Kenya Threshold 21 (T21) Model

1.0 OVERVIEW AND BACKGROUND OF KENYA THRESHOLD 21 MODEL

In Kenya, where about 75% of the population depends directly on land and natural resources for their livelihoods, the impact of climate change and related disasters on land and natural resources has the potential to severely affect the lives and livelihoods of most Kenyans. This expectation was expressed in the First National Communication of Kenya to the Conference of the Parties to the United Nations Framework Convention on Climate Change, and the State of the Environment Report 2006/2007, which stated that adverse environmental, economic and social repercussions are anticipated as the impacts of climate change become increasingly manifested. Some of the adverse impacts include water and food shortages, famine, energy shortages, desertification, forced mass migration, diseases, and overall economic, environmental, and human degradation. Risk assessment, adaptation and mitigation measures must therefore be comprehensive and encompass all sectors of national life in Kenya.

The Kenyan component of the African Adaptation Programme (AAP) set out to put in place an adaptation framework to provide a practical response strategy to climate variability. Its objective is strengthening Kenya's institutional and systemic capacity and leadership to address climate change risks and opportunities through a national planning approach to adaptation.

To achieve this, a dynamic, quantitative and transparent planning tool called Threshold 21 (T21) model has been developed. This is uniquely customized for the long-term integrated development planning as well as carrying out scenario analyses of adaptation options under uncertainty in Kenya. The model allows the cost of adaptation to be quantified, which is a pre-requirement for attracting much needed financing for adaptation.

The T21-Kenya model is fully integrated in a single framework by the complex interactions between the three spheres of development, namely economy, society and environment. The model also integrates the analysis of the risks and impacts of climate change across the major sectors in the economy, society and environment, in order to inform coherent national development policies that encourage sustainable development, poverty eradication, and increased wellbeing of vulnerable groups, especially women and children, within the context of *Vision 2030*.

In addition to using the model for providing the socio-economic evidence for Kenya to invest in climate change adaptation, it also serves to translate Vision 2030 including its Medium Term Plans (MTPs) and the National Climate Change Response Strategy (NCCRS) into practical actions.

To ensure continuous use of T21-Kenya in integrated development planning, the model has been institutionalized in the Ministry of State for Planning, National Development and Vision 2030 in Macro

Planning Directorate. A core team of 12 modelers have been trained to maintain T21-Kenya and use it for policy scenario analysis, while a larger group of 25 government official has been trained in the more general use of System Dynamics and T21.

The T21-Kenya model is composed of 50 modules, whose internal mechanisms can be understood in isolation from the rest of the model, but is linked to the other modules through feedback loops. These modules are regrouped under 18 sectors (6 social sectors, 6 economic sectors, and 6 environmental sectors) based on their functional scope, as indicated in figure 1 below.

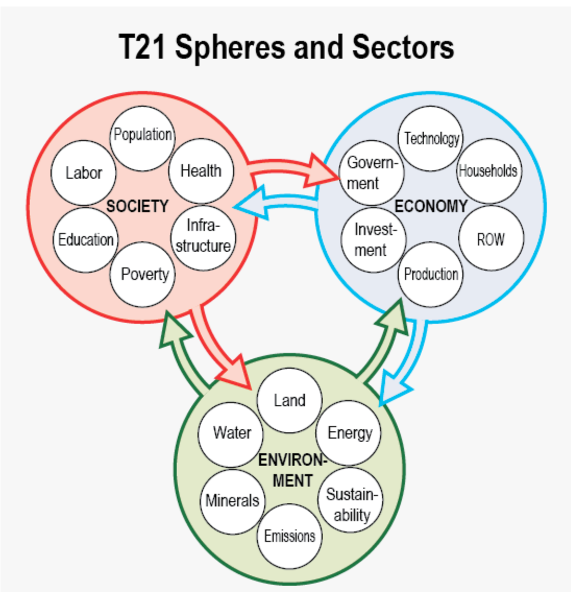

Figure 1: The T21 spheres and sectors

The strength of T21-Kenya is its flexibility to accommodate additional modules or sectors depending on new issues to be analyzed, and also in its structural nature, being able to integrate economic sectors with biophysical variables for the environment and society.

2.0 IMPORTANCE OF T21

The T21 model is the most diffused and validated System Dynamics model available today for long-term integrated development planning. It has been vetted by experts at the World Bank, United Nations Development Programme, Carter Center, renowned universities and Conservation International, and found to be effective for integrated development planning.

T21 harnesses the strengths of other tools such as Econometric Models (EM), Social Accounting Matrix (SAM) and Computable General Equilibrium (CGE) models, making it an essential complement to them. It can incorporate sections from these and other sector models into its overall framework to draw on high quality modelling work; or it can use outputs from these models as inputs into certain sectors.

Models that have historically been used in Kenya to inform policy such as econometric modeling and Computable General Equilibrium (CGE) lacked a capacity to model the complex causal relationships between economic, social and environmental spheres of development and forecast the effects of policy changes especially in the long run. T21 has a capacity to model the aspects of society and environment that are relevant for comprehensive and long-term planning unlike other models which have generally a strictly economic focus. It is also transparent in a manner that formulae underpinning causal relationships between variables can be checked, verified, and amended as required to reflect real world conditions.

The Business As Usual (BAU) case replicates history over the period 1980-2009, and assumes no fundamental changes in policy or external conditions going forward to 2050. Simulations are run with BAU scenario (No Adapt scenario) as well as with climate change adaptation measures (Adapt scenario).

3.0 OBJECTIVES OF KENYA T21

a. General objective

To provide the Government of Kenya with a dynamic, quantitative, and transparent tool to understand and analyze the multi-sectoral impacts of climate change, develop institutional and systemic capacity to manage climate change risks, and facilitate development of adaptation and mitigation policies.

b. Specific objectives;

i) A better understanding of the potential impacts of climate change and climate variability on Kenya in an integrated manner across the major sectors.

ii) The identification of the most important climate change/variability challenges to address in an integrated manner, the development of appropriate policies to address these challenges and maintain sustainable development, and gaining the necessary support from domestic and international sources to implement the necessary policies and programs to help Kenya adapt to the changes in its climate.

iii) Monitoring and evaluation capacity of the progress being made with policies, the ability to identify potential shortfalls as early as possible, and helping find ways to improve performance.

iv) A means of bringing together experts and policy makers from different sectors, government agencies, NGOs and donors, to reach agreement on consistent and integrated policies to address climate change and promote sustainable development.

