impact by cultivating multiple crops, selling other goods at the market, or by finding a temporary off farm job. In the game, this price drop will decrease the total yield return with 10%.
- The contrary story is applicable when daily living costs will drop. The impact of this is small, as prices rarely drop all at the same time. Should the price of a product drop, farmers will spend the normal amount and keep the extras in stock for difficult times. In the game, a decrease of 10% of the living costs will be used.
- During the game, farmers can fall seriously ill with Malaria. This is in addition to the annual Malaria treatment a player can choose, as chances are high that once in several years a household member falls more seriously ill than usual from Malaria and has to be hospitalized.

Altogether, these input characteristics were matched with the functional design of the game, resulting in the first version. As this is rather abstract without having played the game itself, figure 2 shows the interaction design presenting the different 'screens' with options and information, i.e. a basic storyline of the game.

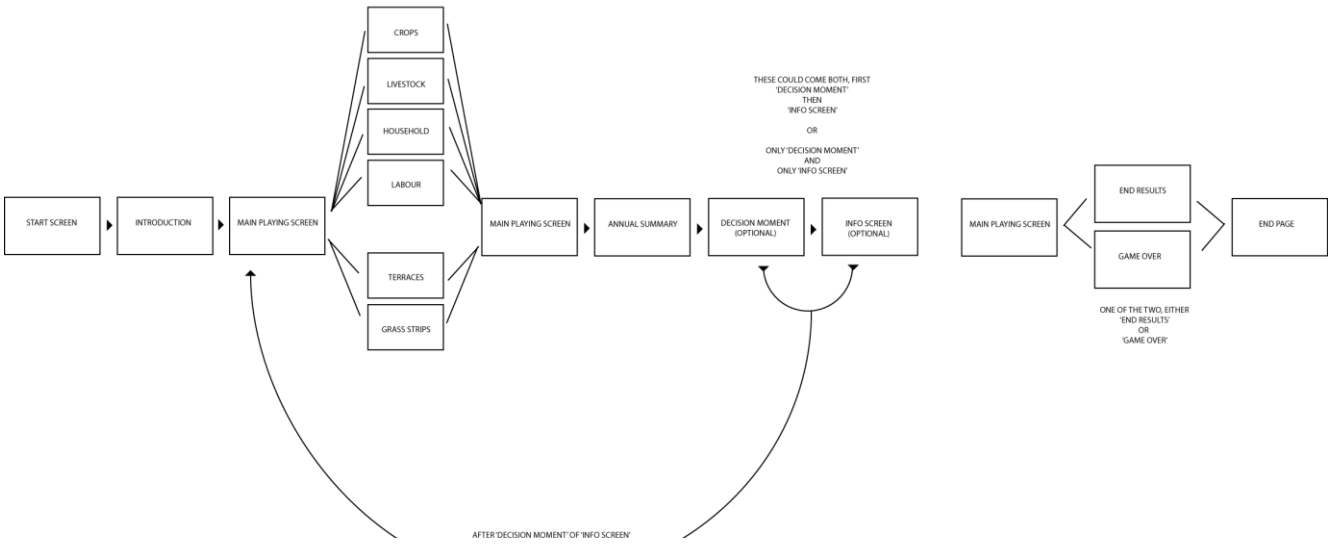

Figure 2 - Interactive Design of African Highland Farmer game

CONCLUSIONS

For concluding this research, it is good to go back to its initial goal *"to develop a computer game based on choices in land management and critical decision moments for farmers and policy makers"*.

Farmers in Shashui are smallholders cultivating a mix between staple and cash crops. Their farming tools and tenure techniques are simple and traditional. Possession of livestock and poultry is common, although amounts vary widely. Their implementation of SLM techniques also varies, i.e. some farmers construct terraces on (some of their) plots while others apply no SLM techniques at all. It seems that many farmers lack some knowledge on the possible benefits of these measures.

Resulting from the multiple cropping system, farmers have a relatively high resilience to pests, diseases and droughts. Losses due to pests and diseases are partly compensated because of the multiplicity of crops, and, though in lesser extent, the same can be said in case of drought. With regard to the latter, farmers usually wait for the rains to start before planting. In order to cope with this delay, farmers have savings in the form of stocked goods, but also in livestock or cash.

