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Economywide and Distributional Impacts of Water Resources Development in the Coast Region of Kenya

Implications for Water Policy and Operations

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Cover photos (left to right): Installation of water pumps and motors, Wanderi Wachira; New water well opens in Shant Abak, Naval Mobile Construction Battalion 40; Water distributor, Mauryndinar.
Cover design: Jean Franz, Franz & Company, Inc.

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Abbreviations

BAU	business-as-usual
CAPS	Costs of Agricultural Production Survey
CES	constant elasticity of substitution
CET	constant elasticity of transformation
CGE	computable general equilibrium
CIP	Census of Industrial Production
CRU	climate research unit
CPI	consumer price index
DSPE	Dam Safety Panel of Experts
FGT	Foster-Greer-Thorbecke
FTZ	free trade zone
GDP	gross domestic product
GFCF	gross fixed capital formation
GoK	Government of Kenya
GPCC	Global Precipitation Climatology Centre
HDI	Human Development Index
JICA	Japan International Cooperation Agency
KIHBS	Kenya Integrated Household Budget Survey
KNBS	Kenya National Bureau of Statistics
LAPSSET	Lamu Port and Southern Sudan-Ethiopia Transport Corridor
MoA	Ministry of Agriculture
MOWASCO	Mombasa Water and Sewerage Company
MTP	Medium Term Plan
SAM	Social Accounting Matrix
STOMSA	Stochastic Model of South Africa
UMIC	upper-middle-income country
WAT	composite water commodity

Executive Summary

The prominence of the agriculture sector in the Kenyan economy makes economic growth particularly vulnerable to erratic climatic patterns and limited water resources availability. Agriculture contributes about 24 percent of the gross domestic product (GDP), 75 percent of industrial raw materials, 65 percent of export earnings, and 60 percent of total employment. Thus, water resource investments are necessary to shield the economy against drought and flood risks. However, no major dams have been constructed since mid-1990s. Consequently, Kenya's current storage capacity is about 103 cubic meters per capita, of which 100 cubic meters are predominantly for hydropower production. Moreover, the Kenyan development profile reveals strong regional disparities. Differences in the share of income and social services are observed across regions. Five of the six counties in the Coast region are among the 14 counties regarded as the poorest and least developed nationwide in terms of access to key infrastructure and services. The Coast region has the second-highest rural poverty levels in Kenya (after the northeastern region), while even urban poverty levels in Mombasa are somewhat higher than in other major cities in Kenya. Whereas poverty and access to services remain high across many regions in Kenya, the available statistics paint a clear picture of socioeconomic inequality and high levels of poverty in many rural and urban communities in the Coast region, especially with regard to access to key services such as water supply, sanitation, food security, health, and education. The dire poverty and inequality situation coupled with frequent droughts and the complex sociopolitical factors in Somalia that affect northeastern Kenya and other adjoining regions, has the potential to fuel conflict and reduce security, which can affect peace and sustainable development across the whole region.

Realizing the seriousness of the prevailing poverty levels and the limited water infrastructure, which heighten the vulnerability of livelihoods in the region to frequent droughts and climatic shocks—as well as the high economic potential of the region—the Government of Kenya (GoK) initiated water-centered infrastructure investments in the Coast region. The major premise for this initiative is that multipurpose water investment is the key to unlocking the potential of the Coast region and enhancing the ability to adapt to climate change.

The main objective of this study was to understand the potential socioeconomic impacts of the proposed multipurpose Mwache Dam investment in the Coast region. More specifically, the study aimed to

- Assess the contribution of the dam to regional and national economy
- Assess the relative impacts of alternative dam water allocation scenarios to the regional and national economy as well as the micro-level poverty and distributional impacts
- Draw insights and potential lessons for operations and policy.

Methodology

The study applied a computable general equilibrium (CGE) model to evaluate the economywide impact of the dam in the Coast region and the rest of Kenya. This was supported by a water module, which was developed and embedded in PEP 1-t (recursively dynamic CGE) to evaluate the impacts of multipurpose water investments on the Kenyan economy. The Kenya social accounting matrix (SAM), developed by Thurlow, Kiringai, and Gautam (2007) and Mabiso, Pauw, and Benin (2012), was revised to create a biregional SAM that captures the interlinkages and flows between different economic activities in the Coast region and the rest of Kenya. Because the CGE methodology ignores household heterogeneity with regard to consumption patterns, an integrated microsimulation framework that links the macro impacts (from the CGE model) to the microhousehold level was developed to assess poverty and distributional effects.

The model analyzed impacts of four alternative water allocation scenarios: (a) 80 percent of water allocated for domestic and nonagricultural economic sectors; (b) 100 percent of water allocated for domestic and industrial uses; (c) 20 percent of water allocated for irrigation purposes; and (d) combined allocation of 80 percent for nonagricultural and 20 percent for agricultural uses.

Economic Impacts

Changes in the final and intermediate demand for water. All three types of water supply (public, vendor, and other private) are substitutable following relative price changes. Under increased water allocation to domestic use, water users benefit from increased availability of public and vendor water at a lower cost. Consequently, demand for private water decreases, while demand for public and vendor water increases. Water consumption by all households in the Coast region increases. Moreover, increased water availability benefits all industries operating in the Coast region, in particular, those relatively more intensive in water.

Impact on economic growth. The economic growth impact of water allocations to irrigation is quite significant. Allocation of a mere 20 percent of dam water to irrigation results in a 1.1 percent and 0.1 percent economic growth in the Coast region and nationally in Kenya, respectively. The corresponding growth rates for both 80 percent and 100 percent allocations to urban and rural water supply are only about 0.5 percent and 0.1 percent for the Coast region and Kenya, respectively. With irrigation water, increased production of maize, pulses, oil crops, fruits, and vegetables in the hitherto drought-prone region fuels agricultural productivity growth that benefits the regional and national economies. Thus, allocation of water to irrigation could have considerable effects on food availability and food and nutritional security in the region, which suffers from persistent food deficits.

Impact on trade. Total exports and imports expand for all of water allocation scenarios considered. However, for scenarios 3 and 4, which include at least 20 percent water allocation to irrigation, agricultural imports decline and exports significantly expand, further enhancing the agricultural export earnings of Kenya (which already accounts for 65 percent of Kenya's total exports).

Income and consumption effects. Development of Mwache Dam affects the income and consumption of households in the Coast region through its effects on wages and returns to capital. For scenarios 1 and 2, the nominal rural household income increases while urban household income declines. However, due to reduction in consumer price index (CPI) and the substitution effect, total household consumption ultimately increases. For scenarios 3 and 4, which include water allocation to agriculture, the nominal income and consumption of all households in the Coast region significantly increases.

In addition, the increased availability of water in the Coast region affects household income and consumption in the rest of Kenya through price, income, and regional substitution effects. For scenarios 1 and 2, income of rural households in the rest of Kenya increases because of higher labor and capital income, which also leads to increase in total consumption, especially under a 100 percent allocation. For scenarios 3 and 4, the nominal income of all households in the rest of Kenya declines slightly especially for poorer households. However, because of reductions in the total CPI, mainly driven by reduction in agricultural CPI, the real income or consumption increases slightly for both urban and rural households in the rest of Kenya (scenario 3). Despite these regional differences, the overall effect on household consumption at the national level from allocation of water to irrigation is largely positive.

Poverty and Distributional Impacts

The micro simulation results show that significant poverty reduction is achieved if a portion of the water is allocated to irrigation. An allocation of 20 percent of the water to irrigation reduces poverty by about 5 percent in the Coast region, while allocation of 100 percent of the water to urban and rural water supply reduces poverty incidence by a mere 0.4 percent. The highest poverty reduction (6.2 percent) is achieved when 80 percent of the water is allocated to rural and urban water supply and the remaining 20 percent is used for irrigation. There are significant disparities among household types with regard to changes in real income and poverty outcomes. As expected, urban households benefit most with regard to changes in real income and poverty reduction from allocations to domestic and industrial sectors while rural households benefit most from allocations to irrigation.

Implications for Policy and Operations

The pathways and channels through which access to water affects the economy and the well-being of people are multidimensional. The three main impact transmission channels are (a) the price effect (when households can consume more with the same budget); (b) the income effect (inducing further expansion of goods and services); and (c) the regional substitution effect (or enhancing regional specialization). In the long run, some of the indirect impacts, such as improved child health and school attendance, lead to enhanced cognitive development and better outcomes form education that could increase well-being. For adults, increased water availability could reduce the effects of climate shocks, leading to better resilience and increased short-term productivity and quality of life.

The economic growth impact of access to water depends on the prevailing economic structure. Increased water availability at lower cost would have the greatest growth impact in an economy dominated by water-intensive sectors and economic sectors with strong backward and forward linkages with the water-intensive sectors, which will generate growth-inducing multiplier effects. In the Coast region, the most water-intensive sectors, as indicated by the share of water in the total intermediate input demand of the sectors, are textiles and leather, mining, other cereals, and livestock. Consequently, real GDP increases the most in these sectors. Thus, to exploit the synergies and maximize the regional socioeconomic development benefits, there is a need for appropriate packaging of development projects. Access to water supply is not always enough for accelerating economic growth.

In the Coast region, water allocation to agriculture is key for inclusive growth and poverty reduction. Water allocation to agriculture would have the greatest poverty reduction impacts. The number of people lifted out of poverty in the Coast Region because of allocation of just 20 percent of the water to agriculture is about 11 times more than the number of people lifted out of poverty when allocating 100 percent of the water to nonagricultural sectors. Moreover, in urban areas, the poverty reduction effects of 80 percent to 100 percent allocations to domestic and industrial sectors is about the same as the effect of allocating 20 percent of water to agriculture. In fact, the best poverty reduction outcome results from the scenario that allocates 80 percent of the water to domestic and industrial sectors and 20 percent to agriculture, leading to benefits both in rural and urban areas.

There are two plausible explanations for these results. First, the concentration of poor people among rural communities engaged in agricultural production activities is high. Second, the share of food in the total consumption budget of poor and net-buyer households is high. Consequently, introducing irrigated agriculture in predominantly low-input and -output, drought-prone areas such as the Coast region substantially benefits both rural and urban food deficit households (through price effect). Given the large potential gains in agricultural productivity with the availability of irrigation technology, the Coast region experiences a growth of 1.1 percent, mainly driven by the significant growth in the agricultural sector.

Provision of domestic water supply is necessary but not sufficient for overcoming extreme poverty. In situations in which the severity of poverty is high, even a substantial gain in income relative to the preexisting situation may not lift poor households out of poverty. For instance, while a significant proportion of households in the fourth and fifth quintiles that are closer to the poverty line are lifted out of poverty, the poorest quintiles are not able to escape poverty because of the initial big gap between their prevailing consumption levels and the poverty line. It is evident that access to domestic water allows people to gain time and money and to pursue broader economic goals. The conversion of the gains in time, money, and good health to credible improvements in well-being presupposes the existence of gainful and productive employment and investment opportunities. Thus, to make a significant dent in the incidence of poverty, domestic water supply projects should be bundled with interventions geared toward creating economic opportunities and access to productive assets. The careful mixing and bundling of water supply and sanitation projects with economic projects that benefit from increased water availability not only results in better economic growth and poverty reduction outcomes but also contributes to the sustainability of water supply and sanitation services.

Water resource development in the Coast region would have interregional and intersectoral income distribution effects. Increased availability of water in the Coast region results in positive economic growth in Kenya as a whole, more than compensating for the slight decline in the GDP in the rest of Kenya. Some economic activities expand or contract in the Coast region and the rest of Kenya because of regional factor flows and substitution effects. For instance, following the multipurpose water investment, the agriculture sector grows in the Coast region, while it slightly declines in the rest of Kenya because of reduced demand for agricultural imports in the Coast region. Consequently, transport and communication sector contracts in the Coast region because of reduced demand for these services following reduction in demand for imported agricultural commodities. The sectoral and regional economic dynamics and interlinkages would have implications on the welfare of people affected. Thus, projects need to be planned considering the potential economywide effects within the framework of the overall national economic development strategies and goals to avoid a possible zero sum game.

Chapter 1 Introduction

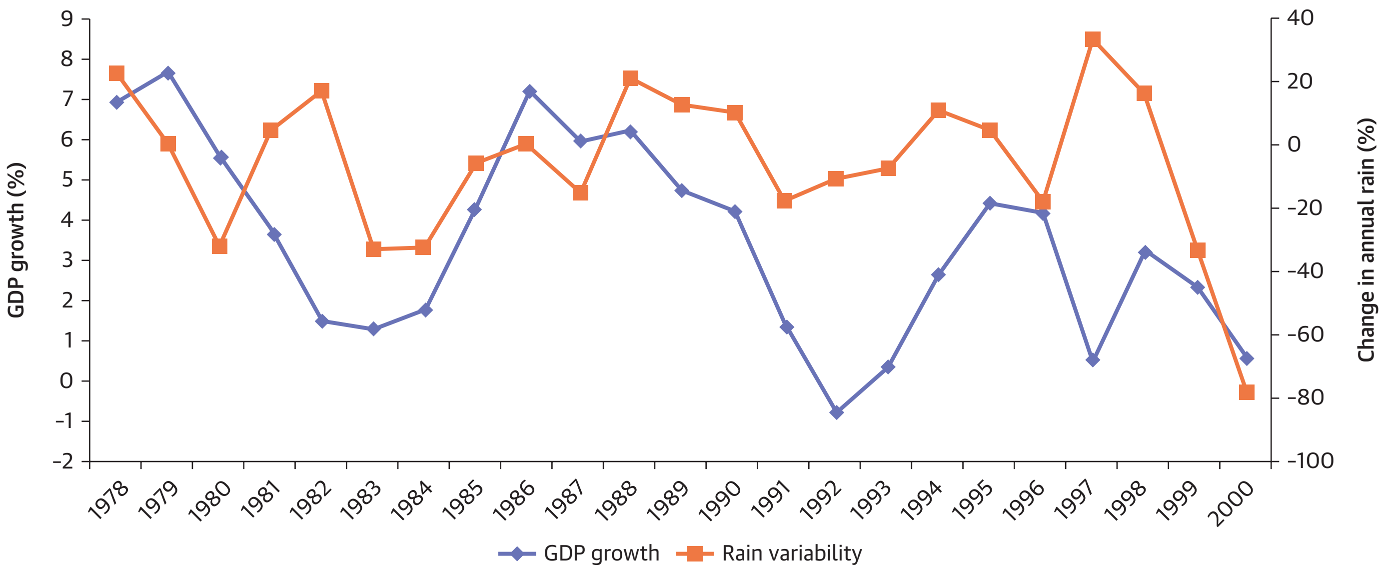
Over the past 50 years, Kenya has established itself as an important regional economic player in East Africa. The country is emerging from a strong but uneven decade of growth. From 2000 to 2009, annual growth rates in the gross domestic product (GDP) averaged 3.9 percent, a notable increase from the previous decade's average of 2.3 percent. In 2008, the country's economic performance declined dramatically, with postelection violence, drought, the global financial crisis, and high food and fuel prices contributing to a negative per capita GDP growth rate. Nevertheless, the economy—underpinned by structural reforms, a new constitution, and a spur in infrastructure investment—recovered in 2010, climbing to a growth rate of 5.6 percent. Since then, a series of domestic and external shocks reversed this momentum, decreasing growth rates to approximately 4.5 percent in 2012. Kenya is among the world's poorest countries, ranking 145 out of 188 countries on the 2015 Human Development Index (HDI). The head count poverty in the country is high, at 43 percent. In 2014, the per capita gross national income was US$2,762 (UNDP 2015).

Achieving the status of an upper-middle-income country (UMIC) in 2030, as stated in the Vision 2030 strategy, implies a rapid and sustained increase in per capita income. Vision 2030 foresees GDP growth of 10 percent over the medium term (KIPPRA 2010), and the second Medium Term Plan (MTP) projects that growth will accelerate to 10 percent by 2017 (GoK 2013). Tourism and agriculture, followed closely by industry and services, are the main drivers of growth. However, the performance of these sectors is significantly influenced by Kenya's meteorological and hydrological realities. Kenya's low freshwater endowment of 526 cubic meters per capita per year puts it in the bottom 8 percent of the countries globally (World Bank 2013). Kenya's economy is vulnerable to erratic climatic patterns and a fragile natural resource base, including limited water availability (see figure 1.1). Climate variability costs the country an average of 2.4 percent of GDP per year and water resources degradation another 0.5 percent (World Bank 2013). Whereas many of the economic sectors depend on water availability and rainfall conditions, agriculture, which is primarily rainfed and accounts for about 30 percent of the GDP (KIPPRA 2016), is most vulnerable to changes in weather conditions.[1]

The problem is compounded by Kenya's current limited storage capacity of about 103 cubic meters per capita, of which 100 cubic meters per capita is for single purpose storage for hydropower production only. This means that only 3 cubic meters per capita of storage is available for water supply and other uses such as irrigated agriculture and livestock. No major dams have been constructed since the mid-1990s.

Furthermore, the Kenyan development profile and poverty ratios reveal strong regional disparities; and the historical pattern of Kenya's regional inequality has undergone very little change. Inequalities in the distribution of incomes in urban areas continue to rise.

FIGURE 1.1. Gross Domestic Product Growth and Rainfall in Kenya, 1978–2000



Source: UNESCO 2006.
Note: GDP = gross domestic product.

Differences in share of income and social services are observed across regions, genders, and even specific segments of the population. Inequality is observed not only in incomes but also in social exclusion and the inability of different population groups to access social services and enjoy sociopolitical rights (KIPPRA 2010).

Water and Development in the Coast Region

The Coast region in particular is faced with complex challenges that may hinder the realization of its full development potential, including rampant poverty, youth unemployment (which may lead to religious radicalization and insecurity), gender disparity, food and nutritional insecurity, natural resources degradation, climate change and variability, and inadequate infrastructure.[2] Four of the six counties in this region are among the 14 counties regarded as the poorest and least developed nationwide with regard to access to key infrastructure and services.[3] This area is also particularly susceptible to climate variability and change, not only from changes in upstream hydrology, land degradation, and water quality but also from sea level rise.

In 2009, the population of the Coast region was estimated at 3.3 million, of which about 80 percent reside in just three counties, namely Mombasa, Kwale, and Kilifi. The population of the Coast region is estimated to more than double, reaching about 8 million in 20 years. Even today, the Coast region is known for a range of sociopolitical and economic problems, including widespread poverty, combined with a very high degree of inequality. The Coast region has the second-highest rural poverty levels in Kenya (after the northeastern region), while even urban poverty levels in Mombasa have been found to be somewhat higher than in other major cities in Kenya. In conclusion, the available statistics paint a clear picture of socioeconomic inequality and high levels of poverty and deprivation in many rural and urban communities in this region, especially with regard to access to key services including water supply, sanitation, food security, health, and education. The dire poverty and inequality situation coupled with other sociopolitical factors in Somalia and the northeastern Kenya region, has the potential to fuel conflict and reduce insecurity, which can destabilize the whole region.

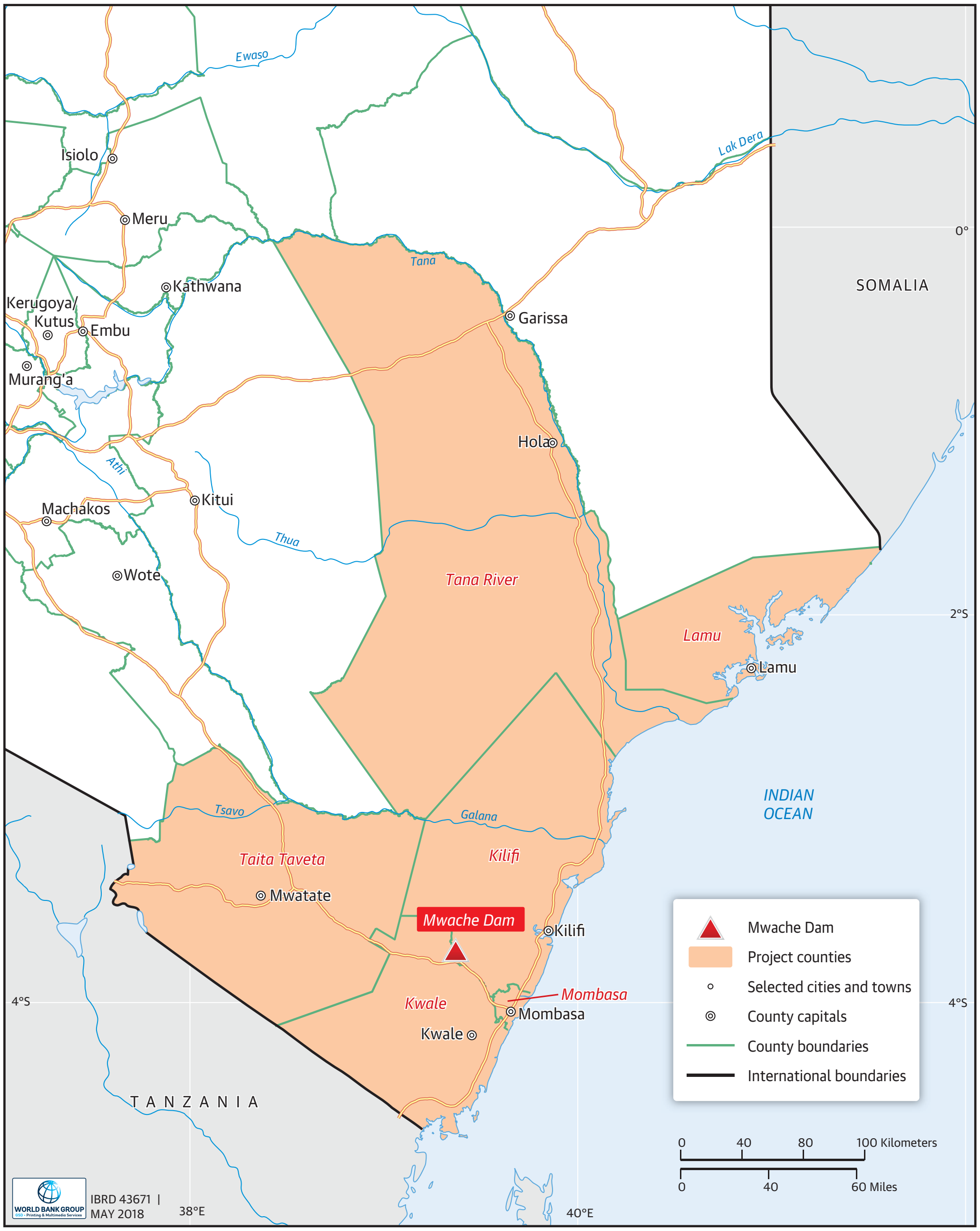
However, the Coast region, endowed with a long coastline and other resources, promises significant economic potential for Kenya as a whole. The province harbors several flagship projects, including the US$20 billion Lamu Port and Southern Sudan-Ethiopia Transport Corridor (LAPSSET), the Mombasa Port Expansion, the Dongo Kundu bypass, and so on. The latter two are part of the grand plan of creating a Mombasa free trade zone (FTZ) similar to that of Dubai, at an overall cost of about US$2.1 billion. Mombasa is one of the six counties of the Coast region and is home to the largest seaport in East Africa. It plays an important role in both the country's and the region's economy because the commercial imports and exports of Kenya's neighboring land-locked countries transit through the port. The city is also a popular tourist destination, drawing large number of tourists every year. This generates significant pressure on infrastructure, housing, transport, and social services, as well as on the environment and water resources.

