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Scenario-based approach in dealing with climate change impacts in Central Tanzania

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ABSTRACT

Climate variability and change continue to be a threat to Africa's agro-ecosystems. This is anticipated to have a multitude of immediate and long-term impacts on sub-Saharan Africa's natural resources of the present study attempts to establish the potential benefit of integrating local stakeholders' knowledge into climate scenarios. Specifically, the study sought to tap into the expertise and perspectives of locally important stakeholders in the potentially sensitive Wami/Ruvu River catchment of Tanzania. Participatory scenario planning was used to explore sectors sensitive to climate variability and change. This included 84 selected smallholder farmers and their leaders spread across six villages within the catchment. Quantitative household surveys were conducted across 199 households and Supplementary information sourced from regional statistics. The survey indicates that farmers project that land and agricultural productivity and water resources will be affected by climate change. From the participatory approach adopted for the study, thematic scenario categories featuring land and water resource-use and management and farm productivity were developed. The research found scenario analysis as a useful tool in development planning, as it incorporates interacting risks and uncertainties. If adopted by local farmers, leaders, regional institutional frameworks and policy makers, the tool has the potential to improve responsiveness to changes and risks through its collaborative management approach. This study demonstrates the need for sustainable water use and management systems and land use and farming practices that will increase crop productivity and resilience to climate variability and change.

1. Introduction

There are rapid changes and increased uncertainties within the climate system, hence a critical need for relevant and appropriate tools in addressing climatic uncertainties (Alcamo, 2001; IPCC, 2007). Generally, planned investments will have useful long-term benefits if designed in a way that they can offer alternative opportunities to local communities (Enfors, Gordon, Peterson, & Bossio, 2008). Scenarios, which are identified as significant tools in solving complex situations in a

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number of disciplines have the potential to address previously alluded uncertainties. Scenarios describe how the future might unfold under certain situations, considering various assumptions regarding changing trends from the past to present, while providing potential actors, risks and uncertainties (Alcamo, 2001; Kemp-Benedict, 2004; UNEP, 2002). The International Panel on Climate Change (IPCC) defines a scenario to be a rational, internally consistent and likely description of a possible future state of the world (IPCC, 2007). Thus, a scenario presents a series of pictures or images of how the future would unfold under given conditions (Kemp-Benedict, 2004). Scenario processes vary from local, regional or global levels across varying levels or similar scales (Biggs et al., 2007) and have been found to be ideal platforms for sharing and learning new information while addressing complex situations that could be costly in terms of time, logistics and financial resources.

The use of scenario planning was initially applied to identify future opportunities and threats along useful trajectories in socio-ecological systems (Peterson, Cumming, & Carpenter, 2003). Commonly, however complex the dynamics might seem, scenario planning has been found to be effective in many disciplines (Kok, Biggs, & Zurek, 2007), and their outcome easily accessible for use by planners, managers and implementers from different disciplines. Global studies from different disciplines indicate the relative value of scenario planning tools in their specific development pathways and applied research projects. Wollenberg, Edmunds, and Buck (2000) used scenario planning for decision making in management of community forests. Alcamo (2001) highlights scenarios as ideal platforms for sharing new knowledge and ideas while addressing complex situations. Davis (2002) used scenarios for identifying opportunities and risks that a given community might face in relation to planned interventions. Peterson et al. (2003) demonstrated the importance of scenario information in addressing complex environmental conditions in a given area while Peterson (2007) used scenario planning to build consensus for shaping the future while avoiding possible risks in Northern Highlands Lake District Wisconsin to the year 2025. Scenario application in Tanzania was found to be useful in information dissemination, as a way to enhance agricultural productivity at the Makanya catchment in Tanzania (Enfors et al., 2008). Alcamo (2008) used scenarios in assessment of environmental changes while Frazier, Wood, and Yarnal (2010) used scenarios for balance creation between community growth and resilience development against natural hazards.

Many patterns within the climate system have changed. The globally averaged combined land and ocean surface temperature data as calculated by a linear trend show a warming of 0.85 °C (0.65–1.06 °C) over the period 1880–2012 (IPCC, 2014), largely because of human activities (Boko et al., 2007). Projections indicate that in the medium (2030–2040) and long (2080–2100) term, climate change impacts are expected to exacerbate poverty in most developing countries and create new poverty pockets in countries with increasing inequality, in developed and developing countries (IPCC, 2014). It is however