For the socio-economic 'events', multiple cropping increases the coping capacity against low market prices as well. Emergency situations are resolved within the social networks.

However, although the impact of runoff water and heavy rain varies with the slope of the field and the specific cropping pattern of the farmers, sustainable land management techniques prove important solutions [on the short and long term] to cope with this. Additionally, although farmers are relatively resilient to separate events [drought, pests etc.], their social and capital security systems have too little capacity to deal with several of such events at once. For example, if a farmer loses part of his crops to a drought, he/she will be able to cope with that. However, should a flood of runoff water wash away the remaining crops, their possible coping strategies will not always be sufficient.

The influence of the district authorities and extension workers is limited: new laws and regulations do not extent to the villages beyond the main roads and market points, and initiatives are not well enough adapted to farmers' capital and meet little acceptance.

Taking all the above into account, the game should show the resilience as well as the limitations of the farmers coping capacities in order to give a clear message to policy makers, whose influence on farmers' livelihoods is now more or less invisible. The game wants to show that in order to be relatively successful as a farmer on the short and long term, it is important to implement not just some but almost all coping strategies [livestock, multi-cropping, SLM techniques etc]. It is important not only to deliver such a message but also to give a heads-up towards actual policy adaptations and actions. The discussion in the policy maker workshop following from the launch of this game with the policy makers should be a tool to form the basis for these actions.

Unfortunately, the workshop has not been held yet, so I cannot make any statements about the success of this computer game and the policy maker workshop. Will it really trigger the discussion to adapt policy to a supportive system for local farmers and increase the attention and strategy of decision makers' extension work and incentives? Let us hope it will, if not, at least making this game was one more experience towards an innovative approach in integrated research & policy recommendations.

DISCUSSION

Especially after the completion of an unorthodox study which aim is not to test a certain hypothesis but rather to provide a product, in this case the input needed for the development of a game, there are always debatable aspects about the methodology and execution of the research that are important to be mentioned.

Difficult in this particular research was the quality of the literature that was used.

- Although most of the literature was published after 2000, some date back to 1988, probably including outdated data.
- On some topics literature was scarce: for example there was little to be found on the impact of pests and diseases in Tanzania/East Africa on the yields of the specific crops selected for the game. In this case, only data on maize and bean yields was found and it had to be assumed that the differences with cash crops were irrelevant for the game.
- When searching for information on Usambara Mountains specifically, most available studies were on catchment level, but did not link to the (West-)Usambara mountains as a whole, or compared different study sites.
- Some data was totally absent in literature. Especially details on the process and pricing of coffee cultivation, and data on the amount labour days farmers annually spend on their farm, e.g. for crop cultivation and livestock.

Some of these topics were addressed in the field study or with personal communications instead, but other data could not be obtained at all.

Another issue to discuss is the methodological approach. The benefits of case study research are that it provides, from a representative selection of respondents, in-depth data of specific topics without being too time consuming. Quantitative data, e.g. average plot size, however, would be more reliable from statistical analysis based on a significant sample size of respondents.

As researcher for this study the most challenging part of was to balance between the development of the game and the fulfilment of an academic research, not because the two exclude each other but because the requirements of these products lie in an opposite scope. For the game it is important that the input information is simplified, generalised and/or combined in order to keep the player focussed on the main idea behind the game. Contrary, for academic research the aim is to make an in-depth analysis of the gathered data. In this thesis, the aim was to do both, starting with an analysis of the data and to narrow down from here onwards to simplified game input.

RECOMMENDATIONS

If a similar game would be developed, it would be more than sensible to start this after the current PhD research in the area is finished. These would give useful insights in the farming systems and SLM practices in the area. In this thesis, while the game process was already started, additional literature research had to be done in a later stage to complete the game.

For policy makers, as was found in the conclusion, it is important to think about the adoption behaviour of farmers with

regard to SLM practices. These practices are being adopted in some parts of the region, but the intensity varies widely. The most credible explanation for this low and varying adoption rate is that farmers do not always see the urge of conserving their land, either because they are unaware of the effects of soil erosion on their production, or because they do not believe in the result of soil erosion, as they usually have several different plots smoothing out the effects soil loss on just some of them.