4.0 T21 DEVELOPMENT PROCESS;

i) *Planning*: This stage drew on the outcome of the broad risk assessment, national workshop, primary researches conducted on climate change to determine the scope of the T21-Kenya; the critical climate change and environmental, social, and economic relations to be incorporated into the model; and the necessary data required to construct the model.

ii) *Construction of T21-Kenya Model and Capacity Building:* Experts from ministries and agencies responsible for the priority sectors highly affected by climate change and policy research institutions were identified and trained to build their capacity in dynamic modeling and T21 in particular. The group then participated in group model building sessions to construct the T21-Kenya model. These local experts skilled in using the model have modeled climate change and its impacts. The model is undergoing continuous presentation to community of climate change and development experts to get their inputs for refinements and extensions of the model. Their experts' opinions and suggested modifications are continuously incorporated into the model.

iii) *Institutionalization of T21-Kenya* : For continued operation, maintenance and expansion of T21 model, the model is domiciled within the Ministry of Planning National Development and Vision 2030, where it will used as a tool in development planning and climate change management.

5.0 SOME PRELIMINARY RESULTS FROM THE MODEL

5.1 GOVERNMENT

Existing climate variability has significant economic costs in Kenya. With increasing climate variability in the future, aggregate models indicate additional (on top of existing climate variability) net economic costs could be equivalent to a loss of almost 3% of Gross Domestic Product (GDP) each year by 2030 in Kenya. While climate adaptation can reduce the economic costs of climate change, it has a cost as well. The costs of adaptation are still emerging that relate to the balance between economic development and climate change.

5.1.1 Government Revenue

Government revenue comprises of tax revenue, non tax revenue and grants. As a result of the economic growth, tax revenue (calculated as a share of GDP) will grow over time. It is expected that the government will raise the necessary revenue to finance the Climate change mitigation projects, assumed to start from 2010; hence government revenue is expected to grow (as shown below).

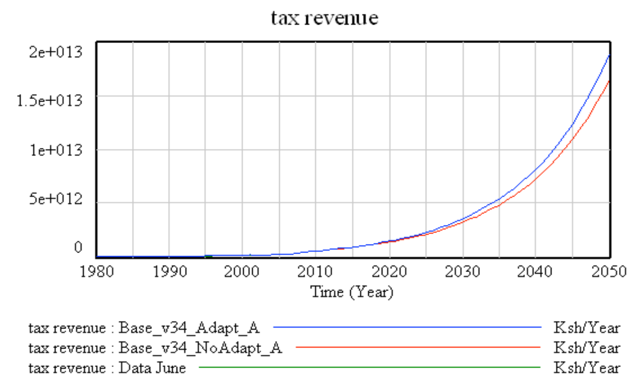

Figure 2: Simulated tax revenue

5.1.2 Government Expenditure

Government expenditure is a sum of general public services expenditure, social services expenditure, economic services expenditure, environmental protection expenditure and interest payments. As a result of the climate change mitigation projects, total government expenditure will increase from Ksh 650.44 billion in 2010 to approximately Ksh 4.36 trillion in 2030 and Ksh 22.63 Trillion in 2050. Due to the climate change mitigation projects, expenditures in the various sectors will also increase compared to the baseline scenario.

5.2 AGRICULTURE

Kenya, being a developing economy, relies heavily on the agriculture sector which contributes about a quarter of the GDP. The country's agriculture production depends heavily on rainfall which has proven to be unsustainable. About 75% of the country's population depends directly on agricultural production for their livelihoods, thus the impact of climate change and related disasters have the potential of severely affecting the lives of most Kenyans.

Extreme events in the form of periodic floods and droughts has already caused major socio-economic impacts and reduced economic growth in the country. This has serious implications for the food security and environmental vulnerability if no actions are taken. Towards this, the government has planned climate change adaptation investments in the sector through irrigation, research and development, increased use of fertilizer, pest control, afforestation and forestry management, and fisheries management. The resulting improvements in productivity and restoration of natural resources will lead to increased agricultural production relative to a BAU scenario.

As evidenced by the model simulations, climate change will have adverse effects on crop productivity as shown in figure 3, if no adaptations are done.

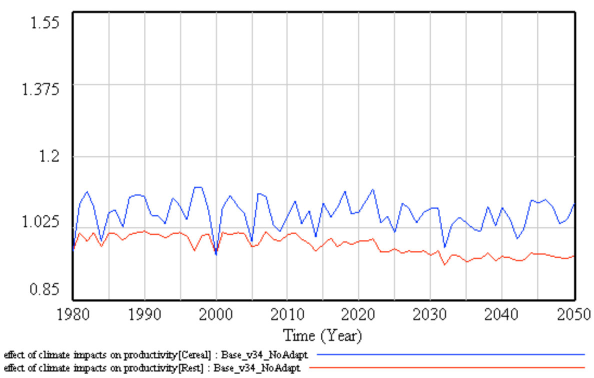

Figure 3: Effect of Climate Impacts on crop productivity

The proposed climate change investments will promote more sustainable agriculture in the primary sector (crop production, livestock, fishery and forestry) and consequently improve nutrition and food security. The overall production for this sector will increase with the planned investment in climate change adaptation as shown in figure 4.

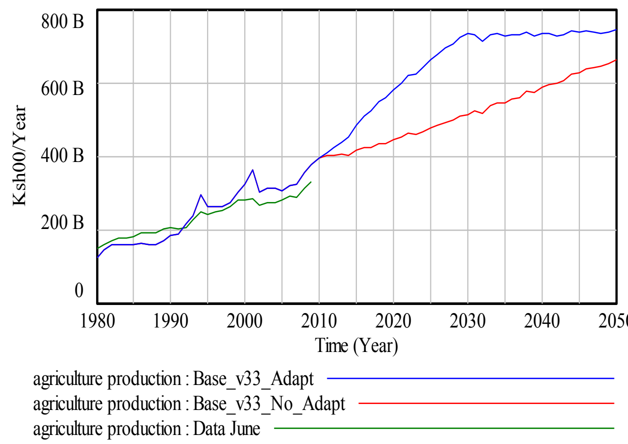

Figure 4: Effect of climate change investment on agricultural production

5.2.1 Crop Production

As shown in Figure 5, crop production is set to increase more than the BAU scenario for cereals and other crops, if the government implements the planned climate change investments.