Coast Region Water Security and Climate Resilience Project

Without sufficient water storage, the development potential of the Coast region and that of Kenya would be difficult to realize under increasing climate variability and change, which continue to undermine economic growth and threaten with devastating economic and livelihood consequences. Underinvestment in water storage leaves Kenya's economy with limited potential to adapt to climate change and makes it highly vulnerable to meteorological and hydrological uncertainties. Realizing the seriousness of this situation, the Government of Kenya (GoK) has initiated many water-centered infrastructure investments and institutional and policy-strengthening projects, one of which is the Coast Region Water Security and Climate Resilience Project.

The major component of this project is building a big dam on the Mwache River in Kwale County (see map 1.1). The Mwache River was identified by the Japan International Cooperation Agency (JICA) in the National Water Master Plan in 1992 as a possible river for damming to supply water to Mombasa city. The dam is located a few kilometers before the river empties into the Indian Ocean at Port Reitz.

MAP 1.1. Mwache Dam in the Coast Region of Kenya



Source: World Bank.

Hydrological Analyses

Since the identification by JICA and its inclusion in the National Water Master Plan of 1992, the Mwache Dam has been the subject of numerous technical, hydrological, and economic analyses to assess its storage-yield reliability under different climate change, climate variability, and demand scenarios. These technical studies were necessary because there was no adequate flow measurement data in the catchment area of the Mwache River. The only available record is from the river gauging station 3MA03, which was active for only 14 years (1976–90), which is insufficient for designing big dams like Mwache, because the station usually cannot capture extreme flows during droughts and floods.

In 2010, Consulting Engineering Services India Private Ltd. in association with Associated Professional Engineering Consultants (APEC) Consortium Ltd. carried out a feasibility study and detailed design for the Mwache Dam. In the absence of sufficient flow data for proper hydrological analysis, they applied the stochastic model of South Africa (STOMSA) to generate 50 years of flows and proposed a 207 MCM design storage volume, with a dam height of 85 meters above ground level and dead storage of 4 MCM. After a series of reviews by the Dam Safety Panel of Experts (DSPE), the dam height was lowered to 65 meters above ground level, the gross storage capacity was estimated to be 120 MCM, and the dead storage was increased to 20 MCM.

In addition, TAHAL Consulting Engineers Ltd. applied a deterministic approach—in contrast to the stochastic approach of Consulting Engineering Services India Private Ltd./APEC—because the STOMSA method, which generates flows according to the average and standard deviation of the measured flows, is limited in the event of modeling of extreme events such as low flows. The results of TAHAL's study concludes that the reliability of water supply from the Mwache Dam could increase from 90.9 percent to 95.5 percent by increasing the reservoir volume to 150 MCM. This was later followed by a team of experts, led by the RAND Corporation, which evaluated alternative designs of the Mwache Dam and concluded that a smaller design capacity of 60 MCM to 80 MCM would be more robust under climate and demand uncertainties.

Most recently, University of Massachusetts applied the Climate Decision Tree Framework and assessed the risks to the Mwache Dam design from climate and demographic changes. The modeled performance of the Mwache Dam was systematically evaluated (stress tested) across a wide range of climatic and demographic uncertainties by simulating the hydrology and the water resource operation models across thousands of conditions representing plausible climatic and demographic changes. Using publicly available hydro-climatological data and published census data (including projections for demographic change), researchers showed that the Mwache Dam was sensitive to climate data uncertainty, hydrologic model uncertainty, natural climate variability, mean climate changes, and long-term demand changes. This analysis consulted three global gridded climate datasets—Princeton, Global Precipitation Climatology Centre (GPCC), and Climate Research Unit (CRU)—given the lack of long-term or consistent meteorological and streamflow data.

These results from various hydrological studies indicate that the calculated safe yield values from the stress test range from 65 MCM to 120 MCM per year, encompassing the intended annual delivery of 80 MCM. Unsatisfactory safe yield estimates occurred only under substantially warmer (3°C to 5°C temperature increase) and drier (−30 percent precipitation change) conditions, the likelihood of which, during the lifespan of the Mwache Dam, is small according to the most current generation of downscaled climate model projections. There is, therefore, low risk that the Mwache Dam will fail to meet the target safe yield of 80 MCM per year.

Initially, the dam was identified as the cheapest alternative to supply water to Mombasa city because the existing sources either are very far from the city or are groundwater sources, which involve costly pumping efforts using an expensive energy source. The water for Mombasa city comes from distant areas since the county does not have enough freshwater resources. However, the development of water at Mwache potentially releases significant amount of water for use in other towns and villages of the Coast region through reallocation.

The water going to major urban centers in the Coast region originate in other counties. As such, pipelines supplying water to Mombasa pass through villages and towns, which often do not have enough water for both livelihoods and domestic uses. Consequently, many villagers and town dwellers resent suffering from water shortages while the pipelines pass through their territory. Kenya's decentralization initiative helped the bolder articulation of the sense of deprivation of the people of the Coast region.

Literature Review and Study Objectives

Despite the significant deficit in water supply for alternative uses, multipurpose water investment is the key to unlocking the potential of the Coast region and enhancing the ability to adapt to climate change. In 2015, the water deficit in the Coast region was nearly 60 percent of the 365,000 cubic meters per day demanded. Half of this deficit was from Mombasa County alone. According to the technical and hydrologic analysis done by several entities, the dam can safely provide 80 MCM per year. or 220,000 cubic meters of water per day.

Water demand in the Coast region depends mostly on a bulk water supply system comprising the Mzima pipeline, the Marere pipeline, Tiwi boreholes, and the Sabaki pipeline as part the water resources spectrum, supplying Mombasa and other counties within the region (see table 1.1).

TABLE 1.1. Current Water Supply Capacity in the Coast Province

	Water source	Installed capacity (m^3 per day)
1	Mzima Springs	35,000
2	Marere Springs (with Pemba)	12,000
3	Baricho Wellfield	90,000
4	Tiwi Aquifer	13,000
5	Njoro Kubwa Springs	3,000
6	Tana River	1,400
7	Shella Aquifer	1,800
	Total	**156,200**

Source: CWSB 2012.

In 2010, Kenya adopted a new constitution, which espouses devolution of authority and accountability to the counties. With the adoption of the new constitution, the GoK was required to review and align all institutional and legal frameworks with the new constitution. The constitution includes provisions that have important implications for the water sector, including devolution of certain functions from the national to county level.

The importance of water in economic growth and poverty reduction has compelled governments to design water policies and invest in multipurpose water development projects. Water policies can be designed at different levels including at the national, regional, and sectoral levels. Similarly, investments in water resource development can benefit a particular subregion or sector or serve multiple objectives (e.g., consumptive and nonconsumptive uses). A key issue in water policy design is the allocation of water resources and, in particular, efficiency, equity, and fairness of allocation (Dudu and Chumi 2008). Investment on water development determines water use for agricultural production and, thus, food security. It also determines water use and availability for nonagricultural activities in which quality, prices, and affordability are essential factors. Depending on how water is allocated to different uses, the Mwache Dam is expected to have local and economywide effects, which may affect growth and economic opportunities at different levels for different household and economic agents.

Water-related policies and shocks and the resulting impacts on economic growth and welfare have been the focus of several empirical studies. Partial and general equilibrium models, among others, have been extensively used to analyze the impact of water policies and interventions. Partial equilibrium models allow for a greater level of disaggregation but fail to capture the effects of water policies and investments on other economic variables. In the context of competing demands over water and in the case of large shocks or major policy reforms, an economywide approach is preferable. The advantage of computable general equilibrium (CGE) models for studying the impact of water interventions is their ability to capture multiple agents, sectors, markets, and regions. Due to the presence of sectoral and market interlinkages and multiplier effects, general equilibrium models are better suited to reflect the role of water resources in an economy and the impact of policies and shocks on water allocation, pricing, and availability and, in turn, the potential effects on welfare.

An extensive literature has flourished in the past 25 years analyzing water policies in a CGE framework. Water issues have been analyzed using single-country CGE models as well as multiple country or region models. Researchers have incorporated water in their models in different manners. Water has been treated as a production factor (either explicitly or in fixed proportions of other inputs such as land), as an intermediate input, or as a final output. Some models further disaggregate water into groundwater and surface water. The research questions addressed also differ. The most common issues deal with the competition between different uses of water resources or between agricultural and other activities. Another set of research focuses on water pricing policies (volumetric or nonvolumetric) and the institutional framework under which prices are determined (market-based, public administration, or user-based administration) for an efficient allocation of water resources accounting for quantity and quality dimensions. Other researchers addressing water issues do so by incorporating the water component in a micro module and linking it to a macro model.

Studies focusing on multipurpose water investment in an economywide modeling framework are very few. Goodman (2000) compares the impact of increased reservoir storage with temporary water transfers in the southeastern Colorado economy. Strzepek et al. (2006) evaluate the impact of the High Aswan Dam in the Nile Basin in the Arab Republic of Egypt. Wittwer (2009) uses a multiregional model to evaluate the impact of a new dam in South-East Queensland. Robinson and Guenau (2014) analyze the potential impact on the economy of Pakistan of building the Diamer-Bhasha Dam. These four studies analyze the impact of increased water supply through investment in storage or transfers (Goodman 2000) and the construction of a dam (Robinson and Gueneau 2014; Strzepek et al. 2008; Wittwer 2009). Although the four studies focus on different countries (United States, Pakistan, Egypt, and Australia) they are motivated by similar concerns: alleviating and coping with scarcity of water resources. An economywide approach is applied in all four papers, but the CGE modeling approach differs. The models built for southeastern Colorado and South-East Queensland are regionally disaggregated while the models for Egypt and Pakistan have no spatial dimension. The treatment of water in the modeling approach also presents some differences. For Goodman (2000), land and water are substitutable factors of production. The model treats water as a storable factor. Furthermore, water is assumed to be use-specific, indicating that it may be designated either for agricultural or municipal (domestic, commercial, and industrial) use. Strzepek et al. (2008) also consider water as a production factor, but it is assumed to be in fixed proportions of land. In Wittwer's (2009) approach water is considered through the water sector, which provides water as an intermediate input. The water sector is treated as an infrastructure industry in which investment is driven by long-term planning. Finally, Robinson and Gueneau (2014) adopt an approach in which water is incorporated into the CGE through its effect on crop productivity, with separate water demand, basin management, and water stress modules linked to the CGE model. Water scarcity is generally reflected by fixed water supply while demand for water is endogenously determined by the model (Goodman 2000; Strzepek et al. 2008; Wittwer 2009).

Agriculture is a main focus area when considering water scarcity. All four studies discuss the impact on agricultural output or GDP in their baseline and aftershock. Overall, even if the modeling approach differs from one study to the other, findings show that increased storage tends to have a positive impact on agriculture by reducing water stress. The impact of building dams or increasing storage capacity is found to be significant under relatively high water stress conditions such as droughts. Increased water storage is also found to have a positive impact at representative household level.

Looking at the impact on other activities and the transmission channels, Wittwer (2009) finds that the Traveston Dam, by alleviating water scarcity, allows water prices to diminish, which creates cost competitiveness in South-East Queensland relative to other regions in Australia. Goodman (2000) finds that with the introduction of increased transfer and storage, municipal water price is significantly lower compared to the benchmark in which water is increasingly scarce. Robinson and Gueneau explicitly model the impact of the Diamer-Bhasha Dam on crop production and hydropower electric production. Nonagricultural effects are captured through the impact of increased energy production. Strzepek et al. (2008) find a negative impact of the removal of the High Aswan Dam in three nonagricultural sectors: electric power, tourism, and transportation. This shows that an economywide approach is necessary to capture indirect effects since this has implications on sectoral and overall GDP growth and well-being of households.

Adding value to this earlier literature, our study provides an assessment of the growth and welfare impacts of the Mwache Dam in the Coast region of Kenya. We use an economywide CGE modeling approach, which analyzes the direct impacts and indirect effects of the multipurpose water investment as it filters through the regional and national economies. The study applies a microsimulation model to capture the distributional effects in particular for the bottom two quintiles of the income group in the Coast region.

Thus, this study was initiated with the following specific objectives:

- To assess the contribution of the dam to regional and national economies
- To assess the relative importance of alternative dam water allocation scenarios with respect to (a) contribution to the regional and national economy and (b) distributional and poverty impacts
- To derive lessons for operations and policy.

Notes

1. The agriculture sector remains the leading source of employment in the rural sector, accounting for an estimated 75 percent of the labor force (KIPPRA 2016).

2. The Coast region in this study refers to the Coast Province of Kenya, along the Indian Ocean, which was one of Kenya's eight provinces until the regional administration changed to counties following the devolution and decentralization in 2013. This now includes six countries—Mombassa, Kwale, Taita-Taveta, Kilifi, Lamu, and Tana River.

3. Tana River, Kwale, Kilfi, and Taita-Taveta counties with poverty ratio of 75.6 percent, 70.7 percent, 58.4 percent, and 50.4 percent, respectively, display much higher poverty incidence than the national average of 45.2 percent. Other Coast counties, Lamu and Mombasa, have relatively lower poverty ratio, 34.8 percent and 32.3 percent, respectively (KNBS 2013).

Chapter 2 Methodology

Computable General Equilibrium Model

We use a biregional recursive dynamic computable general equilibrium (CGE) model to evaluate the economywide impact of the Mwache Dam in the Coast region and the rest of Kenya. The CGE model that we implement is based on Partnership for Economic Policy, PEP 1-t (Decaluwé et al. 2010), which is adjusted to include the water module and the two regions of Kenya. The model captures impacts on production, consumption, factor markets, and prices in an economy in which producers adopt a cost minimization approach and consumers adopt a welfare maximizing behavior. In this model, market prices adjust to reconcile endogenous supply and demand decisions, thus determining levels of production, employment, and consumption. This chapter discusses the main behavioral assumptions that are embedded in dynamic CGE and applied to the Kenyan economy to address multipurpose water investments. The technical details of the standard model, including the equations, are presented in appendixes A and B.

Water Module

Water activity refers to produced water used as a commodity for household consumption and as an input in other production processes. There are two industries producing water in each region: public and private. The former is classified as public because water production and supply are managed by the government. The quantity of water produced by the public water industry remains unchanged unless a specific shock is introduced (e.g., increase in the stock of capital or employment). The private water industry produces water similar to that produced by the public water sector, but production can increase to meet higher demand. Table 2.1 presents the main sources of drinking water for households in the Coast region. The total amount of water produced and supplied by public providers represents 52 percent of the total water provision. The rest is provided either by water vendors (19.9 percent) or through self-provision or production (23.3 percent). We consider that water provided by tanker or truck vendors is initially produced and supplied by public water authorities. Water vendors use water produced by the public sector and then redistribute it at a higher price. For example, while the Mombasa Water and Sewerage Company (MOWASCO) tariff ranges from US$0.80 to US$1.00 per cubic meter, vendors' tariff amounts to US$2.87. Other private suppliers' tariff to industries can reach US$10.3 per cubic meter.

The model captures the three major sources of water provision. Given that the tanker and truck vendors use water produced by the water authorities, which they resell, we consider that there is one source of public water production. This means that the public water sector produces one category of water. At the supply level, water produced by the water authorities is distinguished between public water (provided through public pipelines) and vendor water (provided through trucks and vendors). The difference between the two lies in their initial prices. Water supplied by vendors is up to three times more expensive than water supplied through public pipelines. Overall, the public water authorities produce 72 percent of total

TABLE 2.1. Percentage Distribution of Households in the Coast Region by Main Source of Drinking Water

Sources of drinking water	Distribution (%)
Piped into dwelling	8.5
Piped into plot/yard	7.7
Public tap	35.8
Borehole with pump	3.8
Protected dug well	4.2
Protected spring	0.2
Rain water collection	1.9
Unprotected dug well	6.3
River/ponds stream	6.7
Tanker/truck vendor	19.9
Bottled water	0.2

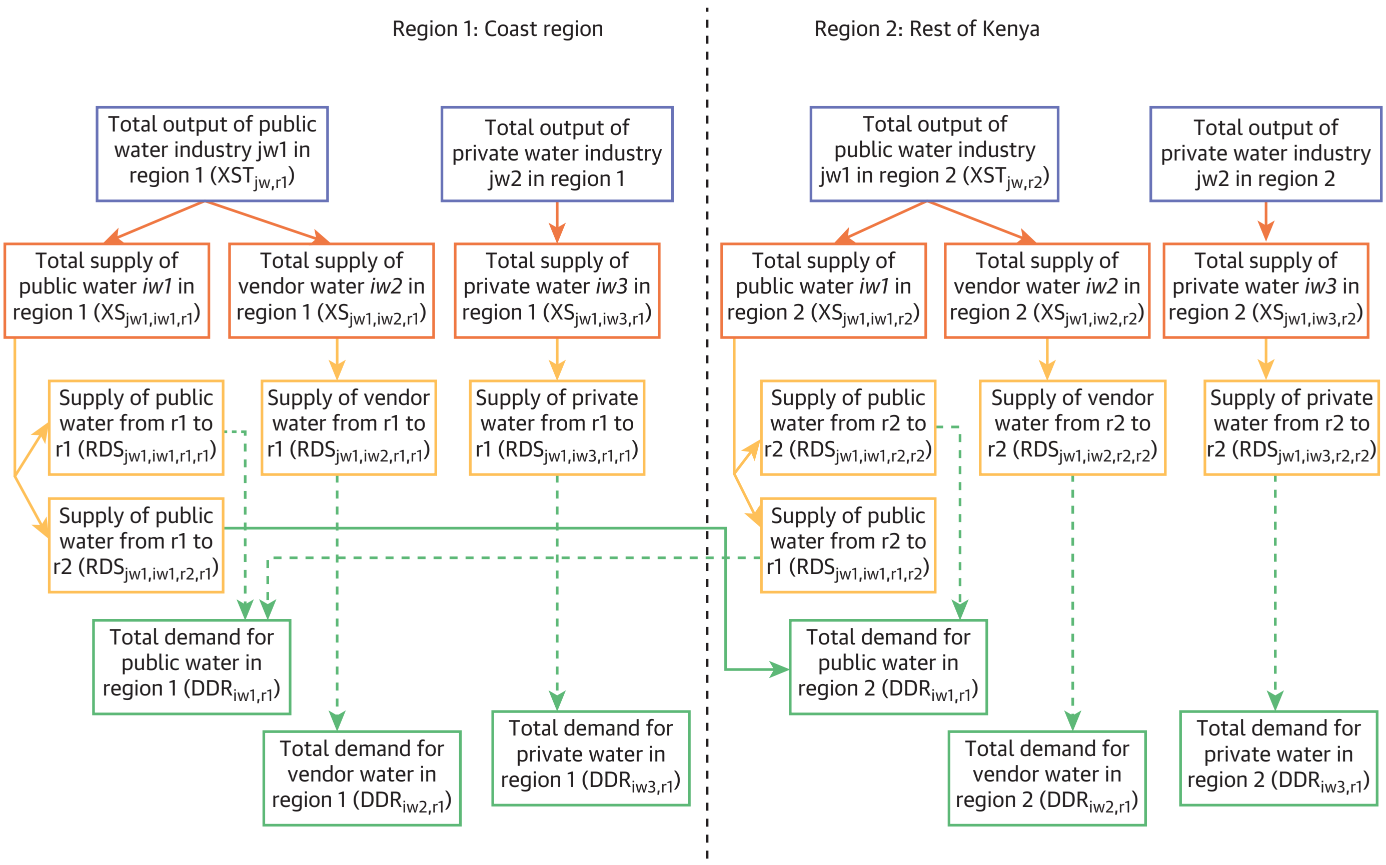
Source: KNBS 2007.

water in the Coast region. In line with the data in table 2.1, public provision of water covers 52 percent of supply, while provision of water through vendors covers 20 percent. The second sector producing water is the private sector. It encompasses the following sources of water: borehole, well, spring, rain, river or ponds, and bottled water.

The public water industry in each of the two regions produces[1] and supplies public water (representing water available through public pipelines) and vendor water (representing water supplied by truck vendors). This is represented by means of a constant elasticity of transformation (CET) function that describes how easily the product mix can be adjusted in response to price changes.[2] The private water industry produces only private water. In the initial year, private water has a higher price than vendor water, which in turn is costlier than public water. Figure 2.1 illustrates the structure of production, supply, and demand of water in the Coast region and the rest of Kenya. This section provides a description of the water model. More details and model equations are presented in appendix A.

Unlike other goods and services, water is supplied at the regional level instead of the national market. This means that consumers in the Coast region will be consuming water produced in the region where they reside. An investment in water infrastructure in the Coast region will therefore primarily benefit residents of the Coast region. However, there are possibilities of regional transfers of water. Vendor and private water produced in one region are supplied in the same region. Indeed, water vendors essentially use water supplied through public pipelines and resell those to households and businesses that do not have access to public or private water. It cannot be exported to another region since that would be too costly. Private water is also assumed to be supplied in the region of production. Because the sources of private water are essentially borehole, well, spring, rain, and rivers or ponds, it is reasonable to assume there is no regional transfer. In contrast, public water can be exported to another region. In the presence of interregional water transfers, the output of one region differs from the supply to the same region. To capture this, we adapt the standard PEP model in such a way that each region's production of water is allocated to itself and the other region.[3] We use a Leontief function to capture this in which the share of own output supplied to own region and that transferred to the other region are

FIGURE 2.1. Structure of Production and Supply of Water, Coast Region and Rest of Kenya



Source: World Bank conceptualization.

calibrated using data in the Social Accounting Matrix (SAM). Total supply of water received by each region equals total demand.

Water is not internationally traded. Domestic demand of public, vendor, and private water equals total demand in each region. The demand for public, vendor, and private water in each region consists of intermediate demand and household consumption demand.

Aggregate intermediate consumption is made up of various goods and services, including public, vendor, and private water. We create a composite water commodity (WAT), which combines public, vendor, and private water. Here, it is still assumed that intermediate inputs are perfectly complementary and are combined following a Leontief production function. The amount of total water needed as an intermediate input in industries' production process is maintained complementary to other intermediate inputs. However, the producer has the possibility of substituting public, vendor, and private water following relative price changes.[4] In this way, if supply increases and price of public water is to fall due to investment in the sector, industries (and households) will have the possibility to shift toward public water by reducing their demand for vendor or private water. We use a constant elasticity of substitution (CES) function to capture this behavior.[5]

With household consumption of water, we assume that households have Stone-Geary utility functions. This specification offers a degree of flexibility with respect to substitution possibilities in response to relative price changes. At the top level, type *h* household in the Coast region (or the rest of Kenya) can substitute composite water and other goods and services. At the second level, with its budget for composite water consumption, it can choose to consume more water that is public and reduce demand for vendor and private water in response to relative price changes. We use a CES function to capture this behavior.

