Adaptation to the Impacts of Climate Change on Agriculture in eThekwini: A literature review

Research Report 2016 No 7

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This work is based on the research co-supported by the South African Research Chairs Initiative of the Department of Science and Technology and National Research Foundation of South Africa (NRF Grant No 71220) and the European Union's Programme to Support Pro-Poor Policy Development Phase II (PSPPD II) through the project titled *"An analysis of climate change adaptation and poverty reduction: a case study of eThekwini Municipality, KwaZulu-Natal, South Africa".*
EuropeAid/134258/M/ACT/ZA PSPPD2/CfP/2014/15/42.2

Acknowledgements

This paper benefitted from critical peer review by Bahle Mazeka, Andrew Okem and Kathleen Diga.

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http://appliedpovertyreduction.com/

ISBN: 978 1 86840 633 3

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Introduction

eThekwini Municipality is globally recognised as South Africa's most competent metropolitan-level local government (Robbins, 2005). The municipality has emerged from a number of continuous restructuring processes under the recent legislative structures with a comparatively stable political, administrative, and financial status. During this course of change, eThekwini Municipality persists on improving the quality of life for the urban poor as a priority in the official planning systems (Robbins, 2005). However, the metropolitan inhabitants face complexities ranging from social, economic, environmental and governance (Statistics South Africa, 2015).

Climate change is one of the imperative issues that not only affects the eThekwini Municipality, but the country and the continent as a whole. For decades, climate change has affected rural and urban areas, particularly within the setting of agricultural systems. Increasingly, farmers are experiencing difficulties in adapting to unpredictable climatic conditions for farming and marketing their products (Knegtel, 2014). Such insecurity can have major consequences on the stability of the food system in a region like eThekwini Municipality and thereby has burdening costs, especially on the poorest.

Adaptation and mitigation are two strategic responses to the climate change. Adaptation can be defined as shifting human actions and planning while taking climate change into account and attempting to reduce the undesirable impacts that extraordinary climatic events might have on a person's quality of life (eThekwini Municipality, 2007). Mitigation refers to reducing the level of greenhouse gases (GHG) entering the atmosphere as a result of anthropogenic activities (eThekwini Municipality, 2007). This reduction of GHG intends to decrease the amount of heat excess and the corresponding effect on the earth. These are two of the major strategies to addressing climate change and both are required within an appropriate balance in order to reduce the vulnerability and risk of negative impacts.

South Africa has 63% of its total population (52 million) in urbanised areas, inhabiting towns and cities, in 2011 compared to 58% in 2001 and 55% in 1996 (Statistics South Africa, 2011). Extreme poverty is measured using the food poverty line which is calculated "by determining the daily cost of a basket of foods which would satisfy the minimum caloric requirement (Budlender et al., 2015:9). In using the latest Statistics South Africa's food poverty line

estimate (2010/2011 Income and Expenditure Survey, March 2011 prices), 20,76% of the South African population live in extreme poverty (noted as R335 per capita per month), (Statistics South Africa, 2015). Rapid urbanisation and climate change will further exacerbate this condition and endanger current agriculture practices. The outcome of this is a further increase in the number of South Africans that will become food insecure. The incremental changes of temperature and conditions for either small scale or large commercial farming may even exacerbate the cases of extreme poverty and thereby having devastating quality-of-life effects on the most poor. There is already evidence of hunger issues in rural regions and urban metropolitan areas. Some of the worse hunger events were documented in the Umzinyane Municipality, KwaZulu-Natal. eThekwini also has its share of hunger cases, where the informal settlements' movements, such as those of the Umkhumbane and Cato Manor areas, are formed against exploitation, disparity and hunger (Gibson, 2007).

This paper is informed by the broader project on climate change adaptation and poverty reduction. The aim of this project is to understand what forms of government policy and practice intervention in KwaZulu-Natal, and beyond, can lead to successful pro-poor climate change adaptation activities. Furthermore, the project intends to interrogate the best means of implementing such interventions. Another important facet of the research is to examine the activities already undertaken by small-scale farmers and to interrogate how policy enhances or undermines existing adaptation strategies of the small-scale farmers in the Municipality. In achieving this goal of improved results in terms of climate change adaptation and poverty reduction, the project aims to help the private sector, all levels of government and donors to learn the forms of intervention and investment, as well as the nature of interactions between international and national agencies and persons on the ground that are most conducive to both reducing poverty and adapting to climate change.

Using desktop research, this specific report looks at both the published and grey literature to determine the agricultural adaptations due to climate change in the eThekwini municipal area. The report comprises a brief description of agricultural contribution to poverty reduction and sustainable livelihoods. It further documents available municipal policies, institutional arrangements, multi-level governance of climate change adaptation strategies as well as programmes and strategies in the area of agriculture. The paper report acknowledges the significance of indigenous knowledge in responding to climate change in the agricultural sector. Lastly, this report looks at possible expenditure allocated for climate change adaptation programmes.

An Overview of Agriculture in eThekwini Municipality

eThekwini Municipality is located on the east coast of South Africa in the province of KwaZulu-Natal (KZN). The municipality is made up of an area of approximately 2 297km² and is home to some 3.5 million people (Statistics South Africa, 2011). It is made up of a diversified society characterised by numerous social, economic, environmental and governance challenges. One of the economic challenges facing the Municipality is an increasing rate of unemployment. The 2011 census indicated that about 30.2% of the metro populations are unemployed (Statistics South Africa, 2011). The Municipality endeavours to address these challenges by meeting the needs of a rapidly increasing urban population (Statistics South Africa, 2011).

Small-scale farming is known for its significant role in reducing poverty, especially in rural areas, both as a food source and a source of income. Preliminary research conducted during Phase 3 of the Municipal Climate Protection Programme (MCPP) indicates that 50% of the food consumed by the rural poor is locally produced. Therefore, adaptation within this sector is critical if food security is to be ensured in the future (Roberts, 2008). Currently, there has been an increasing interest in transforming urban agriculture as a significant activity that is positioned to buffer against poverty in urban and peri-urban areas.

Like most municipalities located in the KZN province, eThekwini has a great volume of sites with quality agricultural potential. However, there are currently limited agricultural activities that are taking place in the Municipality (eThekwini Municipality, 2015/16). For example, only about 105,567 households of the municipality's 956,713 households are practicing any form of agriculture (Statistics South Africa, 2011). Farming activities in eThekwini include livestock (12.8%), poultry (20.9%), vegetable (39.6%), other crops (12.3%) and other agricultural activities (15.4%), (Statistics South Africa, 2011). Monthly income of agricultural activities to households is divided into five categories: 1) 20.7% of households do not financially benefit from agriculture; 2) 4.5% earns at least R1-R4 800; 3) 46.4% earns around R3 800-R4 801; 4) about 15.6% earns R38 401-R307 200 and; 5) 2.5% generate more than R307 201 income (Statistics South Africa, 2011).

A study conducted using small-scale farming surveys in 1992 demonstrated that people who are dependent on urban agriculture (UA) continue to practice and become advocates of it (Smith et al., 2005). The findings demonstrated that 25% of households in urban areas of the eThekwini municipality were active in UA, 10% of those were trading their produce (Smith et

al, 2005). While the level of agricultural practice differs amongst economic groups, UA is most popular for middle-income groups (people with relatively good access to resources). Nevertheless, the significance of small-scale farming varies within areas; responses from a study that examine UA activities in Umlazi, Isipingo and Wentworth reveal a collective interest in promoting nutrition, food security, household income and community development (Smith et al., 2005). According to the Centre for Development Support (2010), urban agriculture can play a small yet significant role in addressing poverty. However, literature has consistently shown that unstable climatic conditions may negatively disrupt the production of food and thereby interrupt food production in both urban and rural scale.