As the involvement and adoption of other incentives, such as subsidized, improved maize seeds, is low as well, it seems that policy makers and extension makers need a different strategy to reach out to the farmers altogether. My opinion is that from here on the project should focus on developing such a change in strategy. Apart from starting the discussion, brought up by this game, the organisers of the workshop should bring forth the idea of changing strategy and approach during these workshop debates.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Dr Aad Kessler, who started with the idea of making a game and supervised me during the process. Also, I would like to thank Anna Ngyanga, Juma Wickama, Martin Clement and the farmers and local authorities in Shashui and Soni for helping me with my field work in Tanzania. For working together in making this game a reality, I thank Hannah Kay Piché [graphic design] and Joram Rafalowicz of WeirdBeard Games [technical design]. Lastly, I thank the LDD Chair group [WUR], the African Highland Initiative and Lushoto District Authorities for making this research possible.

REFERENCES

Abate, T and Ampofo, JKO. 1996. *"Insect pests of beans in Africa: their ecology and Management"*. Annual Reviews Entomology, number 41. Annual Reviews Inc.

Abate, T; Huis, A van and Ampofo, JKO. 2000. *"Pest management strategies in traditional agriculture: an African perspective".* Annual Reviews Entomology, number 45. Annual Reviews Inc.

Barron, J; Rockström, J; Gichuki, F and Hatibu, N. 2003. *"Dry spell analysis and maize yields for two semi-arid locations in east Africa".* Agricultural and Forest Meteorology, no. 117.

Eck, R van. 2006. *"Digital Game-Based Learning: It's Not Just the Digital Natives Who Are Restless…."*. in EDUCAUSE Review, vol. 41, no. 2.

García Herrero, L. 2010. *"Biophysical & Social features in Sustainable Land Management in Highlands, Shashui Watershed"*. MSc Thesis with Land Degradation and Development Group, Earth System Science Group and Integrated Water Management Team, Wageningen University, the Netherlands

Gomiero, T; Giampietro, M and Mayumi, K. 2006. *"Facing complexity on agro-ecosystems: a new approach to farming system analysis*", Int. J. Agricultural Resources, Governance and Ecology, Vol. 5, Nos. 2/3, pp.116–144.

Graesser, A; Chipman, P; Leeming, F and Biedenbach, S. 2009. *"Deep Learning and Emotion in Serious Games"* In (book): "Serious games: mechanisms and effects". Edited by Rinerfeld, U; Cody, M and Voderer, P. Published by Routledge, 5 August 1999

Nyanga, AW. 1998. *"The introduction of a labour saving technology: an evaluation of the process used and its impact on social relations, including gender"*. MSc thesis for Management of Agricultural Knowledge Systems, Wageningen University, the Netherlands.

Rafalowicz, J. 2012. *"Guidelines to Game Design and Development".* Unpublished, for personal use. WeirdBeard Games, Amsterdam, the Netherlands

Risbey, J; Kandlikar, M; Dowlatabadi, H and Graetz, D. 1999. *"Scale, context, and decision making in agricultural adaptation to climate variability and change"*. In: Mitigation and Adaptation Strategies for Global Change 4: 137–165, Kluwer Academic Publishers, Belgium.

Tenge AJM. 2005. *"Participatory appraisal for farm-level soil and water conservation planning in West Usambara highlands, Tanzania".* Doctoral Thesis, Tropical Resource Management Papers, no. 63, Wageningen University and Research Centre (WUR), The Netherlands

Wickama, J and Nyanga, A. 2009. *"Reconnaissance assessment of sustainable land management measures in the western Usambara Highlands – Lushoto, Tanzania."* Wageningen University and Utrecht University, the Netherlands.

Willock, J; Deary, IJ; Edwards-Jones G; Gibson, GJ; McGregor, MJ; Sutherland, A; Dent, JB; Morgan, O and Grieve, R. 1999. *"The Role of Attitudes and Objectives in Farmer Decision Making: Business and Environmentally Oriented Behaviour in Scotland".* Journal of Agricultura1 Economics - Vol. 50, No. 2.