The prices depend on the hypotheses and functional forms presented in this section. In aggregations, the price of an aggregate is a weighted sum of the prices of its components. This is the case for the basic price of water industries' production of public, vendor, and private water, which is distinguished by region.[6] There are no taxes and margins levied on water.

Dynamic Model

Economic shocks or economic policy reforms can have dynamic impacts on the economy. Some reforms could be implemented gradually and, therefore, their effects would be spread over successive periods. In this particular case, the Mwache Dam is assumed to be operational in 2018. The dynamic model allows us to implement this.

PEP 1-t is a sequential dynamic CGE model, also called a recursive model. Dynamic assignments link one period to the next. While one set of statements updates variables that grow at a constant rate per period, the other equations control the accumulation of capital. A full description of the model can be found in Decaluwé et al. (2013).

As the Mwache Dam is planned to be operational in 2018, the business-as-usual (reference scenario) in the present model is calibrated to reproduce the observed[7] (until 2014) and projected[8] (until 2018) GDP of the Kenyan economy at constant price from 2007 to 2018.

Data and the Social Accounting Matrix

CGE models are operationalized through calibrating the model parameters such that the model equations reproduce the benchmark situation given by the SAM. Because our objective is to assess the economywide impact of water supply in the Coast region in Kenya, we need a biregional SAM that captures the interlinkages and flows between different economic activities in the Coast region and the rest of Kenya. In line with this, we have revised the Kenya SAM by Thurlow, Kiringai, and Gautam (2007) and Mabiso, Pauw, and Benin (2012) by separating the activities of the Coast region from the rest of the Kenya. The original SAM has three agroecological zones with 143 production activities across the three zones and 53 commodities. Labor is disaggregated by skills. Other factors of production include livestock, land, and agricultural and nonagricultural capital. Households are classified into rural and urban, agricultural and nonagricultural, and expenditure quintiles.

To adapt this SAM to the present study, as the first step, the agroecological regions were aggregated to get one national SAM. We then split the overall Kenyan activities and

TABLE 2.2. Production Activities in the Coast Region and the Rest of Kenya

Agriculture	Industry	Services
Maize	Mining	Trade
Other cereals	Food processing	Hotels
Cassava and roots	Textile and leather	Transport and communication
Pulses and oil seeds	Other manufacturing	Other private services
Fruit and vegetables	Public water	Public services
Export and other crops	Private water	
Livestock and livestock products	Electricity	
Fishery and forestry	Construction	

Source: Social Accounting Matrix.

consumptions between those in the Coast region and the rest of Kenya. Production activities and commodities produced are also aggregated to few sectors relevant to our study. We have 21 activities, each produced in the Coast region and in the rest of Kenya. The list of activities is presented in table 2.2. Household categorizations remain similar, but we have aggregated farm and nonfarm rural households to have 10 categories for the Coast region and 10 for the rest of Kenya. The same factors of production are also retained as in the original SAM, except for aggregating the different categories of labor to obtain two types: agricultural and nonagricultural labor.

We used various data sources to split the activities, including factors of production, ownership of factors, and consumption by households, into the Coast region and the rest of Kenya in the aggregated SAM. The Coast region consists of six counties: Taita-Taveta, Kilifi, Mombasa, Malindi, Lamu, and Tana River. Most of the information and data used are based on the Kenya Integrated Household Budget Survey (KIHBS) 2005/06 (KNBS 2007), Annual Labor Enumeration Survey (KNBS 2010a), Census of Industrial Production (CIP) (KNBS 2010b), and Costs of Agricultural Production Survey (CAPS) (KNBS 2012). Other sources are the Ministry of Agriculture (MoA), County Statistics Kenya,[9] and county economic activities prepared by the World Bank. Only the ratios of the Coast region to the rest of Kenya are used to apportion the information in the SAM between the Coast and rest of Kenya regions. The details on the procedures used to aggregate and disaggregate the initial SAM are presented in appendix A.

Microsimulation Model

The study uses a microsimulation model for its poverty analysis. This system endogenously estimates the impact of the investment scenarios on poverty by using a top-down approach in which changes in the CGE model are imported into the microsimulation model. The analysis is based on micro data from the most recent Kenya Integrated Household Budget Survey (KIHBS) for information on households' detailed expenditure in the Coast region and in the rest of Kenya. In the micro-simulation approach that links the economywide analysis to the micro-level decision makers, each household in the household survey is linked directly to the corresponding representative household in the CGE model. Changes in representative households' consumption in the CGE model component are passed down to their corresponding households in the survey data. Only commodities used in the calculation of the poverty lines are considered.

In the next step, real total and per capita consumption expenditures are recalculated for each household in the survey. This new level of per capita expenditure is compared to the exogenously given poverty line and standard poverty measures are recalculated. Poverty changes are evaluated using the standard Foster-Greer-Thorbecke (FGT) poverty measures.

Representative households have been disaggregated across three dimensions:

- Regional distinction: the Coast region and the rest of Kenya
- Settlement pattern (urban and rural)
- Disaggregation by consumption quintiles

Mapping between the CGE model representative households and those in the survey were necessary to connect the households in the two sets of data. First, survey households were distinguished by region: Coast region and the rest of Kenya. Second, within each group, urban households were distinguished from the rural. Finally, within each group, households were classified by consumption quintile. A second level of mapping matched the commodities in the CGE model and SAM with the commodities used in the calculation of the poverty line. This means that although total household consumption may have been notably affected in the economywide analysis, the composition in different commodities determines gains in poverty reduction.

Our analysis, therefore, accounts for the poverty impact in each region across rural and urban households, each disaggregated by consumption quintile. This allows us to capture the effect on the bottom 40 (B40) percent of the wealth quintile of the Kenyan population, which is considered as an indicator of shared prosperity. Although shared prosperity refers to income, in many cases, household consumption must be used as a proxy for household income, particularly when income data are unavailable or of poor quality. In this microsimulation approach, consumption is used as the metric to measure poverty and distributional impacts.

The poverty lines were obtained from the KIHBS (KNBS 2007) data, which use the Cost of Basic Needs method as suggested by Ravallion (1998a, 1998b). The overall monthly average adult equivalent poverty lines were computed as K Sh 1,562 for rural areas and K Sh 2,192 for urban areas. Our microsimulation is based on 12,892 sample households, of which 8,368 are from rural and 4,524 from urban. There are 1,222 sample households in the Coast region (668 rural and 554 urban).

Mwache Dam Reservoir Water Allocation Scenarios

The Coast region shares about 13 percent of the national output. Service sector, a major player in the region, accounts for 91 percent of the Coast output, followed by the industry

TABLE 2.3. Simulated Water Allocation Scenarios after Construction of Mwache Dam

Scenario	Description
1	Allocation of 80% of the water to urban/rural water supply (partial allocation)
2	Allocation of 100% of the water to urban/rural water supply (full allocation)
3	Allocation of 20% of the water to irrigation (partial allocation)
4	Allocation of 80% of the water to urban/rural water supply and 20 percent to irrigation (full allocation)

(7 percent). Moreover, out of the six counties in the Coast region, most activities occur in Mombasa County, indicating a highly skewed economic distribution in the region. The contribution of agricultural activities in the region is very small. Water from the multipurpose dam is expected to relieve the supply pressure in different sectors, including household and industrial uses, tourism and other services, and agriculture.

The water allocation scenarios analyzed are described in table 2.3. The Mwache Dam is expected to supply 220,000 cubic meters of water per day in the coast. Allocating 80 percent of this total (186,000 cubic meters) almost doubles the level of current water supply in the Coast region, which is about 156,200 cubic meters. Water is supplied to customers through public pipelines and by water vendors. Vendors mainly buy water supplied through public pipelines and redistribute to customers at a much higher price (about three times).[10] The main customers of water vendors are households and businesses not yet reached by the network of public pipelines or those not receiving adequate public water supply for various reasons. The private water sector includes water produced and supplied from the following sources: boreholes, protected dug wells, protected springs, rainwater harvesting, unprotected dug wells, ponds, rivers or streams, and bottled water. The perfect competition context of the model implies that the excess water produced by the dam is supplied to the Coast region at lower prices, allowing the regional water market to clear for water publicly supplied and water sold by vendors.

Notes

1. Water is produced in each region using the technology described in appendix A. The production technology is represented by a nested structure. At the top level, the water output of each of the two water industries in each region combines value added and total intermediate consumption in fixed shares. At the second level, each industry's value added consists of labor and capital, following a CES specification.

2. The elasticity of transformation of public water into vendor water is set at 0.8.

3. This specification was integrated in the model because the Coast region is supplied by two water catchments. If at a later stage of this study it is assumed that water supply through one of the two catchments is to be reduced because of the operationalization of the Mwache Dam, the model is designed to capture such potential regional redistribution of water.

4. Water is not distinguished based on quality but based on the user. It is a final consumption good when used by households and an intermediate input when used for production activities. Quality is not considered in the model. The water consumed by households may be used for drinking, cooking, cleaning, washing, and so on. Similarly, water consumed by industries may be used to produce food, for cleaning, cooling, and so on. This aspect is not captured in the CGE model. We consider consumption of water by households and industries as a whole regardless of specific use. Nevertheless, because

water can be used for different functions, the three sources of water are necessary. We introduce the possibility of substituting public, vendor, and private water using a CES function. This type of specification allows for substitution between the three types of water (here differentiated essentially by their initial price and sector of production) but avoids situations in which a relative price change results in zero demand for the water commodity that has become relatively costly because some users do not have access to public water and rely essentially on vendors.

5. The elasticity of substitution between public, vendor and private water in the CES function is set at six for industries and at three for households. Income elasticity of demand of composite water (WAT) by household *h* is set at 0.5.
6. We conducted a sensitivity analysis where the basic price of public water is fixed instead of adjusting to equalize supply and demand. We find that this has little impact on the simulation results. For instance, in the simulation where 20 percent of water is allocated to agriculture and 80 percent to industrial and domestic use, GDP in the Coast region would increase by 1.5 percent with fixed price of public water compared to 1.6 percent if prices are endogenous. Similarly, if all the water is allocated to industrial and domestic use, GDP in the Coast region would increase by 0.58 percent with fixed price of public water compared to 0.53 percent if prices are endogenous.
7. Data from Kenya National Bureau of Statistics.
8. Based on World Bank data.
9. See County Statistics Kenya's website, www.CountryStat-Kenya.org.
10. Water vendors may also supply water from their own source such as shallow wells, as observed in Mombasa. In this case, the water is salty and can only be used for cooking and washing.

Chapter 3 Computable General Equilibrium Model Simulation Results

The impact of increased water supply in the Coast region transmits to the rest of Kenya through three major channels. The first transmission channel is the price effect.[1] If the prices of some goods and services fall due to increased availability of water in the Coast region, households and industries in the Coast region and in the rest of Kenya will benefit. For households, lower prices imply that, for the same budget, they may be able to consume more. Industries in the rest of Kenya will benefit from reduced production costs due to reduction in the prices of intermediate inputs. The second transmission channel is the income effect, which is induced by changes in households' real income in the Coast region. Following increases in household income in the Coast region, the demand for goods and services supplied at the national level increases, affecting the demand for products produced in the rest of Kenya, since the Coast region produces less than 15 percent of total national output. The third transmission channel is the regional substitution effect. The analysis shows that while some activities expand in the Coast region, others contract. This creates a partial substitution between the Coast region and the rest of Kenya in which the Coast region specializes relatively more in those activities that have benefited from increased supply of water. The rest of Kenya tends to focus relatively more on the production of goods and services whose output contracts in the Coast region.

Changes in Final and Intermediate Demand for Water

Considering that water supply to nonagricultural activities is largely responsible for changes in final and intermediate demand for water, we limit our discussion to 80 percent and 100 percent allocation of the water for industrial and domestic uses (scenarios 1 and 2). All three types of water are substitutable following relative price changes. End users of water, therefore, benefit from increased availability of public and vendor water at a lower cost, that is, −26.2 percent for public water and −28.9 percent for water supplied by vendors with the 80 percent allocation and −30.14 percent and −33.15 percent, respectively, in case of 100 percent allocation. Consequently, consumer demand for private water decreases when demand for public and vendor water increases. Water consumption by all households in the Coast region increases by 31.6 percent for 80 percent allocation and by 44.73 percent for full allocation (table 3.1). The Mwache Dam has an initial impact of increasing public water supply. This means that vendors have access to public water at a lower price, which they redistribute at a price initially higher than public water. If the vendors do not reduce their price at a level lower than public water, they may not be able to sell. However, note that water vendors provide water to areas that are not reached by the network of public pipelines or areas getting inadequate or unreliable public water supplies. Demand for private water declines since it is relatively more expensive.

TABLE 3.1. Impact on Final and Intermediate Demand for Water in the Coast Region

Percent change from reference scenario

Source of water supply	80% for industrial and domestic		100% for industrial and domestic	
	Household consumption	Industrial consumption	Household consumption	Industrial consumption
Public	50.30	171.90	66.80	207.65
Vendor	53.90	170.10	71.62	204.24
Private	−20.10	−28.60	−18.45	−32.49
Total	**31.60**	**115.10**	**44.73**	**142.83**

Source: World Bank simulation results 2018.

TABLE 3.2. Structure of Demand of Water as an Intermediate Input in the Coast Region

	Share of water in total intermediate consumption of the activity (%)	Share of water supplied to the activity in total water supply as an intermediate input (%)
Other cereals	9.9	0.1
Livestock	7.2	9.4
Mining	13.1	0.6
Textile and leather	22.5	53.7
Hotels	1.2	8.3
Transport and communication	0.3	8.5

Source: World Bank calculation based on SAM 2007.

Industries are able to increase their consumption of water much more than households because industries are more likely to be connected to public pipelines since they are concentrated in urban areas where the infrastructure for water supply is more developed. Moreover, households can consume only a given amount of water to satisfy their needs. In contrast, water consumption by industries is demand driven since it is used as an intermediate input.

Increased water availability benefits all industries operating in the Coast region, especially those relatively more intensive in water. Water-intensive sectors are textile and leather, mining, other cereals, and livestock. About 53.7 percent of total water supplied as an intermediate input is essentially destined for textile and leather production (table 3.2).

Total demand for water by industries in the Coast region increases by 115.1 percent and 142.83 percent in scenarios 1 and 2, respectively. Demand increases relatively more in the water-intensive sectors. These industries recruit additional labor to expand production. Real gross domestic product (GDP) increases the most for textile and leather industry followed by the livestock sector, mining, and hotels. The products from these industries are supplied on the national market and, hence, their prices decline to the benefit of households and activities. This in turn affects activities intensive in these products. Indirect and feedback effects result in the expansion of trade and other private services (table 3.3).

TABLE 3.3. Effect on Water Demand, GDP, Employment, and Prices in Water-Intensive Sectors in the Coast Region

Percent change from reference scenario sectors

	Water demand				GDP	Labor demand	Product prices
	Total	Public	Water vendor	Private			
	80% for industrial and domestic use						
Textile and leather	123.1	176.0	189.5	−22.0	22.2	88.6	−1.89
Mining	90.6	135.8	147.4	−33.4	4.4	4.8	−1.88
Livestock	106.4	155.4	167.9	−27.8	13.1	23.3	0.02
Hotels	86.3	130.5	141.7	−34.9	2.1	4.8	−0.81
	100% for industrial and domestic use						
Textile and leather	150.8	211.3	229.5	−25.6	26.6	108.4	−2.40
Mining	107.9	157.9	173.0	−38.4	7.09	5.1	−2.20
Livestock	130.1	185.5	202.2	−31.8	15.9	28.5	−0.07
Hotels	141.0	151.8	166.6	−39.8	2.37	5.3	−0.85

Source: World Bank simulation results 2018.
Note: GDP = gross domestic product.

Impact on Economic Growth

Table 3.4 presents the impact of the four allocation scenarios of additional water supply (because of the Mwache Dam) on economic growth in the Coast region, the rest of Kenya, and Kenya, differentiated by sectors. The sectoral and regional comparison of the economic impacts of scenarios that do not include water allocations to agriculture (i.e., scenario 1, or 80 percent allocation to urban and rural water supply; and scenario 2, or 100 percent allocation to urban and rural water supply) reveals similar impact patterns. The impact for these scenarios varies only in magnitude in response to the absolute amount of water allocation. However, the gains from allocating 100 percent (i.e., putting an additional 20 percent of water to urban and rural water supply in addition to scenario 1) are very small compared to allocating water for irrigation uses (scenarios 3 and 4).

For scenarios 1 and 2, real GDP at basic price increases by 0.5 percent and 0.53 percent, respectively, in the Coast region assisted by growth in industrial and service sectors, although the gain is quite small (table 3.4). Industrial GDP increases significantly while services grow only slightly. Agricultural GDP contracts slightly. The impact on the Kenyan economy is also small but positive, pulled mainly by growth in the service and agricultural sectors. The GDP slightly declines in the rest of Kenya, which is partly related to the assumption of full employment of all factors of production in the model in which the price of each factor adjusts to maintain full employment on the factor markets.

Allocation of 20 percent of water to irrigation (scenario 3) significantly increases crop productivity from its current extremely low level and boosts the Coast region's economy by

TABLE 3.4. Changes in Gross Domestic Product due to Increased Water Availability in the Coast Region

Percent change from reference scenario

Economic sectors	80% for industrial and domestic use			100% for industrial and domestic use			20% for irrigation			20% for irrigation and 80% for industrial and domestic use		
	Coast	Rest of Kenya	Kenya	Coast	Rest of Kenya	Kenya	Coast	Rest of Kenya	Kenya	Coast	Rest of Kenya	Kenya
Total GDP	**0.5**	**−0.001**	**0.1**	**0.53**	**−0.001**	**0.1**	**1.1**	**−0.00001**	**0.1**	**1.6**	**−0.001**	**0.2**
Agriculture	**−0.05**	**−0.002**	**0.0001**	**−0.07**	**0.00**	**0.00**	**3.2**	**−0.005**	**0.5**	**3.2**	**−0.01**	**0.5**
Industry	**5.6**	**−0.9**	**−0.4**	**7.09**	**−1.04**	**−0.62**	**0.04**	**−0.02**	**−0.02**	**5.9**	**−0.8**	**−0.4**
Mining	4.4	0.3	0.7	5.08	0.37	0.77	0.3	−0.1	−0.1	4.5	0.2	0.6
Textile and leather	22.2	−0.5	−0.25	26.60	−0.91	−0.55	−0.2	−0.01	−0.02	21.6	−0.8	−0.5
Food Processing	0.02	0.3	0.3	0.04	0.35	0.32	0.4	0.2	0.2	0.4	0.5	0.4
Services	**0.08**	**0.23**	**0.21**	**0.08**	**0.26**	**0.24**	**−0.01**	**0.01**	**0.005**	**0.05**	**0.2**	**0.2**
Trade	1.3	0.04	0.2	1.41	0.04	0.18	0.03	0.03	0.03	1.2	0.1	0.2
Hotels	2.0	0.8	1.0	2.37	0.86	1.17	0.1	0.1	0.1	2.0	0.8	1.0
Transport and communication	−1.82	1.20	0.49	−2.07	1.35	0.55	−0.02	−0.04	−0.03	−1.7	1.1	0.4

Source: World Bank simulation results 2018.
Note: GDP = gross domestic product.

about 1.1 percent. As expected, the agricultural sector grows substantially in the region and in Kenya overall but slightly shrinks in the rest of Kenya. The agricultural sector growth is fueled mainly by significant growth in the production of maize (12.8 percent), pulses and oil crops (3.7 percent), and fruits and vegetables (5.5 percent), with considerable effect on food and nutritional security of the region. This is a welcome development given that the region suffers from persistent food deficits due to recurrent drought. The food deficit is bridged by commercial imports both from within Kenya and from international and humanitarian aid. Growth in agricultural activities prompts the expansion of the food and processing sector.

At the national level, the highest economic growth is obtained from scenario 4, which allocates 80 percent of water to domestic, industrial, and service sectors and 20 percent to irrigation. In this scenario, the economy of the Coast region grows by 1.6 percent because of significant development in the agricultural and industrial sectors. From the agricultural sector, maize, pulses, oil crops, livestock, fruit, and vegetables are the best performers. From the industrial sector, the textile and leather sector followed by the mining sector contribute the most to economic development of the region. The service sector growth is small but positive (0.05 percent). Regarding services, all water-intensive activities and those with strong forward and backward linkages with agriculture and industry expand. However, the transport and communication sector contracts due to low demand for these services following the increased food production in the Coast region.

Trade Impacts

The impact on trade is captured for the whole country (table 3.5). Import and export data are not disaggregated by region since the model was designed to represent trade relations at the national level. In the scenarios that exclusively allocate water to urban and rural water supplies (scenarios 1 and 2), total imports and exports slightly increase. Agricultural exports decline and demand shifts away toward imports due to increase in prices. Exports and imports of industrial products increase because both import penetration and export intensity are high for industrial products. As local prices slightly decrease, industrial goods are more competitive allowing an increase in exports. This effect is essentially driven by the textile and leather sector. The service sector's export also expands mainly due to growth in hotel business.

In the scenario that allocates 20 percent of water to agriculture, total imports and exports increase. Agricultural exports increase—driven by lower export prices—and the demand shifts away from imported agricultural goods toward those locally produced. One interesting observation in this scenario is that while exports slightly decline in industrial and service sectors, the overall export growth in Kenya is higher than the scenario that allocates the entire dam water to urban and rural water supply.

In the scenario that combines allocations to agriculture and other sectors, exports and imports of industrial sectors expand. Exports of service sectors expand and imports decline. The export for agricultural sector expands, driven by lower export prices, but its imports

TABLE 3.5. Changes in Exports, Imports, Output, and Local Demand in the Coast Region

Percent change from reference scenario

Scenario	Economic sectors	Exports	Imports	Output	Local demand
1: 80% for industrial and domestic use	Agriculture	−0.43	0.94	0.02	0.13
	Industry	0.75	0.06	−0.23	−0.11
	Service	0.62	−0.24	0.16	0.16
	Total	0.38	0.07	0.04	0.08
2: 100% for industrial and domestic use	Agriculture	−0.48	1.04	0.02	0.15
	Industry	0.85	0.07	−0.21	−0.07
	Service	0.71	−0.28	0.18	0.18
	Total	0.43	0.08	0.06	0.10
3: 20% for irrigation	Agriculture	0.60	−0.34	0.64	0.41
	Industry	−0.02	0.01	−0.01	−0.01
	Service	−0.04	0.12	0.01	0.01
	Total	0.13	0.002	0.19	0.08
4: 20% for irrigation and 80% for industrial and domestic use	Agriculture	0.22	0.47	0.65	0.53
	Industry	0.68	0.07	−0.13	−0.02
	Service	0.54	−0.11	0.15	0.15
	Total	0.49	0.07	0.25	0.17

Source: World Bank simulation results.

increase to meet additional local demand, which is the highest of all four scenarios. Total imports and exports increase slightly. While exports slightly decline in service sectors, the overall trade growth in Kenya is higher than the scenario that allocates the entire dam water to urban and rural water supply.