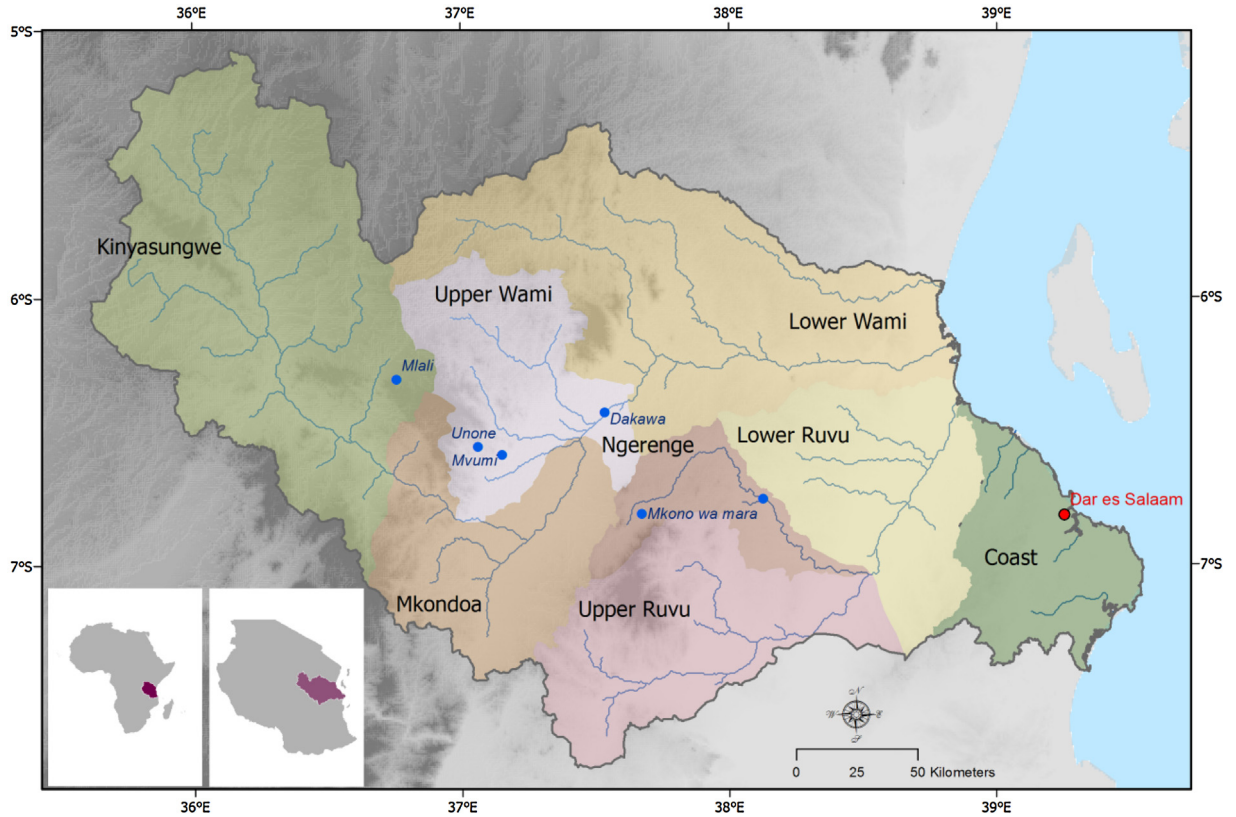

Fig. 1. Overview of Wami/Ruvu river basin and its sub-basins. The map also shows the location of the six villages where the study was conducted.

important to note that emission of greenhouse gases in Africa is low (about 3.5%) compared to other regions (IPCC, 2007). The length of growing seasons may decrease, forcing large agricultural areas out of production, hence compromising overall agricultural productivity. Projected yields in some countries are expected to reduce by 50% by 2020, with a resulting 90% net crop revenues decrease by the year 2100. (IPCC, 2007). According to IPCC (2007), over 50% of the small-holder farmers will be seriously affected. Africa's smallholder farmers and therefore food security are particularly at risk in the coming years. Smallholder farmers in the context of the paper refers to farmers who produce crops at a small-scale without the use of modern technology and most of whom rely on rain-fed agriculture. In Tanzania, changes are predicted to affect major sectors of the economy including water, agriculture, health, fisheries, coastal zones and forestry sectors (NAPA, 2006; VPO, 2003).

The Wami/Ruvu catchment in Tanzania is dominated by small-scale farmers. However, there is no clear participatory land and water use planning measures through which local crop and livestock farmers could express their demands and needs (NAPA, 2006). Furthermore, information provided by government officials from the National Land Use Planning Commission (NLUPC) argue that planners do not know villagers' needs on resources such as agriculture, conservation, forestry, and other livelihood support activities (NAPA, 2006). This is a necessity for most developmental activities, which should be accompanied by dissemination of new information and knowledge to the local community for effective implementation. This paper explores the use of scenario planning in the development and management of land and water resources to enhance agricultural productivity in a climate change environment.

2. Study area

2.1. Wami/Ruvu river basin

Wami/Ruvu river basin is one of the nine basins of the United Republic of Tanzania. The basin covers an area of about 72,930 km^2 and comprises the Wami and Ruvu river systems and coastal rivers south of Dar es Salaam that drain into the Indian Ocean (Fig. 1). The Wami river system encompasses about 40,000 km^2, the Ruvu system is 17,700 km^2, and other coastal river catchments make up about 15,230 km^2.

Analysis of historical river discharge time series indicate significant flow reductions for both Wami and Ruvu river systems resulting from declining regional rainfall, which has had ecological and economic impacts including water shortages, lowered agricultural production, increased fungal and insect infestations, decreased biodiversity and variable hydropower production (Orindi and Murray, 2005).

Participants in this study were drawn from six villages upstream, middle stream and downstream of the catchment (Fig. 1). The villages included: Wami/Dakawa, Mvumi, Unone, Sinyaulime, Mkono wa Mara and Mlali (Fig. 1). At the onset of the scenario process, exploratory data on land use, water resources and impacts of climate change was acquired through one on one interviews from randomly selected 199 household respondents. Random sampling strategy adopted factored in age, gender, origin, knowledge ability, land size owned, economic status and education level of the individuals. Two weeks after the surveys, 84 participants were selected across the villages in the catchment to participate in the scenario process (Table 1).

