Table 2

Ecosystem Service	Biophysical valuation				Economic value per unit	Economic valuation (year 2030)		
	BAU change 2014- 2030	SAGCOT vs BAU	SAGCOT wc vs BAU wc	AI vs SAGCOT		**SAGCOT vs BAU**	**SAGCOT wc vs BAU wc**	**AI vs SAGCOT**
Carbon	(732,587)	(414,946)	(239,562)	289,913	43 US$/ton	- $17,842,678	- $10,301,166	$12,466,259

24. When applying the Social Cost of Carbon of 43 US$/ton, the result is that under **SAGCOT (Scenario 2) there is an economic loss of 17.8 million US$**. This loss is higher than under Business As Usual (Scenario 1) in the period 2014-2030. On the other hand, the Agriculture Intensification (Scenario 4) would mitigate (and not fully offset) the loss forecasted for the SAGCOT scenario by 12.4 million US$ as less woodland will be converted into cropland in the period 2014-2030.

4.0 Recommendations:

1. Since the **SAGCOT development programme is associated with potential conflicting interests within the agriculture and natural resources sectors** that may cause unsustainable behavioral patterns, e.g. competition for land and water resources, it is essential to integrate the social and environmental interests under SAGCOT, to ensure that socio-economic gains are maintained, while ecosystem degradation is avoided so as to ensure that the environment is properly managed and sustainably contributes to socio-economic development.
2. It is **strongly recommended that a combination of agriculture intensification and water use efficiency should be adopted so as to increase the sustainability of SAGCOT**, through maintenance of the expected performance on production and employment creation, while significantly improving the environmental performance of the agriculture sector, and ensuring longevity and sustainability for SAGCOT investments.
3. There is need for consideration of tradeoff between agriculture development through SAGCOT alongside sustainable management of the water resources of the Kilombero cluster, so as to **avoid the risk of overusing surface and ground water**, thus in the long run eroding the capacity of the cluster, as well as of the Rufiji Delta downstream, and continue maintaining the role of the cluster as a provider of food and livelihood.
4. Since the BAU scenario in the Kilombero cluster is subsistence based, and implementation of SAGCOT is associated with increased extraction of ground water beyond the maximum sustainable threshold (83bn liter per month), there is need to **regularly monitor ground water levels**, thereby avoid depletion of the ground water stock of the Kilombero cluster.
5. Agriculture Intensification should be adopted as a means of increasing crop output per hectare of maize, paddy and sugarcane, while **diversification is further encouraged** to provide further opportunity to grow other crops that fit well with the respective seasons, thereby reducing land conversion.
6. Implementation of SAGCOT programme should **ensure conservation of natural woody vegetation** in order to enhance carbon sequestration, CO2 absorption capacity, and thus reduce emissions and avoid contribution to climate change and its related risks.
7. Implementation strategies should be designed to ensure that socio-economic gains are maintained, while ecosystem degradation is avoided so as to ensure that the environment is properly managed and sustainably **contributes to socio-economic development**.

TEEB Focal Point

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Host institution

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MANAGING ECOSYSTEM SERVICES IN RUFIJI RIVER BASIN: BIOPHYSICAL MODELING AND ECONOMIC VALUATION

The Economics of Ecosystems and Biodiversity (TEEB) in Tanzania

Prepared by the Institute of Resource Assessment, University of Dar es Salaam with support from KnowlEdge Srl