Impacts on Government Accounts

The capital expenditure for the Mwache Dam development is obtained from International Development Association (IDA) at a highly concessional term. However, government income is affected by the operationalization of the dam through indirect effects on taxes and revenues. The main sources of government income are transfers, which are considered exogenous but indexed to consumer price index CPI and tax revenues. For all of the water allocation scenarios considered, the CPI declines, albeit at varying levels. For the scenarios that allocate 80 percent and 100 percent of water to urban and rural water supply and the scenario that allocates 20 percent of water to irrigation, the CPI declines by 0.3 percent, 0.4 percent, and 0.3 percent, respectively. For the scenario that involves water allocation to agriculture and rural and urban water supply, the CPI declines quite substantially (that is, 0.6 percent for scenario 4).

For scenario 1 (80 percent allocation to urban and rural water supply), revenue from household income taxes declines by 0.3 percent because the household nominal income declines by the same proportion, while government revenue from indirect taxes on products and imports increases by 0.2 percent. The cumulative effect is a reduction by 0.1 percent. Government revenue from taxation on household income declines because income taxes are essentially paid by richer households for which income declines. Similarly, for scenario 2 (100 percent allocation of water to urban and rural water supply), revenue from household income taxes declines by 0.4 percent, while government revenue from indirect taxes on products and imports increases by 0.2 percent. The cumulative effect is a reduction by 0.1 percent.

For scenario 3 (allocation of 20 percent of the water to irrigation), revenue from household income taxes and government revenue from indirect taxes on products and imports slightly declines by 0.04 percent and 0.02 percent, respectively. Consequently, government revenue reduces by 0.1 percent, which is quite negligible. Similarly, for scenario 4 (20 percent allocation to agriculture and 80 percent allocation to urban and rural water supply), revenue from household income taxes slightly declines by 0.3 percent, while government revenue from indirect taxes on products and imports increases by 0.1 percent. The cumulative effect is a slight reduction of 0.2 percent.

Income and Consumption Effects

Impact on Nominal Income

Scenarios 1 and 2. The effect of alternative water allocation scenarios on factor income differentiated by region, settlement pattern, and household income quintile is summarized in table 3.6. The patterns of factor income effects of 80 percent (scenario 1) and 100 percent (scenario 2) allocations of the dam water to urban and rural water supply are similar, slightly varying only in relative magnitude. Thus, the income effect of only 80 percent allocation scenario is presented in detail. Households are affected by changes in returns to labor and capital because these are the two sources of household nominal income. The impact varies from one category of household to the other depending on their initial factor endowments.

In the Coast region, allocation of 80 percent of the dam water to urban and rural water supply increases water availability to industries in the region and enhances the expansion of water-intensive activities, thereby increasing labor demand and inducing movement of labor away from other activities toward those expanding sectors. This affects wages and returns to capital. Agricultural wages increase by 2.5 percent, pulled by the expansion in livestock sector. Nonagricultural wages decline somewhat (−0.3 percent) due to reduction in labor demand in construction, transport, and communication sectors, where 43.8 percent of nonagricultural labor is initially employed (excluding labor employed in water and other public services). Mining, textile, and hotel industries expand, but their effect is not enough to countervail the overall decline in nonagricultural wages. Returns to land and livestock rise by 0.4 percent and 22.0 percent, respectively, while returns to agricultural and

TABLE 3.6. Effect on Factor Income, by Region, Settlement Pattern, and Income Quintiles in the Coast Region

Percent change from reference scenario

Scenarios	Regions	Factor income	Income quintiles									
			Rural					Urban				
			1	2	3	4	5	1	2	3	4	5
1: 80% for industrial and domestic use	Coast	Labor	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2
		Capital	1.3	0.4	0.3	0.3	0.1	−0.9	−0.9	−0.9	−0.9	−0.9
		Total	0.9	0.3	0.2	0.1	0.0	−0.3	−0.5	−0.4	−0.5	−0.5
	Rest of Kenya	Labor	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		Capital	0.8	0.7	0.4	0.1	−0.5	−0.9	−0.9	−0.9	−0.9	−0.9
		Total	0.6	0.5	0.4	0.1	−0.1	−0.2	−0.4	−0.2	−0.2	−0.5
	Kenya	Labor	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		Capital	0.8	0.6	0.4	0.0	−0.4	−0.8	−0.8	−0.8	−0.8	−0.8
		Total	0.6	0.4	0.3	0.1	−0.1	−0.2	−0.4	−0.3	−0.2	−0.4
2: 100% for industrial and domestic use	Coast	Labor	−0.3	−0.3	−0.3	−0.3	−0.3	−0.3	−0.3	−0.3	−0.3	−0.3
		Capital	1.4	0.3	0.2	0.2	0.1	−0.9	−0.9	−0.9	−0.9	−0.9
		Total	0.9	0.2	0.1	0.0	−0.1	−0.4	−0.6	−0.5	−0.6	−0.6
	Rest of Kenya	Labor	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		Capital	0.8	0.7	0.4	0.0	−0.5	−0.9	−0.9	−0.9	−0.9	−0.9
		Total	0.6	0.5	0.3	0.1	−0.2	−0.3	−0.5	−0.3	−0.2	−0.5
	Kenya	Labor	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		Capital	0.9	0.6	0.4	0.0	−0.4	−0.9	−0.9	−0.9	−0.9	−0.9
		Total	0.6	0.5	0.3	0.1	−0.2	−0.3	−0.5	−0.3	−0.3	−0.5
3: 20% for irrigation	Coast	Labor	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		Capital	3.9	4.1	4.1	3.6	2.6	0.1	0.1	0.1	0.1	0.1
		Total	2.8	3.0	2.9	2.4	1.5	0.1	0.1	0.1	0.1	0.1
	Rest of Kenya	Labor	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2
		Capital	−1.4	−1.3	−1.0	−0.7	−0.3	0.1	0.1	0.1	0.1	0.1
		Total	−1.0	−0.9	−0.7	−0.5	−0.2	−0.1	−0.03	−0.1	−0.1	−0.02
	Kenya	Labor	−0.2	−0.2	−0.2	−0.2	−0.2	−0.1	−0.1	−0.2	−0.2	−0.1
		Capital	−0.7	−0.5	−0.2	−0.1	0.0	0.1	0.1	0.1	0.1	0.1
		Total	−0.5	−0.4	−0.2	−0.1	−0.1	−0.1	0.005	−0.1	−0.1	−0.001
4: 20% for irrigation and 80% for industrial and domestic use	Coast	Labor	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
		Capital	5.0	4.4	4.3	3.8	2.6	−0.7	−0.7	−0.7	−0.7	−0.7
		Total	3.5	3.2	3.0	2.4	1.5	−0.2	−0.3	−0.3	−0.4	−0.3
	Rest of Kenya	Labor	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03
		Capital	−0.7	−0.7	−0.6	−0.7	−0.7	−0.7	−0.7	−0.7	−0.7	−0.7
		Total	−0.4	−0.5	−0.4	−0.4	−0.4	−0.3	−0.4	−0.3	−0.3	−0.5
	Kenya	Labor	−0.03	−0.03	−0.03	−0.02	−0.03	−0.02	−0.01	−0.02	−0.03	−0.02
		Capital	0.1	0.04	0.2	−0.03	−0.3	−0.7	−0.7	−0.7	−0.7	−0.7
		Total	0.1	0.02	0.1	−0.03	−0.2	−0.3	−0.4	−0.3	−0.3	−0.4

Source: World Bank simulation results 2018.

nonagricultural capital decline by 6.0 percent and 7.2 percent, respectively. Consequently, nominal income increases for all rural households while it declines for the urban. Rural households have diversified income sources, while urban ones are highly dependent on labor income for which remunerations decline. Income increases relatively more for rural households in lower quintiles. Although nominal income declines somewhat for urban households, those in the lower income quintiles are relatively less affected. The reason is that when the share of labor income in total household income is high, the overall impact on factor income is less because wages have declined less than return to capital. For example, urban households in quintile 1 have the highest share of labor income; therefore, the overall reduction in factor income is lower than for the other urban household categories.

In the rest of Kenya, when 80 percent of the Mwache Dam water is allocated to water supply in the Coast region, the price channel results in reduction in intermediate input prices for industries such as mining; textile and leather; other manufacturing; hotels; and other service sectors. The increase in income of the Coast region households allows them to increase their consumption, which is satisfied by the supply of goods and services produced in the Coast region and the rest of Kenya. As demand by the Coast region households' increases, it also affects the activity level of industries operating in the rest of Kenya. For instance, under the 80 percent allocation scenario, demand for agricultural products by households residing in the Coast region increases, while all agricultural activities (except livestock) in the Coast region reduces their production level. This additional demand is therefore satisfied by supply from agricultural production in the rest of Kenya. Similarly, for those industrial and services sectors in the Coast region whose level of production declines (such as in construction, transport, and communication), the rest of Kenya adjusts output to satisfy demand. Excess demand for industrial products is mostly met by increased production in the Coast region while additional demand for services is met by production in the rest of Kenya. The expansion or contraction of industries operating in the rest of Kenya induces labor movement thereby affecting wages and return to capital. Both agricultural and nonagricultural wages increase. Returns to land, livestock, and agricultural capital also increase by 1.0 percent, 0.2 percent, and 2.3 percent respectively, while returns to nonagricultural capital decline by 0.6 percent. Income of rural households in the rest of Kenya increases due to higher labor and capital income. Rural households in all quintiles benefit from a higher income except those in the fifth quintile, which earns an important share of their income from nonagricultural capital when return declines. For the same reason, the urban households across all quintiles face reduced income.

Scenario 3. In the scenario that allocates 20 percent of water to irrigation in the Coast region, agricultural and nonagricultural wages increase by 0.6 percent and 0.1 percent, respectively. Returns to land and nonagricultural capital increase by 5.4 percent and 0.1 percent, respectively, while returns to agricultural capital and livestock capital decline by 3.9 percent and 3.6 percent, respectively. The nominal income of all households in the Coast region increases, pulled by aggregate increase in labor and capital income. Income increases the most for rural households. Looking at households in the five income and consumption quintiles, we see that rural households in the two lowest quintiles benefit relatively more than those in higher income quintiles. The rest of Kenya is affected through indirect and feedback effects of irrigation water in the Coast region. In the rest of Kenya, agricultural wages decline by 1.2 percent while nonagricultural wages increase slightly (0.1 percent). Returns to land, livestock capital, and agricultural capital decrease by 2.0 percent, 0.8 percent, and 0.6 percent, respectively, while returns to nonagricultural capital increase by 0.14 percent. The nominal income of all households in the rest of Kenya declines. The effect is more severe for poorer rural households.

Scenario 4. For the Coast region, in the scenario that allocates 20 percent of the water to irrigation and the remaining 80 percent to water supply, agricultural wages increase by 2.9 percent while nonagricultural wages decline by 0.2 percent. Since capital is sector-specific, changes in wages and returns to capital are driven by labor movements within the agricultural and nonagricultural sectors in the region. Of the 68 percent of total employment that is concentrated in the service sector, the public service sector accounts for 26.4 percent and the private service sector accounts for 41.6 percent. Employment is fixed in the public service sector, while growth in private sector service contracts put a downward pressure on nonagricultural wages. Returns to land (5.7 percent) and livestock capital (16.7 percent) increase, while returns to agricultural and nonagricultural capital decline by 9.6 percent and 6.9 percent, respectively. Similar to employment, service sectors concentrate 81.2 percent of total nonagricultural capital and 46.2 percent of which contracts, thereby pushing capital remuneration downward. Changes in factor remuneration affect household income. Ultimately, the nominal income of all rural households in the Coast region increases. Income declines slightly for urban households because of the decline in income from nonagricultural capital. Across rural households, those in the two lowest income quintiles gain relatively more than others.

The impact in the rest of Kenya is negligible as total GDP contracts by 0.001 percent. Agriculture contracts by 0.01 percent (mainly due to contraction in maize and pulse production, because of competition from production of the same crops in the Coast region) and industry by 0.8 percent, while services GDP increases by 0.2 percent. The service sector GDP slightly grows, but the growth is not sufficient to counterbalance contractions in agricultural and industrial sectors. The overall impact on wages and return to capital in the rest of Kenya is that agricultural wages decline by 0.6 percent while nonagricultural wages increase by 0.2 percent. Returns to land, livestock, and nonagricultural capital decline by 1.2 percent, 0.7 percent, and 0.5 percent, respectively. Returns to agricultural capital increase by 1.5 percent. Consequently, the nominal income of all households in the rest of Kenya declines. The effect is more severe for poorer households in rural settings.

Impact on Real Consumption

The effects of alternative scenarios of water allocation on consumption differentiated by region, settlement pattern, and income quintiles are summarized in table 3.7. The effect on

TABLE 3.7. Effects on Consumption, by Region, Settlement Pattern, and Income Quintiles in the Coast Region

Percent change from the reference scenario

Scenario	Region	Consumption	Income quintiles									
			Rural					Urban				
			1	2	3	4	5	1	2	3	4	5
1: 80% for industrial and domestic use	Coast	Real consumption budget	1.17	0.59	0.5	0.43	0.32	−0.02	−0.16	−0.12	−0.21	−0.16
		Agriculture	1.17	0.49	0.15	0.07	−0.17	0.99	0.82	0.55	0.62	−0.10
		Industry	3.93	3.01	1.64	1.69	1.19	7.29	6.28	5.59	6.33	2.07
		Services	1.64	0.82	0.47	0.36	0.09	1.96	1.43	1.20	1.25	0.12
		Total	2.30	1.37	0.81	0.65	0.22	4.20	3.31	3.32	3.31	0.87
	Rest of Kenya	Real consumption budget	0.93	0.84	0.67	0.43	0.18	0.09	−0.12	0.08	0.13	−0.17
		Agriculture	0.58	0.52	0.36	0.19	0.03	0.13	0.04	0.19	0.17	−0.12
		Industry	0.62	0.56	0.39	0.2	0.03	−0.31	−0.17	0.07	0.05	−0.37
		Services	0.85	0.78	0.61	0.42	0.26	0.42	0.30	0.50	0.47	−0.01
		Total	0.62	0.57	0.41	0.24	0.10	0.01	−0.02	0.23	0.22	−0.15
	Kenya	Real consumption	0.88	0.74	0.59	0.39	0.19	0.08	−0.10	0.06	0.10	−0.13
		Total	0.80	0.63	0.45	0.29	0.12	0.69	0.87	0.64	0.59	0.03
2: 100% for industrial and domestic use	Coast	Real consumption budget	1.24	0.52	0.42	0.36	0.28	1.24	0.52	0.42	0.36	0.28
		Agriculture	1.11	0.32	0.01	−0.04	−0.23	0.74	0.62	0.37	0.43	−0.17
		Industry	5.09	3.91	2.03	2.18	1.60	9.45	8.17	7.13	8.25	2.72
		Services	1.6	0.6	0.3	0.2	0.0	1.5	1.1	0.9	0.9	0.0
		Total consumption	2.7	1.5	0.9	0.7	0.2	4.8	3.8	3.8	3.8	1.0
	Rest of Kenya	Real consumption budget	0.97	0.87	0.70	0.45	0.20	0.10	−0.11	0.09	0.15	−0.16
		Agriculture	0.61	0.54	0.38	0.19	0.02	0.09	0.01	0.17	0.16	−0.13
		Industry	0.69	0.63	0.46	0.25	0.08	−0.18	−0.10	0.16	0.13	−0.33
		Services	0.9	0.8	0.6	0.4	0.2	0.3	0.3	0.5	0.4	0.0
		Total consumption	0.7	0.6	0.5	0.3	0.1	0.004	−0.02	0.3	0.2	−0.2
	Kenya	Real consumption budget	1.00	0.83	0.66	0.43	0.20	0.08	−0.14	0.06	0.10	−0.17
		Total consumption	0.92	0.72	0.51	0.32	0.13	0.80	1.01	0.74	0.69	0.02
3: 20% for irrigation	Coast	Real consumption budget	3.0	3.3	3.2	2.6	1.8	0.4	0.4	0.4	0.4	0.4
		Agriculture	3.4	3.3	3.5	3.0	2.1	0.5	0.6	0.4	0.4	0.4
		Industry	3.0	3.3	3.1	2.7	1.9	0.3	0.4	0.3	0.3	0.4
		Services	3.4	3.6	3.4	3.0	2.0	0.4	0.4	0.3	0.3	0.3
		Total	3.2	3.3	3.3	2.9	2.0	0.4	0.5	0.3	0.4	0.4

table continues next page

TABLE 3.7. continued

Scenario	Region	Consumption	Income quintiles									
			Rural					Urban				
			1	2	3	4	5	1	2	3	4	5
	Rest of Kenya	Real consumption budget	−0.7	−0.6	−0.4	−0.2	0.1	0.2	0.3	0.2	0.2	0.3
		Agriculture	−0.4	−0.3	−0.1	0.1	0.3	0.3	0.4	0.3	0.3	0.3
		Industry	−0.6	−0.6	−0.4	−0.2	−0.1	0.2	0.3	0.1	0.1	0.1
		Services	−0.8	−0.7	−0.5	−0.3	−0.1	0.2	0.2	0.1	0.1	0.1
		Total	−0.5	−0.5	−0.3	−0.1	0.0	0.2	0.3	0.2	0.2	0.2
	Kenya	Real consumption budget	−0.2	−0.1	0.1	0.2	0.2	0.2	0.3	0.2	0.2	0.3
		Total	−0.1	0.004	0.2	0.3	0.2	0.3	0.3	0.2	0.2	0.2
4: 20% for irrigation and 80% for industrial and domestic use	Coast	Real consumption budget	4.1	3.8	3.7	3.1	2.1	0.5	0.3	0.3	0.2	0.3
		Agriculture	4.3	3.7	3.6	3.0	2.0	1.2	1.2	0.8	0.9	0.3
		Industry	7.4	6.7	5.0	4.6	3.3	8.4	7.3	6.3	7.3	2.7
		Services	4.8	4.3	3.8	3.2	2.1	1.8	1.5	1.1	1.2	0.4
		Total	5.6	4.7	4.2	3.6	2.3	4.7	3.9	3.7	3.8	1.3
	Rest of Kenya	Real consumption budget	0.2	0.1	0.2	0.2	0.2	0.3	0.2	0.3	0.3	0.1
		Agriculture	0.1	0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.5	0.2
		Industry	−0.1	−0.05	−0.01	−0.01	0.01	0.1	0.2	0.3	0.3	−0.1
		Services	−0.004	−0.004	0.1	0.1	0.1	0.5	0.4	0.5	0.5	0.1
		Total	0.1	0.1	0.1	0.1	0.1	0.3	0.3	0.4	0.4	0.03
	Kenya	Real consumption budget	0.7	0.6	0.7	0.6	0.4	0.3	0.2	0.3	0.3	0.2
		Total	0.7	0.6	0.7	0.6	0.3	1.0	1.2	0.8	0.8	0.2

Source: World Bank simulation results 2018.

real income or household consumption budget depends on the magnitude of the CPI. Through direct, indirect, and feedback effects, the increased supply of water affects the CPI of different sectors of the economy.

Scenario 1. In the scenario that allocates 80 percent to urban and rural water supply in the Coast region, the increased supply of water results in the decline of the CPI by 0.3 percent. Agricultural CPI increases by 0.5 percent, but industrial and services price indexes decrease by 1.0 percent and 0.1 percent, respectively, affecting households' real consumption budget (see table 3.7). All rural households in the Coast region gain while consumption budget declines slightly for urban households. With their new budget, households allocate a higher share of their budget to goods and services, for which prices fall depending on their initial preferences. All households are able to increase their total consumption. Even those that have a budget slightly lower than in the reference scenario are able to substitute goods for which prices increase by those for which prices fall and maintain higher level of consumption. In the rest of Kenya, consumption increases for all rural households, and those in the two lowest quintiles relatively benefit more than the rest. Consumption declines for urban households in quintiles 2 and 5 because of reductions in their real consumption budget.

Scenario 3. In the scenario that allocates 20 percent of the water to agriculture in the Coast region, the total CPI declines by 0.3 percent due to decline in the agricultural CPI (−0.9 percent) and the industrial CPI (−0.032 percent). The services CPI increases by 0.05 percent. The consumption demand of all households in the Coast region increases. Consumption gains are more important for rural households. Furthermore, consumption increases relatively more for households in the two lowest income quintiles. This shows that irrigation is likely to promote shared prosperity and inclusive growth in the Coast region. In the rest of Kenya, total CPI declines, mainly driven by reduction in agricultural CPI. The effect on real income (consumption) is positive for urban households but negative for rural households. The decline in consumption is more severe for those in lower income quintiles. Overall, the impact on the rest of Kenya is small, but negative as economic growth declines slightly. The impact on household income and consumption is penalizing for rural households and, in particular, those in lower income quintiles. In contrast, consumption gains are small but relatively higher for urban households in the two lowest income quintiles.

Scenario 4. In the scenario that allocates 20 percent of the water to irrigation and 80 percent to urban and rural water supply, the total CPI in the Coast region declines by 0.6 percent, driven by decline in agricultural CPI (−0.5 percent), industrial CPI (−1.0 percent) services CPI (-0.1 percent). The consumption demand for all households in the Coast region increases. Consumption gains are more pronounced for rural households. Furthermore, consumption increases relatively more for households in the two lowest income quintiles. This shows that the multipurpose Mwache Dam is likely to improve the livelihood of inhabitants of the Coast region if a portion of its water is allocated to irrigation. It is also likely to promote shared prosperity and inclusive growth in the Coast. In the rest of Kenya, the total CPI declines as well. The consumption effect is small but positive for all households. The effect on real income (consumption) is higher for urban households. Because of the price effects, consumption increases slightly more for all urban households.

Although computable general equilibrium (CGE) models are effective in capturing the transmission of policy shocks on the sectors of the economy, household income, and consumption, they are too aggregate to analyze the welfare and distributional effects.

The CGE methodology ignores household heterogeneity in terms of consumption patterns. Therefore, a macro-micro household simulation model was developed to analyze income and consumption gains or losses of individual households in Coast region because of the development of the multipurpose dam and alternative allocation scenarios of developed water. The results of this analysis are presented in the following section.

Note

1. All goods and services are supplied on the national market except water. Consumers do not distinguish between products based on the region of origin or production.

Chapter 4 Poverty and Distributional Impacts: Results of Household Microsimulation

Descriptive Results

Before discussing the results of the microsimulation, we present the state of poverty in the Coast region and in the entire country. New poverty estimates are compared to this starting point or reference situation. The initial situation is important when conducting poverty analysis since the initial poverty headcount ratio, poverty gap, and poverty severity influence the scope of poverty reduction gains of a given policy.

Table 4.1 presents some characteristics of the population in the Coast region, the rest of Kenya, and the country as a whole. The Coast region concentrates 12 percent of the poor while its share in total population is much lower (9.2 percent). The reference situation also shows higher poverty incidence in the Coast region compared to the national average. Poverty gap and poverty severity are also much higher in the Coast region compared to the national average.