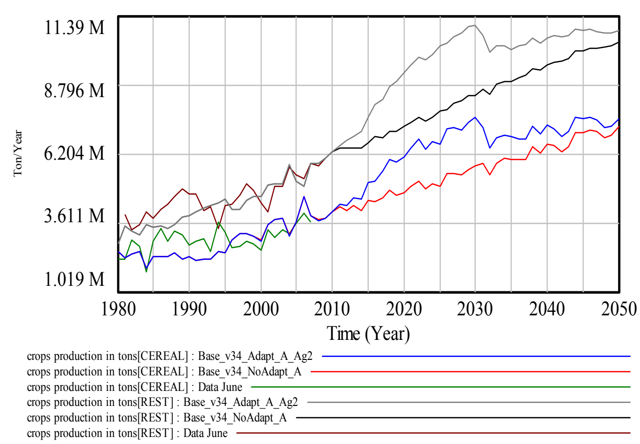

Figure 5: Effect of Climate Change investments on Crop production

5.2.2 Livestock Production

The country's livestock sector yields direct benefits in the form of food, wool, or hides, and can raise farm productivity by providing manure. Livestock provide a critical reserve against emergencies and decrease vulnerability to financial shocks from ill health, crop failures, and other risks. Livestock production risks from harsh weather, predators and lack of proper veterinary care are very evident in the country. The results of model simulation shows that livestock mortality will increase as a result of climate change induced pests and diseases and droughts. This will lead to stock reduction, resulting in reduced livestock production. Thus, urgent interventions are required to reduce the effects.

The government can invest in irrigation, breeding of animals from various agro-ecological zones that adapt well to climatic variations and provide special livestock insurance to spread and transfer risks from climate change as pointed out by the NCCRS.

5.2.3 Forest Management

Forests serve as the ultimate climate regulators through the slowed spread of deserts and thus there is need for sustainable management of forest resources. Better control measures would reduce the rate of deforestation, limiting fast depletion of forestland and natural resources. In the forestry sector, climate change will affect the growth, composition and regeneration capacity of forests resulting in reduced biodiversity. The planned climate change investments by the government in forest research and development, forest management and afforestation will play a big role in forest restoration. The T21 model simulations illustrated the impacts of this investment and as shown in figure 6, the total forest area will increase as a result of forest regeneration and afforestation, during the investment period.

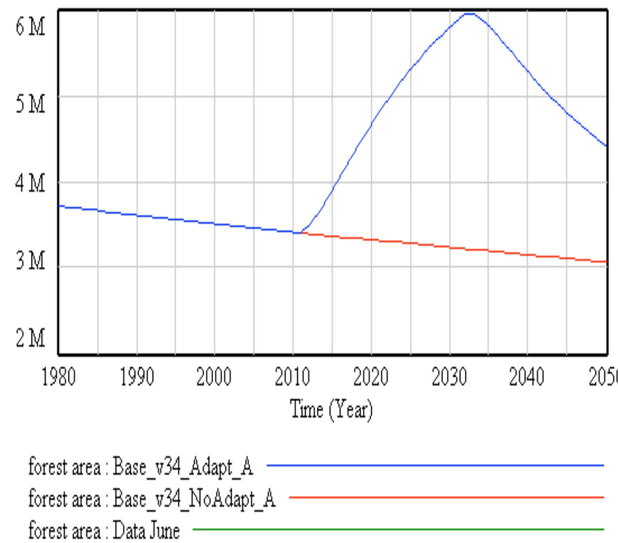

Figure 6: Effect of CC investment on total forest area

5.2.4 Fishery

The importance of the fisheries sector in Kenya through creating income, employment and food security support cannot be overemphasized. The sector is prone to drought which eventually leads to deaths, and thus decline in the fish stocks. Due to the importance of this sector, the government has planned climate change investments for fishery ecosystem restoration, fishery carbon emission and other fishery adaptation measures. This will be enhanced through enactment of laws, investment in monitoring and surveying and up-scaling fish production. To carefully evaluate the effectiveness of the planned climate change investments in the fishery sector, the T21 model was used to simulate different scenarios. The simulations projected better performance of the sector than the BAU case through these investments as illustrated in figure 7.

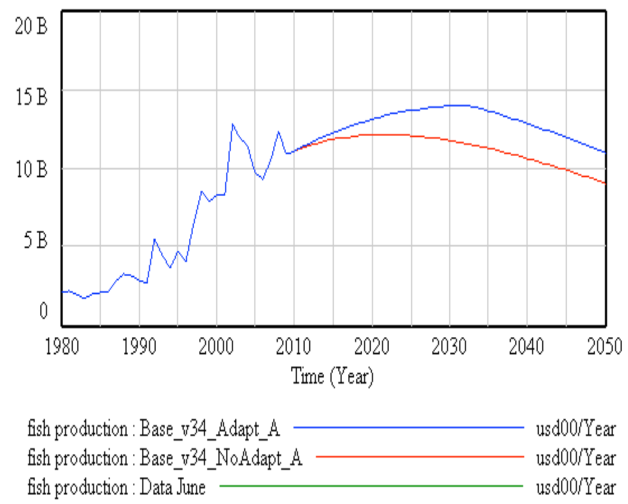

Figure 7: Effect of investment on carbon emission on fish production

5.3 WATER

Water is life. Water is highly used virtually in all spheres of human, animal and plant life.

5.3.1 Water Supply

Kenya's water supply is mainly through rainfall, underground water, dams, rivers and lakes.

For rainfall, the data indicates an average of 900 mm / year but with oscillations that throughout the period, carefully examining the results indicate that seasons of high rains are followed by seasons of droughts roughly recurring every 3 years. The baseline projection of the model is based on the assumption that current trends will continue as shown in the figure 8 below:

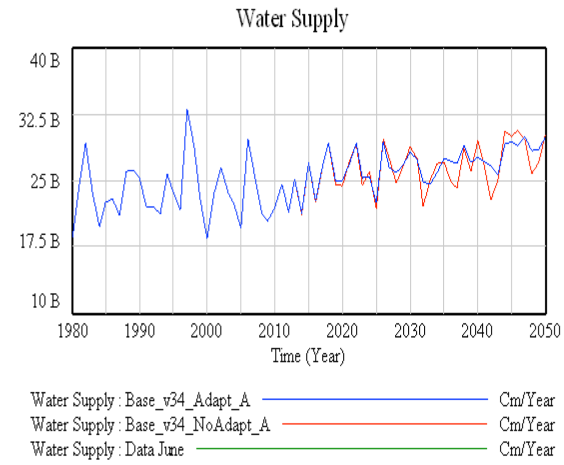

Figure 8: The trends in water supply

The water supply is highly dependent on the rainfall patterns in the country. Figure 9 shown below indicates a positive relation.