Impacts of Climate Change on Agriculture

The projected impacts of climate change on agriculture are anticipated to be comprehensive. Systems for agriculture worldwide are already subjected to both positive and negative impacts, where the negative ones are highly prevalent (Climate Change Synthesis Report, 2014). The South African Long-Term Adaptation Scenarios' (LTAS) Flagship Research Programme identified various climate change impacts on the agricultural sector that are anticipated to have severe implications on food production (Climate Change Synthesis Report, 2014).

In Durban, the eThekwini Municipality commissioned a study of localised climate change impacts for the city in 2004 (eThekwini Municipality, 2007). The results indicated that the municipal area is likely to encounter drastic changes where factors, such as unfavourable temperatures and rainfall conditions, will have major impacts on agriculture. In Durban, the daily maximum temperatures are expected to increase by 1.5°C and 2.5°C by 2065, and increase between 3°C and 5°C by 2100 (eThekwini Municipality, 2014; eThekwini Municipality, 2007). Heat waves and temperatures over 30°C will also increase from October to March (eThekwini Municipality, 2007). Rainfall patterns are expected to become more concentrated into heavy rainfalls and/or floods, which will result in longer dry periods. Future projections also identify expected intensity in rainfall by 2065 with an increase of up to 500mm by 2100 (eThekwini Municipality, 2014). In relation with these weather patterns, climate change is predicted to pose significant challenges in the agricultural sector. For instance, extended dry periods will result in water availability shortages from various sources (dams, underground water recharge, etc.) that will result in decreased agricultural productivity (eThekwini Municipality, 2007).

Increased temperatures in eThekwini municipal areas will further contribute to crop impairment and heat stress for livestock. Higher temperatures could also have nefarious impacts on rain fed arable land, thus creating a greater need for irrigation. Extreme weather patterns are forecasted to affect food supply chains by disrupting transport networks, food storage warehouses, and processing facilities (eThekwini Municipality, 2014). For example, climate change disasters such as rainstorms and floods can disrupt food transportation networks (Kasavel et al., 2014). Moreover, predicted flooding will result in water-logged soils and leaching of nutrients, resulting in low yields. Projected climate inconsistency may compromise both commercial and small-scale farming and affect food security (eThekwini Municipality, 2014).

A study by the BioResource Unit of eThekwini Municipality on the impacts of climate change on crops showed a consistency on various agricultural yields, including improved conditions for pumpkins (mostly suitable for hotter climates), bananas, mangoes and pawpaws (suitably inland rather than in coastal areas), (BioResource Unit, cited in Golder Associates, 2011). The analysis showed that conditions are poor for avocados in the municipality and this issue does not improve with alterations in temperature. The harvest of dry green beans also indicates a drop in yields with temperature, especially in areas along the coast, but it stays a practical crop for cultivation within the municipality (Golder Associates, 2011). Cabbages and carrots yield is projected to decline with increasing temperatures. Moreover, sorghum, although primarily identified as a possible substitute for maize, is expected to bear low yields, particularly along the coast. Soybeans farmed along the coast will decline substantially (in 2045-2065) and (2081-2100), (Golder Associates, 2011). It is also projected that dry-land maize (eThekwini's main subsistence crop) will experience low yields with an increase in temperature, especially for subsistence farmers who fail to carry out irrigation and other supplementary farming techniques. To ensure food security in the municipality, it is important to identify alternative climate resilient crops (Golder Associates, 2011). Table 1 below provides a brief summary of the above discussions on the impacts of climate change on food security.

Table 1: Summarised impacts of climate change on agriculture in eThekwini Municipality

Climate Change Scenario: Increase in Temperature	
Food System Impacts	**Food Security Impacts**
Food production: · Shift in agro-ecological zones · Change in crops grown per area · Decrease in yield due to heat stress · Increased weed pressure · Increased disease pressure · Heat stress impact on animal productivity · Reduction in fish number (coastal) *Food processing:* · Increased need for cooling of perishable products · Change in postharvest losses *Food distribution:* · Shorter shelf life of perishables · Improved refrigeration needed *Food consumption:* · Food perishes quicker, requires more preservation or refrigeration	*Food availability:* · Overall decrease in food supply · Shorter shelf life for perishable products reduces availability *Food accessibility:* · Reduced availability leads to increase in food prices which would make food less affordable, particularly for urban populations *Food utilisation:* · Need to eat food sooner with shorter shelf life · Might require more fluid intake · Change in food types consumed *Food stability:* · Reduction in stability of food supply due to decreased availability · Potential greater seasonal variation in supply
Climate Change Scenario: Increase in Severe Weather events e.g. storms and floods	
Food System Impacts	**Food Security Impacts**
Food consumption: · Change in growing conditions (damaged crops, lower yields; soil erosion) · Impact on livestock health *Food processing:* · Damaged storage facilities and processing plants *Food distribution:* · Damage to transport network *Food consumption:* · Food basket composition changed · Increased water-related health risks and cleanliness of food	*Food availability:* · Decrease in food availability · Increased need for food aid · Increase in food imports *Food accessibility:* · Increase in food prices make food less affordable · Food supply chains can be affected, resulting in allocation problems *Food utilisation:* · Food safety problems due to spoilage or emergency rations being used · Preferred foods not available *Food stability* · Overall decrease in food stability

Source: eThekwini Municipality, 2014

Responses of the commercial sector to climate change

KwaZulu-Natal (KZN) is ranked the highest of the South African provinces that is most vulnerable to climate change and is the third lowest in adaptive capacity (Wilk et al., 2012). The effects of climate change on food supply has been long expected and commercial farmers have been proactive in adapting to climate change compared to small scale farmers. As a result, there is more written about commercial farming and climate change.

According to Sanpath (2009), commercial farmers in KZN are investing in new technologies to make their produce resistant to climate change. The president of the KZN Agricultural Union (KWANALU) asserted that farmers are investing money to guarantee that they keep producing similar crops and breeding the same livestock. This strategy ensures that in the short-term there are no alterations to the types of livestock and crops produced, but production techniques and systems are altering. For instance, farmers are reassessing irrigation strategies to increase the water supply in light of projected water scarcity due to climate change (Sanpath, 2009). In the upper Thukela basin, for example, farmers have invested in increasing water supply by investing in irrigation systems and reservoirs, purchasing bulk water from dams and limiting water demand through growing high-value, drought-resistant crops (Wilk et al., 2012). Correspondingly, seed producers are developing drought-resistant seeds for farmers (Sanpath, 2009). Crops that are resistant to harsh climatic conditions are expensive; however, it is worth the investment since they increase their resilience to drought (Wilk et al., 2012). Like crop farmers, livestock farmers are making substantial investments on advanced ventilation structures to overcome increasing temperatures (Sanpath, 2009). Some commercial farmers stress the importance of increasing their insurances to respond to agricultural climate change issues. Across the Municipal area, there are various initiatives being undertaken by farmers to better adapt to climate change. We present some of these initiatives below.