We find significant disparities in poverty indices disaggregated by settlement pattern and consumption quintile. About 63 percent of the Coast region population lives in the rural areas and the remaining 27 percent is urban. The bottom 40 percent (B40) of the Coast region population (quintiles 1 and 2) represent 31.2 percent of total population and account for 44.3 percent of the poor households in the region. Similarly, Foster-Greer-Thorbecke (FGT) poverty indexes are significantly higher among this group. When comparing rural and urban inhabitants by consumption quintile, the 2005/06 survey shows important disparities. Rural inhabitants in the first and second quintiles have very high poverty incidence (91.9 percent and 85.0 percent, respectively). The B40 in the urban areas of the Coast region are also characterized by high poverty incidence (80.9 percent and 78.6 percent for quintiles 1 and 2, respectively) although slightly lower compared to the rural.

The Coast region inhabitants have not only higher poverty incidence but also high poverty gap and poverty severity. At the disaggregated level, rural and urban inhabitants in the first and second quintiles have the highest poverty incidence and the highest poverty gap. This implies that significant gains in real consumption are necessary to lift the poor out of poverty since they have extremely low levels of consumption. In contrast, those in quintiles 4 and 5 have high poverty incidence but low poverty gap. As such, since numerous members are just below the poverty line, relatively small gains in real consumption are likely to result in higher numbers being lifted out of poverty.

Changes in Poverty Incidence

Our simulation results show that the Mwache Dam has a potential for reducing poverty in the Coast region (table 4.2). The highest poverty gains are registered under the scenario in which 80 percent of water from the dam is allocated for industrial and domestic use in

TABLE 4.1. Population Characteristics in Kenya, 2005–06

	Total population	Poor population	Share in population	Share in poor population	Poverty incidence	Poverty gap	Poverty severity
National	35,186,083	16,571,443	100	100	47.1	16.8	8.4
Coast	3,254,373	1,992,219	9.2	12.0	61.2	22.3	10.8
Rural Q1	400,301	367,900	12.3	18.5	91.9	51.9	32.5
Rural Q2	499,699	424,678	15.4	21.3	85.0	36.1	18.4
Rural Q3	501,191	398,208	15.4	20.0	79.5	24.9	9.9
Rural Q4	384,407	229,028	11.8	11.5	59.6	15.0	5.3
Rural Q5	253,077	66,069[a]	7.8	3.3	26.1	4.9	1.1
Urban Q1	29,287	23,697	0.9	1.2	80.9	43.7	27.7
Urban Q2	85,067	66,859	2.6	3.4	78.6	26.4	12.9
Urban Q3	138,543	88,505	4.3	4.4	63.9	20.6	9.1
Urban Q4	313,634	138,888	9.6	7.0	44.3	13.0	4.9
Urban Q5	649,167	188,387	19.9	9.5	29.0	5.7	1.6

Source: World Bank calculations based on 2005/06 KNBS.

a. The richest 40 percent population has poor individuals both in the Coast region and in the rest of Kenya. This is because the quintiles were defined at county level in the survey data. The regional aggregation into Coast region and the rest of Kenya was carried out based on this initial classification. This means that a household belonging to the richest quintile in Kwale or Tana River counties may be classified as a poor household because its expenditure level is below the poverty line; thus also reflecting the inequality in consumption across counties.

TABLE 4.2. Changes in Poverty Incidence in Kenya

Percent change from reference or baseline scenario

	80% for industrial and domestic use	100% for industrial and domestic use	20% for irrigation	80% for industrial and domestic use and 20% for irrigation
National	**−0.8**	**−0.9**	**−0.1**	**−1.3**
Urban	−0.9	−0.9	−0.4	−2.1
Rural	−0.7	−0.9	−0.1	−1.1
Coast	**−0.4**	**−0.4**	**−5.0**	**−6.2**
Urban	−0.9	−1.6	−1.7	−5.5
Rural	−0.7	−0.2	−5.8	−6.4

Source: World Bank simulation results (2018).

combination with a 20 percent allocation of water for irrigation. Such an allocation reduces poverty incidence by 6.2 percent. Allocating water for irrigation has important implications since the poverty reduction gains are very important (5.0 percent). The results in table 4.2 indicate that this large poverty reduction is mainly a rural phenomenon, where those households gain significantly through increased food consumption. According to the KIHBS (KNBS 2007), the mean consumption expenditure per month per adult equivalent for rural households in the Coast region was K Sh 1,731 with the major share taken by food consumption (68 percent). On the other hand, the monthly mean consumption expenditure per adult equivalent for urban households in the region was K Sh 5,503 with about 42 percent share of consumption expenditure on food items (KNBS 2007). The macro computable general equilibrium (CGE) results show that consumption has significantly increased for the rural households. Given that 63 percent of the Coast population is rural, the impact on the poverty incidence is large. In contrast, when 80 percent of water is allocated for domestic and industrial use, the poverty impact is quite limited (0.4 percent). Allocating all the water from the dam for industrial and domestic use reduces poverty by the same percentage. At the national level, the poverty reduction gains vary from 0.1 percent to 1.3 percent, the highest gain resulting from the combined allocation scenario.

Table 4.3 presents the distributional impact at the disaggregated level. Results from the CGE model in terms of change in real consumption are compared to change in poverty in the microsimulation. Across all scenarios, poverty declines or remains unchanged. Allocating water from the dam only to industrial and domestic users does not yield notable changes in poverty reduction. As in the CGE model, in the 80 percent allocation scenario, the microsimulation results show that poverty reduction tends to be higher for urban households than for rural households. Moreover, poverty declines only for those households in the fourth quintile than for those in the lower-income quintiles. This is not surprising as the B40 has a very high poverty gap while the top 40 percent (T40) has a low poverty gap (see table 4.1). Consequently, in the 80 percent allocation scenario, a 4.2 percent increase in the real consumption of urban Coast households in the first quintile does not yield any poverty reduction. In contrast, a 3.3 percent increase in consumption of urban coastal households in the fourth quintile results in a 7.3 percent reduction of poverty incidence among this group.

TABLE 4.3. Macro (Consumption) and Micro (Poverty) Impacts in Kenya, by Location and Consumption Quintile

Percent change from reference scenario

	80% for industrial and domestic use		100% for industrial and domestic use		20% for irrigation		80% for industrial and domestic use and 20% for irrigation	
	CGE	Poverty	CGE	Poverty	CGE	Poverty	CGE	Poverty
Rural Q1	2.30	**−0.31**	2.7	**−0.31**	3.2	**−1.24**	5.6	**−1.24**
Rural Q2	1.40	**0**	1.5	**0**	3.3	**−4.86**	4.7	**−6.85**
Rural Q3	0.80	**−0.30**	0.9	**−0.30**	3.3	**−9.24**	4.2	**−9.24**
Rural Q4	0.60	**0**	0.7	**0**	2.9	**−14.20**	3.6	**−14.20**
Rural Q5	0.20	**0**	0.2	**0**	2.0	**0**	2.3	**0**
Urban Q1	4.20	**0**	4.8	**0**	0.4	**0**	4.7	**0**
Urban Q2	3.31	**0**	3.8	**0**	0.5	**0**	3.9	**0**
Urban Q3	3.32	**0**	3.8	**0**	0.3	**0**	3.7	**0**
Urban Q4	3.31	**−7.34**	3.8	**−7.34**	0.4	**−1.39**	3.8	**0**
Urban Q5	0.90	**0**	1.0	**0**	0.4	**−6.70**	1.3	**−6.70**

Source: CGE model and Microsimulation results 2018.

Note: CGE results pertain to the change in real consumption. Poverty results are based on poverty head-count ratio (poverty incidence). CGE = computable general equilibrium.

Similarly, because of the difference in the initial poverty gap between rural households in the first and second quintiles, a 2.3 percent increase in consumption of the rural households in quintile 1 results in poverty reduction of 0.3 percent, while a 1.4 percent increase in real consumption among rural households in quintile 2 does not reduce the poverty incidence among this group. This means that significant gains in real consumption are necessary to lift the 20 percent poorest (rural and urban) out of poverty as they have extremely low levels of consumption. This is true for all of the water allocation scenarios considered.

As indicated in our findings from the economywide impact analysis, this microsimulation exercise also shows that allocating water for irrigation purposes results in significant poverty reduction gains (table 4.3). All rural Coast households benefit significantly from allocating water from the Mwache Dam for irrigation purposes except the rural groups in quintile 5. Although the CGE model indicates higher income gains for the B40 (quintiles 1 and 2), a higher proportion of poor households in quintiles 3 and 4 were lifted out of poverty. Allocating water for irrigation and for industrial and domestic uses allows higher poverty reduction gains across all quintiles in both urban and rural areas of the Coast region. Across all scenarios, the only groups of households that do not see any change in their poverty status are the urban groups in quintiles 1, 2, and 3 and the rural groups in quintile 5 despite a 4.7 percent, 3.9 percent, 3.7 percent, and 2.3 percent increase, respectively, in real consumption.

Changes in Poverty Gap

The construction and operationalization of the Mwache Dam is also likely to reduce poverty gap (table 4.4). With the 80 percent and 100 percent allocation of water for nonagricultural

TABLE 4.4. Changes in Poverty Gap in Kenya

Percent change from reference scenario

	80% for industrial and domestic use	100% for industrial and domestic use	20% for irrigation	80% for industrial and domestic use and 20% for irrigation
National	−1.0	−1.2	−0.2	−1.2
Coast	−1.1	−1.1	−5.9	−7.0
Rural Q1	−1.2	−1.4	−3.7	−4.9
Rural Q2	−0.8	−0.8	−7.4	−8.2
Rural Q3	−0.6	−0.4	−11.9	−12.5
Rural Q4	−0.3	0	−12.0	−12.3
Rural Q5	2.3	3.5	−32.8	−30.3
Urban Q1	−1.1	−1.1	−0.4	−1.5
Urban Q2	−1.8	−1.9	−0.9	−2.7
Urban Q3	−1.9	−1.9	−0.9	−2.8
Urban Q4	−3.1	−3.3	−1.5	−4.5
Urban Q5	−0.5	−0.2	−1.5	−2.0

Source: World Bank simulation results 2018.

uses, our results indicate a potential reduction of 1.0 percent and 1.2 percent, respectively, at the national level. Poverty gap is expected to decline by 1.1 percent in the Coast region for the same allocation schemes. When we look at the disaggregated results, we find important disparities between the different incomes groups and between urban and the rural inhabitants (table 4.4).

Although the urban groups in quintiles 1 and 2 do not see poor households lifted out of poverty because of preexisting high poverty gaps, the latter has declined across all scenarios. The gap between the consumption level of these groups and the poverty line has been reduced with maximum gains obtained when water is allocated for irrigation, domestic, and industrial users. Comparing rural to urban populations in the Coast region, we find that when water is allocated to industrial and domestic use only, the urban tend to gain more. In contrast and as expected, when water is allocated for irrigation, industrial, and domestic uses, rural households in the Coast region tend to benefit significantly more than the urban households across all consumption quintiles. Furthermore, this combined allocation allows urban households to register the highest gain compared to the three other allocation schemes. Regardless of location, the higher the income or consumption group, the higher the poverty gap declines.

Changes in Poverty Severity

The impact of the Mwache Dam on poverty severity is positive. The results are presented in table 4.5. At the national level, poverty severity declines by 1.3 percent when water is

TABLE 4.5. Changes in Poverty Severity in Kenya

Percent change from reference scenario

	80% for industrial and domestic use	100% for industrial and domestic use	20% for irrigation	80% for industrial and domestic use and 20% for irrigation
National	−1.2	−1.3	−0.1	−1.3
Coast	−1.4	−1.5	−6.7	−8.1
Rural Q1	−1.7	−1.9	−5.2	−6.8
Rural Q2	−1.0	−0.9	−8.6	−9.6
Rural Q3	−0.7	−0.5	−13.5	−14.2
Rural Q4	−0.3	0.1	−15.6	−15.9
Rural Q5	4.6	7.1	−54.8	−51.5
Urban Q1	−1.5	−1.6	−0.6	−2.2
Urban Q2	−2.0	−2.1	−1.1	−3.1
Urban Q3	−2.0	−2.1	−0.9	−2.9
Urban Q4	−3.5	−3.7	−1.8	−5.2
Urban Q5	−0.6	−0.2	−2.1	−2.6

Source: Simulation results.

allocated for irrigation, industrial, and domestic use. Other allocations yield lower gains. Similarly, the Mwache Dam is likely to reduce poverty severity by as much as 51.5 percent in the combined allocation scenario. At the disaggregated level, the result is analogous to that of poverty gap.

We note that poverty gap declines more than poverty incidence and that poverty severity declines more than poverty gap across all scenarios and groups. Furthermore, as reflected by the 2005/06 survey data, poverty is a rural phenomenon in Kenya. Coast inhabitants tend to have higher risk of being in poverty compared to the national average. The Mwache Dam not only has the potential for reducing poverty but it is also likely to be pro-poor. In the combined allocation scenario, the rural regions are able to lift a greater share of their poor households out of poverty.

Absolute Number of Poor Households Lifted Out of Poverty

The microsimulation approach not only allows us to capture the impact of the dam on poverty incidence but also reveals the actual number of poor households lifted out of poverty. Table 4.6 presents the actual number of poor households likely to be lifted out of poverty across the four water allocation scenarios. The results show that about 111,171 poor people could be lifted out of poverty if water from the Mwache Dam is allocated to irrigation, domestic, and industrial uses. Allocating all of the water to domestic and industrial users lifts only 10,879 people out of poverty in the Coast Region as a whole.

TABLE 4.6. Changes or Reductions in the Number of Poor People in Kenya

	80% for industrial and domestic use	100% for industrial and domestic use	20% for irrigation	80% for industrial and domestic use and 20% for irrigation
Coast	10,879	10,879	89,398	111,171
Rural Q1	1,391	1,391	5,617	5,617
Rural Q2	0	0	22,204	31,330
Rural Q3	1,044	1,044	32,201	32,201
Rural Q4	0	0	23,627	23,627
Rural Q5	0	0	0	0
Urban Q1	0	0	0	0
Urban Q2	0	0	0	0
Urban Q3	0	0	0	0
Urban Q4	8,444	8,444	1,603	14,249
Urban Q5	0	0	4,146	4,146

Source: World Bank simulation results 2018.

At the disaggregated level, although poverty incidence declines relatively less for the rural households in the first and second quintiles (see table 4.3), significant number of poor individuals are still lifted out of poverty, because they are concentrated in these quintiles. Indeed, 59.8 percent of poor households in the Coast region are concentrated in quintiles 1, 2, and 3 in rural areas. When we combine the first three income quintiles for the rural households, 69,148 poor people are lifted out of poverty.

Chapter 5 Conclusions and Policy Implications

Conclusions

The Coast region has the second-highest rural poverty levels in Kenya after the northeastern region and is less developed nationwide with regard to access to key infrastructure and services. The available statistics paint a clear picture of the deprivation regarding access to water supply, sanitation, food, health, and education. The study applied a computable general equilibrium (CGE) model and a microsimulation analysis and confirmed that multipurpose water investment is the key to unlocking the economic development potential of the Coast region, particularly if proper sectoral water allocation decisions are made. The main results and conclusions of the study are summarized as follows.

Changes in final and intermediate demand for water. Water users benefit from increased availability of public and vendor water at a lower cost (−34.9 percent for public water and −35.4 percent for water supplied by vendors). Consequently, demand for private water decreases, while demand for public and vendor water increases. Water consumption by all households in the Coast region increases on average by 31.6 percent. Moreover, increased water availability benefits all industries operating in the Coast region, in particular those relatively more intensive in water. The total demand for water as intermediate input for industries increases by about 115.1 percent.

Impact on economic growth. The economic growth impact of water allocations to irrigation is quite significant. Allocation of a mere 20 percent of the dam water to irrigation results in a 1.6 percent, −0.001 percent, and 0.2 percent economic growth in the Coast region, the rest of Kenya, and Kenya, respectively. The corresponding growth rates for 80 percent and 100 percent allocations to urban and rural water supply were only about 0.5 percent, −0.001 percent, and 0.1 percent for the Coast region, the rest of Kenya, and Kenya, respectively. The agricultural sector growth is fueled mainly by significant increase in the production of maize, pulses, oil crops, fruits, and vegetables in the hitherto drought-prone and low-productivity region of Kenya. Thus, allocation of water to irrigation would have considerable effects on food and nutritional security in the region, which suffers from persistent food deficits and is dependent on humanitarian aid and commercial imports both from the rest of Kenya and from abroad.

Impact on trade. The total exports and imports expand for all of the water allocation scenarios considered. However, for scenarios 3 and 4—which include at least 20 percent water allocation to irrigation—agricultural imports decline while exports significantly expand, further enhancing the agricultural export earnings of Kenya, which already account for 65 percent of Kenya's total exports.

Income and consumption effects. Development of the Mwache Dam affects the income and consumption of households in the Coast region through its effects on wages and returns to capital. For scenarios 1 and 2, the nominal income of rural households increases while that of urban households declines. However, because of reduction in the

Consumer Price Index (CPI) and the substitution effect, ultimately, the total consumption level of all of the households increases. For scenarios 3 and 4, which include water allocation to agriculture, the nominal income and consumption of all households in the Coast region significantly increase.

The increased availability of water in the Coast region affects household income and consumption in the rest of Kenya through price, income, and regional substitution effects. For scenarios 1 and 2, income of rural households in the rest of Kenya increases because of higher labor and capital income. For scenarios 3 and 4, agricultural wages decline by 2.9 percent while nonagricultural wages increase slightly by 0.1 percent. Returns to land, livestock capital, and agricultural capital significantly decrease while returns to nonagricultural capital slightly increase. Consequently, the nominal income of all households in the rest of Kenya declines and the reduction is more severe for poorer households. However, because of significant reductions in the total CPI, mainly driven by reduction in agricultural CPI, the real income or consumption increases slightly for all households in the rest of Kenya. The effect on real income (consumption) is higher for urban households. Because of the price effects, consumption increases slightly more for all urban households.

Poverty and distributional impacts. The macro-micro simulation results show that significant poverty reduction is achieved if a portion of the water is allocated to irrigation. An allocation of 20 percent of the water to irrigation reduces poverty by about 5.0 percent in the Coast region, while allocation of 100 percent of the water to urban and rural water supply reduces poverty incidence by a mere 0.4 percent. The highest poverty reduction (6.2 percent) is achieved when 80 percent of the water is allocated to rural and urban water supply and the remaining 20 percent is used for irrigation. There are significant disparities among household types with regard to changes in real income and poverty outcomes. As expected, urban households benefit most from changes in real income and poverty reduction from allocations to domestic and industrial sectors, while rural households benefit most from allocations to irrigation.

Implications for Policy and Operations

The pathways and channels through which access to water affects the economy and the well-being of people are multifarious. The three main impact transmission channels are (a) the price effect (meaning that households can consume more with the same budget); (b) the income effect (inducing further expansion of goods and services); and (c) the regional substitution effect (or enhancing regional specialization). Some of the impacts, such as improved health of children and improved school attendance, are played out in the long run and revealed through enhanced cognitive development and opportunity to work. Access to water has immediate health implications on adults through effects on productivity and quality of life. People gain time and money to pursue economic and educational goals.

The economic growth impact of access to water depends on the prevailing economic structure. Increased water availability at lower cost would have the greatest growth impact in an economy dominated by water-intensive sectors and economic sectors with strong backward and forward linkages with the water-intensive sectors. In the Coast region, the most water-intensive sectors, as indicated by the share of water in the total intermediate input consumption of the sectors, are textile and leather, mining, other cereals, and livestock. Consequently, real gross domestic product (GDP) increases the most in these sectors. Thus, to attain the regional socioeconomic development goals, there is a need for appropriate sequencing or packaging of development projects.

In the Coast region of Kenya, water allocation to agriculture is key for inclusive growth and poverty reduction in both rural and urban areas. Water allocation to agriculture would have the greatest poverty reduction impacts. The number of people lifted out of poverty due to allocation of 20 percent of the water to agriculture is about eight times more than that of those lifted out of poverty when allocating 100 percent of the water to domestic and industrial sectors. Moreover, in urban areas, the poverty reduction effects of 80 percent to 100 percent allocations to domestic and industrial sectors is about the same as the effect of allocating 20 percent of the water to agriculture.

In fact, the best poverty reduction outcome is recorded for the scenario that allocates 80 percent of the water to domestic and industrial sectors and 20 percent to agriculture in both rural and urban areas. There are two plausible explanations for these results. First, the concentration of poor people among rural communities engaged in agricultural production activities is high. Second, the share of food in the total consumption budget of poor people is high. Consequently, introducing irrigated agriculture in predominantly low-input, low-output drought-prone areas such as the Coast region of Kenya substantially benefits both rural and urban (through price effect) people. Given the large potential gains in agricultural productivity with availability of irrigation, the Coast region experiences a growth of 1.6 percent, mainly driven by the significant growth in agricultural sector.

Provision of domestic water supply is necessary but not sufficient for overcoming extreme poverty. Where the severity of poverty is high, even a substantial gain in income relative to the preexisting situation may not lift the poor out of poverty. For instance, while significant proportion of households in the fourth and fifth quintile closer to the poverty line are lifted out of poverty, the poorest quintiles are not able to escape poverty because of the initial big gap between their prevailing consumption levels and the poverty line. It is evident that access to domestic water allows people to gain time and money and pursue economic goals. The conversion of the gains in time, money, and good health to credible improvements in well-being presupposes the existence of gainful employment and investment opportunities. Thus, to make significant dent in the incidence of poverty, there is a need for bundling domestic water supply projects with interventions geared toward creating economic opportunities and access to productive assets. The careful packaging or bundling of water supply and sanitation projects with economic projects not only results in better economic growth and poverty reduction outcomes but also contributes to the sustainability of the water supply and sanitation services.

Water resources development in the Coast region would have interregional and intersectoral income distribution effects. Increased availability of water in the Coast region results in positive economic growth in Kenya as a whole, more than compensating the slight decline in GDP in the rest of Kenya. Some economic activities expand or contract in the Coast region and the rest of Kenya because of regional substitution effect. For instance, the agriculture sector grows in the Coast region, while it slightly declines in the rest of Kenya because of reduced demand for agricultural imports in the Coast region. Consequently, the transport and communication sectors contract in the Coast because of reduced demand for these services following reduction in demand for imported agricultural commodities. The sectoral and regional economic dynamics would have implications on the welfare of people affected. Thus, projects need to be planned within the framework of the overall national economic development strategies and goals to avoid a possible zero sum game.

Appendix A Technical Description of the Model

Computable General Equilibrium Model

Production

A representative producer in each industry and in each region maximizes profit under a set of given constant returns to scale technology and independent prices. Producers are assumed to operate in a perfectly competitive environment. Therefore, each industry's representative firm maximizes profits subject to its production technology, while it considers the prices of goods and services and factors as given (price-taking behavior).

The nested structure of production presented in figure A.1 is as follows. At the top level, the sectoral output of each productive activity[1] in each region combines value added and total intermediate consumption in fixed shares. In other words, the two aggregate inputs are considered to be strictly complementary, without any possibility of substitution, following a Leontief production function.

