

Development and adjustment of sustainability indicators to evaluate outgrower schemes in bioenergy production: The case of Tanzania.

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Abstract: Bioenergy production is rapidly increasing on a global scale, whereby the estimated effects are still under discussion in scientific and political circles. Discussions on potentially negative effects such as soil degradation and unclear land tenure increase the pressure on the production system "intensive monocultures". Especially in the context of Tanzania, outgrower schemes, which might avoid most of the potentially negative effects, promise to be more sustainable. Therefore, outgrower systems seem to be theoretically favourable and well accepted by producers and decision makers. To assess the actual effects of out grower schemes on local, regional and national scales a group of researcher of ZALF undertakes a stakeholder process to develop a set of sustainability indicators for small scale farming of bioenergy crops. Preliminary results from a three months research period in Tanzania will be presented in this paper with special attention to the methodological framework. Finally, challenges and potential solutions will be discussed together with local experts.

Keywords: biofuel, rural development, *Jatropha*, outgrower schemes, sustainability impact assessment, indicators

2. Introduction

At the beginning of the 21st century, a number of massive global challenges such as climate change and a depletion of the fossil energy resources are emerging.

One option to partly solve these issues is the substitution of fossil fuel consumption with alternative fuels, generated out of biomass – the so-called biofuels¹. These hold, in theory, the potential to combine positive effects such as a climate neutral transportation sector which is additionally not increasing the depletion of fossil fuel reserves with the creation of jobs in rural and underdeveloped areas and the (re)claiming of former unproductive lands.

On the global scale, currently three different alternative biofuel consumption pathways of the so-called first generation can be distinguished: The first one is the direct use of purified natural oils, whereby these can be separated into animal oils and fats² and straight vegetable oil (SVOs). In a process called transesterification, which is based upon a blending of purged natural oils with alcohol to trigger the precipitation of the by-product glycerine, these natural oils can be transformed into biodiesel – the second alternative. The refined biodiesel holds a number of advantages to straight vegetable oil (SVO) such as higher viscosity allowing a

¹ There is an ongoing discussion about the correct titling for fuels produced out of biomass. The term "biofuels" is, although widely spread, challenged by its critics as it carries (from their point of view wrongly) the "positive" connotation "bio" (cf. e.g. ABN 2007). In the following, the term "biofuels" will be used out of practical reasons.

² Which will, as they represent a minor share of the overall potential, not be discussed further in this article

direct blending of fossil diesel with biodiesel without necessary pre-heating (Rutz 2008). Alternatively, bioethanol – third option - can be used as substitute for gasoline. It is produced by, if necessary, enzymatic cracking of starchy plant components to glucose and a subsequent fermentation to ethanol (Senn 2001). The biggest markets for this emerging industry, the transportation sector in developed or emerging countries, is currently mainly supplied by the US and Brazil in case of bioethanol and by the European Union in case of biodiesel (UNEP 2008, p. 34).

Until now, the production of biofuels is mainly taking place in large scale, highly intensive monocultural operations. This production system has many economical based advantages, especially its high productivity and favourable economies of scale. Brazil's position as one of the leading producer of bioethanol, for example, is, among other reasons, mainly based upon the fact that in states like São Paulo wide spread monocultural bioethanol operations can take place. This in connection with a long experience in related technological development activities as well as governmental support (cf. e.g. Hall 2009) is very much contributing towards comparably low production prices. In this context it needs nevertheless to be mentioned that the, for this production system, very favourable although highly unequal land distribution in Brazil is contributing to these economies of scale.