Diversification

Over the years, many farmers have lost interest in monoculture on a single farming technique. Consequently, large scale farmers have established alternative businesses on their farms such as tourism and other adventure trials (Massey, 2008). Others have started their own consultancies, such as engineering and farm activities, or work for others to subsidise farm income. Rearing livestock is also likely in sugarcane farms as a part of land-use practices as a subsidisation for farm activities as well as income (Massey, 2008). Shifting from crop production to livestock rearing has also been the case in the upper uThukela region (Wilk et

al., 2012). Seed cane production and retailing are among the important adaptation strategies in Eston. If nurtured properly during drought and secured from pests and diseases, seed cane can allow farmers to start again after a period of adverse climate conditions. The seed cane can be utilised on farmers' own farms or sold to surrounding groups (Massey, 2008).

Changing Land Use and Farm Practices

Like diversification, altering land use and farm practices are responses to climate change risks and climate variability. Growing suitable varieties of sugarcane to cope with changing weather, pests, soil, and diseases is a crucial decision for commercial cane farmers. Once a farmer has decided on which sugarcane to grow, it takes a number of years before changing it again (Massey, 2008). Cane variety practices are one of the important adaptation strategies for Illovo sugar (Illovo Sugar, 2015). This variety of development and ploughing is aimed at increasing the resilience to drought and pest vectors.

Sustainable use and management of natural resources are also essential strategies for adapting to changing climatic conditions. A specific change implemented by commercial farmers [assisted and provided by South African Sugar Association (SASA)] was to switch from crop burning to removing the leaves by hand, regarded as trashing (Massey, 2008; Illovo Sugar, 2015). Crop burning negatively impacts the soil while the benefits of trashing include a reduction in soil erosion and water run-off. The practice further aids water infiltration, moisture conservation and weed destruction (Massey, 2008).

Land use planning is another significant response for a large number of commercial producers. Land planning acknowledges that different areas of the farm need different management practices. The planning is directed towards agronomic practice, climate, soils, water and the landscape with an aim to receive great economic results while conserving the environment (Massey, 2008). These farming practices reduce the threat of natural resource degradation (i.e. erosion and leaching) and crop failure, while improving natural resource management and sustainability. They also safeguard against pests and diseases. These practices are essential in reducing the negative impacts of climatic and non-climatic issues (Massey, 2008).

The Use of Social Networks and Support Systems

Social network platforms and support structures include the use of cooperatives and societal gatherings. This has been used as a medium for knowledge sharing and empowerment of farmers in problem solving (Massey, 2008). Commercial farmers attend monthly meetings,

consult on their challenges with extension officers and technicians from the Department of Agriculture, and ask for advice from fertiliser and chemicals experts. For commercial farmers, continuous education and sharing of knowledge are of utmost importance as they are enabled to keep up with current technologies, know-how, breeding practice, pesticides and crop varieties. Thus, it is critical that commercial farmers seek their advice from the experts (Wilk et al., 2012).

The Use of Crop Modelling and Seasonal Climate Forecasts

Crop modelling strategy is important for commercial farmers and access to it is usually provided by SASA and South African Sugar Research Institution (SASRI). Seasonal climate forecasting is facilitated by numerous support and scientific departments within SASRI. Illovo sugar is also engaged with these institutions and funds SASRI (Illovo Sugar, 2015). SASRI provides forecast, crop and climate modelling systems, harvests approximation and early warning systems. It also provides information on sugarcane varieties that are less prone to pests and diseases, improved drought tolerance as well as sustainable crops and farm management systems (Illovo Sugar, 2015). The information is accessible through the internet, via SASRI extension officers, and literature obtainable by those that utilise SASA services (Massey, 2008).

Cutting sugarcane at an early stage to prevent production loss due to the droughts (and due to high temperatures) is another adaptation strategy by farmers in KZN (Benhin, 2006). A study by Benhin (2006) identified various adaption strategies by farmers across the nine provinces of South Africa. These include (i) delaying ploughing during drought; (ii) greater usage of modern machinery to take advantage of shorter planting periods; (iii) harvesting rain water through furrows near plants and; (iv) increased use of irrigation (with sprinklers as the preferred option as they use less water) (Benhin, 2006).

In environments with higher temperatures, famers have used (i) heat-tolerant crop varieties; (ii) crop varieties with high water use efficiency; (iii) quick maturing crop ranges and; (iv) mixed farming (Benhin, 2006). Farmers have also resorted to improved chemical application to reduce evapotranspiration. There is also an increase of shade and shelter farming where farmers plant trees around their produce and use fishnets, vegetation and plastics as coverings to protect plants against bad climatic conditions (Benhin, 2006). Accordingly, the commercial sector has identified and adopted considerable techniques to deal with climate change. For

small-scale farmers, climate-smart farming is slowly becoming the key instrument for adaptation to climate change. eThekwini Municipality is amongst the municipalities that have taken steps to develop policies essential for climate change adaptation by small-scale farmers.

Policies on Adaptation to Climate Change in Agriculture

Climate-Smart Urban Agriculture Policy

After 67% of the eThekwini region was defined as 'rural' in character and some peri-urban in 2000, the eThekwini municipality adopted the Rural Agricultural policy for eThekwini in 2004 (Gilmore, 2015). This policy aimed to develop Rural Agricultural Services and Marketing Hubs within rural space as identified in the Rural Spatial Framework Plan of 2003. This was aimed at providing accessible agricultural services as well as creating partnership between rural farmers, non-governmental organisations (NGO) and private and public sector organisations (Gilmore, 2015).

eThekwini Municipality also shows support for urban agriculture. While policy on urban agriculture is usually incorporated into mainstream development programmes at the local and city level, eThekwini seems to be an exception. A policy on the environment also exists in eThekwini where a purposive attempt is created to offer public, open space in selected low-income locations for urban agriculture (Centre for Development Support, 2010). This approach saves the eThekwini Metro the costs of maintaining open spaces, it helps address the challenges of alien invasive plants and, at the same time, it offers people access to financial opportunity (Centre for Development Support, 2010). The increase of urban agriculture in eThekwini, and nationally, can be associated with the phenomenon of urbanisation in post-Apartheid South Africa. With the rising population in urban areas, agricultural sector finds it difficult to meet increasing urban food demand (Knegtel, 2014). Urban agriculture can respond to the daily demand of consumers within the cities or within the urban and peri-urban areas (Knegtel 2014).

There are various definitions of urban agriculture or urban and peri-urban agriculture. In a holistic sense, urban agriculture may be defined as any agricultural related activities within the 'intra-urban' scenery and on the 'peri-urban' fringes (Centre for Development Support, 2010). Urban agriculture is not only limited to crop farming but can also incorporate animal husbandry, aquaculture, agro-forestry and horticulture (Centre for Development Support, 2010).

The use of sustainable farming methods and natural resource conservation, as part of urban agriculture, signify a climate-smart technique for the destitute and future generations to endure their livelihoods together with their surrounding environment. Consequently, the eThekwini Municipality supports the Climate-Smart Urban Agriculture Policy to benefit urban farmers and help them cope with climate change (Knegtel 2014). The Municipality is increasingly investing in eco-friendly and 'green' programmes. The key municipal institutions that play part in these policies are discussed below.