At the second level, each industry's value added consists of composite labor and composite capital, following a constant elasticity of substitution (CES) specification. Profit maximization (or cost minimization) by the firms leads them to employ labor and capital to the point where the value marginal product of each is equal to its price (the wage rate and the rental rate of the capital, respectively).

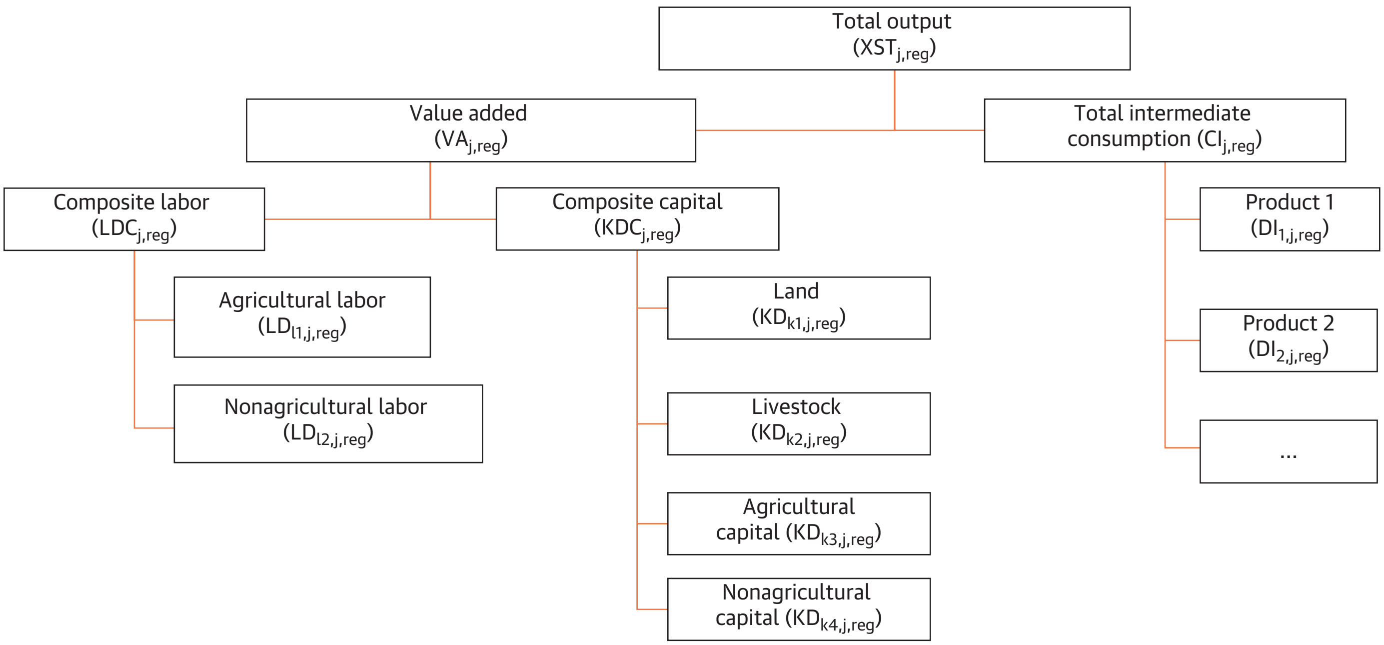
At the bottom level on the value added side, the various categories of labor are combined following a CES technology, which reflects the imperfect substitutability between different types of labor.[2] The firm chooses its labor composition to minimize its labor cost given the relative wage rates. Likewise, composite capital is a CES combination of the different categories of capital. As in the case of labor, it is assumed that different categories of capital (land, buildings, cattle, machinery and equipment, and so on) are imperfect substitutes.

Finally, returning to the second level, but on the intermediate consumption side, aggregate intermediate consumption is made up of various goods and services. Here, it is assumed that intermediate inputs are perfectly complementary and are combined following a Leontief production function.

Agents

One of our objectives is to capture the contribution of multipurpose water investment to household livelihoods. Income and expenditure patterns vary considerably across households, especially across regions, rural and urban areas, and income categories in Kenya. These differences are important for distributional change because the direct and indirect income effects resulting from the Mwache Dam will accrue to different households depending on their location and factor endowments. To capture these differences, the model distinguishes between 20 representative households, distinguished by region, urban or rural settings, and income quintile.

FIGURE A.1. Structure of Production



Source: World Bank conceptualization.

These 20 representative household consumers maximize their well-being under budget constraints and given market prices. Household incomes come from two sources: labor income and capital income. Household savings are a linear function of disposable income.

The model takes into account a large variety of tax instruments. Indeed, the government draws its income from household income taxes, taxes on products and imports, and other taxes on production. According to the 1993 System of National Accounts (SNA93), taxes on products (not “production”) and imports consist of indirect taxes on consumption, taxes and duties on imports, and export taxes, while other taxes on production consist of payroll taxes, taxes on capital, and taxes on production. In addition to these various forms of fiscal revenue, the government receives part of the transfers from other agents.

The rest of the world receives payments for the value of imports. Foreign spending in the domestic economy consists of the value of exports and transfers to domestic agents. The difference between foreign receipts and spending is the amount of rest-of-the-world savings, which are equal in absolute value to the current account balance, but of opposite sign.

Demand

It is assumed that households have Stone-Geary utility functions (from which derives the Linear Expenditure System). A characteristic of these utility functions is that there is a minimum level of consumption of each commodity. This specification offers a degree of flexibility with respect to substitution possibilities in response to relative price changes. Type h household demand for each good is determined by utility maximization subject to the budget constraint.

Investment demand includes both gross fixed capital formation (GFCF) and changes in inventories. Inventory changes are exogenous in Partnership for Economic Policy(PEP) 1-t, fixed in volume. GFCF, on the contrary, is endogenous in the default closure of PEP 1-t, in which total investment expenditure is determined by the savings-investment equilibrium constraint, with endogenous savings. GFCF includes both private and public investments. The quantity demanded of each commodity i for investment purposes is the sum of the quantity demanded for private investment and for public investment. Both private and public investments are distributed among commodities in fixed shares; implicitly, the production function of new capital is Cobb-Douglas. Therefore, for a given amount of investment expenditures, the quantity demanded of each commodity i for investment purposes of either kind is inversely related to its purchaser price. The same hypothesis is made regarding government current expenditures on goods and services. With a given current expenditure budget, the quantity demanded of each commodity varies inversely with its price.

Producer Supplies of Products and International Trade

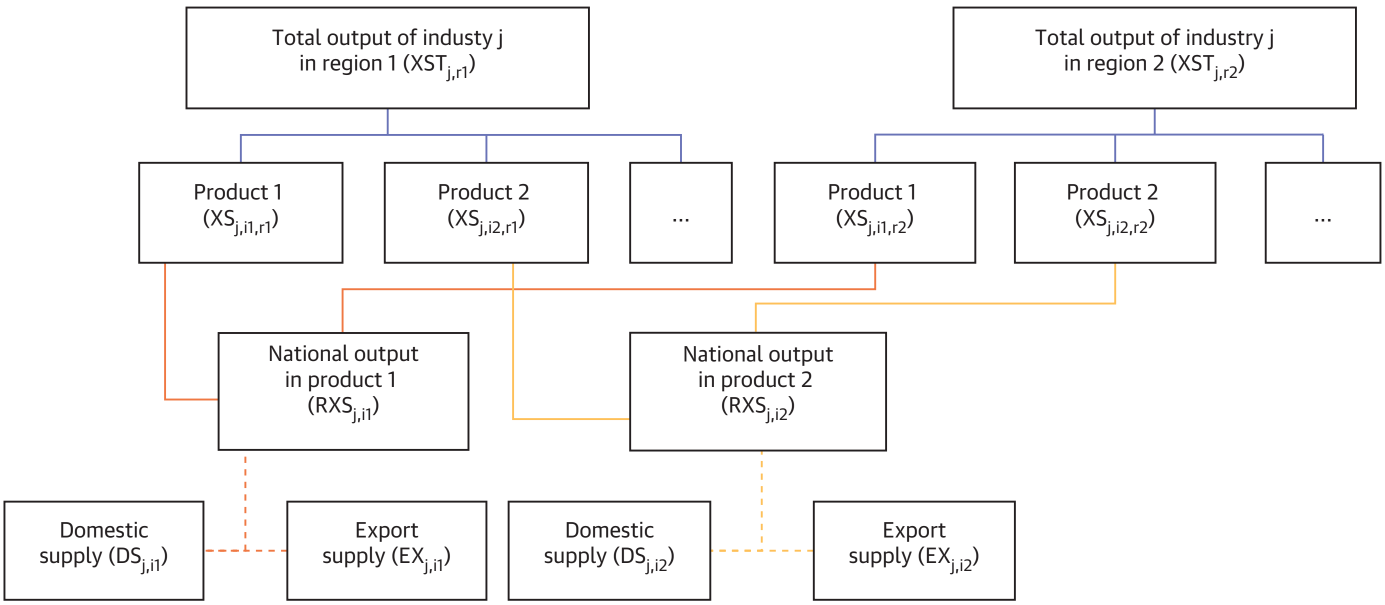
Industries in each region can produce more than one commodity. It is assumed that although an industry can reorganize its production to change the proportions of goods produced, the different products are not perfectly "transformable" into one another. This is represented by means of a constant elasticity of transformation (CET) function that describes how easily the product mix can be adjusted in response to price changes (equations A.1 and A.2).

$$XST_{j,reg,t} = B^{XT}_{j,reg}\left[\sum_i \beta^{XT}_{j,i,reg} XS^{\rho^{XT}_j}_{j,i,reg,t}\right]^{\frac{1}{\rho^{XT}_{j,reg}}} \quad \text{(A.1)}$$

$$XS_{j,i,reg,t} = \frac{XST_{j,reg,t}}{\left(B^{XT}_{j,reg}\right)^{1+\sigma^{XT}_{j,reg}}}\left[\frac{P_{j,i,reg,t}}{\beta^{XT}_{j,i,reg} PT_{j,reg,t}}\right]^{\sigma^{XT}_{j,reg}} \quad \text{(A.2)}$$

$XS_{j,i,reg,t}$	Industry *j* production of commodity *i* in region *reg*
$XST_{j,reg,t}$	Total aggregate output of industry *j* in region *reg*
$P_{j,i,reg,t}$	Basic price of industry *j*'s production of commodity *i* in region *reg*
$PT_{j,reg,t}$	Basic price of industry *j*'s output in region *reg*
$B^{XT}{}_{j,reg}$	Scale parameter (CET—total output)
$\beta^{X}_{j,i}$	Share parameter (CET—exports and local sales)
$\sigma^{XT}_{j,reg}$	Elasticity (CET—total regional output)
$\rho^{XT}_{j,reg}$	Elasticity parameter (CET—total regional output)

FIGURE A.2. Structure of Supply of All Commodities Except Water



Furthermore, while regional production structures and technologies are captured in the model, regionally produced commodities are traded in national and international markets (except in the case of water; see figure A.2). This means that two similar products are differentiated by their region of origin. However, when these two commodities are supplied in the domestic or the international (exports) markets, they are treated as one commodity regardless of the region in which they have been produced. For example, maize is produced in the Coast region and in the rest of Kenya but when maize is traded as an intermediate or as a final consumption good, or when it is sold as an export commodity, there is no regional differentiation. Markets clear at the national level and not at the regional level. The output of every product of an industry in the Coast region ($XST_{j,i,r2}$) is combined with the output of similar products in the rest of Kenya ($XST_{j,i,r1}$) using a CET aggregator function constituting the national aggregate output ($RXS_{jsw,i,t}$) (equations A.3 and A.4). The imperfect substitutability reflects the difficulty with which production can be shifted from one region to the other.

$$RXS_{jsw,i,t} = B^{XTR}_{jsw,i}\left[\sum_{reg}\beta^{XTR}_{jsw,i,reg}XS^{\rho^{XTR}_{jsw,i}}_{jsw,i,reg,t}\right]^{\frac{1}{\rho^{XTR}_{jsw,i}}} \quad (A.3)$$

$$XS_{jsw,i,reg,t} = \frac{RXS_{jsw,i,t}}{\left(B^{XTR}_{jsw,i}\right)^{1+\sigma^{XTR}_{jsw,i}}}\left[\frac{P_{jsw,i,reg,t}}{\beta^{XTR}_{jsw,i,reg}PRXS_{jsw,i,t}}\right]^{\sigma^{XTR}_{jsw,i}} \quad (A.4)$$

$RXS_{jsw,i,t}$	National aggregate output of *jsw* industry in commodity *i*
$P_{jsw,i,reg,t}$	Basic price of industry *jsw*'s production of commodity *i* in region *reg*
$PRXS_{jsw,i,t}$	Basic price of national output of *jsw* industries in commodity *i*
$B^{XTR}_{j,i}$	Scale parameter (CET—total output)

$\beta^{XTR}_{jsw,i,reg}$ Share parameter (CET—total output)
$\rho^{XTR}_{jsw,i}$ Elasticity parameter (CET—total sectoral output)
$\sigma^{XTR}_{jsw,i}$ Elasticity (CET—total sectoral output)

Next, the national aggregate output of every product is shared out among markets (domestic or export), again with the goal of maximizing the firm's total revenue, given the demand in each market and the various taxes that apply (equations A.5 and A.6). But it is assumed that production directed to one market is somewhat different from production directed to another market. This imperfect substitutability is represented in PEP 1-t by means of a CET aggregator function that describes how readily production can be redirected from one market to another.

$$RXS_{jsw,i,t} = B^X_{jsw,i}\left[\beta^X_{jsw,i} EX^{\rho^X_{jsw,i}}_{jsw,i,t} + \left(1-\beta^X_{jsw,i}\right) DS^{\rho^X_{jsw,i}}_{jsw,i,t}\right]^{\frac{1}{\rho^X_{jsw,i}}} \tag{A.5}$$

$$EX_{jsw,i,t} = \left[\frac{1-\beta^X_{jsw,i}}{\beta^X_{jsw,i}} \frac{PE_{i,t}}{PL_{i,t}}\right]^{\sigma^X_{jsw,i}} DS_{jsw,i,t} \tag{A.6}$$

$EX_{jsw,i,t}$ Quantity of product *i* exported by sector *jsw*
$DS_{jsw,i,t}$ Supply of commodity *i* by sector *jsw* to the domestic market
$PE_{i,t}$ Price received for exported commodity *i* (excluding export taxes)
$PL_{i,t}$ Price of local product i (excluding all taxes on products)
$B^X_{jsw,i}$ Scale parameter (CET—exports and local sales)
$\beta^X_{jsw,i}$ Share parameter (CET—exports and local sales)
$\rho^X_{jsw,i}$ Elasticity parameter (CET—exports and local sales)
$\sigma^X_{jsw,i}$ Elasticity (CET—exports and local sales)

To summarize, producers' supply behavior is represented by nested CET functions: in the upper level, the regional aggregate output is allocated to individual products; in the intermediary level, the regional output in each product is combined to form the national aggregate output in each product; and in the lower level, the supply of each product is distributed between the domestic market and exports.

Buyer behavior is symmetrical to producer behavior, in that it is assumed that local products are imperfect substitutes for imports or, in other words, that goods are heterogeneous with respect to their origin. Therefore, commodities demanded on the domestic market are composite goods—combinations of locally produced goods and imports. The imperfect substitutability between the two is represented by a CES aggregator function.

Water Module

In each region, public and private industries produce water. The former is classified as public because water production and supply are managed by the government. The quantity of water produced by the public water industry remains unchanged unless a specific shock is introduced (increase in the stock of capital or employment). The private water industry produces

TABLE A.1. Percentage Distribution of Households in the Coast Region, by Main Source of Drinking Water

Sources of drinking water	Distribution (%)
Piped into dwelling	8.5
Piped into plot/yard	7.7
Public tap	35.8
Borehole with pump	3.8
Protected dug well	4.2
Protected spring	0.2
Rain water collection	1.9
Unprotected dug well	6.3
River/ponds stream	6.7
Tanker/truck vendor	19.9
Bottled water	0.2

Source: KNBS 2007.

water similar to that produced by the public water sector, but production can increase to meet higher demand. Table A.1 presents the main sources of drinking water for households in the Coast region. We can see that the total amount of water produced and supplied by public providers represents 52 percent of the total water provision. The rest is provided either by water vendors (19.9 percent) or through self-provision or production (23.3 percent). We consider that water provided by tankers and truck vendors is initially produced and supplied by public water authorities. Water vendors use water produced by the public sector and then redistribute it at a higher price. For example, while the Mombasa Water and Sewerage Company (MOWASCO) tariff ranges from US$0.80 to US$1.00 per cubic meter, vendors' tariff amounts to US$2.87. Other private suppliers' tariff to industries can reach US$10.30 per cubic meter.

The model captures the three major sources of water provision. Given that the tankers and truck vendors use water produced by the water authorities, which they resell, we consider that there is one source of public water production. This means that the public water sector produces one category of water. At the supply level, water produced by the water authorities is distinguished between public water (provided through public pipelines) and vendor water (provided through trucks and vendors). The difference between the two lies in their initial prices. Water supplied by vendors is up to three times more expensive than water supplied through public pipelines. Overall, the public water authorities produce 72 percent of total water in the Coast region. In line with the data in table A.1, public provision of water covers 52 percent of supply, while provision of water through vendors covers 20 percent. The second sector producing water is the private sector. It encompasses the following sources of water: borehole, well, spring, rain, rivers and ponds, and bottled water.

To capture this, the public water industry in each of the two regions produces[3] and supplies public water (representing water available through public pipelines) and vendor water (representing water supplied by truck vendors). This is represented by means of a CET function that describes how easily the product-mix can be adjusted in response to price changes (equations A.7 and A.8). The private water industry produces only private water. In the initial year, private water has a higher price than vendor water, which in turn is costlier than public water. Figure 2.1 illustrates the structure of production, supply, and demand of water in the Coast region and the rest of Kenya.

$$XST_{jw,reg,t} = B^{XT}_{jw,reg}\left[\sum_{iw}\beta^{XT}_{jw,iw,reg}XS^{\rho^{XT}_{wj}}_{jw,iw,reg,t}\right]^{\rho^{\frac{1}{XT}}_{jw,reg}} \quad \text{(A.7)}$$

$$XS_{jw,iw,reg,t} = \frac{XST_{jw,reg,t}}{\left(B^{XT}_{jw,reg}\right)^{1+\sigma^{XT}_{j,wreg}}}\left[\frac{P_{jw,iw,reg,t}}{\beta^{XT}_{jw,iw,reg}PT_{jw,reg,t}}\right]^{\sigma^{XT}_{jw,reg}} \quad \text{(A.8)}$$

$XS_{js,iw,reg,t}$	Industry *jw* production of commodity *iw* in region *reg*
$XST_{jw,reg,t}$	Total aggregate output of industry *jw* in region *reg*
$P_{jw,iw,reg,t}$	Basic price of industry *jw*'s production of commodity *iw* in region *reg*
$PT_{jw,reg,t}$	Basic price of industry *jw*'s output in region *reg*
$B^{XT}{}_{jw,reg}$	Scale parameter (CET—total output)
$\beta^{X}_{jw,iw}$	Share parameter (CET—exports and local sales)
$\sigma^{XT}_{jw,reg}$	Elasticity (CET—total regional output)
$\rho^{XT}_{jw,reg}$	Elasticity parameter (CET—total regional output)

Unlike other goods and services, water is supplied at the regional level instead of the national market. This means that consumers in the Coast region will be consuming water produced in the region where they reside. An investment in water infrastructure in the Coast region will therefore primarily benefit residents of the Coast region. However, there are possibilities of regional transfers of water. Vendor and private water produced in one region are supplied in the same region. Indeed, water vendors essentially use water supplied through public pipelines and resell those to households and businesses that do not have access to public or private water. It cannot be exported to another region since that would be too costly. Private water is also assumed to be supplied in the region of production. Because the sources of private water are essentially borehole, well, spring, rain, and rivers or ponds, it is reasonable to assume there is no regional transfer. In contrast, public water can be exported to another region. In the presence of interregional water transfers, the output of one region differs from the supply to the same region. To capture this, we adapt the standard PEP model in such a way that each region's production of water is allocated to itself and the other region.[4] We use a Leontief function to capture this where the share of own output supplied to own region and that transferred to the other region are calibrated using data in the social accounting matrix (SAM) (equation A.9). Total supply of water received by each region equals total demand (equation A.10).

$$RDS_{jw,iw,regj,reg,t} = \phi^{RDS}_{jw,iw,regj,reg}XS_{jw,iw,reg,t} \quad \text{(A.9)}$$

$RDS_{jw,iw,regj,reg,t}$	Supply of commodity *iw* by industry *jw* in region *reg* to reg_j

$\phi^{rds}_{jw,iw,regj,reg}$ Share of water industry *jw* output in product *iw* produced by *reg* and supplied to *regj*

$$DDR_{iw,reg,t} = \sum_{jw,regj} RDS_{jw,iw,regj,reg,t} \quad \text{(A.10)}$$

$DDR_{iw,reg,t}$ Domestic demand for commodity *iw* produced locally in region *reg*

As there are no international imports of water, domestic demand of public, vendor, and private water equals total demand in each region (equation A.11).

$$QR_{iw,reg,t} = DDR_{iw,reg,t} \quad \text{(A.11)}$$

$QR_{iw,reg,t}$ Quantity demanded of commodity *iw* at regional level

The demand for public, vendor, and private water in each region consists of intermediate demand and household consumption demand (equation A.12).

$$QR_{iw,reg,t} = \sum_{h} C_{iw,h,reg,t} + \sum_{j} DI_{iw,j,reg,t} \quad \text{(A.12)}$$

$C_{iw,h,reg,t}$ Consumption of commodity *i* by type *h* households

$DI_{iw,j,reg,t}$ Intermediate consumption of commodity *i* by industry *j*

The sum of demands for public, vendor, and private water in each region equals domestic demand for these commodities at the national level (equation A.13).

$$\sum_{reg} DDR_{iw,reg,t} = DD_{iw,t} \quad \text{(A.13)}$$

$DD_{iw,t}$ Domestic demand for commodity *iw* produced locally

Aggregate intermediate consumption is made up of various goods and services, including public, vendor, and private water. We create a composite water commodity (WAT) which combines public, vendor, and private water (*iw1*, *iw2*, and *iw3*) in a CES function (equation A.15). Here, it is still assumed that intermediate inputs are perfectly complementary and are combined following a Leontief production function (equation A.14). The amount of total water needed as an intermediate input in industries' production process is maintained complementary to other intermediate inputs. However, the producer has the possibility of substituting public, vendor, and private water following relative price changes.[5] In this way, if supply increases and price of public water is to fall due to investment in the sector, industries (and households) will have the possibility to shift toward public water by reducing their demand for vendor and/or private water. We use a CES function to capture this behavior.[6]

$$DI_{isw,j,reg,t} = aij_{isw,j,reg} CI_{j,reg,t} \quad \text{(A.14)}$$

$$DI_{iw,j,reg,t} = \left[\frac{\beta^{DI}_{iw,j,reg} PC_{wat,t}}{PCR_{iw,reg,t}}\right]^{\sigma^{DI}_{j,reg}} \left(B^{DI}_{j,reg}\right)^{\sigma^{DI}_{j,reg}-1} DI_{wat,j,reg,t} \quad \text{(A.15)}$$