A series of group discussions and workshops was conducted with the participants and governmental and Non-Governmental Organisations (NGO) representatives from agricultural and water management institutions at both local and regional scales.

2.2. Scenario development process

The Story and Simulation Approach, developed by Alcamo (2001) was adopted during the scenario planning process. This was considered ideal and participatory as it accounts for all essential steps in development of scenarios while involving participants' views at all levels of the process. Most workshops were held in the afternoon and weekends when participants did not have major responsibilities. During the period when the workshops took place, most fields had already been harvested.

The scenario scope targeted three main themes namely: water, land uses and agricultural productivity. Data were obtained from 199 interactive surveys conducted during the explorative surveys which identified key issues on land use trends, agriculture, water resource use and management and climate change indicators. This data provided useful information on key issues facing the region. The information obtained was shared with key scenario participants at the first phase of the scenario process. It provided the best platform for discussion of trends of the state of the region. Examples of

Table 1
Ideal water resource use and management activities.

Group	Role
199 household respondents	This group included individual household respondents that participated in the explorative surveys of the scenario process and in triangulation of information after the scenario process.
84 participants	These included selected participants across 6 villages in Wami/Ruvu catchment which were randomly selected across the villages to participate in the group scenario procedures.

scenario cases based on government projects were used for demonstration purposes and provided the foundation for the scenario logics and understanding.

The identification of key issues facing smallholder farmers was an interactive process where participants identified as many factors as they could. From these factors, the following step involved ranking of key factors in their order of importance. In this case, three categories were used namely worse, better and moderate. Factors which had the highest ranking in terms of uncertainties in the three categories were taken to the next level. These factors were used in the scenario formulation process as they demonstrated a great sense of contrast.

In order to formulate scenarios, participants were clustered by the workshop facilitators into four groups with equal representation of respondents, government and NGOs' representatives (see Fig. 2). The facilitators described the scenario procedure tasks considering the highlighted trends of the main actors of change. The participants were to engage in groups with merged ideas useful in construction of scenarios from the prioritised factors for the catchment. The objective here was that the groups formulate storylines in an iterative process to some form of consistency so that it got them to a projected picture of the region in 2030. Questions of how participants could identify the region's future or likely scenario based on the highly ranked key factors were employed. These included questions such as: how do you see the financial position of the region in the near future? The interactive nature of responses at this stage was useful in formulation of the storylines. Artwork was encouraged amongst the groups as it helped in clarification and better visualisation of the scenarios. It was important to have group representation of the storylines after the process. Any unique patterns defining independent characteristics for each of the scenarios were amplified to sharpen emerging contrasts from the scenarios. Intensive discussions were conducted on what was to be done in order to achieve the scenario storylines developed. Participants responded positively to the scenario workshops as a learning experience and were at the same time enthusiastic about a better future.

3. Results

3.1. Descriptive analysis of the 199 respondents

The descriptive analysis of the respondents' demographic traits (Ojoyi and Mwenge Kahinda, 2015) revealed that the middle-age group (31–50 years old), was the largest age group in the sample (59.3 per cent). The old-age group (51 years old or more) accounted for almost a quarter (24.1%) of the respondents; while the young age group (up to 30 years old) only accounted for slightly more than 15% (16.6%) of the respondents. Female respondents only accounted for 27.7% of the total respondents. Furthermore, about three-quarter of the respondents (74.9%) received primary level education; slightly less than 15% (14.6%) had no access to education, while only about 10 per cent (10.6%) received secondary level education (Ojoyi and Mwenge Kahinda, 2015). Respondents sourced their livelihoods (Ojoyi and Mwenge Kahinda, 2015) from subsistence agriculture (90%), casual employment (5.5%), business (3.5%) and government employment (1%).

3.2. Quantitative results from respondents

The 199 respondents identified various factors as ideal practices in the use and management of land, water resources and agricultural strategies. Most respondents identified subsistence farming (32%) and tree planting (16%) as sustainable use of land resources (Fig. 3). While only 0.5% identified the protection of riverbanks as sustainable land use (Fig. 3), 21.6% consider it to be a sustainable water resources management activity (Table 3). Sustainable agriculture practices have been

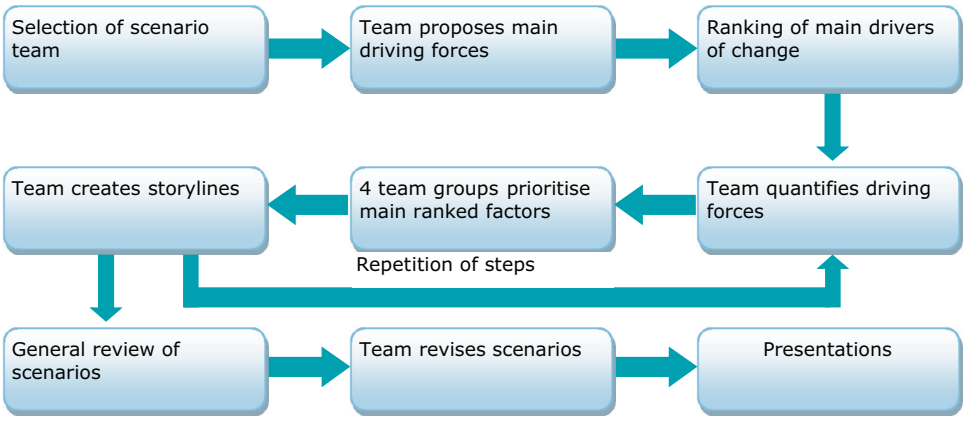

Fig. 2. Story and simulation approach to scenario development (modified from Alcamo, 2001).