Municipal Institutions with a Role in Agriculture and Climate Change

The eThekwini Municipality Municipal Climate Protection Programme (MCPP) was founded by the Department of Environmental Management in 2004. In 2009, it was converted into what is today known as the Environmental Planning and Climate Protection Department (EPCPD) (Knegtel, 2014). The MCCP comprised two segments, the 'Climatic Future for Durban' and the Headline Climate Change Adaptation Strategy (HCCAS). The 'Climatic Future for Durban' is a partnership between the municipality and the Council for Scientific and Industrial Research (CSIR) to study local climate changing trends and their magnitude. The Headline Climate Change Adaptation Strategy (HCCAS) of 2006 identifies the main interventions needed by the municipality to adapt to climate change (eThekwini Municipality, 2012). The MCPP is responsible for monitoring and reacting to climate change issues within the municipality. As a result, it is responsible for launching various strategies/policies to help urban farmers adapt to climate change. However, the eThekwini Parks Office is largely responsible for some urban agriculture initiatives. While there are a number of prosperous individual gardens and municipal nurseries around eThekwini, the assistance from the Parks Office is strictly directed towards assisting community efforts so that urban agriculture can eventually spread into households (Smith et al., 2005).

These mainstreamed adaptation strategies later informed the establishment of the Community Adaptation Planning (CAP), where eThekwini Municipality recognised the significance of societies to engage climate change adaptations through the establishment of CAP pilot projects in Ntuzuma and Ntsongweni (Roberts, 2010). This is discussed further in the community-based adaptation section below.

Actors Involved with Climate and Agricultural Programmes

The municipality has been making efforts to partner with external organisations for agricultural support. Newlands Mashu Permaculture Learning Centre (NMPLC) is amongst the metro

partners. NMPLC is an NGO established as an agro-hub to give training courses in sustainable farming, agricultural extension support as well as agricultural development planning (Newlands Mashu Perarculture Learning Centre, 2012). The relationship between NMPLC and eThekwini municipality contributed considerably to the eThekwini Urban Agriculture Forum which attempted to co-ordinate and develop urban agriculture projects. This relationship eventually materialised and produced a dedicated eThekwini Agricultural Management Unit (AMU). NMPLC also influenced the AMU to fully embrace permaculture organic farming as its main principles for sustainable agricultural development (NMPLC, 2012). The NGO has further trained a considerable number of government officials, extension officers and local communities in permaculture (NMPLC, 2012).

Another partner of the eThekwini municipality is Bremen Overseas Research and Development Association (BORDA). BORDA is an NGO that guides and facilitates projects in the areas of decentralised sanitation, waste water treatment, water and solid waste disposal in Asia and Africa (NMPLC, 2012). The NGO assists eThekwini Municipality with the Decentralised Wastewater Treatment System (DEWATS). Since there is evidence that the effluent from waste water is rich in minerals such nitrogen and phosphorus which are essential for plants, there have been field evaluations of different crops and sources of treated water in the horticulture field trial facilities (Reuter et al., no date). One of the investigations examined the effect of using Anaerobic Baffled Reactor (ABR) effluent on the nutrient uptake, growth and yield of Swiss chard on selected soil types. As treatment, it compared the results to plants that were irrigated with tap water without fertiliser; tap water with fertiliser and rain water with fertiliser. The results showed that Swiss chard pots irrigated using the effluent showed significantly higher dry mass, fresh mass and leaf area index compared to those irrigated with tap water (Musazura, 2014).

Most recently, Food and Trees for Africa (FTFA), South Africa's original countrywide social and environmental initiative, has been selected as eThekwini Municipality's recognised food security co-ordination partner, via the public benefit organisation's Food Eco Enterprise Development (FEED). The appointment of FEED and FTFA was sanctioned on the 8 October 2015 when signing of the contract process took place (Food and Trees for Africa, 2015). FEED Africa provides support to organic farmers using land and infrastructure development, educating and mentoring assistance and the distribution of local, super and global markets.

FEED Africa projects are centralised on a three to five year business model of a 'core farm' that assists core food producers and numerous 'outgrowers', who finally run their own ventures as independent enterprises (Food and Trees for Africa, 2015). This development merges nearly seamlessly with eThekwini's Municipality's current agro-ecology programmes mentioned later, which is deliberately designed to improve food security, sustainability and self-sufficiency for its inhabitants. The eThekwini officials, Dr Zandile Gumede and Ms Roshino Bob, who has been the acting strategic manager of the project, believe that this affiliation with Food and Trees for Africa will progress the small–scale farming into ensuring more food security and economic independency for eThekwini communities than before (Food and Trees for Africa, 2015). While there is a growing partnership in eThekwini Municipality's agriculture sector, multi-level control remains significant in most matters incorporating climate change. The paper will now explore the multi-level governance of climate change initiative in the city.

Multi-level Governance of Climate Change

Climate change is a multi-level governance issue incorporating different disciplines, and it is a cross-cutting challenge that needs multi-disciplinary attention. Therefore, it is essential for the municipality to work in sync with global and national governance structures and to participate in specifically local climate adaptation strategies. The South African government has taken an initiative to address climate change by engaging in the international and adaptation incentive mechanisms. The South African government endorsed the United Nations Framework Convention on Climate Change (UNFCCC) in 1997 and the Kyoto Protocol on 2002 (City of Johannesburg, 2009). The former National Department of Environmental Affairs and Tourism (DEAT), which is currently known as the Department of Water Affairs and Environment (DWAE), (City of Johannesburg, 2009), submitted the original national carbon inventory to the UNFCCC in 2000 and prepared National Climate Change Response Strategy for South Africa that recognises the need to adapt to climate change (EThekwini Municipality, 2007; Holgate, 2007). The National Climate Change Strategy was responsible for providing a common government action plan to assimilate and capacitate different departments to engage in the adaptation, mitigation and educational research, and emission trading activities. Thus, it detects adjustments to be employed in segments ranging from disaster management, healthcare to agriculture and irrigation, as well as development planning. The National Department of Environmental Affairs and Tourism also has a sub-directorate for Global Climate Change that is directed to build capacity in other national departments to incorporate climate change in their

activities and planning (Holgate, 2007). More recently, South Africa finalised the White Paper on the National Climate Change Response Strategy (NCCRS) and Action Policy of 2011-2014 "to ensure a coordinated, coherent, efficient and effective response to the global challenge of climate change" (Department of Environmental Affairs and Tourism, 2004; 2014).

Although limited actions have been undertaken to specifically address climate change at a national level, there are few existing national projects and policies that can help the country to adapt to climate change. A limited number of national projects and policies link vertically and are active in eThekwini Municipality (EThekwini Municipality, 2007). For instance, the National Department of Water and Forestry (DWAF) controls several projects that help the country deal with water scarcity. In relation to this, eThekwini Municipality runs adaptations programs such as:

- Working for environment - this aims to remove invasive alien plants that absorb excessive amounts of water and to provide employment opportunities in the municipality.

- Integrated Water Resource Management (IWRM) - intend to assist various municipal sectors, from industry to agriculture, to use water resources more proficiently.

- Catchment Management Forums (CMF)/ Catchment Management Agencies (CMA) - these are still in an introductory stage. The aim is to assemble government departments and stakeholders such as community associations, industries, and agricultural experts to look into, and plan water usage and development among river and dam catchment zones in order to sustain and increase water access and quantity.

The above cross-governmental projects have direct application (in this case water provision) to the success of agricultural initiatives.