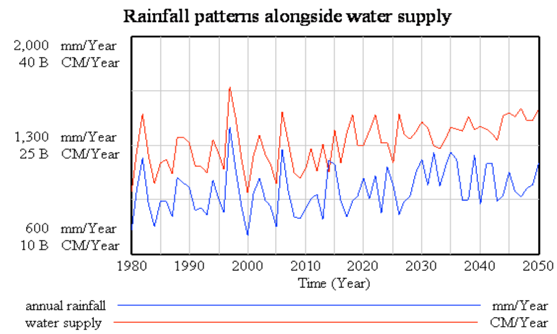

Figure 9: Trends in rainfall patterns alongside water supply

The country has 17 mid-to-large dams with about 2.9 billion M^3. To maintain continuous supply of water, the government plans to build 24 dams and maintain the existing ones. The government is to inject KES 56 billion in the next 20 years to this expansion and maintenance process. By building new dams, the capacity would substantially increase.

If the expansion and maintenance drive is not done the capacity of the dams would remain at 2.9 billion

M^3 but after the investment the capacity of all the dams goes up to 6.4bn M^3.

The water supply also is highly dependent on total renewable water resources.

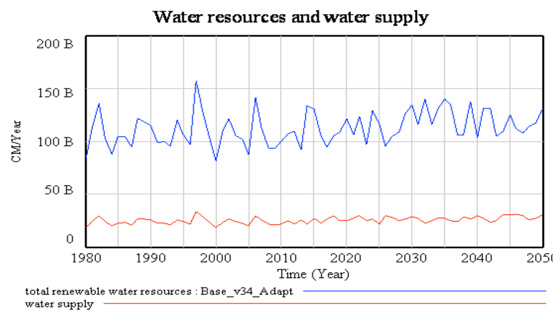

Figure 10: Water resources and supply in BAU scenario

The water stress index is going up, from about 13% (1980) to 20% (2011) to 33% (2050) as shown in figure 11 below. This implies that the water supply and demand is indeed under strain.

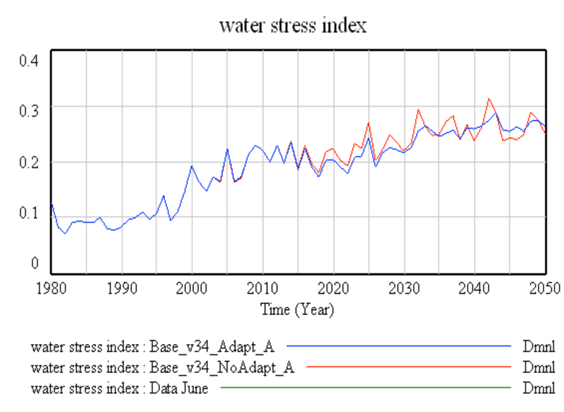

Figure 11: Water stress index

Hence to make the water stress index low, it requires more capacity to be built in the water sector to reduce straining the available resources.

The renewable resources per capita are declining at an alarming rate; the rate is marginally higher if the adaptation measures are in place unlike in the BAU situation. This is shown in the figure 12 below.

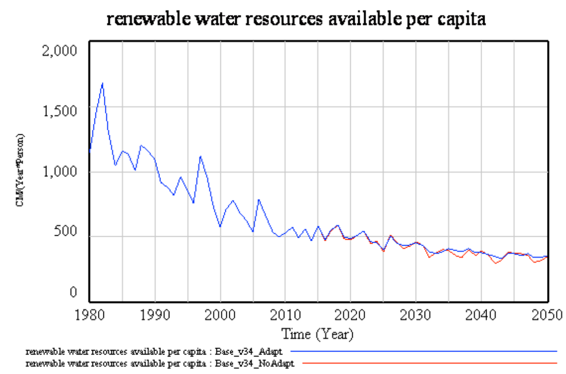

Figure 12: Trends in renewable water resources available per capita

5.3.2 Water Demand

Water demand has been going up in the recent years owing to its demand for household, agriculture, industrial use among others. Clearly, looking at the trends, as the human population grows so does the demand for water. This is because there are more people who demand the water resource as the increased use in other sectors has the ripple effect. This is shown in figures 13 below.

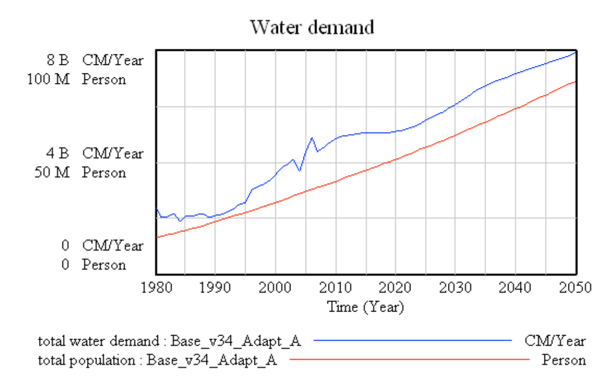

Figure 13: Population trend and water demand

The water demand is also on the increasing phase as a result of the expanding economic activities in the country. Figure 14 illustrates how the water demand is simulated in the future. The demand is higher if all the climate change adaption strategies are put in place unlike in BAU.

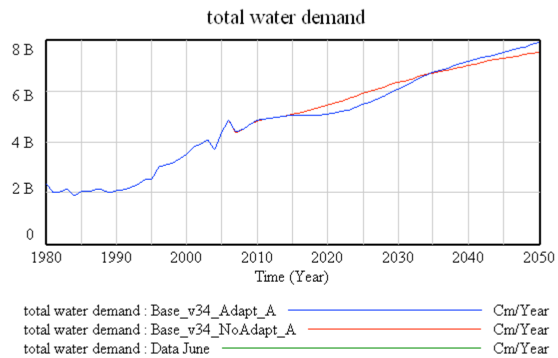

Figure 14: Water demand in the BAU and the Climate Change adaptation investment scenarios

5.3.3 Irrigation

Irrigation is highly used in many countries around the world to enable crop production all-year round even in dry seasons.