On the other hand large-scale operations are more likely to cause negative effects upon ecological and social parameters due to e.g. the utilisation of pesticides and fertilizers or struggles about land access (cf. e.g. von Braun 2009). Especially the topic of land rights rose great concerns in various regions in Africa and South East Asia, as the displacement of marginal groups from areas dedicated to large scale biofuel production is a serious risk for the social sustainability of these production systems (cf. e.g. Cotula 2008). In Tanzania, for example, small scale overlapping and mostly not institutionalised land ownership patterns are representing a major challenge for monocultural biofuel investments. This is especially due to the fact that, in difference to Brazil where the "latifundistas" can date their ownership back even until the times of colonial rule, land allocation by foreign investors is a very recent phenomenon. To avoid negative side-effects of high intensive and monocultural bioenergy crop production, a trend towards decentralised small scale production systems can be observed as they generally hold the potential to maximise social and economic benefits within a countries frontiers. Apart from the non-existing negative effects, these systems combine a number of positive effects such as lower costs for the investors (no land purchase) and a potential bioenergy crop implementation into already existing agricultural practices.

In the BMZ financed project Better-iS³ is the project leader ZALF⁴ therefore focussing at a sustainability impact assessment (SIA) of the production and processing of oil bearing crops, mainly produced in small scale agriculture. In addition to the export of biofuels for the outlined global markets does ZALF also analyse the potential optimisation of local value chains, be it in the context of outgrower schemes⁵, a specific form of contract farming, or in the context of local consumption of SVOs. Latter includes a wide range of possible

³ Better-iS: **B**iofuels **E**valuation for **T**anzanian **T**echnological **E**fficiency using **R**enewables – integrated **S**trategy

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⁵ An outgrower scheme is one form of contract farming and is characterised as being "much used in developing countries for crops such as bananas, palm oil, rubber and sugar, with a central processing facility surrounded by farmers who produce, on their own land, under contract. The processor generally provides inputs and technical assistance to growers, and guarantees the purchase of their crop (if it meets standards)" (UNCTAD 2002, p. 10-11)

applications such as decentralised electricity production (UNDP 2004) or extended value creation via e.g. soap production. In any case, it needs to be proven that the decentralised production of biofuel crops is able to positively influence the livelihoods of the affected villagers before any action should be taken to promote this system.

To define the facets of sustainability important for the local value chains in the main case study village Tandai in the eastern foothills of the Uluguru Mountains in Morogoro/Tanzania, regional and local experts and practitioners participated in two, several days lasting Better-iS workshops at the Sokoine University of Agriculture (SUA) and in the village itself. The developed results were fed into a questionnaire which was subsequently used in a two month data collection period, covering over 300 households in the case study village. Relevant outcomes are in the process of being adjusted in accordance with the criteria set to enable the ZALF team to estimate the sustainability of the current agricultural practices on the one hand and the sustainability of potential changes mainly due to bioenergy production on the other.

In terms of bioenergy crops does the Better-iS project mainly focus upon value chains including *Jatropha curcas* and oil palm - with other words on potential biodiesel value chains analysis (including the direct use of SVOs). Additionally, the production of traditional biofuels in form of woodfuel and charcoal is assessed to be able to compare the introduction of new forms of bioenergy with already existing ones. Charcoal is the by far biggest source of household energy - especially in urban areas - and expected to increase in the coming years (Worldbank 2009). These traditional forms of bioenergy are taken into account as they provide a baseline for the scenario analyses. To anticipate further development, scenarios will be separated into "business as usual" on the one hand and "efficiency increased" via the usage of e.g. efficient cooking stoves on the other.

Main reason for the exclusion of bioethanol from the study is that simply enough no bioethanol production currently exists in Tanzania. Although a number of recent projects were explicitly focussing upon bioethanol production from sugarcane, most of them withdrew from the country since the emergence of the global financial crisis and a growing scepticism in the Tanzanian civil society (cf. e.g. Sulle 2009, p. 29).