There is also the National Environmental Management Act (NEMA) and the Environmental Impact Assessment (EIA) regulations (eThekwini Municipality, 2007). These policies aim to limit developments from destroying essential ecosystems; and open spaces with operative ecosystems, particularly in and around urban areas, grant various services including city cooling, erosion prevention as well as storing and filtering water that will be essential in adapting to climate changes (eThekwini Municipality, 2007). This is consistent with eThekwini Environmental Service Management Plan (EESMP) which intends to protect and plan an open space system that grants both adaptation and mitigating amenities. The Durban Open Space

System (D'MOSS) contains a number of ecosystems, including beaches, grasslands, wetlands, woodlands, and forests both on public and private spaces (eThekwini Municipality IDP, 2015/16). The Environmental Management Department (EMD) is specifically responsible for keeping open space system operational by decreasing development on these spaces. Areas in the open space systems are conserved by the Parks, Leisure, and Cemeteries Department working in collaboration with a number of conservancies, private landholders and other parties (eThekwini Municipality, 2007). In regards to agriculture and food systems, D'MOSS programme does have implications on the availability of land for agricultural activities, although they complement a climate smart strategy in climate change. These natural conservation systems may also have indigenous foods that are not commercially harvested and used as food by local citizens.

In examining how climate change adaptations strategies link across the eThekwini municipal structures, Environmental Planning and Climate Protection Department (EPCPD) has chosen to integrate with people and the municipal departments that are passionate about climate change issues and adequately capacitated to act on it. This technique is about adopting 'sectoring champions', or 'climate change moles', who work within the segments to shift rationalities and actions of officials towards climate change adaptation (Taylor et al., 2014). For example, given the steep slopes and concentrated rainfall in the municipality, the quick integration of the Storm Water and Catchment Management departments into evolving climate change energies has been essential. The method; however, has also left gaps. The capacity constraints and continual reorganisation of the Health Department and Disaster Risk Management departments, for instance, result in these departments making only slight contributions to the municipal climate change adaptation effort, despite the significance of their mandates (Taylor et al., 2014). Correspondingly, some of the large infrastructural sectors including housing, roads and traffic have yet to be approached and incorporated in the climate protection agenda (Taylor et al., 2014).

Other corresponding adaptation sectors in the eThekwini Municipality assists the city to remain operational and liveable as the climate changes. The eThekwini Department of Water and Sanitation (EWS) has developed programmes that are directed at the issue of water availability threatened by climate change. These include the Water Loss Management, that comprised of improved water pressure control and leak surveys. The EWS also implements the Waste Water Education Programme which coaches communities on how they can prevent sewer blockages and drips, which, in turn, will stop water contamination and waste (EThekwini Municipality,

2007). The eThekwini Municipality also supports a number of agricultural activities, some with adapting potentials to climate impacts.

Signature Programmes and Activities Pertaining to Climate Change and Agriculture

The eThekwini Municipality has undertaken multiple projects and activities in agriculture to promote food security for the poor communities in its jurisdiction (eThekwini Municipality, 2011). The state of urban food production in the eThekwini Metro is greater than anywhere else in South Africa, particularly with the city's enormous peri-urban region and its auspicious climate (Zerbe, 2012). The municipality has established a number of programmes to assist in food insecurity alleviation. These include over 600 community gardens that supply the soup kitchen programmes (eThekwini Municipality, 2011), aqua-and poultry farming, soya bean projects, mushroom and hydroponics project, One Home One Garden and many others (Spatial Development Framework Review, 2015/16). The Municipality also provides seedlings, compost and expertise to communities to assist them in attaining food security. The municipalities' support for urban agriculture is notable through a number of initiatives outlined below.

Organic and Sustainable Agricultural Initiatives

Local and sustainable agriculture is important as it mitigates and responds to climate change. eThekwini Municipality launched the Agricultural Management Section (AMS) in 2009 to test and encourage various organic and sustainable agricultural initiatives (eThekwini Municipality, 2011). The intended vision for this innovation is food sovereignty, food security, economic empowerment and environmental sustainability for eThekwini residents. Services such as training in bio-intensive agriculture are provided by AMS.

The use of renewable technologies to enhance water supply to gardens is another important project of eThekwini. There are experiments that use ram pumps, to transport water upslope, rainwater harvesting, and the use of biodigesters. The biggest of these digesters are found in Cato Manor. It functions to receive sewage and organic waste from the higher ground community and supplies 60 kilometres of nontoxic, full of nutrient water for both small-scale farm irrigation and aquaculture (eThekwini Municipality, 2011). Underground storage ponds, designed to capture and store storm water for irrigation purposes, and aquaculture systems with fish and food crops are used as another source of water (eThekwini Municipality, 2011). In addition, the AMS has initiated cultivating perennial crops and 'food forests' that work to grasp eThekwini's steep slopes while also producing different types of foods.

