SAVI Sustainable Asset Valuation

The Sustainable Asset Valuation of the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) Initiative:

A focus on irrigation infrastructure

Summary of Results

IISD International Institute for Sustainable Development

MAVA FONDATION POUR LA NATURE

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About SAVi

SAVi is a simulation service that helps governments and investors value the many risks and externalities that affect the performance of infrastructure projects.

The distinctive features of SAVi are:

- Valuation: SAVi values, in financial terms, the material environmental, social and economic risks and externalities of infrastructure projects. These variables are ignored in traditional financial analyses.
- Simulation: SAVi combines the results of systems thinking and system dynamics simulation with project finance modelling. We engage with asset owners to identify the risks material to their infrastructure projects and then design appropriate simulation scenarios.
- Customisation: SAVi is customised to individual infrastructure projects.

https://www.iisd.org/project/SAVi-sustainable-asset-valuation-tool

Glossary

Debt Service Coverage Ratio (DSCR): A measure of the cash flow available to pay current debt obligations. The ratio states net operating income as a multiple of debt obligations due within one year, including interest and principal.

Equity Internal Rate of Return (IRR): An indicator of the profitability prospects of a potential investment. The IRR is the discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero. Cash flows net of financing give us the equity IRR.

Equity Net Present Value (NPV): The difference between the present value of cash inflows net of financing costs and the present value of cash outflows. It is used to analyze the profitability of a projected investment or project.

Feedback loop: "Feedback is a process whereby an initial cause ripples through a chain of causation ultimately to re-affect itself" (Roberts et al., 1983).

Green economy: An economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities (UNEP, 2011).

Loan Life Coverage Ratio (LLCR): A financial ratio used to estimate the ability of the borrowing company to repay an outstanding loan. It is calculated by dividing the NPV of the cash flow available for debt repayment by the amount of senior debt outstanding.

Scenarios: Expectations about possible future events used to analyze potential responses to these new and upcoming developments. Consequently, scenario analysis is a speculative exercise in which several future development alternatives are identified, explained, and analyzed for discussion on what may cause them and the consequences these future paths may have on our system (e.g., a country or a business).

System dynamics (SD): A methodology to create descriptive models that focus on the identification of causal relations influencing the creation and evolution of the issues being investigated. Its main pillars are feedback loops, delays and nonlinearity through the explicit representation of stocks and flows.

Executive Summary

The Southern Agricultural Growth Corridor of Tanzania (SAGCOT) is an initiative that aims to strengthen Tanzania's agriculture sector. It foresees an expansion of 350,000 hectares (ha) of agriculture land to increase production and processing of agricultural goods. The SAGCOT plan will also significantly increase the pressure on the water resources in the Kilombero Valley, where 51,800 ha of the expansion is planned (The Economics of Ecosystems and Biodiversity [TEEB], 2017). Because of this impact, TEEB suggests various options to improve water efficiency and reduce water shortages.

IISD has carried out an economic and financial assessment of the options suggested in the TEEB report. The options are the use of flood and drip irrigation, assuming irrigation efficiency of 25 per cent and 82 per cent respectively. IISD used the Sustainable Asset Valuation (SAVi) tool to compare the financial performance and socioeconomic impacts of these two different irrigation systems, under the following scenarios:

1. SAGCOT reference (RE) scenario: the extensive use of flood irrigation leads to water shortage. This reduces the total production and revenues by approximately 15 per cent.
2. SAGCOT green economy (GE) scenario: the use of drip irrigation with an irrigation efficiency of 82 per cent results in sufficient water savings that can be used to irrigate the additional agriculture land under SAGCOT. This scenario used two cost assumptions for drip irrigation: USD 1,500 per ha (low-cost assumption) and USD 3,000 per ha (high-cost assumption).

Results show that, when assuming low costs for drip irrigation, the capital and operating expenditures total USD 54.7 million, compared to the cost for flood irrigation of USD 14.8 million over a period of 25 years. The annual cost of water per hectare is USD 69.23 and USD 47.74 for flood and drip irrigation respectively. Total revenues under flood irrigation are USD 117.65 million, which is 43.3 per cent lower than the USD 168.6 million in revenues obtained when using drip irrigation. This is primarily due to water savings, and the application of that water to additional plots of land. The analysis estimates that 10,600 ha could be unlocked for agriculture production. This will result in a 20 per cent increase in agriculture production, generating USD 51 million in additional revenues over 25 years. This increases the profitability of drip irrigation and creates employment for 10,000 people. The net benefits after 25 years are projected to total USD 12.9 million for flood irrigation and USD 39.2 million for and drip irrigation. When using the high capital costs for drip irrigation model, the net benefits decrease to USD 3.98 million.

The water savings and revenues from the additional plots of land for agricultural production are important externalities that might not be considered in traditional financial analyses. SAVi includes them in financial feasibility assessments of the irrigation infrastructure and demonstrates that they indeed have a significant impact on the financial performance of irrigation projects. Without including these externalities flood irrigation performs better than both the low- and high-cost drip irrigation solutions. However, when all the externalities measured are factored in, drip irrigation proves to be better across all key financial indicators calculated.

IISD's findings indicate that the use of drip irrigation improves resilience, dampens unsustainable work-related migration patterns and improves overall food security in the Kilombero Valley. With the risk of stranded land due to water scarcity, drip irrigation would provide a more compelling case for investors, unlock an additional 10,600 hectares of agriculture land and generating a more stable revenue stream due to higher land productivity and production.

Abbreviations

BAU	business-as-usual
BRN	Big Results Now!
CAPEX	Capital expenditure
CBA	Cost Benefit Analysis
CLD	Causal Loop Diagram
DSCR	Debt Service Coverage Ratio
IRR	Equity Internal Rate of Return
NPV	Equity Net Present Value
FTE	Full Time Equivalent
FYDP	Five Year Development Plan
GDP	Gross Domestic Product
GE	Green Economy
ha	Hectares
LLCR	Loan Life Coverage Ratio
RE	Reference
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SAVi	Sustainable Asset Valuation tool
SD	System dynamics
TEEB	The Economics of Ecosystems and Biodiversity

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Part I: Introduction

The Rufiji River basin is critical for Tanzania's development, particularly in relation to food and water security. Multiple development options cause environmental pressures on the basin: forestation of mountain grasslands, development of dams for irrigation and power generation, and water-intensive farming practices. This makes sustainable management of the basin a challenge.