Irrigated land is projected to increase in the future. This is attributed to the increasing frequencies of occurrence of drought in the country and the demand for agricultural production. Investment in irrigation capital, the acreage of land was 33,000 acres (1980) and is expected to go up to 230,000 acres (2050).

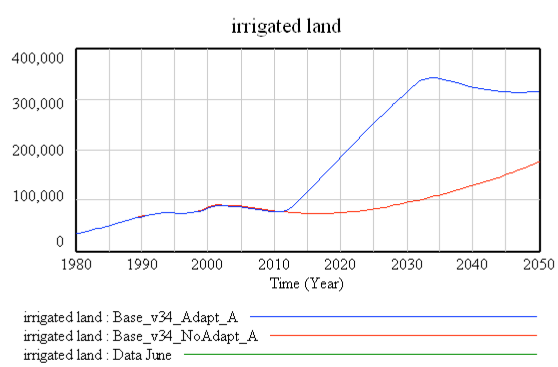

Figure 15: Trends in Irrigated land

The water demand for irrigation is also projected to increase as the irrigated land acreage is expanded.

Irrigation capital also in BAU is growing up owing to the yearly government/private sector investments. The capital was KES 10 Billion (1980) and is projected to KES 70 Billion (2050).

The effect of irrigation capital on agricultural production also goes up since farmers are able to plant crops all-year round unlike the dependency on rain-fed agriculture. The effect of irrigation to production indicates that productivity in the whole agriculture sector would be increased by 30% if climate change investments in irrigation take place.

5.4 ENERGY

5.4.1 Energy Supply

Energy drives the economy. In Kenya the main sources of energy are electricity, wood, solar, geothermal and fossil fuels.

The energy production is expected to expand if the mitigation and adaption measures are put in place from 20Trillion Btu/yr (2011) to 60 Trillion/yr (2030) and thereafter stabilize. The BAU is also expected to grow as a result of the government's annual investments.

Total electricity generation is mainly from hydro, geothermal and thermal power. The BAU assumes that no climate change adaptation measures are implemented and that no green energy measures will be implemented.

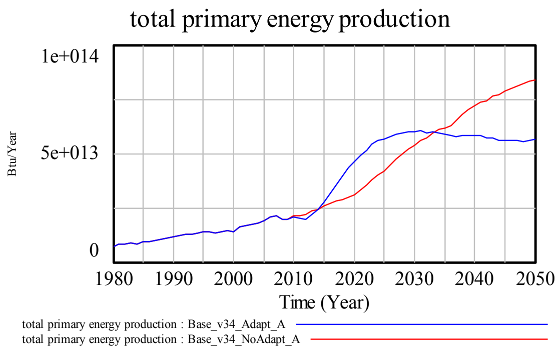

Figure 16: Primary energy produced

The reality is that temperature changes as well as rainfall variations brought about by climate change will have an impact on power generation.

It has been assumed that floods will cause siltation in the dams which will reduce the hydro power generation capacity and damage to power infrastructure power cable during floods. This will lead to a decline in distributed power for consumption.

Accelerated development of geothermal power by the government and its development partners and the private sector – this is estimated to cost KES 32.4 billion/year for 10 years. At a unit cost of $3.3 million/MW, the new investment is expected to add on to the grid 0.1136 GW by the end of 10 years.

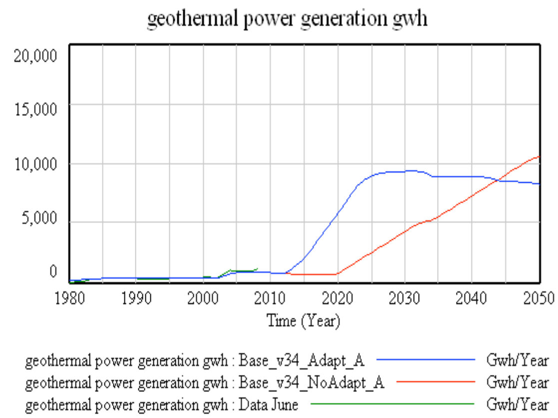

Figure 17: Geothermal power generation with additional investment

Accelerated development of green energy by the government and development partners will be at a cost of KES 37.5 billion/year for 5 years. The result is a steady increase in power generation for approximately 5 years during which investments are continually being made into the sector, after which generation stabilizes with the installed capacity. It is assumed that the installed capacity has a lifetime of 30 years.

Total renewable power generation increases with the addition of solar and wind power generation by 270% (2030), 257% (2040) and 246% (2050). The decline of renewable power generation is due to installed plant for wind and solar generation reaching its maximum lifetime.

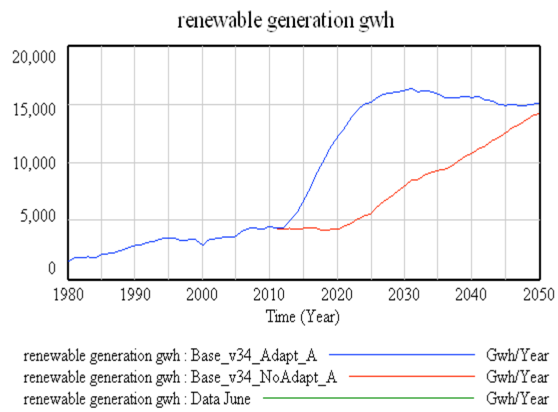

Figure 18: **renewable power generation**

5.4.2 Energy Demand

The climate change impact that has been assessed is the increased demand for electricity for services such as refrigeration, air conditioning and irrigation due high frequency extremes of weather patterns.

Provision of efficient bulbs to domestic consumers at a cost of KES 360 million for 10 years is also indicated in the strategy at an assumed unit cost of KES 350/bulb and this would result in the reduction in energy demanded. Assuming the total electricity generated was 6500gwh, and the average domestic consumption is 5000gwh the share of domestic energy consumption will be 80%.

With the use of efficient bulbs, the actual residential lighting will be 2,441.88Gwh by 2030 compared to 3,860.96Gwh if efficient bulbs were not used, translating to 36.75% of energy saved. By 2050, this will have reduced to 2,186.37Gwh compared to 5,975.07Gwh, saving 63.4% of energy, if the normal bulbs continued to be used.

5.5 ROADS SECTOR

Kenya faces a challenge of differed maintenance and under-investment in the road network infrastructure. This situation has been worsened by the extreme effects of climate variation. For instance floods will erode the road network and other infrastructure. Destruction of Information Communication Technology (ICT) infrastructure will affect access to health and education services as well as new sources of income and employment for the poor. Robust ICT infrastructure could leverage on the impacts of the climate e.g. people can telecommute instead of using road transport. Generation and distribution of electricity will also be affected. When roads and other infrastructure are in a poor condition, the cost is transferred to other road users and sectors of the economy.