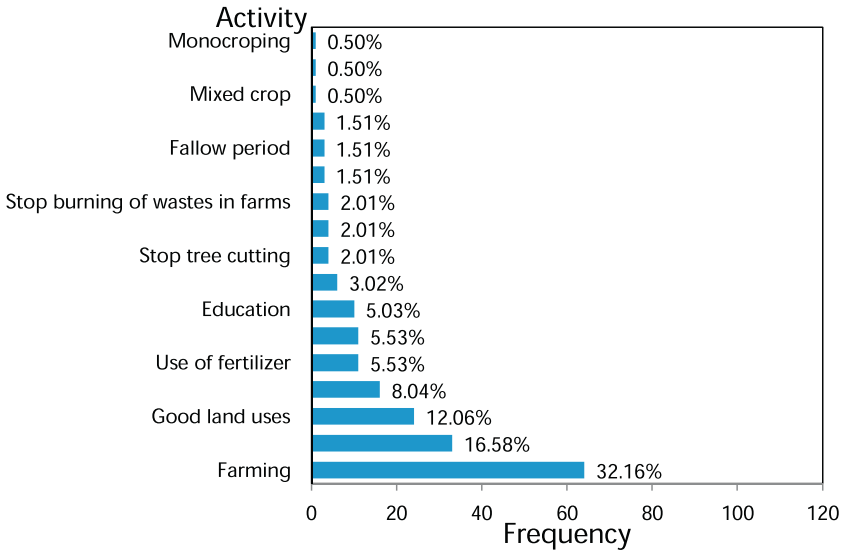

Fig. 3. Sustainable use of land resources and management practices selected by the 199 respondents.

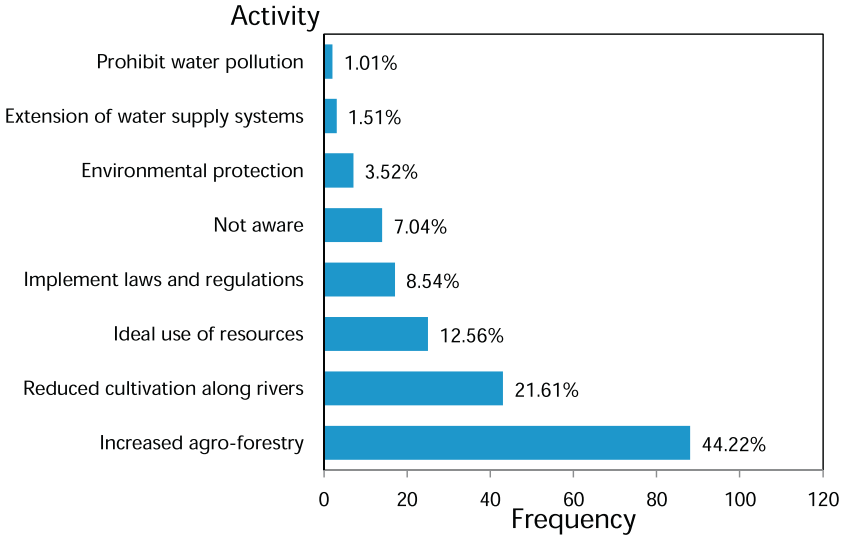

Fig. 4. Ideal water resource use and management activities as perceived by the 199 respondents.

represented in (Fig. 5). Increased tree planting was identified as the ideal water resources use by 44.2% of the respondents (Fig. 4).

3.3. Formulation of scenarios

From a list of driving forces identified for land use, agriculture and water resources, smallholder scenario participants ranked major factors deemed to affect them significantly in three categories from high, medium and low based on their level of significance (Table 2). In line with findings by Enfors et al. (2008), participants identified the lack of capital investment (finances/capital) as the main factor affecting their enterprise. Other factors prioritized included drought, climate change, poor farming tools, lack of agricultural inputs, inadequate knowledge and extension services, finances, poor irrigation facilities and lack of relevant seeds. Participants then projected the future of the ranked factors and categorised them as better, moderate and worse (Table 3) and the factors according to their level of significance (Table 4).

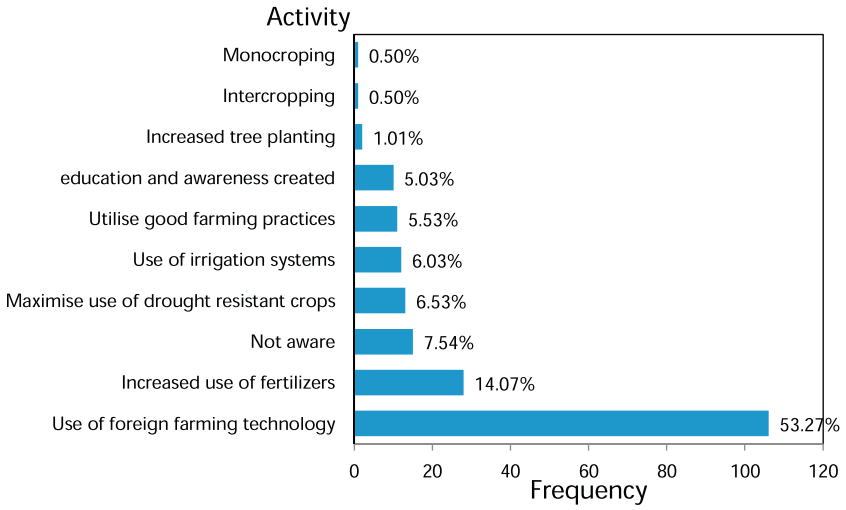

Fig. 5. Sustainable agriculture practices selected by the 199 respondents.