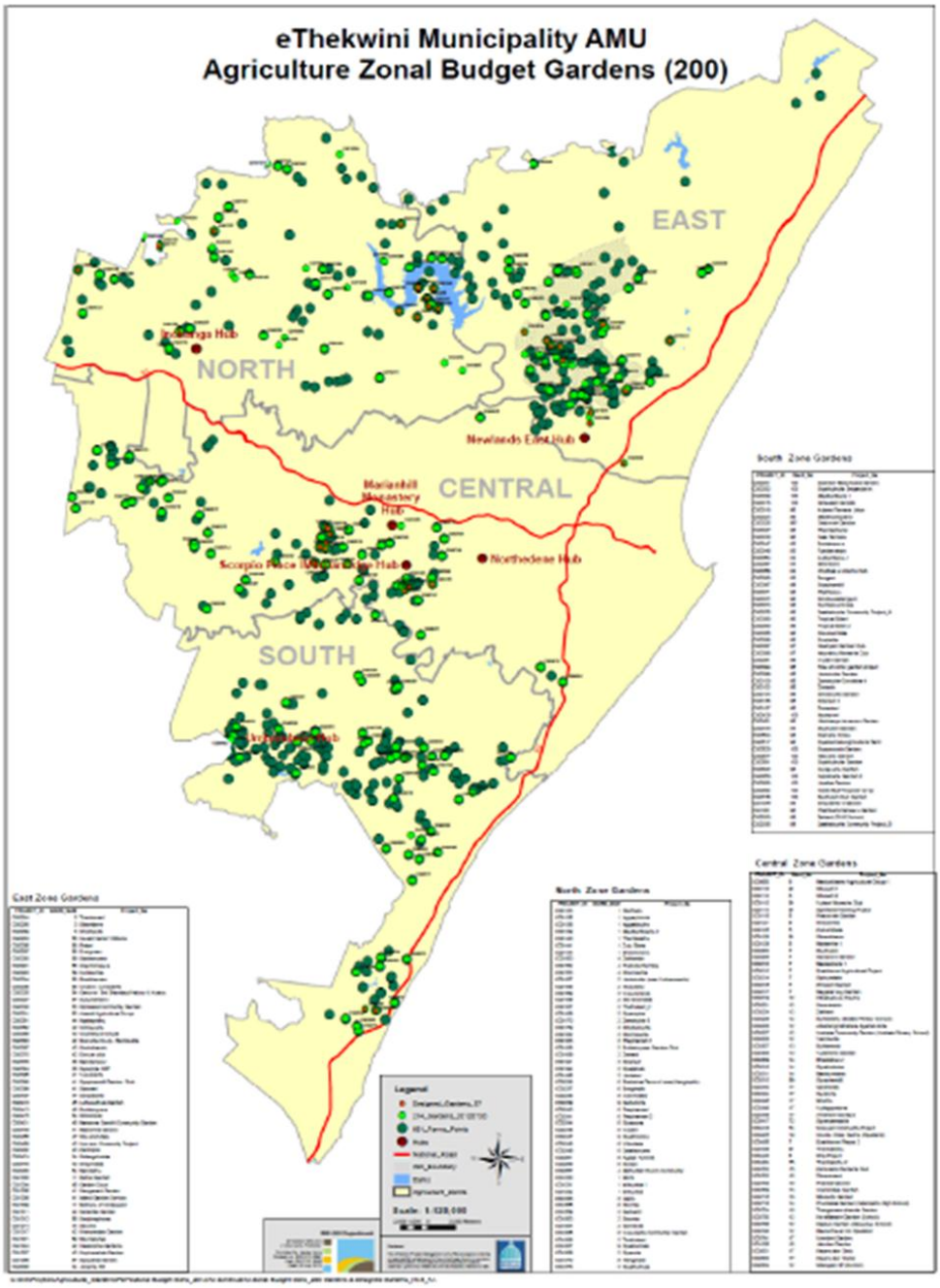
EThekwini Municipality's Green Hub

For its green and eco-friendly programmes, the municipality commissioned the Municipal Climate Protection Programme (MCPP) in 2004. This programme is accountable for monitoring and counteracting issues pertaining climate change within the municipality (Knegtel, 2014; Taylor et al., 2014; Roberts, 2010). The programme is mainly responsible for implementing approaches to aid poor citizens and urban farmers in adapting to climate change. For example, some of the initiatives include community-led installations of barrels and gutters to harvest rainwater, training in composting and permaculture methods and making roof gardens (Knegtel, 2014). Within the inner city, the Priority Zone precinct has partnered with a local security company to create a rooftop food garden, used to attract tourism and as a mechanism to improve conditions within the area (Botes, 2013). The objective of the municipality is to teach and prepare food producers to apply proven climate-smart agricultural practices to preserve their farms. In addition to climate-smart urban agriculture, the municipality has also launched an agro-ecology programme.

Agro-Ecology Programme

This agricultural support hub examines how farming can be a complementary strategy to buffer against poverty, food insecurity and joblessness. Among the outcomes of this has been the establishment of six large-scale demonstration farms in peripheral areas to help deprived people to source seeds, to package and market their products and get training in eco-friendly and climate smart agriculture methods (Knegtel, 2014; eThekwini Municipality, 2014). Under the municipality's Infrastructure Management and Socio-Economic Development Department (IMS), (since at least 2013), these agricultural hubs include the following: Northdene Agro-ecology Research & Development Centre, Newlands-Mashu Permaculture Centre, Inchanga, Scorpio Place in Mariannridge, Mariannhill Monastery and Umbumbulu (as per Figure 1). These hubs help to service the needs of the Agricultural Zonal Budget programme or the small farming co-operatives and gardens in all 103 wards (Ndlovu, 2013). Some of the services provided include fencing, access to transport routes, storm water control, water, tools, micro-irrigation, compost as well as training on garden maintenance (Tancott, 2013). A total of R40 million has been assigned from the Zonal budget to establish four of the six agricultural hubs to provide agricultural assistance, support and practical training (IMESA, 2013).

Figure 1: Map showing eThekwini's Regional Agricultural Hubs



Source; eThekwini Municipality Review, 2015/16

Expenditure on Agriculture

The total consolidated budget for the eThekwini Municipality for 2015/16 is R39.1 billion (Mthethwa, 2015). Since agriculture cross-cuts multiple departments, the exact figures for

agricultural support are not easy to calculate. However, of this total, agriculture represents about R9.9 million in 2015/16 or 0.00002 percent of the budget. This is spread across three signature agricultural categories, including agricultural hubs, community gardens and fish ponds. As shown in the Table below, the expenditure for the three years 2015/16, 2016/17 and 2017/18 is set to be R9 892 000; R5 473 000 and R2 221 000 respectively. For agricultural hubs in Inchanga, Newlands, Mariannridge and Umbumbulu, the Municipality planned to spend R1 755 000 in 2015/16, R1 766 000 in 2016/17 and R 717 000 in 2017/18. The Zamokuhle community garden is only receiving R 237 000 in 2015/16. Furthermore, fish ponds within the municipality are budgeted to obtain R7 900 000 in 2015/16, R3 708 000 in 2016/17 and R1 505 000 in 2017/18 (eThekwini Municipality, 2015/16).

Table 2: eThekwini's budget for agriculture (R'000) for 2015/16-2017/18

		2015/16	**2016/17**	**2017/18**
Agriculture		9 892	5 473	2 221
Agri Hub Upgrades		1 755	1766	717
	Inchanga	439	441	179
	Newlands	439	441	179
	Mariannridge	439	441	179
	Umbumbulu	439	441	179
Community Gardens	Zamokuhle Gardens	237	0	0
Fish Ponds		7 900	3 708	1 505

Source: EThekwini Municipality, Medium Term Revenue and Expenditure Framework 2015/2016 to 2017/2018

Other agricultural climate change adaptation projects that received funding previously are: Community Adaptation Plans, which received R2.50 million; Luganda School Water

Harvesting and Micro Agricultural Water Management, which received R350 000, and; the construction of the DWATTS at Newlands-Mashu Agricultural Hub Technology, which cost R2.30 million, while its testing and research for the infrastructure to facilitate field trials and test water cost R 1.15 million. Moreover, the Durban Botanic Gardens' Permaculture Centre and Food Garden Network received R250 000 (eThekwini Municipality, 2011).

Durban Climate Change Strategy (DCCS)

This DCCS project is funded and lead by the Environmental Planning and Climate Protection Department (EPCPD) and the Energy Office (EO) of eThekwini Municipality. The vision of the DCCS is for the Durban population to have a strong food security status. The DCCS identifies five aims and strategies that will lead to food security (Kasavel et al., 2014) in the table below.

Table 3: Showing strategies for improving food security in eThekwini

Aims	**Proposed Strategies**
Durban has robust local food production systems that are able to withstand future climate threats	Promote ecological and sustainable farming practices as an overarching approach. Raise awareness and provide widespread training for farmers and communities on how to farm sustainably using techniques such as crop rotation, companion planting, organic farming, permaculture, roof gardening, permanent crops, open pollinated seeds and regenerative agricultural planning. Educate farmers and communities to use water more efficiently through the promotion of rainwater harvesting technologies, retention ponds, catch-pits, drip irrigation and storage during dry periods. Promote the separation of green and organic waste for composting and mulching which prevents methane generation from organic waste at landfill sites. Seeds should not be genetically modified and heirloom seed saving should be encouraged. Cooperation amongst small-scale growers should be encouraged and supported. There should be a shift from fossil fuel driven monoculture to small scale communal farming. Indigenous knowledge is drawn upon to produce food in a changing climate.

Durban has robust local food production systems that are able to withstand future climate threats (cont'd)	• Urban development projects must include reservation of space for food cultivation and proper utilisation of land. • Integrate departments and sectors to work together to develop local policy and laws on agricultural practices that integrates efforts and removes obstacles. • Localise food production and distribution through the preservation of agricultural hubs and small scale local community farming efforts • Research and identify crops that are better suited to new climatic patterns. • Educate communities and farmers on alternative crops that are more suited to Durban's changing climate. • Identify crops that are pest and disease resilient • Provide access to awareness and education on climate change and its effect on food production and consumption especially in the poorest areas
Durban has adequate food distribution and marketing networks in place to adapt to climate change	• Promote the decentralisation of the fresh produce marketing system through a system of distribution hubs that can supply small traders more effectively and efficiently. • Establish food markets at transport hubs with local, and other, farmers supplying local communities. • Provide support to informal traders i.e. micro-credit, shade and trading facilities that take account of climate change. • Provide localised storage (and refrigeration) facilities for informal food marketers. • Use food waste from processing/marketing facilities to provide clean energy (biogas generation). • Use the clean energy to power facilities in a localised manner that is independent of the energy grid.
Durban residents have economic access to food in the face of climate change	• Improve people's livelihoods by supporting entrepreneurial activities so that people can earn income and pay for food. • Consider paying for certain activities with food coupons that people can trade in at designated food stores/facilities. • Promote small business that enhance food security in the face of climate change.