The Kilombero basin covers 40,330 km2, extending from the south-western Kipengere and Livingstone Mountain Ranges up to the Swero station, just below the Kilombero swamp. The Kilombero River contributes up to 62 per cent 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 basin potentially has more than 300,000 hectares for irrigation (SAGCOT Centre, 2013).

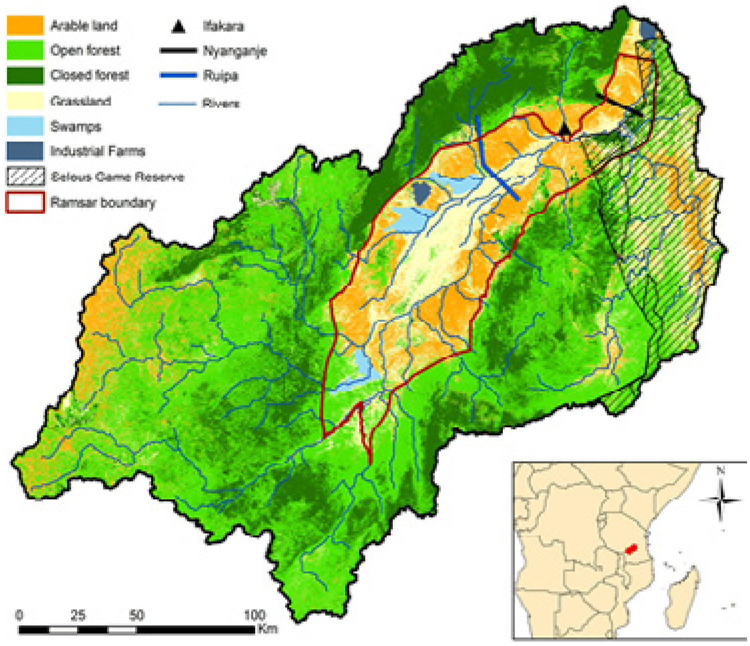


Figure 1. Land use and geography of the Kilombero Valley, Tanzania

The Government of Tanzania has developed the Southern Agriculture Growth Corridor of Tanzania (SAGCOT) initiative to deliver rapid and sustainable agricultural growth in Southern Tanzania. It includes the development of 51,800 ha for agricultural production in the Kilombero basin to generate sufficient output to attract processing and other agriculture service businesses (SAGCOT Centre, 2013).

The main aim of SAGCOT is to increase agriculture production, enhance economic development and provide employment opportunities. A key component of SAGCOT is providing farmers with improved access to irrigation systems. The implementation of SAGCOT in the Kilombero Valley is estimated to generate annual gross revenues of USD 35 million within the first five years, and create 4,500 jobs and wider employment benefits to almost 40,000 people (SAGCOT, 2013).

Despite its high agricultural potential, the Kilombero basin 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 flood plain.

The SAGCOT development plan acknowledges the potential emergence of conflicting interests within the agriculture sector that cause unsustainable behavioural patterns, such as the competition for land and water resources between farmers and livestock owners. SAGCOT emphasizes the need for integration of social and environmental interests and the critical importance of ecosystem health and natural resources.

The SAGCOT plan assumes that its implementation will lead to economic development in the agricultural sector, but acknowledges that attention should be paid to the negative impacts of land use and land cover change, and to the consequences of 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 are minimized or avoided.

The SAVi Irrigation model was used to estimate the impacts and externalities of using different irrigation systems for the implementation of the SAGCOT initiative in the Kilombero basin (Bassi, McDougal, & Uzsoki, 2017). The SAVi analysis of SAGCOT provides information about required investments, avoided costs and added benefits of different irrigation technologies. SAVi provides information about direct and indirect impacts of the SAGCOT policy, such as employment generated, water use and demand, agriculture productivity and externalities such as CO2 emissions from water pumping and deforestation. The results of SAVi are presented in the form of an integrated cost benefit analysis (CBA) and using project finance indicators (equity internal rate of return [IRR], equity net present value [NPV] and debt coverage ratios).

Part II: National Context

The Government of Tanzania is currently implementing various agricultural policies, each with a different scope and focus. Big Results Now! is a nationwide policy aimed at socioeconomic development, in addition to agricultural expansion; the second Five Year Development Plan (FYDP) is a medium-term policy agenda for the whole country; Kilimo Kwanza is a region-wide policy that should provide funding for the implementation of SAGCOT; SAGCOT is an agricultural development plan that directly affects the Kilombero Valley, among other parts of the country.

Under Big Results Now! (BRN), the Government of Tanzania aims to increase the output and quality of all agricultural products for which Tanzania enjoys a comparative and competitive advantage, to position itself as the food basket for the East Africa region and beyond. At a later stage, the scope will be expanded to include other crops to improve food security in Tanzania (Republic of Tanzania, 2013).

The FYDP II—"Nurturing Industrialization for Economic Transformation and Human Development"—focuses on growth and transformation for poverty reduction by 2020–2021. It also incorporates aspects of Tanzania's Development Vision 2025, which aspires to transform Tanzania into a middle-income and semi-industrialized nation by 2025 (Republic of Tanzania, 2016). On agricultural transformation, the FYDP II includes interventions for the acceleration of growth in crop production: expansion and improvement of irrigation systems; improvement of R&D in crop cultivation; improvement of extension services; improving agricultural land use plans; and enhancing availability of markets.

To unlock the region's potential, the SAGCOT initiative seeks to attract more than USD 3 billion of investment to greatly increase food production, increase annual farming revenues by more than USD 1.2 billion, benefit small-scale farmers and the rural poor, and establish Southern Tanzania as a regional food exporter. Meeting these ambitious goals requires a targeted strategy and realistic action plan to deploy resources, engage partners, and coordinate activities and investments throughout the Corridor. In 2011, the SAGCOT Blueprint was released, describing where and how investment in the agriculture sector could be scaled up and better coordinated to establish productive clusters of new economic activity (SAGCOT Centre, 2013).