A commonly cited example for this process is the Swedish company SEKAB Tanzania Ltd. which aimed at growing sugarcane on 400.000 hectare in the Rufiji Delta, south of Dar es Salaam. This project created serious political struggles in Tanzania as well as in Sweden, as the reliability of a conducted environmental impact assessment was hardly questioned. Additionally, Scandinavian development aid support was sought for this, in the eyes of the public, questionable project (Robnertz 2009, Benjaminsen 2009). As consequence of incidences like this did the Tanzanian government announce in October 2009 a Moratorium for land allocation for future large scale biofuel operations until further notice (Mande 2009).

The choice for *Jatropha* and palm oil was made as both plants are already produced with the purpose of energy production in Tanzania in outgrower schemes. In the case of *Jatropha*, two companies, PROKON Renewable Energy Ltd. and Diligent Tanzania Limited are already producing *Jatropha* oil. Palm oil, in comparison, is produced by FELISA, an outgrower based company located in Kigoma in the west of Tanzania. It is planned to involve these companies in later stages of the research process.

3. Case study area: Kinole Ward and the village of Tandai

Topography, vegetation, soils and climate

As shown in figure 1 Kinole Ward borders partly at the Uluguru North Forest Reserve (FR) of the Uluguru mountains which dominate with several steep high peaks the landscape. The topography ranges from about 600 m on the mountain foothills to the highest peak (2156 m) at Bondwa. Some areas of the Forest Reserves (FRs) are inaccessible due to steep rocky outcrops. With the exception of latter are the Uluguru FRs characterised by moist forest. Sub montane forest (canopy 30 - 50 m tall) occurs between 800 and 1500 m above sea level, montane forest (canopy 15 - 30 m tall) between 1500-1900 m and upper montane forest (canopy 15 – 20 m tall) above 1900 m altitude (Lovett and Pocs 1993). Tree species dominance varies with type of forest. Outside the FRs, isolated degraded forests, woodlands or lowland forests as Village Land Forest Reserves (VLFRs) can be found. Soils are acidic lithosols and ferralitic red, yellow and brown latosols, which have developed from Precambrian granulite, gneiss and migmatite rocks (Lovett and Pocs 1993).

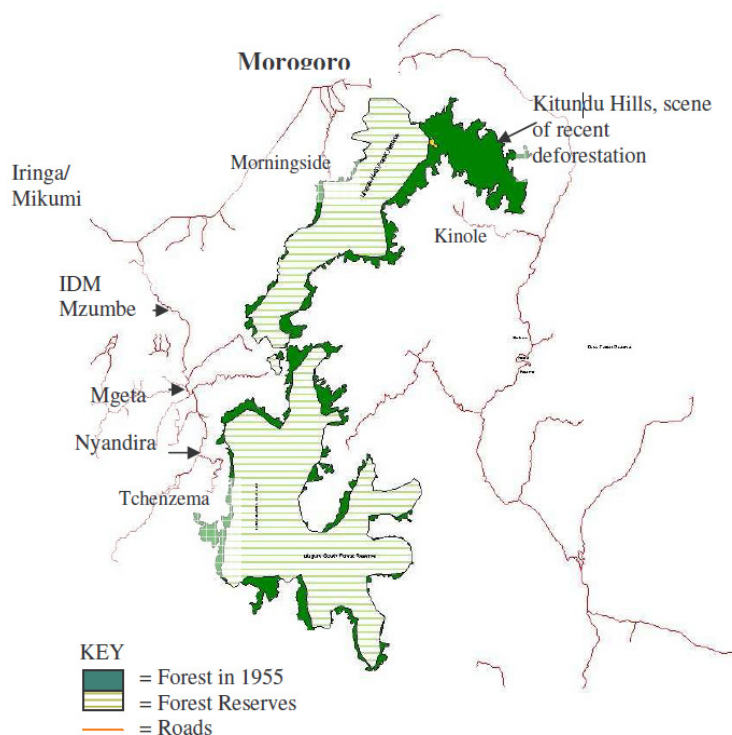


Figure 1: Village Tandai lies in Kinole Ward on the eastern slopes of the Uluguru Mountains (Source: WCST, 2000)