Durban residents are able to utilise food in the best possible manner in the light of climate change	• Provide clean, safe drinking water to all communities and residences. • Educate people on utilisation and preparation of crop types that may be more appropriate for production under changed climatic conditions. • Investigate and promote sustainable food preparation and preservation technologies. • Provide refrigeration facilities at decentralised marketing hubs where small traders can pay for, and store, refrigerated food, thereby increasing the shelf life of foods and increasing the overall amount of food in storage. • On-going education on healthy eating habits (e.g. eating orange rather than white sweet potato which has higher Vitamin A content)
Durban is prepared for climate related disasters or events and is able to supply its residents with adequate food during these disasters	• Link with existing food banks and promote more. • Consider a system of smaller, localised food banks or fresh produce hubs that are able to effectively supply food locally to extreme weather disaster affected households. • Establish emergency rations storage at such facilities. • Consider alternative logistic methods for bringing food into the city and surrounding areas and distributing within. • Investigate modern, emergency ration food preservation.

Source: Kasavel et al., 2014.

Durban Botanic Gardens Projects

These projects have developed a number of innovative activities. The educational and interactive exhibitions address challenges associated with climate change embracing the value of biodiversity, water conservation, food security, and renewable energy (eThekwini Municipality, 2011). Durban Botanic Gardens has a number of programmes that support both formal and informal urban and peri-urban agriculture within the city. For instance, it has developed a Food Garden Network program which assists the local community's access to land for small-scale farming. It also offers technical assistance and training to producers (Zerbe, 2012).

Although metropolitan cities such as eThekwini and Johannesburg have expressed rhetoric backing for urban agriculture, there has been very limited tangible and quantifiable support. It is estimated that there are to be 800 million urban food producers worldwide, a quarter of them

are commercial farmers producing for markets, and almost 150 million are fulltime producers. Yet, despite the efforts of municipal officials, urban food producers largely function on the margins of the formal sector in eThekwini, and more so in the informal sector. These producers are not benefiting from any peripheral state support and instead are exposed to harassment for their informal activities (Zerbe, 2012).

An important point to consider is that urban agriculture is most popular among middle-income groups (for instance those with relative access to resources), (Smith et al., 2005). Therefore, those who are without active command over resources may be food insecure even in regions where there is local level food security (Zerbe, 2012). In light of this problem in the Municipality, there have been three main frameworks for food production. There are formal community gardens, informal 'guerrilla' gardens, and a number of initiatives by the Durban Botanic Gardens Project (Zerbe, 2012). The formal community gardens include those activities which intend to use urban areas for farming activities parallel to the wishes of the ones who own the land. This includes the official provision of idle urban plots by the city management to poor communities for local farming (Zerbe, 2012). In the case of informal or guerrilla gardening, the land used for agriculture is illegally obtained, thus farmers produce their crops on vacant property without legitimate right. The reasons for this range from anarcho-syndicalist political opinions, including the comprehensive denial of concepts of ownership and private property, to simpler and restricted claims of social justice and necessity (Zerbe, 2012). However, the extent to which the Botanic Gardens assists the bottom rungs of society is unclear since demands for access to food in the metro have commonly been outlined in the most traditional manner, using food security instead of food sovereignty.

Land, Development and Agriculture

Land access also remains the main area of struggle, despite the abundance of land that has potential for agriculture. However, such land does face competition with development programmes (e.g. housing) as well as the established of natural environment systems (in this case D'MOSS). Land that is suitable and allocated for agriculture is also under-utilised. The Metro has identified the Dube Trade Port, and its nearest areas, as the main municipal investment area; on the other hand, the area is selected as primary agricultural land. This poses a challenge both for the Municipality and Department of Agriculture and the Environmental Affairs (DAEA) as the municipality wishes to issue this area for development, while the DAEA refuses to give consent for the development of areas marked as having the 'primary agricultural

potential' (eThekwini Municipality Review, 2015/2016). The identified land, with high potential for agricultural development, and classification indicates a number of concerns. These are namely:

a) In as much as the eThekwini Municipality has areas highlighted as having high agricultural potential, this cannot be realised to its full potential because the former is the economic and industrial hub of KZN. Furthermore, there is an expectation to provide job opportunities to alleviate poverty in KZN as well as associated housing and high-order social facilities to accommodate migration (eThekwini Municipality Review 2015/2016:130).

b) Agriculture contributes 1% to eThekwini's Gross Domestic Product (GDP) which is considered insignificant. In other local municipalities (such as Jozini, Msinga and Nongoma) the agricultural sector is able to generate the largest share of the GDP. Therefore, it becomes difficult for eThekwini to prioritise agriculture as a critical economic sector and give it the attention it deserves (eThekwini Municipality Review 2015/16:130).

Community Based Adaptation Strategies

Community-based adaptation (CBA) provides an opportunity to incorporate community perspectives, institutionalising new actors and methods as a mechanism for increasing top-down planning approaches associated to local dynamics. According to Archer et al. (2014:2), "CBA refers to the participatory identification and implementation of community-based development activities that strengthen the capacity of local people to adapt to climate change, and building on communities' expressed needs and perceptions to address local development concerns which underlie vulnerability."

A study conducted in some wards in the eThekwini Municipality shows a very limited formal understanding of climate change by small-scale farmers. As a result, their decisions are built on restricted local knowledge about the occurrence to optimally adapt to climate change. Despite their limited understanding of climate change, some farmers identified long periods of droughts, intense rainfall as well as sharp and falling temperature as contributing factors to low yields (Knegtel, 2014). To some degree, there are practices demonstrating that small-scale farmers do adapt to climate change. For instance, experienced small-scale farmers have substantial understanding of seasonal farming where they expressed that winter conditions are favourable to cultivate spinach, beetroot, green pepper, tomatoes onion and cabbage; plant butternut, sweet potatoes, dry beans and mealies during spring; amadumbe (taro), spinach and butternut in the summer and harvest in autumn (Knegtel, 2014: 42). They are also cited for

sustainable methods of farming such as permaculture. Other farmers are still trying diversification methods, such as integrating poultry or fish farming to their existing crop farming, a strategy that has climate-smart potential. Making contouring and terraces is also used to ensure that crops receive enough water and nutrients especially when farming takes place on steep slope. Older farmers are a great source of information for farming strategies and climate-smart practices. They share their knowledge and experience with younger farmers at meetings (Knegtel, 2014).