The roads have been classified into two, the paved and the unpaved. Such roads are either under construction or functioning roads. The stock of functioning roads is increased by completion of roads under construction and reduced by destruction of roads through normal wear and tear or by other means such as disruption of the construction work. Unpredictable weather patterns have been affecting the construction of roads whereas recurrent flooding has continued to sweep transport and communication infrastructure. Flood induced destructions demand more budget allocation for maintenance at the expense of constructing new roads. As a result, roads density will grow at a lower rate and cause a lesser impact on the economy.

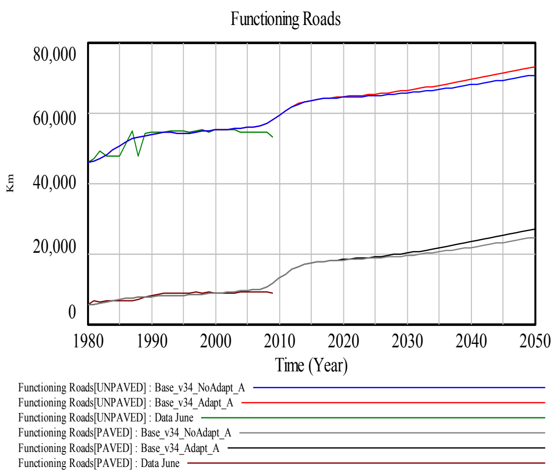

Fig 19: Projection: Length of Road (KMs) for adaptation and no adaptation case

Effects of climate change are real in the Kenyan road infrastructure. As seen from figure 19 above, a BAU case will lead to deterioration of the road infrastructure. According to the NCCRS, an increase of 0.3M above the sea level could submerge 17% of Mombasa which is only 45M above the sea level. In 2006, torrential rains pounded parts of eastern provinces causing massive destruction, cutting off roads and washing away bridges. In 2007, brief but intense rains caused collapse of Kainuk Bridge Rift Valley Province, cutting food supply to the starving masses in areas of Turkana and Samburu. All these occurrences have necessitated climate change adaption intervention, which have been well projected by the T21 Model. Under the roads sector, the adaptation case shows an increase in the stock of functioning roads though not at an increasing rate due to the maintenance cost aspect. The T21 model simulates a climate adaptation case whereby increased road density is seen to increase the total factor productivity across the other sectors of the economy. It increases accessibility and connectivity.

5.6. NUTRITION

Malnutrition could be triggered by droughts especially to those who depend on subsistence farming or worse still by damage of crops by floods. Variation in the diurnal temperature range has profound effects on agricultural production systems since crops have specific range of temperatures within which they grow optimally. Recent crop failures have necessitate Government sponsored imports in order to address food deficits in many parts of the country.

In the model, nutrition represents the average nutritional quality of food consumed. Calories, proteins, fats and macro nutrients are the four main food sources factored when determining the quality of nutrition. The major sources of these nutrients are crops produced fish and livestock products. Modern farming methods like investment in organic fertilizers seem to be increasing crop production per hectare as projected by the model. The model also portrays how research and development, disease and pest resistant crops with short maturity period’s leads to increased area under cultivation and also yields. Fishing in major lakes such as Victoria and Turkana is likely to be affected by recurrent droughts and rising temperatures; these are conditions that will reduce the amount of water flowing into the lake and also cause more evaporation. Thinking of other improper practices such as overfishing, there will be a tremendous reduction in fish stocks which will ultimately affect the nutrition at long last. The livestock production is neither spared by the extremes of weather. Prolonged drought lowers productivity of milk and beef.

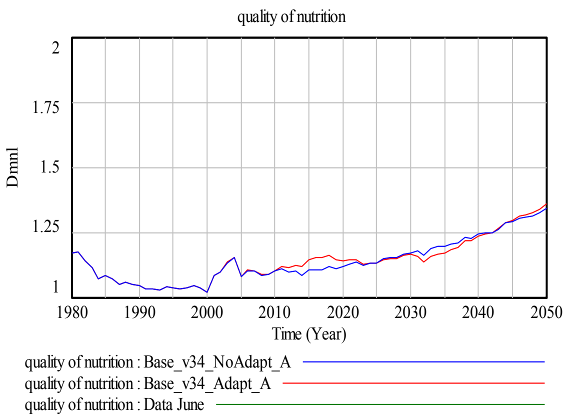

Figure 20: Projection: Changing trends in quality of nutrition due to increased agricultural climate change investment

Figure 20 above shows how a sudden increase in agricultural climate change expenditure causes quality of nutrition to increase.

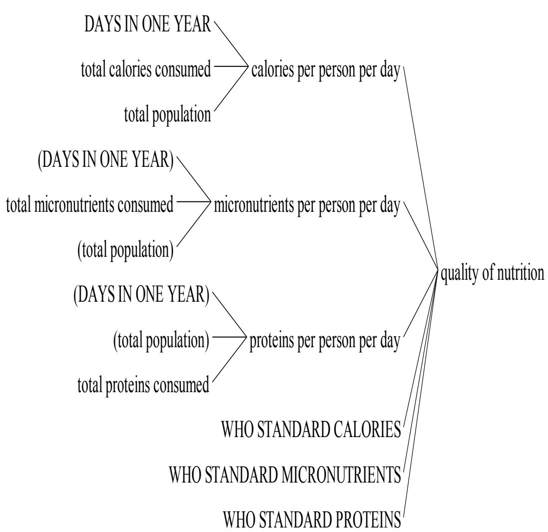

Figure 21: Quality of nutrition causes Tree Diagram

Figure 21 is a tree diagram showing how nutrition is linked to the subsequent sources. Such diagrams could be moved backward or forward in a chain to see various causes and effects respectively for any other variable.

5.8. HEALTH CARE

A healthy population is vital for development. In Kenya the current burden of climate-sensitive disease is high. Climate change and weather variability are responsible for modifications in natural processes leading to negative impacts on human health. Major climate change impacts on human health include increase in malnutrition as well as vector and water borne diseases. Infection disease agents are also affected by changes in climate variables.

Births are determined by total fertility rate, sexually active female population, age specific fertility distribution and proportion of babies by sex. The determinants of total fertility rate are female literacy levels, economic levels of women, under-five mortality rate and contraceptive prevalence rate.