Rainfall varies in different places ranging from 900 mm per annum at Morogoro Municipality to 1200 – 3100 mm on the drier western slopes and to 2500 – 4000 mm on the wetter eastern slopes, where the village of Tandai is located (Lovett and Pocs 1993). There are two rain seasons distinguished, the long rains usually fall from February to June, with dry season extending between July and October. The short rains fall from October to January. The area of the upper mountains is also characterized by cold weather with a mean maximum and mean minimum temperature of 20-22°C and 15-17°C respectively, and much colder than this (-7°C) in high altitudes where frost may occur in July and August (Lovett and Pocs 1993).

Site conditions and farming systems

Kinole is one of the wards of Mkuyuni division in Mvomero District. It is located at the Eastern side of the Uluguru Mountains fifty kilometres off road way from Morogoro town. The altitude ranges from 300 metres above sea level at the Mbezi River to 1000 metres above sea level at the limit of the forest reserve. The climate ranges accordingly from tropical humid at the bottom to subtropical at the top, allowing the production of tropical crops banana, pineapple and citrus as main cash crops, while coconut, coffee and spices constitute as minor ones.

In Mvomero District 90% of the population depends on agriculture for its livelihood. Besides a share of 25 % market orientated cash crop production, subsistence agriculture, as everywhere in rural Tanzania, is the major land use activity shaping the farming landscape of the Ulugurus. Increasing population pressure in combination with limited area capacities and intense utilization of land resources led to high population density, intensive agriculture and land fragmentation⁶. The favourable climate and the general potentiality of the area as well as the relative proximity to urban centres, Dar Es Salaam, Morogoro and Dodoma provide market opportunities for produced fresh products. Due to the current intensification of the farming systems, horticultural crops such as vanilla, black pepper, oranges play an even bigger role now than in the past. One thousand tons of banana fruit and one thousand tons of pineapples and mangoes fruits are exported from the ward per annum (UMADEP 2008). Kinole middlemen also developed an indigenous ripening system for bananas that makes this crop one of the most important cash crops.

Growing of annual crops on steep terrain has intensified the vulnerability of the land to soil erosion. Such poor agricultural practices, especially on marginal lands and areas with exposed risk to erosion (e.g. deforested areas on slopes) eventually lead to fast environmental deterioration. This might be indicated by more and more upclimbing banana plots on the steep slopes of the latest clearing of land⁷. The decline of banana yields on the other hand can be observed through the growing number of pineapple plants on this stands, although, due to low market development, prices and production risk are less attractive for the farmers. Observed but within the survey to be proven is the change of production measures like the increase of contouring or planting of trees which certify a rising awareness of the depletion of soil fertility. At the same time does the difficult market access and a hardly cost efficient production (periodically occurrence of high yields and no drain off to market lead to negligible prices) encourage farmers to seek new production opportunities. This is one of the reasons why the production of spices such as black pepper, cardamom, cinnamon and vanilla within the farming system of Tandai is increasing (see figure 2). This is also the reason for the appearance of the shrub *Jatropha* as host plant, since the normally (but increasingly formerly) used trees caused unacceptable harvesting casualties. Generally was the harvesting process characterised by being much more complicated. Today a lot of *Jatropha* trees – up to 4.5 meters – can be seen in Tandai, but with currently unused seeds. Therefore it can be inferred that a potential for outgrower schemes with *Jatropha* exist.

⁶ Former consideration of forest protection to be only under governmental responsibility together with lack of awareness of villagers led to overexploitation of timber or firewood and deforestation.

⁷ Low prevailed protection could not impede land expansions into the forest up to the late eighties great losses. Nowadays the change of protection programme and the involvement of forest neighbouring villages into forest management raised the awareness of responsibility for the resource forest.