Climate-smart agricultural activities include permaculture which is centred on natural use and waste re-usage. This includes agroforestry which is critical in providing shelter against the elements (sun, wind, and rain) through the strategic use of trees. Raised-bed gardens are important in loosening soil for penetration growth, while integrated or combined cropping combines livestock with crop agriculture. Intercropping is mainly concerned with cultivating more than one crop in the same plot, particularly in changing rows or divisions. Crop rotation, on the other hand, refers to planting different types of crops in the same land but in different periods or seasons. This is essential in improving the quality of soil. Fallowing is another strategy that leaves agricultural land idle with the intention to rejuvenate soil. With the increasing and intense rainfall, erosion control, through terracing and tree cultivation, is a method used to protect soil. Another technique associated with erosion control is windbreak control, where hedgerows or vegetation is used to protect crops against wind. For irrigation, wastewater also regarded as grey-water from bathing or washing, is essential for small-farming. Composting is also usually used in organic gardens for improving soil and providing nutrition to crops. Other techniques include rainwater harvesting trough gutters, drip irrigation, damming urine/sewage nutrient, as well as alternative energy use, which utilises natural energy such as solar power. Out of the sixteen identified climate-smart techniques, twelve were also observable to eThekwini communities or at least in Cato Manor though to a limited extent (Knegtel, 2014: 58).

The municipality has taken initiatives to assist communities in adopting strategies in response to changing climate. In eThekwini, community adaptation project/planning (CAP) began in 2010 with the realisation that poor communities are the most affected by climate change. The CAP project has three sub-projects. It started by viewing the threats encountered in the two pilot communities in Ntuzuma and Ntshongweni to discover how climate change will influence these areas (eThekwini Municipality, 2011; Roberts, 2010).

Secondly, the project inspected food security concerns. The first forecasts proposed that maize production may decrease in the future due to climate change (eThekwini Municipality, 2011/12; Roberts, 2010).This part aim to explore alternative socially acceptable staple crops that are able to survive under climate change (eThekwini Municipality, 2011/12). Field trials of potential new staple crops were carried out in both Ntuzuma and Ntshongweni. The two sites were used to simulate the forecast of a future eThekwini under climate change settings. The results from the field trials showed that cultivating dates and ensuring that crops are irrigated were the only ways that tilled and alternative crops could flourish under climate change conditions. Parallel to this, community members tasted food produced from alternative staple crops (amadumbe or taro, cassava, pumpkin, and sorghum) in order to determine the palatability and acceptability of these new crops (eThekwini Municipality, 2011/12; Carmin et al., 2009).

The third part of Community Adaptation Plans included research for water harvesting alternatives (eThekwini Municipality, 2011; Roberts, 2010). A field trial was conducted at Luganda School (titled 'Luganda School: Water Harvesting and Micro Agricultural Water Management Technology'). This research site was chosen due to the problem of surface run-off eroding on the school premises. The proposed intervention increased water storage on the school surface with water being harvested off school buildings roofs. Harvested water is then used by members of the community for their own gardens as well as school gardens, which is intended to provide vegetables for school children (eThekwini Municipality, 2011/12). Water was made accessible through the use of valves. Individual gardeners are furnished with a valve key joined to a hose-pipe for watering crops yearly. This served as important response to the climate change challenge (eThekwini Municipality, 2011).

Indigenous Knowledge

Case studies from different African regions unveil the positive contribution of indigenous knowledge (IK) to climate change adaptation. Although indigenous knowledge has a role in responding to varying climatic conditions, it is hardly reflected in policy, academic and public dialogues on climate change (Theodory, 2014). Instead, traditional wisdoms have been substituted with modernist universal values (Graaff et. al., 2009). However, a considerable number of the African communities still use indigenous knowledge for a number of climatic conditions such as drought, pests and diseases, strong winds and floods.

Drought

In countries like Tanzania, local farmers respond to prolonged dry spells through agricultural activities such as farming in wetlands along the rivers. Others are reported to use drought-resistant crops such as sweet potatoes, cassava and early maturing plants like maize and beans. Storing seeds for replanting and replacing of those destroyed by drought seasons is another significant strategy. These seeds are usually hung in traditional kitchens where fireplaces help to produce the smoke that aids in preserving the seeds from seed pest (Theodory, 2014). Storage of surplus yields, such as maize and beans during the favourable conditions for use during the drought seasons, serves as a strategy to buffer against food insecurity during dry periods. Similar cases can also be traced in South African communities where preservation of dried vegetables, sweet potatoes and ground maize is common (McLean, 2010). Other practices included fallowing to allow natural richness regeneration of the soil and small-scale irrigation during drought. Reducing the herds of livestock through sale or during drought is another adaptation strategy. However, the most crucial adaptation strategy also cited is praying to God through traditional rainmakers who are consulted for rain. However, modernisation has largely weakened the belief in traditional rainmakers (Theodory, 2014).

Pest and Diseases

The main strategy to deal with pests and diseases is choosing crops and seeds that are resistant to damaging pests and diseases. There are also locally invented pesticides to deal with, and control, pests and disease. Indigenous knowledge (IK) techniques include intercropping, crop rotation as well as primary weeding to remove pests hiding in weeds. However, the most common is to use organic manure to improve crop health, implementing varying planting dates and field rotation. Furthermore, IK strategies involve uprooting damaged plants, adjusting crop density or concentration and killing identified pests by hand (Theodory, 2014). Protecting crops against insects is a major concern for a number of famers. The eThekwini case study showed instances where farmers sprinkle crushed onion all over the garden to deal with insects (Knegtel, 2014).

Strong Winds

In recent times, rains are accompanied by strong winds which damage crops. As an adaption strategy to strong winds, local communities implement agro-forestry practices to act as wind breaks around farms. The use of tree sticks to support crop and balance strong winds is also mentioned among local people (Theodory, 2014).

Floods

The popular adaptation strategy against floods is the construction and digging of water channels to direct and control flooding water (Theodory, 2014). In the South African case study, some locals observe the heights of birds' nests to forecast flooding. For example, amahlokohloko (golden weavers) build their nests near rivers. If their nests are very high, that signals strong rains in the future. Also, certain positions of the sun and the cry of a particular bird, especially standing on top of a cow or in the trees next to the rivers, forecasts the coming of the rainy seasons, while the position of the moon crescent is also used to predict the rain (McLean, 2010).

Conclusion

The eThekwini Municipality has shown strong innovative strategies and activities on climate change adaptation. Putting the improvement of the quality of life of its urban poor remains the main goal in the official planning systems of the municipality and its counterparts. In this era of the changing climate affecting agricultural activities across the world, both small-scale and commercial farmers are adjusting their practices. Commercially, farming has had to adapt to diversified land use plans as well make choices of inputs which would be resilient and work within forecasted conditions. There is also evidence of shifting public policy to adapt to forthcoming changes. The Municipality has designed a food security strategic plan that intends to complement its climate change policy documents. Certainly, the Municipality's food security vision declaration aims to guarantee that eThekwini population has a strong and resilient food security status. Urban agriculture is one of eThekwini's policies supporting urban agricultural programmes and activities, although this policy is complemented with the rural agricultural policy (under the rural area-based management). These include the organic and sustainable agricultural initiatives, essential food sovereignty, food security, economic empowerment and environmental sustainability for eThekwini residents and the Municipality's green leadership, which is mainly responsible for implementing approaches to aid poor citizens to adapt to climate change.

The agro-ecology programme is another important initiative that aims to promote appropriate and sustainable approaches to agricultural planning and implementation. To date, six innovative agricultural hubs have been developed in the following areas: Northdene Agroecology Research and Development Centre, Newlands-Mashu Permaculture Centre,

Inchanga, Scorpio Place in Mariannridge, Mariannhill Monastery and Umbumbulu. Durban's Botanic Gardens comprise of educational and interactive exhibitions that address challenges associated with climate change, embracing the value of biodiversity, water conservation, food security, and renewable energy.

The extent and magnitude of climate change shows that it is a multi-governance issue. Thus eThekwini Municipality adaptation strategies are linked with the national, provincial and local structure.

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