Table 2
Ranking of factors by smallholder farmers according to their level of significance. The values represent the number of participants ranking a given factor according to their level of significance.

Factor	High	Medium	Low
Drought	18	24	0
Lack of agricultural inputs	6	0	12
Lack of irrigation facilities	0	6	6
Climate change	6	18	0
Inadequate knowledge and skills	0	6	18
Increased pests	0	0	0
Use of modern coping seeds	0	0	0
Use of the hand hoe	12	6	0
Markets	0	0	0
Finances/capital	36	18	0
Timing Constraints	0	6	12
Poor Irrigation practices	0	0	0
Livestock trampling	0	0	0
Destructive wild animals	0	0	6
Lack of storage facilities	0	0	0

Table 3
Summarised factors as ranked by smallholder farmers in the scenario process.

Driving force	Better	Moderate	Worse
Finances	72	0	12
Drought	42	36	6
Climate change	78	6	0
Hand hoe usage	6	14	66
Agricultural inputs	72	0	12
Knowledge and extension services	66	0	18
Changes in planting seasonality	24	6	54
Seed usage and availability	72	0	12
Irrigation facilities	18	0	66

3.4. Scenarios categories

Based on the ranked factors, the participants formulated four scenario storylines (Appendix A): the state of stagnation, the state of transition, managing through experience and the stabilised system scenarios.

Table 4
Summary of the highly ranked factors which were thereafter used in the scenario formulation.

Driving force	Worse	Moderate	Better
Drought	18	54	0
Knowledge and extension services	0	42	36
Agricultural practice	18	48	12
Environmental protection	0	36	42
Financial constraints	6	30	42

3.4.1. State of stagnation scenario

Dry spells in the Wami/Ruvu river catchment have gradually increased over the last 20 years (Shongwe, van Oldenborgh, & van Aalst, 2009). While there are very few remnant natural and man-made forests, only a small percentage of the community appreciates the need for re-afforestation. In spite of 30 years of government investment in environmental awareness and education initiatives, brick making and charcoal remain a key source of livelihood and energy in the area. Generally, unemployment and poverty are prevalent in the region. The yield obtained from rain-fed agriculture is often very low and whenever it improves, there is either no market or ready access to reliable markets. Infrastructure in the region remains poor and poverty forces many children to drop out of schools. The community hopes that one day, their situation will improve.

3.4.2. State of transition scenario

The human population in the region has increased over the past 30 years. Although rain fed agriculture remains the main source of livelihood, rainfall is unevenly distributed in space and time, which could be due to the increasing destruction of the existing forests. Charcoal remains the main source of energy for the bulk of the population, despite education and awareness campaigns emerging from multiple government and NGOs. Although many industries have been established in major towns like Morogoro and Arusha, no regulations enforce the safe disposal of industrial wastes into river systems. Communities across Morogoro region believe that environmental conservation is the sole responsibility of the government. The lack of capital investment prevents smallholder farmers from adopting innovative and/or advanced technology. This has led to significant decreases in farm productivity. Although the government initiated a number of irrigation schemes in various parts of Wami River sub-catchment, farmers still lack access to markets. The adverse impacts of climate change in the area are compounded by factors such as widespread poverty, human diseases, increased crime rates and high population density, which is estimated to double the demand for food, water, and livestock forage in the future. The community hopes that the situation will improve in the next years, with extra support from the government and NGOs implementing planned development activities.

3.4.3. The managing through experience scenario

The local community acknowledge the role of collective action towards attaining a stable and resilient system. Education and awareness campaign on environmental conservation have resulted in a number of afforestation and re-afforestation activities that have the support of the population. The government, through the Ministry of Agriculture, has been supporting emerging farmers to invest in use of innovative/advanced farming technologies. This has positively enhanced farm productivity in the region, while at the same time, farmers have organised themselves into cooperatives to benefit from government and NGOs support activities. The region has also benefited from a series of infrastructure development projects that have opened up access to markets. Investors within the country and neighbouring countries are moving in the region and creating jobs. The economic growth of the area is gradually attracting international foreign investments.

3.4.4. The stabilised system state scenario

Owing to the many capacity building initiatives on appropriate land use and farming practices, it is clear that farmers in the region are well informed about the significance of maintaining the ecological integrity of the natural functioning of ecosystems. Heavy investment in education by the government through establishment of more schools, increased training sessions and frequent education campaigns has influenced positive participation of smallholder farmers in education initiatives. Besides, the community has taken it as their role to implement knowledge gained in their own farms. For the past 20 years, the community has been actively involved in afforestation and re-afforestation practices. Despite the population increase, smallholder farmers engage in good land use and farming practices that help in soil conservation. Following strict implementation of water user association regulations by Wami/Ruvu Basin Office, the Wami and Ruvu river systems do not easily dry up from heavy soil deposits. Due to stable '*vuli*' (short rains) and '*masika*' (long rains) rains, the river systems do not face seasonal drying up, hence water flows are constant upstream, middle stream and downstream. With the introduction of better farming practices which smallholder farmers are implementing, productivity in the region has become stable. The government has been supportive in promoting better and stable markets for farm produce in Dar es Salaam and neighbouring countries. As a result, the economic status of the region has improved greatly, leading to increased job opportunities. There is better infrastructure development that enables movement of goods and services in various parts of the catchment and its surroundings.