From the model, the population is projected to grow to about 81.1 million and 87.6 million in year 2045 and 2050 respectively in BAU scenario. On the other hand, on implementation of climate change strategies the population will grow at a slower rate of 79.6 million and 86.1 million in year 2045 and 2050 respectively. In other words, population growth rate will slightly be lower if climate change strategies are implemented. This can be attributed to the fact that implementation of the policies on climate change will lead to an increase in infrastructure such as roads, health care facilities and the number of doctors.

Mortality rate is determined by the natural death, under five mortality rate, infant mortality rate and major diseases such as HIV/AIDS and malaria. Historical trends indicate that total deaths have been increasing exponentially up to the year 2006. The model indicate that on BAU scenario, total deaths will continue increasing from 487,646 in 2010 to

513,658 in 2025, and then decrease to 476,156 in 2050. On the other hand, upon adaptation on climate change investments, mortality rate will drastically go down as shown in the figure below from 487,585 in 2010 to 420,483 in 2050, a difference of 12%.

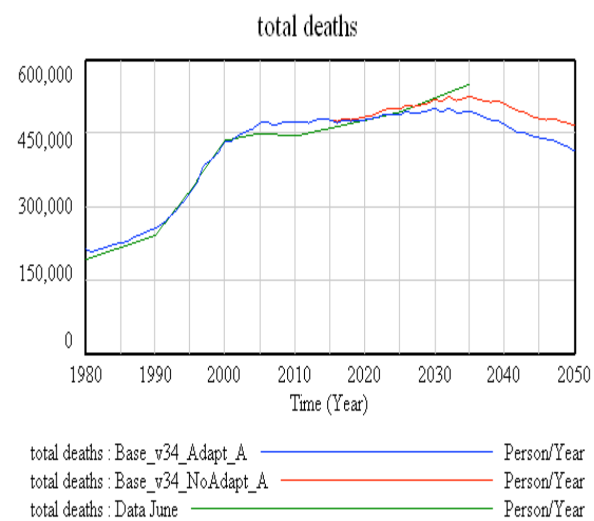

Figure 24: Trends in total deaths

In regard to life expectancy, historic trends indicate that the average life expectancy in the country significantly dropped from 56 years in 1980 to a low of 47 years in 2000 before gradually improving. This could be attributed to the HIV/AIDS scourge. Average life expectancy declined from 56.5 years in 1990 to 47.8 in 2000 and then rose to 50.6 years in 2010. Life expectancy is expected to improve given that the government will invest in climate change strategies compared to BAU scenario. For instance, in the year 2050, life expectancy is expected to increase from 70 in case of BAU to 72 years on adaptation. This is due to the fact that accessibility to health care will improve and more doctors will be trained.

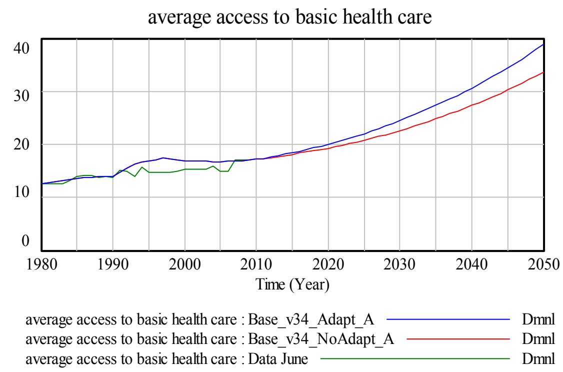

Figure 25: Trends in access to basic health care

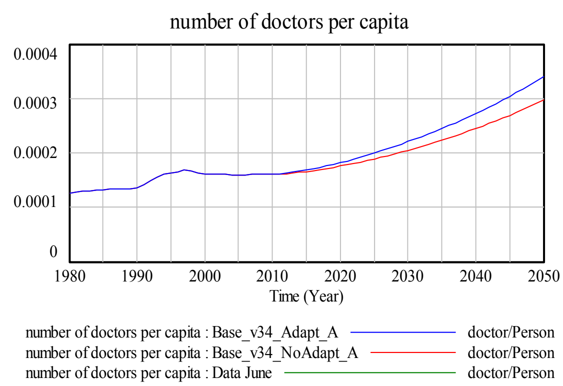

Figure 26: Trends in doctors per capita

HIV/AIDS was declared a national disaster in Kenya in 1999. Available data indicates that HIV average adult prevalence rate in the country was first recorded at 1% in 1986 and peaked at 9% between 1995 and 1999 and has reduced to around 6% in 2010. Total AIDS deaths have also been on a decline from a peak of 131,068 registered in 2003 according to available data. This is reflected by the improvement in adult Anti Retro Viral coverage which improved from 6% in 2004 to 66% in 2009. Prenatal transmission rate (the probability of mother to child transmission of HIV) has also dropped from 36% in 2004 to 23% in 2009. With a combination of these factors, total HIV population is projected to decline as illustrated in the figure below.

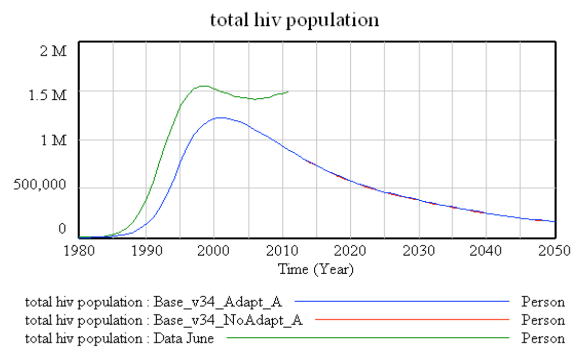

Figure 27: Trends in total HIV population

5.9 HOUSEHOLDS

The household revenue is a function of nominal GDP at market prices (accounting for salaries and profits), private current transfers (which include remittances from abroad), domestic interest payment, private factor income (accounting for income from factors of production owned by the households but used abroad), net lending and subsidies and transfers. Historical data reveals that revenues have been growing since 1980 and are expected to continue with the same trend into 2050.