The SAGCOT Blueprint is a result of the work of an international public–private partnership, the Kilimo Kwanza Growth Corridor, that was launched in 2010. This partnership aims to deliver rapid and sustainable agricultural growth, with major benefits for food security, poverty reduction and reduced vulnerability to climate change. The assessment of the impacts that SAGCOT will have in the Kilombero cluster will also shed light on whether the funding envisioned in the Kilimo Kwanza Strategy is in line with the goal of sustainable development and of agricultural expansion that will minimize the negative impacts on ecosystem services in the floodplain.

Part III: SAVi Analysis: Model overview

In the context of the TEEB project in Tanzania, the team at USD-IRA has carried out surveys on land use and land management practices to inform the use of models such as CROPWAT (for crop water requirements) and SWAT (for water supply). These two tools were identified to be the most suitable to analyze the key characteristics of the Kilombero basin, and how the implementation of SAGCOT could shape future trends.

The combined use of CROPWAT and SWAT estimates the suitability of crops based on their water requirements.

The potential impact of upcoming investment strategies under SAGCOT requires a socioeconomic analysis that complements the combined CROPWAT and SWAT estimations. A system dynamics model, based on the SAVi irrigation model, provides this analysis.

Figure 2 presents the causal loop diagram (CLD) that represents the main drivers of change in the Kilombero basin. There are four main feedback loops that underlie the dynamics of the basin:

- The first feedback loop illustrates that population and demand for food drives the expansion of agriculture land. Population growth results in an increased demand for food, which in turn leads to the conversion of land for subsistence agriculture. The additional income from agriculture production increases the attractiveness to migrate to the region. This further increases the population and demand for food.
- The second feedback loop illustrates that the expansion of agriculture land, under policy scenarios such as SAGCOT, leads to an increase in employment that leads to migration to the region. This facilitates the expansion of agriculture land and attracts more people into the area. This feedback loop is similar to the first one but is viewed from the perspective of commercial establishments rather than from land availability and local food supply.
- The third feedback loop illustrates the relation between the expansion of agriculture land and water availability. The extent to which the expansion can materialize depends on water availability and efficiency of water use. The presence of vegetation increases groundwater recharge and lowers surface water and runoff, impacting the efficiency of water use.
- The fourth feedback loop further refines the relation between the expansion of agriculture land and water availability. It includes the types of crops planted. Those have respective water requirements and can therefore impact the relationships with water availability, which in turn affects the expansion of agriculture land. The lack of water in the dry season causes water stress, reduces agriculture yield and production, and affects human and ecosystem health.

Figure 3 presents an overview of the modelling framework. It indicates that four modelling tools are used as foundations for the system dynamics model (SD): the CLD, spatial maps and biophysical models (such as SWAT and CROPWAT), and SAVi irrigation for the project financing analysis.

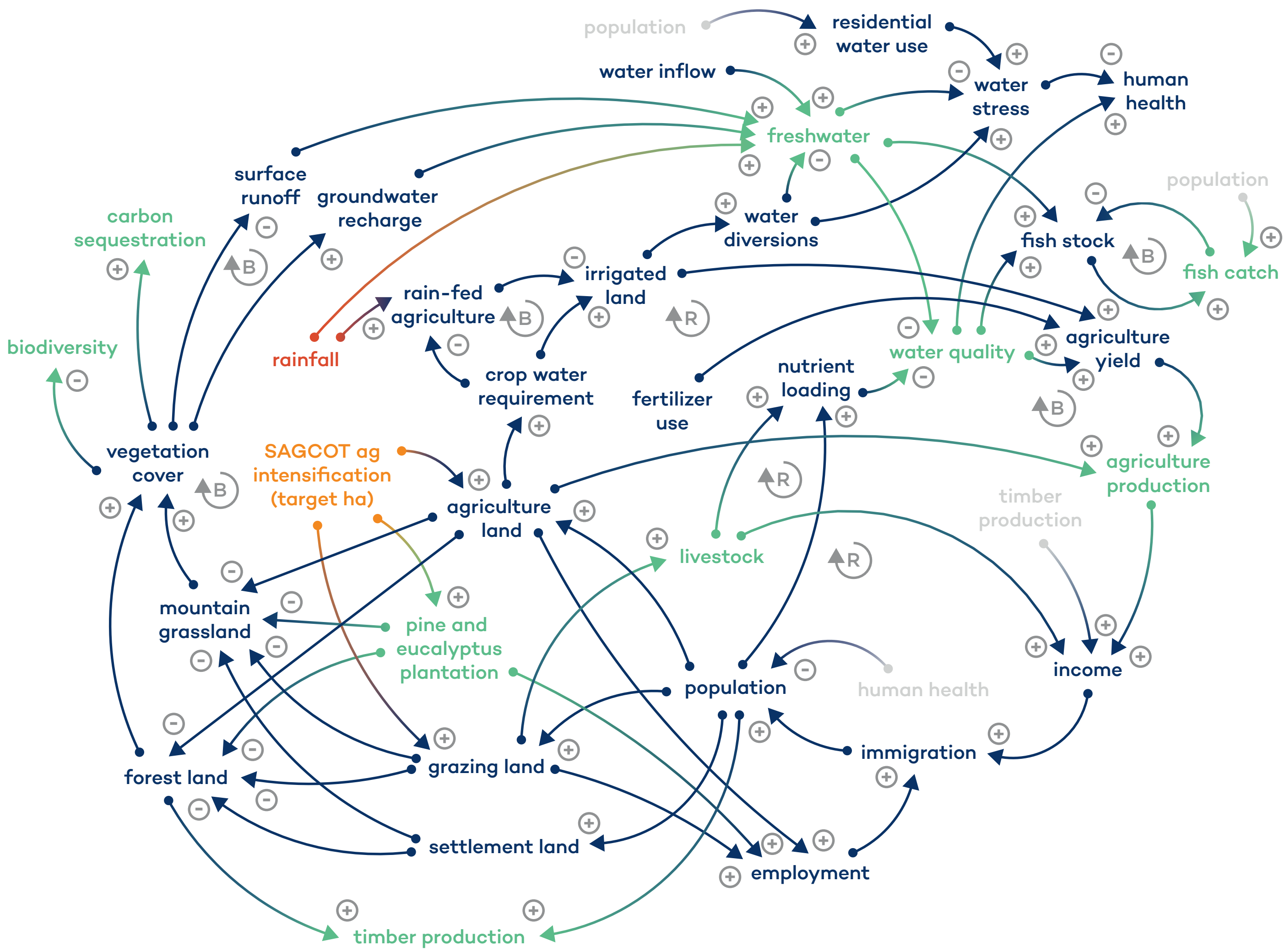


Figure 2. Causal Loop Diagram of the study area, emphasizing the impacts of implementing the SAGCOT initiative.