3.5. Implications of scenarios developed

This section summarises the meaning and relevance of the four scenarios resulting from the Wami/Ruvu catchment case study to the region.

State of stagnation scenario indicates how the area remains trapped in knowledge and technology illiteracy, low agricultural productivity, poor markets and low adaptation to climatic shocks, unstable markets, increased dry spells and frequent floods that lead to displacement of people in various parts of the catchment, besides increased soil erosion affecting agricultural productivity. This scenario illustrates implications likely to be faced if the Wami/Ruvu community prolongs forest destructive activities and brick making. They need to focus on alternative income generating options which are sustainable in the long term. Huge gaps in education need to be narrowed by strengthening education and awareness campaigns as best approaches towards socio-ecological resilience. Smallholder farmers need to be educated on the use of short season and drought resistant crops during both the short and long rainy seasons. Good policies governing water resource use and management need to be strengthened and implemented among all stakeholders. Following the poor state of markets, smallholder farmers should establish farmer associations that can embrace and strengthen better and stable markets.

The State of transition scenario explains a trend of gradual evolution from stagnation. The Wami Ruvu system still drags in most initiatives that combat poverty, climatic shocks, and agricultural productivity. It is unfortunate though that many people across the catchment remain trapped in poor lifestyles due to lack of job opportunities. Consequently, most young people engage in environmental destructive activities such as charcoal production and brick making for income generation. For those involved in agriculture, they still face remarkable market crises, locally and regionally. This in essence explains the need for tailoring development oriented initiatives in addressing the local stakeholders' livelihood support systems as a way of embracing their goodwill in climate resilience initiatives while maximising available opportunities.

The managing through experience scenario, there is a series of challenges experienced by the local community across Wami/Ruvu catchment including increased dry spells, decreased productivity, and financial constraints due to poor local economy. All stakeholders understand the need to address the above mentioned challenges by adopting sustainable agricultural practices and through the sustainable use of natural resources and the effective management of the environment. This case displays the power of collective action towards managing complex situations using concrete and simple solutions. The present case scenario provides an example which can be applied in solving complex situations which require collective efforts from all stakeholders.

The stabilised system scenario corresponds to a state of resilience across the catchment. This is attributed to better access to technology and availability of facilities in agriculture resulting to better productivity, improved markets, and better finance support systems for increased business initiatives. Besides, heavy government investment in infrastructure has positively impacted on improved networks in business and markets. Government institutions can make a huge contribution towards change in a region from a poor to a better state. Main sectors such as infrastructure development, education capacity and finance support systems need to be addressed for stable and productive agro-landscapes.

3.6. The road map to a stable agro landscape

In order to reach a stable agro landscape conducive to growth and development of smallholder farmers, actions that need to be undertaken include:

Education capacity and policy frameworks – the need to design better policies addressing constraints in agricultural productivity and management, water resource use and land use planning can influence governance of communal resources in a huge and unique manner. Appropriate practices should be recommended and the local community's capacity enhanced as a way of strengthening resilience capacity of the system. Better and functional structures should be put in place and implementation effected for all water resources upstream, middle stream and downstream. The community's capacity can be embraced easily through effective leadership and the spirit of collective action such as managing through experience scenario. Better and improved learning platforms for smallholder farmers can influence farmer's learning capacity for new technologies working effectively in their respective regions.

Economy – from the field perspective and as a livelihood improvement initiative, smallholder farmers may consider adopting the 'managing through experience' scenario where everybody makes it their role and responsibility to positively contribute towards improving their well-being and hence local economic growth. Small farmer groups and farmer associations should be formed to promote diverse business ventures and focus on business initiatives. Smallholder farmers could adopt post-harvest technology. The stabilised system and managing through experience scenario demonstrates best practices of administration, marketing, financial management and technical skills in production.

Technology – owing to the changing climatic patterns in the region, the adoption of drought resistant cultivars, rainwater harvesting and conservation agriculture could enhance water and crop productivity even at the onset of dry spells. Furthermore, crops with higher economic returns such as vegetables and fruits could be grown during the short *vuli* rainy season. The regions upstream and middle streams are fertile and can maximise productivity with the introduction of multipurpose crops such as *moringa*. Agricultural specialists from regional government institutions such as Sokoine University of Agriculture need to research and recommend the best crops to be grown for the region, based on soil types

under frequent varying climatic patterns (Paavola, 2008). The implementation of the above requires efficient institutional support from the government and the NGOs.

It is not possible to point out a specific scenario representing Wami/Ruvu catchment. Besides, the scenario planning was not used as a prediction, but rather as a development trajectory for planning by resource managers, researchers and other planners. Major issues emerge from the four scenarios which tend to provide a roadmap for the region by the year 2030, supposing certain trend lines are checked and followed. It is important to note that the region still remains vulnerable, especially to adverse impacts of climate change. However, the likely possibility of the region shifting towards the stabilised system scenario could be reached if the principle of collective action is adopted; strengthening infrastructure development that is already under action by government institutions.