1.0 Background

1. The Economics of Ecosystems and Biodiversity (TEEB) study was conducted in Tanzania with the overall objective of examining major land use/cover and management of trade-offs in three ecological gradients. These included the **mountain highlands, midlands, and the delta of the Ruhudji-Kilombero- Rufiji River sub-catchment**.
2. The study carried out **policy scenario analyses to inform decisions on land management**. It was expected that the study would result in improved awareness of environmental, social, and economic impacts of land use on communities and ecosystems, and potentially inform land use policies in the region.
3. **The Rufiji river basin is critical for Tanzania's development**, particularly in relation to food and water security. Notably, there are competing water/land use options in the basin including: forestation of mountain grasslands, development of dams for irrigation and power generation, and water-intensive farming practices, which make sustainable management of the watershed a challenge. Originally, the study was based on the whole Ruhudji-Kilombero-Rufiji sub- catchments including the Rufiji delta. However, due to the lack of or insufficient relevant data, particularly in relation to the Rufiji delta zone, emphasis of the study subsequently focused on the Kilombero River sub-basin.
4. The Kilombero basin covers 40,330km2 , extending from the south-western Kipengere and Livingstone Mountain Ranges up to the Swero station just below the Kilombero swamp. Kilombero River contributes up to 62 % of the total flow in Rufiji River at Stiegler's Gorge. The river flows through a 35-km-wide flood-plain between the Udzungwa Mountains and the Mahenge massif where it forms the Kilombero swamp. **The Kilombero valley has been identified to have more than 300,000 hectares as potential for irrigation**.
5. While the basin has considerable agricultural potential, it **currently suffers from low productivity, low levels of investment, and high rates of poverty**. The permanent wetland adjoining the floodplain supports one of the largest inland fisheries in Tanzania. The majority of the population depends directly on the agriculture, livestock, fisheries and forestry systems supported by the floodplain.
6. The **Southern Agriculture Growth Corridor of Tanzania (SAGCOT)** initiative was developed by the government of Tanzania to deliver rapid and sustainable agricultural growth in predefined areas (clusters) in Southern Tanzania, and includes the Kilombero cluster (SAGCOT Centre, 2013).
7. The main aim of SAGCOT was to **increase agriculture production, enhance economic development and provide employment opportunities**. SAGCOT was formulated from the acknowledgement that, in the past, the establishment of "out-grower" schemes has proven to create mutual benefits for commercial and smallholder agriculture businesses in terms of knowledge exchange and economies of scale, including providing farmers with improved access to irrigation systems and thereby increasing their access to water and improving resilience to climate variability.
8. The conversion of land in the scope of SAGCOT was planned for between **2018 and 2022** to provide the opportunity to see how the system reacts once the policy is implemented.
9. An area of **51,800 hectare of additional agriculture production** was planned to be developed in the Kilombero cluster, and SAGCOT estimated that this would generate **annual gross revenues of 35 million USD after five years**, yield around 4,500 direct employment opportunities, and provide benefits to almost 40,000 people in total.

10. The **SAGCOT development plan also acknowledges the potential emergence of conflicting interests within the agriculture sector that cause unsustainable behavioral patterns**, e.g. the competition for land and water resources between farmers and livestock owners. The integration of social and environmental interests under SAGCOT is emphasized, and the critical importance of ecosystem health and natural resources acknowledged.
11. Although the SAGCOT plan assumes that it would foster economic development in the agricultural sector, the plan also acknowledges that it should account for the negative impacts of land use/cover and climate change in the river catchment with respect to water quantity and quality. Also, the plan should be implemented in such a way that potentially negative impacts on the functioning of local ecosystems is minimized or avoided. In other words, the implementation of SAGCOT within the Kilombero cluster and careless water management may otherwise have the **risk of water overuse and erosion of the capacity of the cluster** as well as the Rufiji delta.

2.0 Methodology

12. The study in the Kilombero cluster involved surveys on land use and land management practices to inform the **use of models such as CROPWAT and SWAT**. These two tools were used to analyze the key characteristics of the Kilombero basin, and how the implementation of SAGCOT could shape future trends.
13. Given that water availability is a key enabler of agriculture production and one of the main drivers of well-being, **CROPWAT was used to estimate irrigation requirements, while SWAT was used to estimate water yield and runoff**. Combining CROPWAT and SWAT tools allowed for a holistic consideration of development impacts and land-use change – planned or otherwise – and the socio-economic implications of such change, translated into spatial inputs..
14. System Dynamics modeling was used to integrate these different types of analysis. The results of the simulation of the **System Dynamic model was used to generate future land use and land cover maps**, which were created with the InVEST Scenario Generator model.
15. Also, the InVEST model used Land Use/Cover maps and data on **stocks in four carbon pools** (aboveground biomass, belowground biomass, soil matter organic, and dead organic matter) to estimate the amount of carbon currently stored in a landscape or the amount of carbon sequestered over time under various scenarios (Table 1).