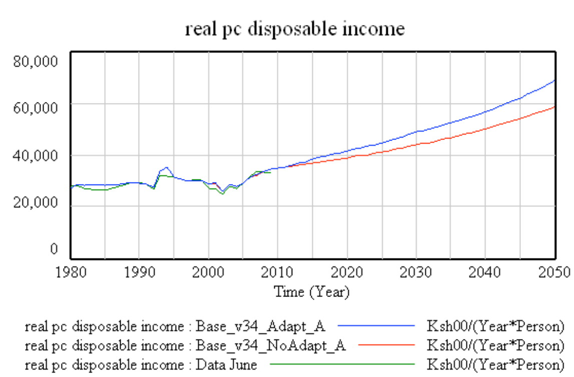

Figure 28: Per capita disposable income

With climate change adaptation measures, incomes are expected to rise more than if there were no adaptation measures due to the nature of investments to be undertaken. With adaptation measures, real disposable per capita incomes are expected to grow by 106.42% while they would only grow by 76.72% under BAU status by 2050.

5.7 THE MILLENNIUM DEVELOPMENT GOALS INDICATORS

The government of Kenya and other development partners have been focusing on the achievement of the eight targets agreed by world leaders to halve poverty by 2015. The target, which later came to be known as the Millennium Development Goals (MDGs) measures how development is being delivered to the people and to what extent. Among the challenges facing the achievement of the MDGs is the impacts of climate change. Increased frequencies of extreme rainfall and temperatures have affected most of the key MDGs indicators. Such range from increased incidence of poverty due to flooding and droughts, to inaccessibility of school and health centres due to destruction of transport and communication infrastructure by floods.

In the model, MDGs sector summarises a number of key performance indicators to tracks goals one to seven. The indicators are measured using the score ranging from zero to one or its equivalent in percentage. Goal one shows the proportion of people below the minimum level of dietary consumption and those living below the poverty line. Simulations from the model show how population growth is putting pressure on food supply whereas varying climatic changes and emerging crop pest and disease seem to constrain food production.

Increasing education expenditure has shown rising projections in the literacy levels. It also shows how gender parity is moving closer to one. Increased literacy levels and expenditure on health and related infrastructure have led to reduced levels of infant and under five mortality rates.

The area under forest cover has been increasing under the adaptation scenario mainly due to the intense climate interventions put in place as envisaged in MDG 7.

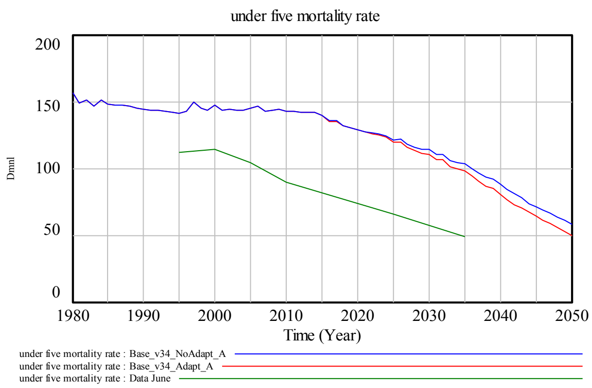

Figure 22: Projections: Decline in the under five mortality rate due to CC investment

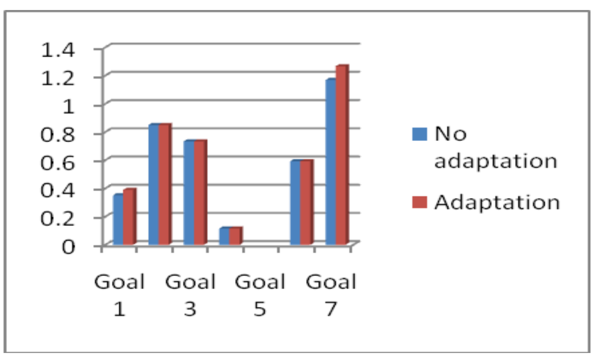

Figure 23: MDGs Dashboard as a bar graph

By using the T21 model it is possible to identify poorly performing indicators then identify the root cause for effective measures to be taken. It is also evident that adapting the climate intervention will go a long way in achieving and sustaining the goals. The MDGs module in the model serves as a dash board that can monitor performance at any instance. Any policy aimed at the achievement of the MDGs can first be tested by running a simulation using the Vensim software to see its suitability.

5.10 ECOLOGICAL FOOTPRINT

The ecological footprint is a measure of humanity's demand on nature and depends on a country's population and the use of natural resources. It represents how much land and water area a human population requires to regenerate the resources it consumes and to absorb its wastes (Global Footprint Network (GFN), 2010).

Different natural resources have varied impacts on the ecological footprint. In the Kenyan T21 model the ecological footprints will originate from cropland, grazing land, forest, fishing ground, carbon emission and built-up land. The GFN data was used for this analysis.

The simulations done comparing the BAU with the climate change investments scenarios showed that the total ecological footprint will decrease as shown in figure 29.

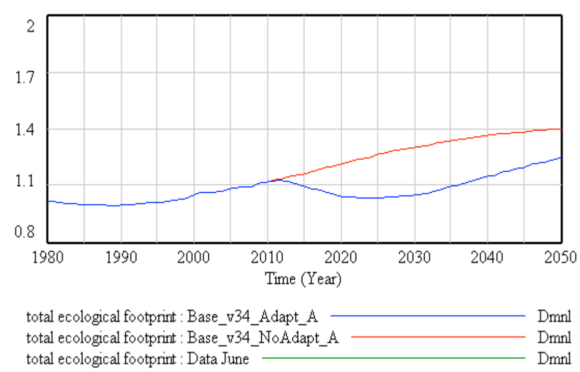

Figure 29: The total ecological footprint

6.0 CONCLUSION

It is imperative to consider climate change in the overall long-term planning and development of Kenya through mitigation and adaptation drives by the government. The use of the T21 system dynamic model is able to incorporate all the social, economic and environment spheres. Hence it becomes a useful tool in the simulation of policy scenarios to policy makers. As witnessed in the last decade, there has been an increase in the occurrence of extreme weather patterns at every 3 years. Climate Change will lead to increased frequency in droughts and floods, especially in the Arid and Semi-Arid Lands (ASALs), which will have significant implications on agriculture and subsequently on the economy.

The situation calls for development and implementation of strategies to mitigate the adverse effects of climate change.

The government has initiated climate interventions in the various sectors that will be impacted by climate change. The sustainable management of natural resources, resulting from a reduced deforestation and afforestation, low fossil fuel usage and maintaining fish stocks will allow the restoration of resources.

The adoption of the T21 model as tool for informing policy guidelines and strategies for developing and implementing adaptation and mitigation measures is a milestone in addressing the issues of climate change in the overall national planning and development of Kenya.