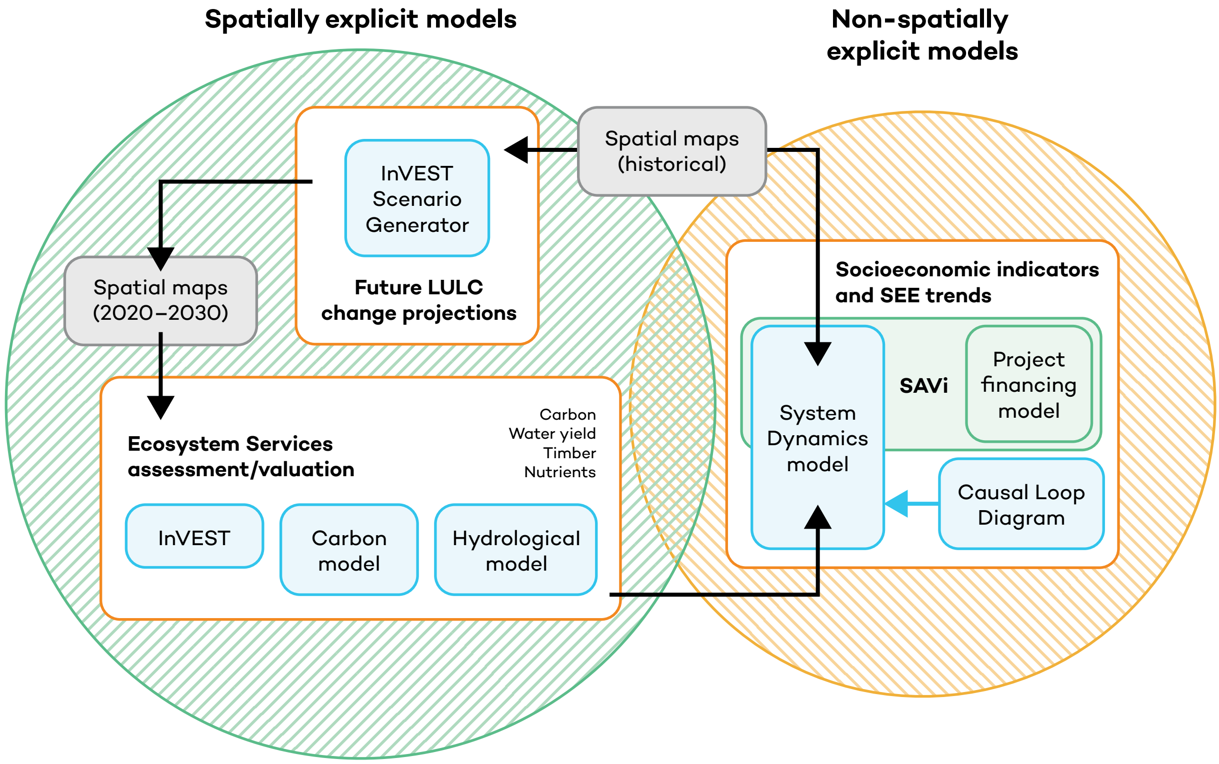


Figure 3. The main methodologies and models utilized: CROPWAT, SWAT, Systems Thinking, InVEST and System Dynamics.

Part IV: Scenarios

SAVi simulates different scenarios to assess the impacts of implementing the SAGCOT initiative in the Kilombero basin. To better contextualize and interpret the results of the implementation as opposed to non-implementation, we simulated a business-as-usual (BAU) case, with no expansion of agriculture land. Further, results are primarily presented for two SAGCOT initiative scenarios, one making use of flood irrigation (reference, or RE), and the one considering drip irrigation (green economy, or GE). In the GE scenario we consider two cost assumptions for drip irrigation, low (USD 1,500/ha) and high (USD 3,000/ha).

Further, two additional assumptions were made for each of the SAGCOT scenarios: (a) unconstrained water supply and (b) constrained water supply where water availability is consistent with historical surface water flows in the dry season and with current estimates of groundwater extraction for irrigation purposes (Helmin-Söderberg, 2014; United Nations Educational, Scientific and Cultural Organization [UNESCO], 2015).

Business-As-Usual

The business-as-usual (BAU) scenario is simulated to estimate projected baseline changes in the Kilombero basin. This scenario assumes a continuation of historical population growth and land conversion for agriculture and settlement land. In addition, it provides information about land conversion-related impacts on ecosystem services such as carbon sequestration and water yield.

SAGCOT Reference and Green Economy Scenarios

The SAGCOT scenarios assume the achievement of the targets set under the SAGCOT initiative for the Kilombero cluster, such as the expansion of agriculture land by 51,800 hectares. The SAGCOT reference (RE) scenario uses floor irrigation technology. The SAGCOT green economy (GE) scenario uses drip irrigation technology.

Table 1 presents the assumptions about land conversion by crop type.

Table 1. Scenario assumptions SAGCOT

Crop type	Additional farmland by 2030
Mixed farmland	13,250 hectares
Rice estates	14,000 hectares
Sugar estates	20,500 hectares
Citrus plantation	3,000 hectares
Banana plantations	1,050 hectares

A Scenario of Constrained Water Supply

The scenario of constrained water supply uses the maximum sustainable extraction thresholds that constrain water consumption from ground and surface. The maximum sustainable ground water extraction is based on a study on the Kilombero water aquifers (Helmin-Söderberg, 2014). A minimum surface water runoff ensures that sufficient water remains in the river to maintain its ecosystem services. A UNESCO study on the environmental flows in the Rufiji River basin (2015) calculated the minimum runoff value for the Kilombero River at Ifakara Ferry (UNESCO, 2015). Total renewable groundwater is estimated to be one cubic kilometre, or 1 billion litres per year (Helmin-Söderberg, 2014).