$DI_{isw,j,reg,t}$	Intermediate consumption of commodity *i* by industry *j*
$CI_{j,reg,t}$	Total intermediate consumption of industry *j*
$PC_{wat,t}$	Purchaser price of composite commodity *wat* (including all taxes and margins)
$PCR_{iw,reg,t}$	Purchaser price of composite commodity *iw* in region *reg* (including all taxes and margins)
$aij_{isw,j,reg}$	Input output coefficient
$B^{DI}{}_{j,reg}$	Scale parameter (CES—composite water)
$\beta^{DI}_{iw,j,reg}$	Share parameter (CES—composite water)
$\rho^{DI}_{j,reg}$	Elasticity parameter (CES—composite water intermediate demand)
$\sigma^{DI}_{j,reg}$	Elasticity (CES—composite water intermediate demand)

The same procedure is applied to household consumption of water. It is assumed that households have Stone-Geary utility functions (equation A.16). This specification offers a degree of flexibility with respect to substitution possibilities in response to relative price changes. At the top level, type *h* household in the Coast region (or the rest of Kenya) can substitute composite water and other goods and services. At the second level, with its budget for composite water consumption, it can choose to consume more water that is public and reduce demand for vendor and private water in response to relative price changes. We use a CES function to capture this behavior (equation A.17).

$$C_{isw,h,reg,t}PC_{isw,t} = C^{MIN}_{isw,h,reg,t}PC_{isw,t} + \gamma^{LES}_{isw,h,reg}\left(CTH_{h,reg,t} - \sum_{iswj} C^{MIN}_{iswj,h,reg,t}PC_{iswj,t}\right) \quad \text{(A.16)}$$

$$C_{iw,h,reg,t} = \left[\frac{\beta^{C}_{iw,h,reg}PC_{wat,t}}{PCR_{iw,reg,t}}\right]^{\sigma^{C}_{h,reg}} \left(B^{C}_{h,reg}\right)^{\sigma^{C}_{h,reg}-1} C_{wat,h,reg,t} \quad \text{(A.17)}$$

$B^{C}{}_{h,reg}$	Scale parameter (CES—composite water)
$\beta^{C}_{iw,h,reg}$	Share parameter (CES—composite water)
$\rho^{C}_{h,reg}$	Elasticity parameter (CES—composite water household demand)
$\sigma^{C}_{h,reg}$	Elasticity (CES—composite water household demand)
$C^{MIN}{}_{isw,h,reg,t}$	Minimum consumption of commodity *i* by type *h* households
$\gamma^{LES}_{isw,h,reg}$	Marginal share of commodity *isw* in household *h* consumption budget
$CTH_{h,reg,t}$	Consumption budget of type *h* households in region *reg*

The different prices depend on the hypotheses and functional forms presented in this section. In aggregations, the price of an aggregate is a weighted sum of the prices of its components. This is the case for the basic price of water industries' production of public, vendor, and private water (equation A.18) at the regional level and the purchase price of composite water at the national level (equation A.21).

$$P_{jw,iw,reg,t} = \frac{\sum_{regj} PRDS_{jw,iw,regj,reg,t}RDS_{jw,iw,regj,reg,t}}{XS_{jw,iw,reg,t}} \quad \text{(A.18)}$$

$P_{jw,iw,reg,t}$ Basic price of industry *jw* production of water *iw* in region *reg*[7]

$PRDS_{jw,iw,regj,reg,t}$ Price of local product *iw* supplied by industry *jw* in region *reg* to region *regj*[8]

Given that there are no taxes on production, the basic price[9] of the regional water industry's output of public, vendor, and private water is equal to the local price excluding taxes on products[10] (equation A.19).

$$PDRS_{jw,iw,regj,reg,t} = PLR_{iw,reg,t} \tag{A.19}$$

$PLR_{iw,reg,t}$ Price of water commodity *iw* in region *reg* (excluding all taxes on products)

The purchaser price and local price are equal because there are no taxes on water (equation A.20).

$$PCR_{iw,reg,t} = PLR_{iw,reg,t} \tag{A.20}$$

$PCR_{iw,reg,t}$ Purchaser price of composite commodity *iw* in region *reg* (including all taxes and margins)

$$PC_{iw,t} = \frac{\sum_{reg} PCR_{iw,reg,t} QR_{iw,reg,t}}{Q_{iw,t}} \tag{A.21}$$

$Q_{iw,t}$ Quantity demanded of composite commodity *i*

Social Accounting Matrix

Production Accounts

There are six crop activities: "maize," "other cereals," "cassava and roots," "pulses and oils," "fruits and vegetables," and "export and other crops." We separate the value of production for each activity in the SAM (column totals) into the Coast and rest of the Kenya regions using the information on total production ratios. For the first three activities, county production statistics from the Ministry of Agriculture (MoA) are used to apportion the value of the production in the SAM into the Coast region and the rest of Kenya. Though we have production information on pulses from the MoA, information on oils is very scanty. We use the same ratio of pulses output in the Coast region to the rest of Kenya for the oils and use the ratios to apportion the SAM output of "pulses and oils" sector. Due to the unavailability of sufficient information on production of other crops in each county, information on area under production (collected from the Kenya Integrated Household Budget Survey [KIHBS] and validated by estimates from the MoA) for fruits, vegetables, and cash crops in the Coast and rest of the Kenya regions are used to separate the output of "fruits and vegetables" and "cash crops" sectors.

The Labour Earnings Survey by KNBS (2010a) gives the value of labor engaged in the "fish and forestry" activities in the Coast and rest of the Kenya regions. Using this information, we split the output of "fish and forestry" in the SAM into the two regions. We use the information on value of livestock in different counties from the CountryStat-Kenya to split the production of "livestock" in the SAM into the Coast region and the rest of Kenya. Mining activities, outputs of all the manufacturing sectors, water, and electricity in the SAM are apportioned into the outputs of the Coast region and the rest of Kenya by using the information provided by the Census of Industrial Production (CIP) on industrial productions (KNBS 2010b) in different counties. For the rest of the activities, namely "construction," "trade," "hotel," "transport and communication," "private services," and "public services," the information on estimates of County Economic Activities by the World Bank and the KNBS is used to separate the production of these sectors in the SAM into the Coast region and the rest of Kenya.

The intermediate demands for an activity in two regions are apportioned based on the output ratios of each region in total activities, assuming that each region maintains the same national intermediate technology coefficients for particular activity.

Factor Accounts

The factor account includes factor inputs or value added (land, labor, capital, livestock, agricultural capital, and nonagricultural capital) used in the production of each activities and the ownership of these factor inputs by households. The distribution of value added by sectors and incomes from the ownership of factors by households need to be divided into the Coast region and the rest of Kenya. The information on the area under crop production, labor costs, and capital expenditures by counties for each crop based on the KIHBS (KNBS 2007b) and CAPS (KNBS 2012) are applied on the value added of land, labor, and agricultural capital to arrive at the distribution for the Coast and the rest of Kenya regions. To derive the nonagricultural capital and labor in the mining and manufacturing activities across the regions, ratios of the Coast region to the rest of Kenya for nonagricultural capital and labor based on the CIP are used. For the rest of the sectors, namely "fish and forestry," "livestock," and services, we apply the respective output ratios between the Coast region to the rest of Kenya.

The KIHBS 2005/06 gives information on the labor earnings, areas under cultivation, value of livestock held by households, agricultural capital expenditures, and capital expenditures (on durables) by households, which are used to derive the factor income distribution by households in each region in the SAM.

Household Consumptions

Detailed crop-wise expenditures by households and counties are taken from the KIHBS 2005/06 (KNBS 2007) and the distributions are applied on the aggregated national household consumption distribution in the SAM to get the consumption expenditures on crops by types of households in both the Coast and the rest of Kenya regions. Similarly, the survey has information on the livestock expenditures by regions. Besides, the household expenditures on the food and nonfood (not including durables) items in the survey give information on the expenditures on fish, textiles, leather products, "processed foods," "other manufacturing," and both private and public services by households in each of the regions. Using this information, we allocate the distribution of consumption expenditures between the Coast and rest of Kenya regions.

Notes

1. This includes agriculture, industry, and services including water. The specificities of the water sector are discussed in later sections.
2. Note that the different types of labor will depend on data we get from the SAM.
3. Water is produced in each region using the technology described in appendix A. The production technology is represented by a nested structure. At the top level, the water output of each of the two water industries in each region combines value added and total intermediate consumption in fixed shares. At the second level, each industry's value added consists of labor and capital, following a constant elasticity of substitution (CES) specification.
4. This specification was integrated in the model because the Coast region is supplied by two water catchments. If at a later stage of this study, it is assumed that water supply through one of the two catchments is to be reduced because of the operationalization of the Mwache Dam, the model is designed to capture such potential regional redistribution of water.
5. Water is not distinguished based on quality but on the user. It is a final consumption good when used by households and an intermediate input when used for production activities. Quality is not considered in the model. The water consumed by households may be used for drinking, cooking cleaning, washing, and so on. Similarly, water consumed by industries may be used to produce food or to clean, cool, and so on. This aspect is not captured in the CGE model. We consider consumption of water by households and industries as a whole regardless of its specific use. Nevertheless, because water can be used for different functions, the three sources of water are necessary. We introduce the possibility of substituting public, vendor, and private water using a CES function. This type of specification allows for substitution between the three types of water (here differentiated essentially by their initial price and sector of production) but avoids situations in which a relative price change results in zero demand for the water commodity that has become relatively more costly because some users do not have access to public water and rely essentially on vendors.
6. The elasticity of substitution between public, vendor, and private water in the CES function is set at six for industries and at three for households. Price elasticity of demand of composite water (WAT) is set at 0.5.
7. For instance, *iw* represents the basic price of vendor water (*iw2*) produced by the public water industry (*jw1*).
8. This could represent the price of public water (*iw1*) produced by the public water industry (*jw1*) in the rest of Kenya (*regj2*) supplied to the Coast region (*reg1*).
9. The public water supply chain includes bulk water suppliers and utilities. The price of bulk water supply is less than the price levied by utilities to end users. The price levied by water vendors is higher than the prices levied by utilities. Water privately produced and provisioned is also much costlier. To account for these differences in prices, the PEP model has different levels of prices. The basic price in the model can represent the price of bulk water. The market price can represent the cost of water levied by utilities to end users as in integrates margins and taxes. It is to be noted that in a CGE model, only relative price changes matter. After having introduced the price difference between bulk water and that supplied by utilities, what matters in the decision making of the household or the industry is the relative price change of the latter compared to the price change of water provisioned by vendor and private suppliers (regardless of the initial situation).
10. Here, because there are no taxes, the sales price of public water (*iw1*) in the Coast region (*reg1*) is equal to the price of public water (*iw1*) produced by the public water industry (*jw1*) in the rest of Kenya (*regj2*) supplied to the Coast region (*reg1*).

Appendix B Equations, List of Variables, and Parameters

Equations

Production

$$VA_{j,reg,t} = v_j XST_{j,reg,t}$$

$$CI_{j,reg,t} = io_{j,reg} XST_{j,reg,t}$$

$$VA_{j,reg,t} = TFP_{j,reg,t}\ B^{VA}_{j,reg} \left[\beta^{VA}_{j,reg} LDC_{j,reg,t}^{-\rho^{VA}_{j,reg}} + \left(1-\beta^{VA}_{j,reg}\right) KD_{j,reg,t}^{-\rho^{VA}_{j,reg}} \right]^{-\frac{1}{\rho^{VA}_{j,reg}}}$$

$$LDC_{j,reg,t} = \left[\frac{\beta^{VA}_{j,reg}}{1-\beta^{VA}_{j,reg}} \frac{RC_{j,reg,t}}{WC_{j,reg,t}} \right]^{\sigma^{VA}_j} KDC_{j,reg,t}$$

$$LDC_{j,reg,t} = B^{LD}_{j,reg} \left[\sum_l \beta^{LD}_{l,j,reg}\ LD_{l,j,reg,t}^{-\rho^{LD}_{j,reg}} \right]^{-\frac{1}{\rho^{LD}_{j,reg}}}$$

$$LD_{l,j,reg,t} = \left[\frac{\beta^{LD}_{l,j,reg}\ WC_{j,reg,t}}{WTI_{l,j,reg,t}} \right]^{\sigma^{LD}_{j,reg}} \left(B^{LD}_{j,reg}\right)^{\sigma^{LD}_{j,reg}-1} LDC_{j,reg,t}$$

$$KDC_{j,reg,t} = B^{KD}_{j,reg} \left[\sum_k \beta^{KD}_{k,j,reg}\ KD_{k,j,reg,t}^{-\rho^{KD}_{j,reg}} \right]^{-\frac{1}{\rho^{KD}_{j,reg}}}$$

$$KD_{k,j,reg,t} = \left[\frac{\beta^{KD}_{k,j,reg}\ RC_{j,reg,t}}{RTI_{k,j,reg,t}} \right]^{\sigma^{KD}_{j,reg}} \left(B^{KD}_{j,reg}\right)^{\sigma^{KD}_{j,reg}-1} KDC_{j,reg,t}$$

$$DI_{isw,j,reg,t} = aij_{isw,j,reg} CI_{j,reg,t}$$

$$DI_{iw,j,reg,t} = \left[\frac{\beta^{DI}_{iw,j,reg}\ PC_{wat,t}}{PCR_{iw,reg,t}} \right]^{\sigma^{DI}_{j,reg}} \left(B^{DI}_{j,reg}\right)^{\sigma^{DI}_{j,reg}-1} DI_{wat,j,reg,t}$$

Income and Savings

Households

$$YH_{h,reg,t} = YHL_{h,reg,t} + YHK_{h,reg,t}$$

$$YHL_{h,t} = \sum_l \left[\lambda^{WL}_{h,reg,l} \sum_{j,regj} \left(W_{l,regj,t} LD_{l,j,regj,t} \right) \right]$$

$$YHK_{h,reg,t} = \sum_k \left[\lambda^{RKH}_{h,reg,t} \left(\sum_{j,regj} R_{k,j,regj,t} KD_{k,j,regj,t} \right) \right]$$

$$YDH_{h,reg,t} = YH_{h,reg,t} - TDH_{h,reg,t}$$

$$CTH_{h,reg,t} = YDH_{h,reg,t} - SH_{h,reg,t}$$

$$SH_{h,reg,t} = PIXCON^{\eta}_t sh0_{h,reg,t} + sh1_{h,reg,t} YDH_{h,reg,t}$$

Government

$$YG_t = YGK_t + TDHT_t + TPRODN_t + TPRCTS_t + YGTR_t$$

$$YGK_t = \sum_k \left[\lambda^{RK}_{gvt,k} \left(\sum_{j,reg} R_{k,j,reg,t} KD_{k,j,reg,t} \right) \right]$$

$$TDHT_t = \sum_{h,reg} TDH_{h,reg,t}$$

$$TPRODN_t = TIWT_t + TIKT_t + TIPT_t$$

$$TIWT_t = \sum_{l,j,reg} TIW_{l,j,reg,t}$$

$$TIKT_t = \sum_{k,j,reg} TIK_{k,j,reg,t}$$

$$TIPT_t = \sum_{j,reg} TIP_{j,reg,t}$$

$$TIPRCTS_t = TICT_t + TIMT_t + TIXT_t$$

$$TICT_t = \sum_i TIC_{i,t}$$

$$TIMT_t = \sum_i TIM_{i,t}$$

$$TIXT_t = \sum_i TIX_{i,t}$$

$$YGTR_t = \sum_{agng} TR_{gvt,agng,t}$$

$$TDH_{h,reg,t} = PIXCON^{\eta}_t \, ttdh0_{h,reg,t} + ttdh1_{h,reg,t} YH_{h,reg,t}$$

$$TIW_{l,j,reg,t} = ttiw_{l,j,reg,t} W_{l,reg,t} LD_{l,j,reg,t}$$

$$TIK_{k,j,reg,t} = ttik_{k,j,reg,t} R_{k,j,reg,t} KD_{k,j,reg,t}$$

$$TIP_{j,reg,t} = ttip_{j,reg,t} PP_{j,reg,t} XS_{j,reg,t}$$

$$TIC_{i,t} = ttic_{i,t}\left[PL_{i,t} + \sum_{ij} PC_{ij,t} tmrg_{ij,i}\right] DD_{i,t} + \left[\left(1+ttim_{i,t}\right) PWM_{i,t}\ e_t + \sum_{ij} PC_{ij,t} tmrg_{ij,i}\right] IM_{m,t}$$

$$TIM_{i,t} = ttim_{i,t} PWM_{i,t}\ e_t\ IM_{i,t}$$

$$TIX_{i,t} = ttix_{i,t}\left(PE_{i,t} + \sum_{ij} PC_{ij,t} tmrg^{X}_{ij,i}\right) EXD_{i,t}$$

$$SG_t = YG_t - \sum_{agng} TR_{agng,gvt,t} - G_t$$

Rest of the World

$$YROW_t = e_t \sum_m PWM_{m,t} IM_{m,t} + \sum_k \left[\lambda^{RK}_{row,k}\left(\sum_{j,reg} R_{k,j,reg,t} KD_{k,j,reg,t}\right)\right] + \sum_{nh} TR_{row,nh,t}$$

$$SROW_t = YROW_t - \sum_i PE^{FOB}_{i,t} EXD_{i,t} - \sum_{nh} TR_{nh,row,t}$$

$$SROW_t = -CAB_t$$

Transfers

$$TR_{nh,gvt,t} = PIXCON^{\eta}_t\ TR^{O}_{nh,gvt}\ pop_t$$

$$TR_{nh,row,t} = PIXCON^{\eta}_t\ TR^{O}_{nh,row}\ pop_t$$

Demand

$$C_{isw,h,reg,t} PC_{isw,t} = C^{MIN}_{isw,h,reg,t} PC_{isw,t} + \gamma^{LES}_{isw,h,reg}\left(CTH_{h,reg,t} - \sum_{iswj} C^{MIN}_{iswj,h,reg,t} PC_{iswj,t}\right)$$

$$C_{iw,h,reg,t} = \left[\frac{\beta^{C}_{iw,h,reg}\ PC_{wat,t}}{PCR_{iw,reg,t}}\right]^{\sigma^{C}_{h,reg}} \left(B^{C}_{h,reg}\right)^{\sigma^{C}_{h,reg}-1} C_{wat,h,reg,t}$$

$$GFCF_t = IT_t - \sum_i PC_{i,t}\ VSTK_{i,t}$$

$$PC_{i,t} INV^{PRI}_{i,t} = \gamma^{INVPRI}_i IT^{PRI}_t$$

$$PC_{i,t} INV^{PUB}_{i,t} = \gamma^{INVPUB}_i IT^{PUB}_t$$

$$INV_{i,t} = INV_{i,t}^{PRI} + INV_{i,t}^{PUB}$$

$$PC_{i,t}CG_{i,t} = \gamma_i^{GVT} G_t$$

$$DIT_{i,t} = \sum_j DI_{i,j,t}$$

$$MRGN_{i,t} = \sum_{ij} tmrg_{i,ij} D_{ij,t} + \sum_{ij} tmrg_{i,ij} \; IM_{ij,t} + \sum_{ij} tmrg_{i,ij}^{X} \; EXD_{ij,t}$$

Producer Supplies of Products and International Trade

$$XST_{j,reg,t} = B_{j,reg}^{XT} \left[\sum_i \beta_{j,i,reg}^{XT} XS_{j,i,reg,t}^{\rho_j^{XT}} \right]^{\frac{1}{\rho_{j,reg}^{XT}}}$$

$$XS_{j,i,reg,t} = \frac{XST_{j,reg,t}}{\left(B_{j,reg}^{XT}\right)^{1+\sigma_{j,reg}^{XT}}} \left[\frac{P_{j,i,reg,t}}{\beta_{j,i,reg}^{XT} \; PT_{j,reg,t}} \right]^{\sigma_{j,reg}^{XT}}$$

$$RXS_{jsw,i,t} = B_{jsw,i}^{XTR} \left[\sum_{reg} \beta_{jsw,i,reg}^{XTR} XS_{jsw,i,reg,t}^{\rho_{jsw,i}^{XTR}} \right]^{\frac{1}{\rho_{jsw,i}^{XTR}}}$$

$$XS_{jsw,i,reg,t} = \frac{RXS_{jsw,i,t}}{\left(B_{jsw,i}^{XTR}\right)^{1+\sigma_{jsw,i}^{XTR}}} \left[\frac{P_{jsw,i,reg,t}}{\beta_{jsw,i,reg}^{XTR} \; PRXS_{jsw,i,t}} \right]^{\sigma_{jsw,i}^{XTR}}$$

$$RXS_{jsw,i,t} = B_{jsw,i}^{X} \left[\beta_{jsw,i}^{X} EX_{jsw,i,t}^{\rho_{jsw,i}^{X}} + \left(1-\beta_{jsw,i}^{X}\right) DS_{jsw,i,t}^{\rho_{jsw,i}^{X}} \right]^{\frac{1}{\rho_{jsw,i}^{X}}}$$

$$EX_{jsw,i,t} = \left[\frac{1-\beta_{jsw,i}^{X}}{\beta_{jsw,i}^{X}} \frac{PE_{i,t}}{PL_{i,t}} \right]^{\sigma_{jsw,i}^{X}} DS_{jsw,i,t}$$

$$EXD_{i,t} = EXD_i^{O} \left(\frac{e_t \; PWX_{i,t}}{PE_{i,t}^{FOB}} \right)^{\sigma_i^{XD}}$$

62rds. $RDS_{jw,iw,regj,reg,t} = \varphi_{jw,iw,regj,reg}^{RDS} XS_{jw,iw,reg,t}$

$$Q_{i,t} = B_i^{M} \left[\beta_i^{M} IM_{i,t}^{-\rho_i^{M}} + \left(1-\beta_i^{M}\right) DD_{i,t}^{-\rho_i^{M}} \right]^{\frac{-1}{\rho_i^{M}}}$$

$$IM_{i,t} = \left[\frac{\beta_i^M}{1-\beta_i^M} \frac{PD_{i,t}}{PM_{i,t}} \right]^{\sigma_i^M} DD_{i,t}$$