Figure 2: Jatropha as support plant for spices (vanilla and black pepper) (pictures by Uckert)

4. Methods

An assessment of sustainability related effects of certain agricultural systems is a challenging task, as at least 300 different definitions of sustainability and sustainable development do exist only in the fields of environmental management and associated disciplines (Johnston 2007). Because of this, it is especially in the context of agricultural production of utmost importance to stress that “a more sustainable agriculture seeks to make the best use of nature’s goods and services, technologies and practices [and] must be locally adapted and fitted to place” (Pretty 2008, p. 451).

Following this argumentation, the ZALF team moderated the development of a set of locally adopted sustainability indicators (cf. figure 3, “Version A”) which should theoretically be able to describe the current situation of agricultural practices as well as potential changes due to an increase of bioenergy crop production for the specific site-conditions for the village of Tandai. Additionally, the quantification or qualification potential of each single indicator as well as their measurable categories and sub-categories has to be assessed before included in the questionnaire⁸.

Apart from the ongoing survey via questionnaire, additional single expert interviews and focus group discussions several workshops were already conducted. They were part of a “Participatory Rural Appraisal” (PRA) as a research approach in which local communities discuss issues that concern community priorities and problems. In evaluating options for solving the problems, the aim is to develop together with a community an action plan to address the concerns that have been raised (FAO 1997). One of such instruments is e.g. resource mapping.

Currently the ZALF team is in the process of analysing the first outcomes of the data collection to publish a sustainability assessment of the agricultural practices and its potential changes on the local level.

In the next step, a national Better-iS project workshop, which is likely to start in November 2010 in Dar es Salaam, the outcomes of this analysis will be fed into focus group discussions

⁸ The questionnaire included also data requirements by the Institute for Environmental Economics and World Trade (IUW) in Hannover (a project partner within the Better-iS framework), who is in the process of developing a Social Accountability Matrix for Tandai.

as well as expert interviews to reshape the first indicator set in accordance with three distinctive research questions (see figure 3):

- 1) How to change the indicator set via reshaping, reformulating and/or adding other indicators to allow a transferability to alternative value chains such as palm oil ("Version B1")?
- 2) Which reshaping and weighting of the set needs to be fulfilled to transfer the indicator set to other villages in Tanzania? Which role do e.g. cultural habits play within this transfer process ("Version B2")?
- 3) Which adjustments need to be done to use the indicator set as a connection of (pre-defined) development goals on the local scale with the nations sustainability aims. How to implement the high complexity of "sustainability" in the national context ("Version B3")?

As final step, these differentiated indicator sets will be fed into a web based decision support tool to allow political and economic decision makers as well as farmer representatives to assess sustainability related effects of the potential establishment of bioenergy crop production systems in the local context. This supporting structure will be based upon an participatory decision support framework, the SCALA tool (Sieber 2006).