Part V: Results

Socioeconomic Trends

SAVi generated scenario projections for the following socioeconomic indicators:

- Average productive agriculture land (hectares)
- Average total agriculture production (tons/year)
- Average water use from agriculture (billions/year)
- Average employment from agriculture (full time equivalent (FTE))

The BAU scenario assumes a steady growth in population. Total population increases from 340,000 people in 2000 to around 620,000 people in 2030. Population growth will drive the expansion of agriculture to produce the required amount of food, and the conversion of land to settlements in order to accommodate the growing number of people in the area. Agriculture production is generally assumed to primarily take place for subsistence, which indicates that employment and total income from agriculture will increase proportionally to population. This implies that income per capita will remain more or less constant over time, at least for farmers. Further, the growing population and the expansion of agriculture land and production increase the demand for water for human consumption and irrigation.

The implementation of SAGCOT in the Kilombero cluster is expected to increase agriculture land by 51,800 hectares. The expansion of agriculture land creates around 46,000 employment opportunities and causes work-related migration to the Kilombero Valley. The additional employment opportunities that are created through the implementation of SAGCOT will reduce the unemployment rate and increase total income. Production output in the SAGCOT case is exceeding the subsistence level, since the increase in agriculture production is aiming at the economic development of the region. Total production (without water constraints) increases by almost 3,000 tons per year in 2030. Higher employment rates and more production output and subsequently turnover cause per capita income to be higher than in the BAU scenario.

Tables 2 through 5 provide an overview of productive agriculture land, total agriculture production and agriculture employment for selected years and scenarios.

Table 2. Average productive agriculture land (hectares)

Scenario	2015	2020	2025	2030
BAU	563,994	628,266	708,284	798,492
BAU with water constraints (WCs)	563,994	617,430	679,288	694,836
Difference	*0.0%*	*-1.7%*	*-4.1%*	*-13.0%*
SAGCOT RE	563,994	646,033	817,150	918,073
SAGCOT RE WC	563,994	628,794	706,978	**736,141**
Difference	*0.0%*	*-2.7%*	*-13.5%*	*-19.8%*
SAGCOT GE with WCs	563,994	637,960	759,643	**792,668**
SAGCOT GE WC vs SAGCOT RE	0.0%	-1.2%	-7.0%	-13.7%
SAGCOT GE WC vs SAGCOT WC	0.0%	1.5%	7.4%	7.7%

Table 2 demonstrates that under a water-constrained scenario the implementation of SAGCOT with drip irrigation (SAGCOT GE) allows for cultivating 792,668 hectares of productive agriculture land compared to 736,141 hectares using flood irrigation (SAGCOT RE) by 2030.

Table 3. Average total agriculture production (tons/year)

Scenario	2015	2020	2025	2030
BAU	247,983	312,333	311,425	351,089
BAU with water constraints	247,983	287,744	292,953	299,462
Difference	*0.0%*	*-7.9%*	*-5.9%*	*-14.7%*
SAGCOT RE	247,983	339,114	346,632	390,778
SAGCOT RE with water constraints	247,983	288,408	293,690	305,987
Difference	*0.0%*	*-15.0%*	*-15.3%*	*-21.7%*
SAGCOT GE with water constraints	247,983	307,679	316,539	330,365
SAGCOT GE WC vs SAGCOT RE	*0.0%*	*-9.3%*	*-8.7%*	***-15.5%***
SAGCOT GE WC vs SAGCOT RE WC	*0.0%*	*6.7%*	*7.8%*	*8.0%*

The additional population growth and the expansion of cultivated area increase the demand for water, which increases the pressure on the water resources of the Kilombero basin. When assuming that water is constrained, land will be stranded and production declines. As a result, the level of economic development as indicated in the SAGCOT Investment Blueprint (SAGCOT Centre, 2013) could be achieved in the short term. Challenges will emerge in the medium and longer term, leading to a reduction of agriculture production by 15.5 per cent and affect the projected revenue streams.

Table 4. Average water use from agriculture (billion litres/year)

Scenario	2015	2020	2025	2030
BAU	30.4	84.5	95.3	107.4
BAU with water constraints	30.4	77.6	83.4	84.8
Difference	*0.0%*	*-8.1%*	*-12.4%*	*-21.1%*
SAGCOT RE	30.4	91.7	121.2	134.6
SAGCOT RE with water constraints	30.4	81.3	92.6	95.3
Difference	*0.0%*	*-11.3%*	*-23.6%*	*-29.2%*
SAGCOT GE with water constraints	30	67	80	82
SAGCOT GE WC vs SAGCOT RE	*0.0%*	*-27.0%*	*-34.4%*	*-39.1%*
SAGCOT GE WC vs SAGCOT RE WC	*0.0%*	*-17.7%*	*-14.1%*	***-14.0%***

The use of drip irrigation reduces annual water use by 14 per cent in the long term. Reducing water use for irrigation reduces the pressure on water resources and increases the carrying capacity of the valley for agriculture expansion as discussed under Table 2. The SAGCOT GE scenario reduces the seasonal fluctuations in migration, meaning that income from agriculture is more constant through the year. This is especially beneficial for smallholder farmers, whose income would be affected by the effects of seasonality (SAGCOT Centre, 2013).

Table 5. Average employment from agriculture (FTE)

Scenario	2015	2020	2025	2030
BAU	214,554	239,005	269,445	303,762
BAU with water constraints	214,554	235,106	257,768	263,303
BAU WC vs BAU	*0*	*-3,899*	*-11,677*	*-40,459*
SAGCOT RE	214,554	246,351	311,528	349,723
SAGCOT RE with water constraints	214,554	239,196	268,121	278,693
SAGCOT WC vs SAGCOT	*0*	*-7,154*	*-43,407*	*-71,031*
SAGCOT GE with water constraints	214,554	244,199	289,019	300,787
SAGCOT GE WC vs SAGCOT WC	*0*	*5,003*	*20,898*	***22,094***

Table 5 illustrates that employment creation in both SAGCOT scenarios and that employment will increase steadily. However, under the SAGCOT GE scenario with water constraints around 22,094 (7.9 per cent) more jobs will be created in the middle and long term than in the SAGCOT RE water constraint scenario.