4. Conclusions

The use of scenario planning is appropriate for implanting government and NGOs funded projects. Scenario planning provided the right platform by harmonising the understanding of the problems facing the area. Nevertheless, because of the series of repetitive steps, participatory scenario planning process is a time consuming process that requires a lot of patience, especially at the initial phases of problem definition and identification of drivers. In the Wami/Ruvu catchment, the interactive nature of the scenario process proved fruitful throughout the scenario formulation processes as it enabled gathering of good background information and provided the right platform for a common understanding of key issues from the beginning. The representative selection of participants not only brought diverse age sets and gender but also captured their views in the design of the scenarios. The participatory approach integrated local opinions into important decisions that could be applied at both local and national scales. The presence of government and NGOs representatives was instrumental for the identification of sectors' weaknesses. Finally, participants and representatives found the scenario approach as a possible way for mainstreaming new projects by helping stakeholders visualise benefits and likely impacts.

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Appendix A. Four scenario categories

	State of stagnation	The state of transition	Managing through experience	Stabilised system
Drought *- Rainfall* *- Temperature* *- Environment* *- Soil insurance* *Environmental Conservation*	*It's the year 2030.Wami and Ruvu river systems have experienced gradual decrease in water levels compared to the past 30 years. There is an increase in population especially from migrants from other parts of Tanzania. In order to support their daily livelihoods, the community engages in forest destructive activities e.g. cultivation along river beds that has led to increased silt deposits along major river beds. There is increased destruction of forests with no proper environmental restoration activities being put into place. There're no guidelines in place formulated regarding use of natural resources e.g. community forests. There is gradual deforestation following previous government regulations on use of communal and government protected forests. Rains though are scattered, because land and water use and management strategies are picking up slowly by the*	*There is increased migration from other parts of the country, while at the same time, the region has experienced gradual population rise. However, land remains a constant factor of production. With the rise in needs and with the ever increasing human population, this has forced locals to seek other livelihood avenues. Many young people are educated, though there is increased lack of job opportunities; as a result, many take part in increased forest destructive activities like charcoal burning and brick making as an alternative income source. This has led to increased soil erosion and dry spells throughout the catchment. Rains are scarce and farmers are wishing that the situation would have been better. Owing to the increase in population and scarcity of jobs, many young people are making efforts into other job creation avenues like brick*	*Many things have changed. Everybody sees the need to co-operate in conservation of the environment by replanting destroyed habitats and participating in re-afforestation practices, especially at the Wami and Ruvu river systems from down, middle and upstream. Farmers who had been involved in traditional irrigation farming, distracting water pathways appreciate the need to stop this practice as it has extensively affected those downstream. Most farmers are actively involved in communal agro forestry regimes in areas which had been designated by the village government under communal land for the region. Majority of the smallholder farmers are well informed following previous intense education initiatives. This has helped with maintenance of the ecological integrity of the environment. The community now extensively carries out afforestation regimes which*	*Majority of the farmers have invested in agro forestry and replanted fast growing tree species in areas where degradation was experienced. The micro climate has improved greatly. Education and awareness programmes are on the rise which has led to improved conservation throughout Wami/Ruvu catchment. Climate change is not a big question at the moment, with introduction of irrigation for short season crops like vegetable farming, fruit growing and horticulture production. This has been made better by availability of rains and ready markets in Dar es salaam and other touristic towns like Arusha and Moshi.*

(*Continued*)

	State of stagnation	The state of transition	Managing through experience	Stabilised system
	locals following heavy dependence on subsistence agriculture, they do not have adequate land to replant trees for carbon sequestration as suggested by local environmental and agricultural organisations. For the past 20 years, there has been a rise in human population which means that the same land resources have to be shared following increased population. There are no ideal land use strategies in place for the available land. The community in the area is not conversant with climate change education and hence does not have adequate knowledge regarding ways to develop resilience against climate change. Smallholder farmers however have felt the previous impacts of scattered rains and that's why, they are making extra efforts to purchase tree seedlings from the government centres and other NGOs for multi-purpose uses.	*making. This has led to increased soil erosion to the environment. There is still water scarcity following increased forest destruction that has affected the ecological integrity interfering with the natural functioning of the ecosystem. Soil erosion is on the increase in many parts of Wami/Ruvu catchment due to poor forest destructive activities; as a result, the productivity in the farms has lowered. The community lacks adequate technology to help in implementation of the necessary rain water conservation measures. There are increased dry spells and during the heavy rainy seasons, they face increased disaster risks like floods.*	*has heavily boosted the level of carbon sequestration within Wami/Ruvu catchment. The 'vuli' and 'masika' rains seem to be reliable. Farmers appreciate the importance of environmental protection. Both rivers Wami and Ruvu are well managed by Water User Associations who participate actively in conservation of the major rivers and their sources.*	
Knowledge and extension - *Trainings* - *Extension services* - *schools*	*The government had targeted that by the year 2030, a larger percentage of the community both in the rural and urban areas of the Wami Ruvu river basin to be knowledgeable and well educated. There are more Environmental and agricultural learning institutions within the catchment compared to the past 20 years. Population within the catchment has equally expanded. The government now employs more trained agricultural extension officers to offer training to farmers in the region. Despite government investment in environmental education on tree planting, and with the increasing level of education in the rural areas, many Tanzanians are slowly appreciating the role of education in agriculture.*	*Farmers attended agricultural training on good practices, but they did not take seriously the information gained in the many seminars and workshops that were organised by the government and non-governmental organisations in the region. A few schools were established with the support from donor funding and government ministry of education. However, majority of the young people are still picking up slowly in appreciating the significance of education. Very few professionals from the catchment are able to reach tertiary levels of learning due to early marriages. The level of understanding on good farming practices is still low due to poor attendance and implementation of knowledge gained from farmer training sessions.*	*With the establishment of more schools and following government heavy investments in education in schools, this has improved on the entire communal capacity in agricultural and the environmental fields. Farmers are currently well sensitised from what they recognise from the indigenous perspective, compared to scientific information provided in relation to the changing climatic patterns from a regional scale.*	*The Tanzanian government fully appreciates the role of education in development oriented activities. They therefore have increased trainings at colleges at an affordable cost, which has encouraged most citizens to go to school. There are more government officers employed to strengthen the communal capacity which has strengthened education resulting to better knowledge across villages*
Agricultural practices - *Farming practices* - *Crops* - *Water availability* - *Labour* - *Technology*	*Farmers now see the need to practice improved agricultural practices that can cope with the changing climatic patterns. Smallholder farmers now plant short season maize and sun flower seed types that can easily cope with increased dry spells. There's increased crop*	*Local governance from both the government and local NGOs have actively participated in enhancing awareness on good farming methods and better ways to develop resilience to climate change. However, farmers were still hesitant to take home the message to utilise in*	*Previously, climate change had been regarded as a threat to food security in Sub Saharan Africa by World Bank. The ministry of agriculture in Tanzania now takes the lead in country initiatives that could better rural development in agricultural programmes.*	*Farmers are trying to practice improved agricultural practices which can cope with the changing climatic patterns. Most farmers across the catchment use maize and sun flower seeds which can easily cope with increased dry spells. There's high crop diversity across the*