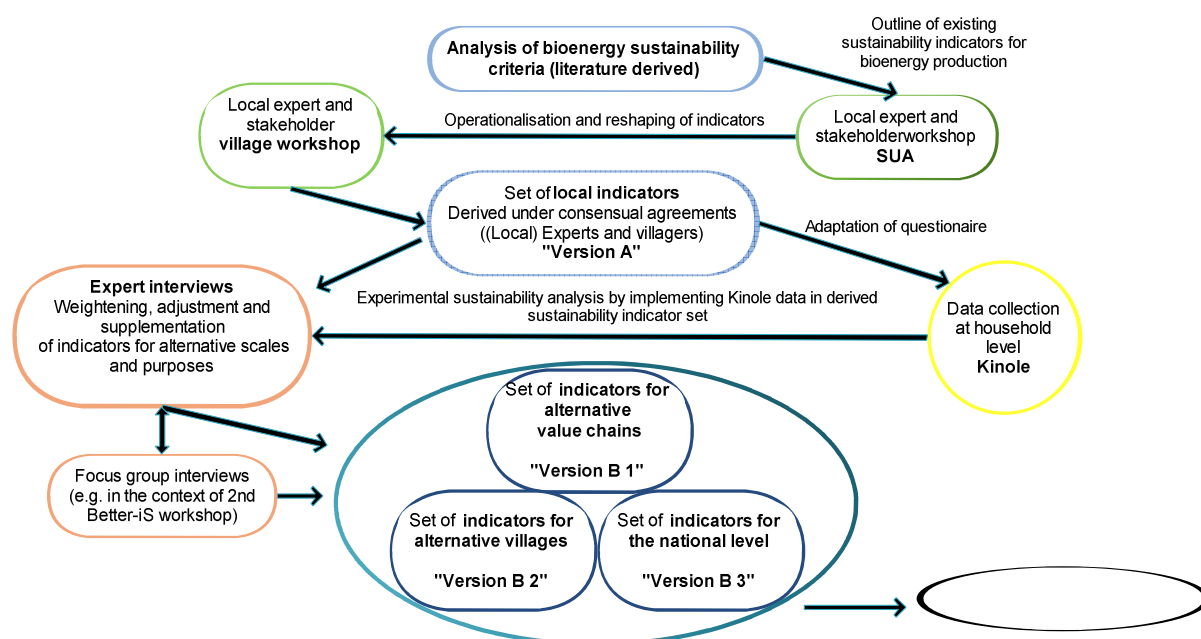


Figure 3: Research design of Better-iS sustainability indicator development (Authors design)

Crucial processes such as the locally embedded definition of the terms “sustainability” and “development” and the subsequent indicator development were closely linked to the participatory stakeholder approach, which is characterised by its involvement of experts and practitioners from the local level. A major challenge in this process is the intended merging of the two different perceptions and understandings of the “academics” on the one hand and the “villagers” on the other.

A first expert meeting during the local Kick-off workshop of the Better-iS project at the SUA was supposed to define sustainability indicators. It was comprised out of various stakeholder groups. These included (local) researchers, NGO as well as ministry representatives, small

and medium enterprises (SME) executives, agricultural extension officers and, of course, local farmers. This composition guaranteed that ideas derived out of literature reviews and guided by academic research approaches were grounded by the comprehensive knowledge of the farmers as local expert group already working in the agricultural sector in Tandai. Although "classic" categories of agricultural sustainability were mentioned during the discussion such as "biodiversity", "generation of additional income" and a guaranteed "food security", a variety of unexpected results could be identified.

5. Lessons learnt

One of the main outcomes of the analysis is the potentially productive inclusion of *Jatropha* as additional crop into the overall agricultural system of Tandai without negatively affecting the already existing production schemes.

An interesting topic has to be assessed in upcoming expert interviews during the ongoing research on the ground: The still occurring matriachats within the tribe of the habitants of Tandai - the Lugurus - is one question of landownership. Land traditionally belongs to women, men (males) after marriage will live on land owned by women, (if man is owner of land as well, there are different cases according to incorporated land sizes). After the wife's death the land is returned to her family. As one of the results of the Village Workshop a moderate impact of gender on household leadership concerning indoor air pollution could be recognized. Women as warden of fire as well as responsible for cooking indicated that bad firewood quality recently started to become a problem. In discussion two major reasons became obvious:

- 1) Decline of firewood quality: Wood supply is still not a massive problem (although highly populated, firewood supply in Tandai seems to be still enough). But high demand resulted in changes of wood quality to less suitable species for kitchen fire due to decrease of heat/duration and increase of smoke building.
- 2) Change of living conditions (smaller houses, respectively denser standing, construction of houses with no extra/outdoor kitchen) - Due to "urbanisation" in villages non smoking energy sources for cooking like charcoal or kerosene are more frequently needed (and additionally they are costly).

All together this raises awareness of the necessity for Tandai villagers to replant trees on own plots (woodlots or agroforestry/intercropping): Cash gaining timber seems to be of higher importance for men, firewood species are more in women interests. Accordingly tree species have been incorporated to the questionnaire to indicate gender struggles⁹. Another opportunity besides tree planting is the substitution of woodfuel with biofuels, e.g. *Jatropha*.