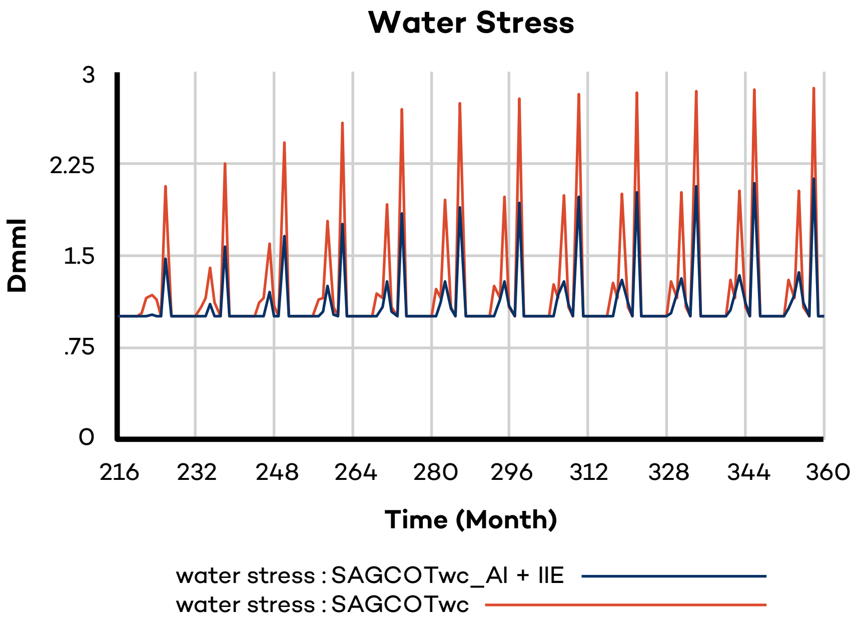
All simulation results indicate that combining agriculture expansion with intensification practices and water efficiency can have considerable potential to mitigate environmental pressures and increase the sustainability of SAGCOT (Table 6). The combination of both investments maintains the expected performance on production and employment creation, significantly improves the environmental performance of the agriculture sector, and ensures longevity and sustainability for SAGCOT investments.

Table 6. Performance comparison of policy scenarios on key indicators, relative to expectations on the implementation of SAGCOT.

	land use	water stress	carbon sequestration	production	employment
SAGCOT RE	↑	↑	↓	↑	↑
SAGCOT RE with water constraints	↓	↑	↑	↓	↓
SAGCOT GE with water constraints	= (or ↓ if water savings are not reallocated)	↓	= (or ↑ if water savings are not reallocated)	↑	↑

Figure 4 illustrates water stress and immigration for the SAGCOT RE (red line) and the SAGCOT GE scenario (blue line). Water stress emerges if the sustainable use of water resources causes total demand for water to be higher than the available supply. In the SAGCOT RE scenario, the sustainable use of water causes demand to be almost three times as high as supply by 2030. While water stress persists in the SAGCOT GE scenario, the projections indicate that drip irrigation reduces water demand to a level where it is only twice as high as available supply.

The reduction achieved from using drip irrigation results in sufficient water supplies to sustain production on most of the newly established agriculture land through the dry season. This reduces the seasonal migration patterns that can be observed in Figure 4. In the SAGCOT RE scenario, people move into the valley (positive immigration) during the rainy season to work in the fields, and move away from the valley (negative immigration) with the onset of the dry season.



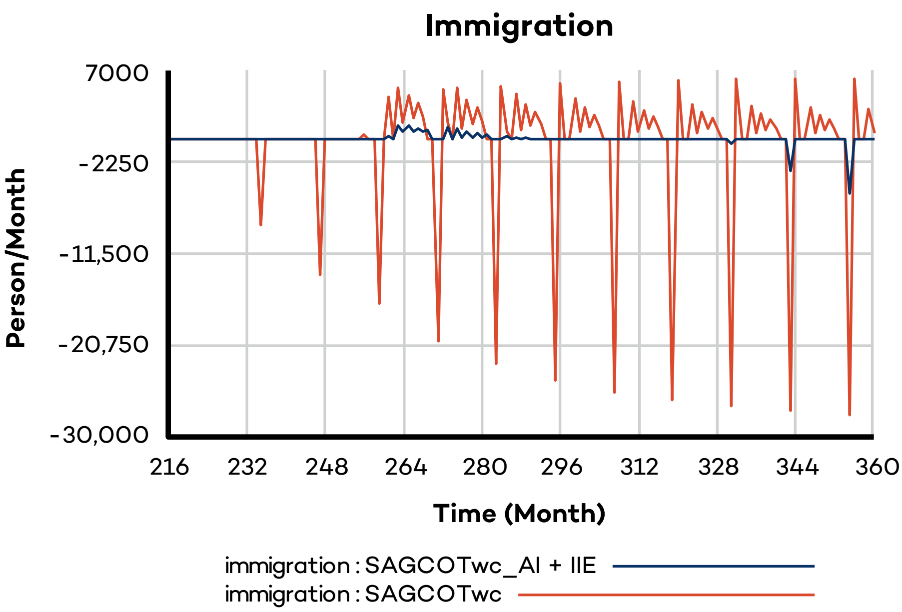
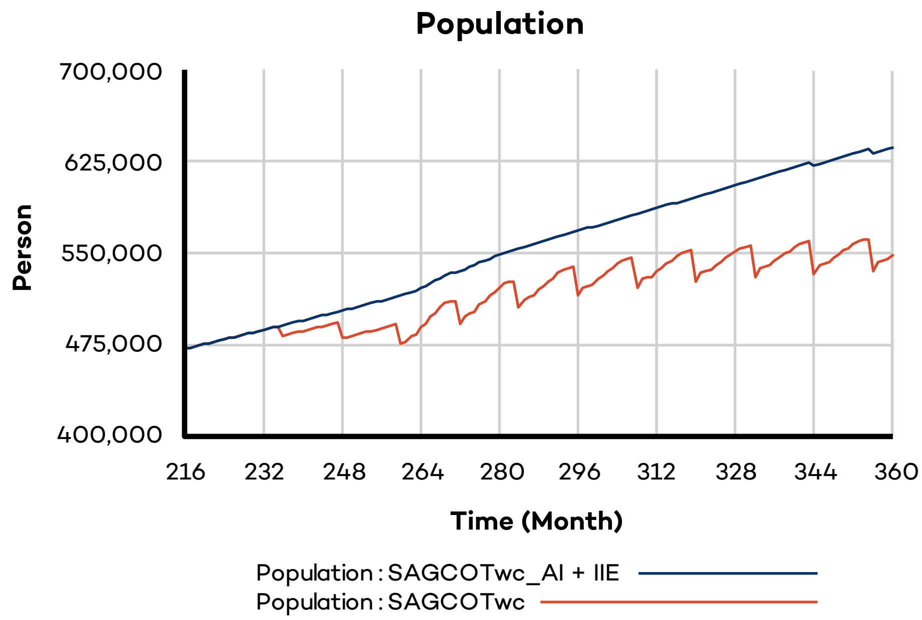