(*Continued*)

	State of stagnation	The state of transition	Managing through experience	Stabilised system
	diversity especially drought resistant species and short seasonal variety. There are increased efforts from NGOs and government institutions e.g. Wami/Ruvu water basin office that is making efforts to train communities on sustainable water resource use.	*their own small farms. The government provided agricultural farm inputs, but farmers still complain of lacking full government and NGO support in production, hence lowering the household productivity.*	*They base most of their action following findings and recommendations from researchers, policy makers and scientists.* *Owing to the rise in communal responsibility especially with increased use of irrigation facilities, the region now is highly productive in vegetable farming.* *There is a fast increase in farmer marketing associations and co operatives; there is considerable stability now in both local and regional markets. There is increased use of commercial vehicles that are transporting farmer products to Morogoro, Dar es salaam, other parts of Tanzania and neighbouring countries like Kenya and Uganda.*	*catchment following increased use of irrigation facilities. A relatively higher percentage of the population in the community is knowledgeable, there's enhanced productivity, increased water availability especially with protection of major water sources in Wami and Ruvu river systems. We have improved facilities amongst farmers and farmer groups; this has improved the productivity for the region.*
Finances - *Markets* - *Income* - *Micro-loans* - *Farming equipment* - *Infrastructure*	*Following adverse losses in the past 20 years due to high exploitation in most local markets by middlemen within the catchment, farmers find it suitable to extend their efforts to other areas. This though has affected the average farmer's income. This has a negative implication in the sense that despite continued efforts to meet the daily basic needs; smallholder farmers are unable to participate in purchase of improved facilities like tractor services. With increased availability of loans and micro-credit facilities in the area, and with the economy not having picked up well, a larger percentage is still struggling with the available little investment. Only the rich farmers, with other income sources are able to afford better advanced facilities in productivity and transport of their produce. The roads are still under development with strained economy, meaning that transportation costs are relatively high and cannot easily be afforded by the average farmer. The living standards are still high; per capita income at the local scale.*	*There are no stable markets yet for their merge produce. Most farmers still expect that the government will one day buy them improved farming equipment due to their financial inability to purchase their own. All the government sectors, NGOs have offered their best financially in developing the region by improving roads and communication networks in various parts of the catchment and the surroundings. They have further developed smallholder farmer industries like tomato processing industries in many of the smaller towns. Productivity however has been heavily dragged backwards by adverse drought conditions since irrigation programmes have not picked up well. With the increase in population and the rise in population, land is still regarded as a scarce commodity that cannot be adequate for diverse activities besides maize growing and vegetable production. Labour source is still manual and costly, and only few individuals are capable of affording tractor hire.*	*Following better local governance through formation of farmer groups targeted at finding good markets in Dar es salaam and neighbouring countries like Kenya and Uganda, there's improved investment by the Tanzanian government in micro loan facilities to enable farmers buy farm inputs and market their farm produce. Local governments are well empowered to assist farmers in purchase of good farming facilities like tractor use, rain water conservation equipment and irrigation facilities. With this already in place, farmers can work throughout the year; this has extensively minimised community reliance on vuli and masika rains. Majority of the smallholder farmers are actively engaged in farmers' associations that facilitate group activities such as marketing of farm produce and purchase of farm machinery.*	*The economy in Morogoro region has greatly improved in the past 20 years. There's increased government investment in the agricultural sector. More locals are attracted to businesses to connect them to the neighbouring countries. Development of better roads has enhanced economic well-being of the region leading to increased job opportunities for many young people as well as more investors developing an interest in the region. There's heavy investment by Tanzanian government in technology, with better roads and infrastructure which has attracted more foreign investors from outside.*

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