Table 1: Definition of Various Policy Scenarios Simulated

Policy Scenario	Description
Scenario 1: Business As Usual (BAU)	This scenario assumes the continuation of existing trends, and estimates impacts on land use and related impacts on the environment. No new interventions are assumed to be implemented, and existing baseline decisions are projected to continue.
Scenario 2: SAGCOT Development (SAGCOT)	This Scenario simulates the achievement of the targets set under the SAGCOT strategy for the Kilombero cluster i.e. the expansion of mixed farmland by 13,250 ha; of rice farmland by 14,000 ha; of sugar estates by 20,500 ha; of citrus farmland by 3,000 ha; and of banana plantations by 1,050 ha (by 2030).
Scenario 3: Water Constraint (WC)	In this scenario, maximum sustainable water extraction thresholds are used to constrain the water consumption from ground and surface water for the SAGCOT program.
Scenario 4: Agriculture Intensification (AI)	In this scenario, intensification of agriculture land occurs whereby increase in productivity of cultivated land reduces the need for land conversion in the SAGCOT development area was simulated.
Scenario 5: Water Use Efficiency (WUE)	In this scenario, improvement in irrigation efficiency was simulated.

3.0 Results and Discussion

16. The proposed cluster approach has been proved to increase the value added by developing a critical mass of agriculture production that allows for processing businesses to be established and flourish. This can support the **transition towards commercialization** of the agriculture sector and increase the generated turnover, as domestic processing enables Tanzania to export processed agriculture goods as well.
17. Scenario analysis within the Kilombero cluster (Table 1) show that the Business as Usual (BAU) scenario tends to assume steady growth of human population and drive expansion of agriculture to meet the demand while implementation of SAGCOT Programme increases agriculture land by 52,000 hectares.
18. When assuming unconstrained water supply the SAGCOT Programme is projected to create 4500 direct jobs and generate revenue for USD 32.8 million. On the other hand, the models project that **in order to meet this agriculture expansion demand, high amount water extraction from the river run off would be required hence causing detrimental consequences to Kilombero cluster as well as the delta downstream**.This is based on projections on (a) water availability from SWAT, indicating highest water availability (due to rainfall) in the months of March, April and May and an average annual flow of 15.8 billion m3/year; and (b) water demand (by crop) from CROPWAT,which indicates highest water requirements from sugar cane, banana and citrus fruits, taking into account soil types, growing and harvest period.
19. Specifically, water shortages as per Scenario 3 would lead to concentration of production in the rainy season and to some of the land being stranded in the dry season. This would result in higher -but only temporary- job creation, with the potential loss of employment in the dry season reaching 20% of the expected 4500 direct jobs. This is forecasted to lead to inefficient use of land, and higher migration patterns due to the seasonality of production. Practically, **in the face of food and water scarcity, and hence with a reduced potential to generate income in the dry season, people would tend to out- migrate from the Kilombero cluster**.
20. Scenario analysis has demonstrated the need for trade-off between development through SAGCOT and sustainable management of water resources and improvement of water use efficiency in Kilombero cluster. This suggests that implementation of SAGCOT without sustainable water management would have a big potential for water overuse and erosion of the capacity of the cluster as well as the Rufiji Delta downstream.
21. Two options were assessed for improving the sustainability and success of the SAGCOT Programme i.e. the intensification of production (to use less land) and the improvement of water efficiency (to reduce water losses and consumption). A practical way of implementing this strategy also consists of **choosing the right crops to plant with systematic approaches, both to ensure value creation and sustainable water use**. An example includes the reduction in sugar cane, bananas and citrus, which require considerable irrigation in favor of potatoes, maize (which is usually rainfed), and paddy (especially under the System of Rice Intensification (SRI) Production Technology which require less water, as well as vegetables, which require less irrigation and are more relevant for food security.
22. A combination of Agriculture Intensification (Scenario 4 - aimed at increasing productivity in order to have the same production yield while using less land), and Water Use Efficiency (Scenario 5 - aimed at improving irrigation efficiency to use water more productively), is projected to lead to lasting economic benefits while avoiding damage to the environment both within the cluster and the Rufiji delta. In other words, proper planning and implementation of SAGCOT investments has the potential to foster agriculture development, and effectively contribute to the national goals of socio-economic development and environmental preservation.
23. With regard to carbon sequestration (Table 2), it has been observed that **the Agriculture Intensification (Scenario 4) in the period 2014-2030 leads to the highest amount of carbon sequestration**. In fact, approximately 290,000 tons more than in the SAGCOT scenario would be sequestered by 2030. When considering that the loss of carbon sequestration in the SAGCOT scenario relative to the BAU case is approximately 415,000 tons, it emerges that SAGCOTwould likely not lead to as much carbon sequestration as other scenarios. In other words, the implementation of the SAGCOT programme would generate jobs and income, but would lead to a reduction of carbon sequestration with also possible negative consequences on biodiversity and the delta.