Figure 4. Water stress and immigration in the combined scenario

The implementation of drip irrigation in the SAGCOT GE scenario almost completely mitigates seasonal migration, which keeps population stable and contributes to the social sustainability of the plan. Figure 5 illustrates total population and total agriculture land used for both the SAGCOT RE and GE scenarios.

While the total amount of land used for agriculture is still affected by water scarcity during the dry season, the projections indicate that the reduction in agriculture production and employment does not significantly impact population. This is illustrated in Figure 5.



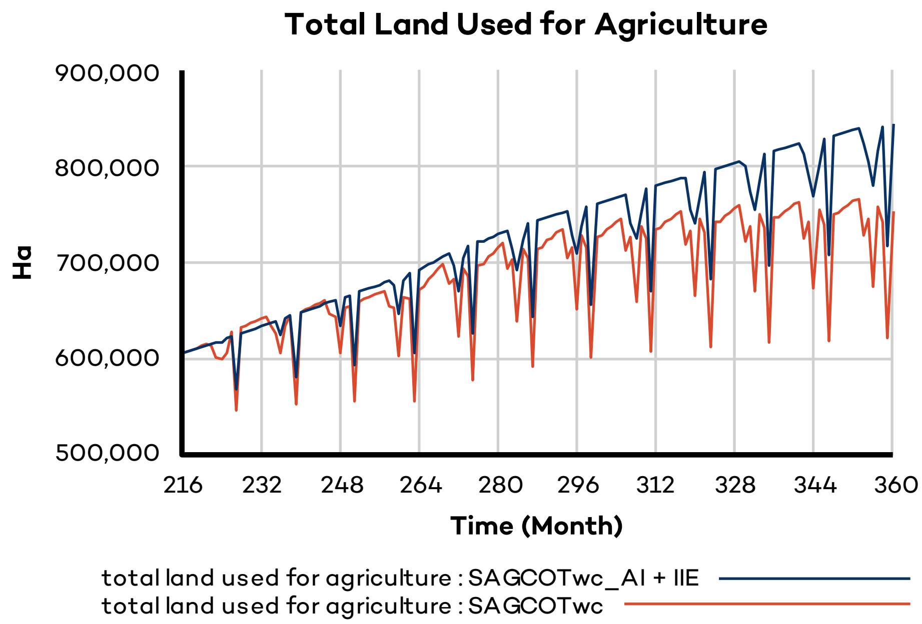


Figure 5. Population and total agriculture land in the combined scenario

Integrated Cost Benefit Analysis

The integrated CBA calculates the net benefits for society of the different scenarios. We used two different capital cost assumptions for the cost of drip irrigation infrastructure: a low-cost scenario (USD 1,500 per hectare) and a high-cost scenario (USD 3,000 per hectare).

Tables 7 and 8 present the results of the integrated CBA between 2018 and 2030.

Table 7. Integrated CBA high capital cost scenario

Variable	SAGCOT RE (million USD)	SAGCOT GE (million USD)	SAGCOT RE vs GE (million USD)
Total investment	3.26	57.43	**54.17**
Flood irrigation	*3.26*	*1.75*	*-1.51*
Drip irrigation		*55.68*	*55.68*
O&M costs	11.53	16.88	5.35
Flood irrigation	*11.53*	*6.19*	***-5.35***
Drip irrigation		*10.69*	*10.69*
Total investment and O&M	14.79	74.31	59.51
Water costs	*89.97*	*74.71*	***-15.27***
Total costs	104.77	149.01	44.25
Costs of additional agriculture land		15.62	**15.62**
Investment		*15.24*	*15.24*
O&M costs		*0.37*	*0.37*
Avoided costs		0.34	0.34
*Avoided social costs of carbon**		*0.34*	***0.34***
Revenue[1]	117.65	168.61	**50.96**
Total CBA	**12.88**	**3.98**	-8.56

Table 7 shows that, under a high capital cost assumption, the net benefits of flood irrigation are higher than those of drip irrigation. Drip irrigation requires total additional investment of USD 54.17 million and increases operation costs by cumulatively USD 5.35 million compared to using flood irrigation. Drip irrigation yields avoided water cost of USD 15.27 million. It also generates USD 50.96

[1] The revenue figures are calculated based on the SAGCOT Blueprint (2013) where revenue estimations for the first five years were included. The revenue under the SAGCOT GE scenario is higher because a larger area of land is "unlocked" for agriculture production due to the drip irrigation technology.

million additional revenues because more agricultural land can be cultivated. Further, drip irrigation leads to an avoided social cost of carbon of USD 0.34 million by reducing the fuel required for water pumping. However, because irrigation capacity is needed on the additional agricultural land available for cultivation, additional cost of USD 15.62 million incur. This ultimately leads to a net benefit of USD 3.98 million for drip irrigation, compared to a much larger benefit of USD 12.88 million in the case of a SAGCOT with flood irrigation.