As there is no potential for further expansion of agricultural area in this region already suffering from high population pressure, the imaginable establishment of *Jatropha* monocultures can only be characterised as maladjusted to the local conditions. This is especially true as the economic sustainability of *Jatropha* is not likely to be competitive with the export of "cash fruits" such as pine-apples and bananas to Morogoro, Dodoma and Dar es Salaam (even though the farm gate prices are strongly fluctuating and are comparably

⁹ Even in Tandai and due to general society standards, men are main holder of cash. Therefore costly decisions can't be done over their heads. An interview with the nursery owner showed this impact on kind of sold tree species (dominant demand on timber species).

low). These results are in accordance with findings of a study from Kenya, commissioned by the GTZ in 2009. In this publication it was calculated that the only way of gaining additional income from *Jatropha* production is the establishment of hedges – every other production system, be it as monoculture or intercropping, resulted in substantial financial losses for the farmers (GTZ 2009).

Especially the production system in hedges does not only hold (albeit marginal) income generation opportunities but also acts as strategy to minimize the potential of social conflicts¹⁰. This refers to the possible application of the perennial shrub *Jatropha* as undisplaceable boundary between two bordering properties. According to a member of the village council in Kinole is the alteration of lines of demarcations a constant reason for conflicts in the subvillages. These findings are also underlined by the results of the Better-iS village workshop in Tandai¹¹, where the villagers were asked for potential functions of *Jatropha*. The replies were, in chronological order, as follows: a) use as medical plant, b) anchoring species for vanilla and black pepper, c) use as graveyard tree, d) utilisation as farm boundary and e) utilisation as housing fence.

There is, although an understanding of *Jatropha* as energy plant is totally absent, a high potential for the establishment of outgrower schemes in Tandai, as 22 out of 29 participants of the representative workshop admitted to own *Jatropha* plants as supporting tree for spices.

Another aspect which seems to be of high importance in term of social sustainability is strongly connected to this issue: The function of *Jatropha* hedges as living fences against feedstock from neighbouring properties. This, again, has the potential to cause severe problems as livestock (mainly goats) migrates into neighbouring fields to graze¹².

In addition to these preliminary agroeconomical findings, varying intercultural development processes in the context of a different understanding of sustainability could be observed. This refers mainly to the researchers' ability to move away from known patterns of understanding reality and include unknown perspectives. One example for this was the unexpected problem of describing concepts such as "scenario" or "criteria". These terms, known to the Better-iS team and numerously discussed during the project preparation, were simply out of the range for most villagers. Their perspective is not shaped by theoretical approaches, as it is common in scientific circles, but constructed out of patterns closely related to locally grounded payoffs. The conducting team learned during the data collection process that it is crucial to translate such ideas into the local perspective, especially by explaining it in stories and storylines. Without giving examples closely related to their livelihoods, theoretically framed questions can be posed, but are not likely to be understood or answered in the preferred way.

In addition to this, it is also important to highlight the different cultural backgrounds in the process of developing consensual agreements and outcomes, e.g. out of the conducted village workshop. Generally, the Tanzanian society is based upon disputes and discussion – agreements are achieved by using the backdoor, not by confronting participants with the need for an outcome. The team of researchers, being brought up in the European society, had to learn quickly and via a number of set backs, that the output orientated scientific data collection is working very differently in the Tanzanian society. What is mainly needed is

¹⁰ Personal information.

¹¹ The workshop took place at the 07th and 8th of April 2010 in the MVIWATA Conference hall in Tandai.

¹² Personal information

therefore time to allow the interviewee to fully develop their understanding of each question to ensure high quality results. This can mainly be done by communicating in pictures and stories to implement the theory driven research questions derived out of western science into the local realities.

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