Table 8. Integrated CBA low capital cost scenario

Variable	SAGCOT RE (million USD)	SAGCOT GE (million USD)	SAGCOT RE vs GE (million USD)
Total investment	3.26	29.59	26.33
Flood irrigation	*3.26*	*1.75*	*-1.51*
Drip irrigation		*27.84*	*27.84*
O&M costs	11.53	16.88	5.35
Flood irrigation	*11.53*	*6.19*	*-5.35*
Drip irrigation		*10.69*	*10.69*
Total investment and O&M	14.79	46.47	31.67
Water costs	*89.97*	*74.71*	***-15.27***
Total costs	104.77	121.17	16.40
Costs of additional agriculture land		8.23	8.23
Investment		*7.85*	*7.85*
O&M costs		*0.37*	*0.37*
Avoided costs		0.34	0.34
Avoided social costs of carbon		*0.34*	***0.34***
Revenue	117.65	168.61	**50.96**
Total CBA	**12.88**	**39.21**	**26.67**

Under the low capital cost assumption, the net benefits of drip irrigation increase to USD 39.21 million compared to USD 12.88 million. The additional investment total for drip irrigation and O&M costs are still higher than flood irrigation. However, the avoided water costs (USD 15.27 million), the avoided social cost of carbon (USD 0.34 million) and the additional revenues (USD 50.96 million) in the case of drip irrigation make that investment in drip irrigation will bring USD 26.67 million more net benefits to the society than flood irrigation.

Financial Performance

We have built a project finance model, using Corality SMART best practices, to assess the financial feasibility of the different irrigation technologies and to demonstrate the financial impact of the externalities measured. A project finance model calculates whether the incoming cash flows in each period are sufficient to cover the operating costs and service the debt used to finance the project. The profitability and financial health of the project are assessed by calculating the following key financial indicators:

- Equity Net Present Value (NPV)
- Equity Internal Rate of Return (IRR)
- Debt Service Coverage Ratio (DSCR)
- Loan Life Coverage Ratio (LLCR)

Table 9. Key financial indicators for the different SAGCOT scenarios

Scenarios	IRR (%)	NPV (USD million)	Min. DSCR (ratio)	Ave. DSCR (ratio)	Min. LLCR (ratio)
1) Flood irrigation (SAGCOT RE)	6.20%	(0.61)	1.18×	1.51×	1.19×
2) Drip irrigation (SAGCOT GE), high capital expenditure (CAPEX)	Negative	(45)	0.14×	0.17×	0.14×
3) SAGCOT GE, low CAPEX	Negative	(20)	0.32×	0.36×	0.32×
4) SAGCOT GE, high CAPEX, incl. social cost of carbon (SCC)	Negative	(45)	0.15×	0.19x	0.15×
5) SAGCOT GE, high CAPEX, incl. SCC and additional revenues	3.06%	(22)	1.11×	1.13×	1.11×
6) SAGCOT GE, high CAPEX, all externalities	6.04%	(12)	1.22×	1.50×	1.22×
7) SAGCOT GE, low CAPEX, all externalities	13.42%	10	2.33×	2.64×	2.34×

The IRR and NPV indicate the financial viability of the project. In other words, they calculate whether the project can pay back investors and still generate a sufficient risk-adjusted return. Flood irrigation generates a positive IRR (6.20 per cent), although it is probably at the lower end for an emerging market project. The NPV is slightly negative, which is also due to the high discount rate used (9 per cent). On the other hand, the drip irrigation project is not financially viable without considering the externalities. Both the lower and higher capex versions generate a negative IRR and NPV. However, when all the externalities measured are included, drip irrigation high capex generates a similar IRR (6.04 per cent) to the flood irrigation solution. In the case of the low capex version both the IRR and NPV improve significantly (13.32 per cent, USD 10 million) outperforming the flood irrigation alternative.

The debt service coverage ratio (DSCR) and the loan life coverage ratio (LLCR) indicate the financial health of the project. These credit ratios are particularly of interest for lenders as they calculate how easily the cash flows can service the outstanding debt in each period. The minimum DSCR and LLCR is the lowest ratio throughout the life of the loan. It is important that these minimum ratios do not reach the so-called lockup ratio, which is 1.15x for DSCR and 1.10x for LLCR. Dropping below these ratios would raise a red flag for lenders and potentially trigger relevant debt covenants (e.g., cash sweeps) to ensure that the investments of senior leaders are not affected by a temporary drop in cash flows.

Flood irrigation maintains a sufficient level of DSCR and LLCR during the life of the loan. While they do not reach the lockup ratios, they do get very close, e.g., min DSCR 1.18x. On the other hand, cash flows are not sufficient to service the debt for the drip irrigation base scenarios. When all externalities are included the credit ratios of both the high and low capex versions outperform the flood irrigation scenario, e.g., min DSCR 1.22x and 2.33x respectively. Of course, the inclusion of externalities as costs does not make the cash flows less or more robust in reality. The purpose of this exercise is to demonstrate that when taking a high-level macro perspective, sustainability can have a positive impact on the financial health of infrastructure investments.

In light of these findings, it is important to consider that several externalities were not included in the financial assessment due to the lack of reliable data. Flood irrigation causes seasonal migration, high water stress, and has potentially detrimental consequences on downstream ecosystems. The consideration of these and other externalities, such as the additional income for workers that could work all year round, would likely affect the outcome of the financial assessment. It is also important to note that we have included a cost for water even though this might not apply in the Tanzania context as people often get water from the river for free.

Part VI: Conclusions

The SAVi analysis reveals that the bankability of efficient irrigation technologies depends on irrigation capital cost and the additional revenues obtained from the agriculture land that has been unlocked by freeing up additional water resources. Multiple scenarios for the Kilombero cluster were simulated. In the SAGCOT scenarios, the ambition is to increase agriculture land by 51,800 hectares compared to the baseline.

The findings of the SAVi analysis indicate that the use of drip irrigation improves resilience, dampens unsustainable work-related migration patterns and improves overall food security in the Kilombero Valley and beyond. Faced with the risk of stranded land due to water scarcity, drip irrigation would provide a more compelling case for investors, as it unlocks an additional 10,600 hectares of productive agricultural land and generates a more stable revenue stream due to continuous land productivity and production.

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