Prices

Production

$$PP_{j,reg,t} = \frac{PVA_{j,reg,t} VA_{j,reg,t} + PCI_{j,reg,t} CI_{j,reg,t}}{XST_{j,reg,t}}$$

$$PT_{j,reg,t} = \left(1 + ttip_{j,reg,t}\right) PP_{j,reg,t}$$

$$PCI_{j,reg,t} = \frac{\sum_i PC_{i,t} DI_{i,j,reg,t}}{CI_{j,reg,t}}$$

$$PVA_{j,reg,t} = \frac{WC_{j,reg,t} LDC_{j,reg,t} + RC_{j,reg,t} KDC_{j,reg,t}}{VA_{j,reg,t}}$$

$$WC_{j,reg,t} = \frac{\sum_l WTI_{l,j,reg,t} LD_{l,j,reg,t}}{LDC_{j,reg,t}}$$

$$WTI_{l,j,reg,t} = W_{l,reg,t} \left(1 + ttiw_{l,j,reg,t}\right)$$

$$RC_{j,reg,t} = \frac{\sum_k R_{k,j,reg,t} KD_{k,j,reg,t}}{KDC_{j,reg,t}}$$

$$RTI_{k,j,reg,t} = R_{k,j,reg,t} \left(1 + ttik_{k,j,reg,t}\right)$$

74a. $R_{k1,j,reg,t} = RK_{k1,reg,t}$

$$PT_{j,reg,t} = \frac{\sum_i P_{j,i,reg,t} \; XS_{j,i,reg,t}}{XST_{j,reg,t}}$$

$$P_{j,i,reg,t} = PT_{j,reg,t} \left\{ if \;\; XSO_{j,i,reg} = XSTO_{j,reg} \right\}$$

$$P_{jsw,i,reg,t} = PRXS_{jsw,i,t} \left\{ if \;\; XSO_{jsw,i,reg} = RXSO_{jsw,i} \right\}$$

$$P_{jw,iw,reg,t} = \frac{\sum_{regj} PRDS_{jw,iw,regj,reg,t} RDS_{jw,iw,regj,reg,t}}{XS_{jw,iw,reg,t}}$$

International Trade

$$PRXS_{jsw,i,t} = \frac{PE_{i,t}EX_{jsw,i,t} + PL_{i,t}DS_{jsw,i,t}}{RXS_{jsw,i,t}}$$

$$PE_{i,t}^{FOB} = \left[PE_{i,t} + \sum_{ij} PC_{ij,t}\, tmrg_{ij,i}^{X} \right] \left(1 + ttix_{i,t}\right)$$

$$PD_{i,t} = \left(1 + ttic_{i,t}\right) \left(PL_{i,t} + \sum_{ij} PC_{ij,t}\, tmrg_{ij,i} \right)$$

$$PM_{i,t} = \left(1 + ttic_{i,t}\right) \left[\left(1 + ttim_{i,t}\right) PWM_{i,t}\, e_t + \left(\sum_{ij} PC_{ij,t}\, tmrg_{ij,i} \right) \right]$$

$$PC_{i,t} = \frac{PM_{i,t}\, IM_{i,t} + PD_{i,t}D_{i,t}}{Q_{i,t}}$$

$$PC_{wat,t} = \frac{\sum_{iw,h,reg} PC_{iw,t}C_{iw,h,reg,t}}{\sum_{h,regj} C_{wat,h,regj,t}}$$

$$PRDS_{jw,iw,regj,reg,t} = PLR_{iw,reg,t}$$

$$PCR_{iw,reg,t} = PLR_{iw,reg,t}$$

$$PC_{iw,t} = \frac{\sum_{reg} PCR_{iw,reg,t}QR_{iw,reg,t}}{Q_{iw,t}}$$

Price Indexes

$$PIXGDP_t = \sqrt{ \frac{\sum_{j,reg} \left(PVA_{j,reg,t} + \frac{TIP_{j,reg,t}}{VA_{j,reg,t}} \right) VA_{j,reg}^{O}}{\sum_{j,reg} \left(PVA_{j,reg}^{O} VA_{j,reg}^{O} + TIP_{j,reg}^{O} \right)} \frac{\sum_{j,reg} \left(PVA_{j,reg,t} VA_{j,reg,t} + TIP_{j,reg,t} \right)}{\sum_{j,reg} \left(PVA_{j,reg}^{O} + \frac{TIP_{j,reg}^{O}}{VA_{j,reg}^{O}} \right) VA_{j,reg,t}} }$$

$$RPIXGDP_{reg,t} = \sqrt{ \frac{\sum_{j} \left(PVA_{j,reg,t} + \frac{TIP_{j,reg,t}}{VA_{j,reg,t}} \right) VA_{j,reg}^{O}}{\sum_{j} \left(PVA_{j,reg}^{O} VA_{j,reg}^{O} + TIP_{j,reg}^{O} \right)} \frac{\sum_{j} \left(PVA_{j,reg,t} VA_{j,reg,t} + TIP_{j,reg,t} \right)}{\sum_{j} \left(PVA_{j,reg}^{O} + \frac{TIP_{j,reg}^{O}}{VA_{j,reg}^{O}} \right) VA_{j,reg,t}} }$$

$$PIXCON_t = PIXCON_{t-1} \frac{\sum_{i} PC_{i,t} \sum_{h,reg} C_{i,h,reg,t-1}}{\sum_{ij} PC_{ij,t-1} \sum_{h,reg} C_{ij,h,reg,t-1}},$$

$$PIXCON_t = \frac{\sum_i PC_{i,t} \sum_{h,reg} C^O_{i,h,reg}}{\sum_{ij} PC^O_{ij} \sum_{h,reg} C^O_{ij,h,reg}}$$

$$PIXINV^{PRI}_t = \prod_i \left(\frac{PC_{i,t}}{PC^O_i} \right)^{\gamma_i^{INVPRI}},$$

$$PIXINV^{PUB}_t = \prod_i \left(\frac{PC_{i,t}}{PC^O_i} \right)^{\gamma_i^{INVPUB}},$$

$$PIXGVT_t = \prod_i \left(\frac{PC_{i,t}}{PC^O_i} \right)^{\gamma_i^{GVT}}$$

Equilibrium

$$Q_{inw,t} = \sum_{h,reg} C_{inw,h,reg,t} + CG_{inw,t} + INV_{inw,t} + DIT_{inw,t} + MRGN_{inw,t}$$

$$QR_{iw,reg,t} = DDR_{iw,reg,t}$$

$$QR_{iw,reg,t} = \sum_h C_{iw,h,reg,t} + \sum_j DI_{iw,j,reg,t}$$

$$\sum_j LD_{l,j,reg,t} = LS_{l,t}$$

$$\sum_j KD_{k,j,t} = KS_{k,t}$$

$$IT_t = \sum_h SH_{h,t} + SG_t + SROW_t$$

$$IT^{PRI}_t = IT_t - IT^{PUB}_t - \sum_i PC_{i,t}\, VSTK_{i,t}$$

$$\sum_{jsw} DS_{jsw,inw,t} = DD_{inw,t}$$

$$\sum_{reg} DDR_{iw,reg,t} = DD_{iw,t}$$

$$DDR_{iw,reg,t} = \sum_{jw,regj} RDS_{jw,iw,regj,reg,t}$$

$$\sum_{jsw} EX_{jsw,i,t} = EXD_{i,t}$$

Gross Domestic Product

$$GDP_t^{BP} = \sum_{j,reg} PVA_{j,reg,t} VA_{j,reg,t} + TIPT_t$$

$$RGDP_{reg,t}^{BP} = \sum_{j} PVA_{j,reg,t} VA_{j,reg,t} + \sum_{j} TIP_{j,reg,t}$$

$$GDP_t^{MP} = GDP_t^{BP} + TPRCTS_t$$

$$GDP_t^{IB} = \sum_{l,j,reg} W_{l,reg,t} LD_{l,j,reg,t} + \sum_{k,j,reg} R_{k,j,reg,t} KD_{k,j,reg,t} + TPRODN_t + TPRCTS_t$$

$$GDP_t^{FD} = \sum_i PC_{i,t} \left[\sum_{h,reg} C_{i,h,reg,t} + CG_{i,t} + INV_{i,t} + VSTK_{i,t} \right] + \sum_i PE_{i,t}^{FOB} EX_{i,t} - \sum_i e_t PWM_{i,t} IM_{i,t}$$

Real Variables

$$CTH_{h,reg,t}^{REAL} = CTH_{h,reg,t} / PIXCON_t$$

$$G_t^{REAL} = G_t / PIXGVT_t$$

$$GDP_t^{BP\_REAL} = GDP_t^{BP} / PIXGDP_t$$

99a. $RGDP_{reg,t}^{BP\_REAL} = RGDP_{reg,t}^{BP} / RPIXGDP_{reg,t}$

$$GDP_t^{MP\_REAL} = GDP_t^{MP} / PIXCON_t$$

$$GFCF_t^{PRI\_REAL} = IT_t^{PRI} / PIXINV_t^{PRI}$$

$$GFCF_t^{PUB\_REAL} = IT_t^{PUB} / PIXINV_t^{PUB}$$

Dynamic Equations

$$KD_{k,j,reg,t+1} = KD_{k,j,reg,t} \left(1 - \delta_{k,j,reg}\right) + IND_{k,j,reg,t}$$

$$IT_t^{PUB} = PK_t^{PUB} \sum_{k,pub,reg} IND_{k,pub,reg,t}$$

$$IT_t^{PRI} = PK_t^{PRI} \sum_{k,bus,reg} IND_{k,bus,reg,t}$$

$$PK_t^{PRI} = A^{K\_BUS} \prod_i \left[\frac{PC_{i,t}}{\gamma_i^{INVPRI}} \right]^{\gamma_i^{INVPRI}}$$

$$PK_t^{PUB} = A^{K\_PUB} \prod_i \left[\frac{PC_{i,t}}{\gamma_i^{INVPUB}} \right]^{\gamma_i^{INVPUB}}$$

$$IND_{k,bus,reg,t} = \varphi_{k,bus,reg} \left[\frac{R_{k,bus,reg,t}}{U_{k,bus,reg,t}} \right]^{\sigma_{k,bus,reg}^{INV}} KD_{k,bus,reg,t}$$

$$U_{k,bus,reg,t} = PK_t^{PRI} \left(\delta_{k,bus,reg} + IR_t \right)$$

$$U_{k,pub,reg,t} = PK_t^{PUB} \left(\delta_{k,pub,reg} + IR_t \right)$$

$$LS_{l,reg,t+1} = LS_{l,reg,t} \left(1 + n_t \right)$$

$$KS_{k1,reg,t+1} = KS_{k1,reg,t} \left(1 + n_t \right)$$

$$CAB_{t+1} = CAB_t \left(1 + n_t \right)$$

$$C_{i,h,reg,t+1}^{MIN} = C_{i,h,reg,t}^{MIN} \left(1 + n_t \right)$$

$$G_{t+1} = G_t \left(1 + n_t \right)$$

$$IND_{k,pub,reg,t+1} = IND_{k,pub,reg,t+1} \left(1 + n_t \right)$$

$$VSTK_{t+1} = VSTK_t \left(1 + n_t \right)$$

Sets, Variables, and Parameters

Industries and Commodities

All industries:

$$j, jj \in J = \{A1, \ldots\ldots A21\}$$

A1: maize; A2: other cereals; A3: cassava and root crops; A4: pulses and oil seeds; A5: fruit and vegetables: A6: cash crops; A7: livestock; A8: fishery forestry; A9: mining, A10: food processing; A11: textile and leather; A12: other manufacturing; A13: public water; A14: private water; A15: electricity; A16: construction; A17: trade; A18: hotel; A19: transport and communication; A20: other private services; A21: public services.

All industries except water:

$$jsw, jswj \in J = \{A1,....A12, A15....A21\}$$

Water industry:

$$jw, jwj \in J = \{A13, A14\}$$

Public sector:

$$pub, pubj \in J = \{A13, A21\}$$

Private sector:

$$bus, busj \in J = \{A1,....A12, A14....A21\}$$

All commodities:

$$itot, itotj \in ITOT = \{C1,....C21, WAT\}$$

C1: maize; C2: other cereals; C3: cassava and root crops; C4: pulses and oil seeds; C5: fruit and vegetables; C6: cash crops; C7: livestock; C8: fishery forestry; C9: mining; C10: food processing; C11: textile and leather; C12: other manufacturing; C13: water supplied through public pipeline; C14: water supplied through water vendors; C15: water supplied via private sources; C16: electricity; C17: construction; C18: trade; C19: hotel and restaurant; C20: transport and communication; C21: other services; C22: public services, WAT composite water (public + vendor + private)

All commodities except WAT:

$$i, ij \in ITOT = \{C1,....C22\}$$

All commodities except the three water commodities:

$$isw, iswj \in ITOT = \{C1,....C12, C16....C22, WAT\}$$

The two water commodities:

$$iw, iwj \in I = \{C13, C14, C15\}$$

All commodities except the four water commodities:

$$inw, inwj \in I = \{C1,...C12, C16,....C22\}$$

Production Factors

Labor Categories

$$l, lj \in L = \{l1,...l4\}$$

L1: agricultural labor employed in the rest of Kenya

L2: nonagricultural labor employed in the rest of Kenya

L3: agricultural labor employed in the Coast region

L4: nonagricultural labor employed in the Coast region

Capital Categories

$$k, kj \in K = \{\ln d1, \ln d2, liv1, liv2, kag1, kag2, kna\}$$

Lnd1: land employed in rest of Kenya

Lnd2: land employed in the Coast region

Liv1: livestock employed in rest of Kenya

Liv2: livestock employed in the Coast region

kag1: agricultural capital employed in rest of Kenya

kag2: agricultural capital employed in the Coast region

kna: nonagricultural capital

Land and Livestock Capital

$$k1, k1j \in K = \{\ln d1, \ln d2, liv1, liv2\}$$

Land Capital

$$land, landj \in K1 = \{\ln d1, \ln d2\}$$

Agricultural and Nonagricultural Capital

$$k2, k2j \in K = \{kag1, kag2, kna\}$$

Agents

All Agents

$$ag, agj \in AG = H \cup \{GVT, ROW\}$$
$$= \{hrur1, hrur2, hrur3, hrur4, hrur5, hurb1, hurb2, hurb3, hurb4, hurb5, GVT, ROW\}$$

Hrur1: rural households in quintile 1

Hrur2: rural households in quintile 2

Hrur3: rural households in quintile 3

Hrur4: rural households in quintile 4

Hrur5: rural households in quintile 5

Hurb1: urban households in quintile 1

Hurb2: urban households in quintile 2

Hurb3: urban households in quintile 3

Hurb4: urban households in quintile 4

Hurb5: urban households in quintile 5

GVT: government

ROW: rest of the world

Household Categories

$$h, hj \in H \subset AG = \{hrur1, hrur2, hrur3, hrur4, hrur5, hurb1, hurb2, hurb3, hurb4, hurb5\}$$

Nongovernmental Agents

$$agng \in AGNG \subset AG = H \cup \{ROW\} = \{hrur1, hrur2, hrur3, hrur4, hrur5, hurb1, hurb2, hurb3, hurb4, hurb5, ROW\}$$

Domestic Agents

$$agd \in AGD \subset AG = H \cup \{GVT\} = \{hrur1, hrur2, hrur3, hrur4, hrur5, hurb1, hurb2, hurb3, hurb4, hurb5, GVT\}$$

All agents other than households:

$$nh, nhj \in AG = \{GVT, ROW\}$$

Periods

Periods: $t \in T = \{T_1 ......T_n\}$

Regions

Regions: $reg, regj \in REG = \{R_1, R_2\}$

R2: Rest of Kenya

R1: Coast region

Variables

NOTE 1: In what follows, the word *taxes* should be understood as taxes minus subsidies.

NOTE 2: Subscript *t* is the time subscript. To avoid overloading the descriptions, the words *at time t* have been deleted from the variable descriptions.

NOTE 3: Subscript *reg* is the regional subscript. To avoid overloading the description, the terms *in region reg* has been deleted from the parameter descriptions.

Volume Variables

$C_{itot,h,reg,t}$	Consumption of commodity *i* by type *h* households
$C^{MIN}{}_{isw,h,reg,t}$	Minimum consumption of commodity *i* by type *h* households
$CG_{i,t}$	Public consumption of commodity *i* (volume)
$CI_{j,reg,t}$	Total intermediate consumption of industry *j*
$CTH^{REAL}{}_{h,reg,t}$	Real consumption expenditures of household *h*
$DD_{i,t}$	Domestic demand for commodity *i* produced locally
$DDR_{iw,reg,t}$	Domestic demand for commodity *iw* produced locally in region *reg*
$DI_{itot,j,reg,t}$	Intermediate consumption of commodity *i* by industry *j*
$DIT_{i,t}$	Total intermediate demand for commodity *i*
$DS_{j,i,t}$	Supply of commodity *i* by sector *j* to the domestic market
$RDS_{jw,iw,regj,reg,t}$	Supply of commodity *iw* by industry *jw* to in region reg to regj
$EX_{j,i,t}$	Quantity of product *i* exported by sector *j*
$EXD_{i,t}$	World demand for exports of product *i*
$G^{REAL}{}_{t}$	Real government expenditures
$GDP^{BP\_REAL}{}_{t}$	Real gross domestic product (GDP) at basic prices
$RGDP^{BP\_REAL}{}_{reg,t}$	Real GDP at basic price at regional level
$GDP^{MP\_REAL}{}_{t}$	Real GDP at market prices
$GFCF^{PRI\_REAL}{}_{t}$	Real private gross fixed capital formation
$GFCF^{PUB\_REAL}{}_{t}$	Real public gross fixed capital formation
$IM_{i,t}$	Quantity of product *i* imported
$IND_{k,j,reg,t}$	Volume of new type *k* capital investment to sector *j*
$INV_{i,t}$	Final demand of commodity *i* for investment purposes
$INV^{PRI}{}_{i,t}$	Final demand of commodity *i* for private investment purposes
$INV^{PUB}{}_{i,t}$	Final demand of commodity *i* for public investment purposes
$KD_{k,j,reg,t}$	Demand for type *k* capital by industry *j*
$KDC_{j,reg,t}$	Industry *j* demand for composite capital
$KS_{k,reg,t}$	Supply of type *k* capital
$LD_{l,j,reg,t}$	Demand for type *l* labor by industry *j*
$LDC_{j,reg,t}$	Industry *j* demand for composite labor
$LS_{l,reg,t}$	Supply of type *l* labor
$MRGN_{i,t}$	Demand for commodity *i* as a trade or transport margin
$Q_{i,t}$	Quantity demanded of composite commodity *i*
$QR_{iw,reg,t}$	Quantity demanded of commodity *iw* at regional level
$RXS_{jsw,i,t}$	National aggregate output of jsw industry in commodity i
$VA_{j,reg,t}$	Value added of industry *j* in region *reg*
$VSTK_{i,t}$	Inventory change of commodity *i*
$XS_{j,i,reg,t}$	Industry *j* production of commodity *i in region reg*
$XST_{j,reg,t}$	Total aggregate output of industry *j* in region reg

Price Variables

e_t	Exchange rate (price of foreign currency in local currency)
IR_t	Interest rate
$P_{j,i,reg,t}$	Basic price of industry *j*'s production of commodity *i* in region *reg*
$PC_{itot,t}$	Purchaser price of composite commodity *itot* (including all taxes and margins)
$PCR_{iw,reg,t}$	Purchaser price of composite commodity *iw* in region *reg* (including all taxes and margins)
$PCI_{j,reg,t}$	Intermediate consumption price index of industry *j* in region *reg*
$PD_{i,t}$	Price of local product *i* sold on the domestic market (including all taxes and margins)
$PRDS_{jw,iw,regj,reg,t}$	Price of local product *iw* supplied by industry *jw* in region *reg* to region *regj*
$PE_{i,t}$	Price received for exported commodity *i* (excluding export taxes)
$PE^{FOB}{}_{i,t}$	FOB price of exported commodity *i* (in local currency)
$PIXCON_t$	Consumer price index
$PIXGDP_t$	GDP deflator
$RPIXGDP_{reg,t}$	Regional GDP deflator
$PIXGVT_t$	Public expenditures price index
$PIXINV^{PRI}{}_t$	Private investment price index
$PIXINV^{PUB}{}_t$	Public investment price index
$PK^{PRI}{}_t$	Price of new private capital
$PK^{PUB}{}_t$	Price of new public capital
$PL_{i,t}$	Price of local product *i* (excluding all taxes on products)
$PLR_{iw,reg,t}$	Price of product *iw* in region *reg* (excluding all taxes on products)
$PM_{i,t}$	Price of imported product *i* (including all taxes and tariffs)
$PP_{j,reg,t}$	Industry *j* in region *reg* unit cost including taxes directly related to the use of capital and labor but excluding other taxes on production
$PT_{j,reg,t}$	Basic price of industry *j*'s output in region *reg*
$PRXS_{jsw,i,t}$	Basic price of industry *jsw*'s production of commodity *i*
$PVA_{j,reg,t}$	Price of industry *j* value added in region *reg* (including taxes on production directly related to the use of capital and labor)
$PWM_{i,t}$	World price of imported product *i* (expressed in foreign currency)
$PWX_{i,t}$	World price of exported product *i* (expressed in foreign currency)
$R_{k,j,reg,t}$	Rental rate of type *k* capital in industry *j* in region *reg*
$RC_{j,reg,t}$	Rental rate of industry *j* composite capital in region *reg*
$RTI_{k,j,reg,t}$	Rental rate paid by industry *j* in region *reg* for type *k* capital including capital taxes
$RK_{k,reg,t}$	Rental rate of type *k1* capital in region *reg*
$U_{k,j,reg,t}$	User cost of type *k* capital in industry *j* in region *reg*

$W_{l,reg,t}$	Wage rate of type *l* labor employed in region *reg*
$WC_{j,reg,t}$	Wage rate of industry *j* composite labor in region *reg*
$WTI_{l,j,reg,t}$	Wage rate paid by industry *j* in region *reg* for type *l* labor including payroll taxes

Nominal Values

CAB_t	Current account balance
$CTH_{h,reg,t}$	Consumption budget of type *h* households in region *reg*
G_t	Current government expenditures on goods and services
$GDP^{BP}{}_t$	GDP at basic prices
$RGDP^{BP}{}_{reg,t}$	Regional GDP at basic prices
$GDP^{FD}{}_t$	GDP at purchasers' prices from the perspective of final demand
$GDP^{IB}{}_t$	GDP at market prices (income-based)
$GDP^{MP}{}_t$	GDP at market prices
$GFCF_t$	Gross fixed capital formation
IT_t	Total investment expenditures
$IT^{PRIT}{}_t$	Total private investment expenditures
$IT^{PUBT}{}_t$	Total public investment expenditures
SG_t	Government savings
$SH_{h,reg,t}$	Savings of type *h* households by region
$SROW_t$	Rest-of-the-world savings
$TDH_{h,reg,t}$	Income taxes of type *h* households by region
$TDHT_t$	Total government revenue from household income taxes
$TIC_{i,t}$	Government revenue from indirect taxes on product *i*
$TICT_t$	Total government receipts of indirect taxes on commodities
$TIK_{k,j,reg,t}$	Government revenue from taxes on type *k* capital used by industry *j*
$TIKT_t$	Total government revenue from taxes on capital
$TIM_{i,t}$	Government revenue from import duties on product *i*
$TIMT_t$	Total government revenue from import duties
$TIP_{j,reg,t}$	Government revenue from taxes on industry *j* production (excluding taxes directly related to the use of capital and labor)
$TIPT_t$	Total government revenue from production taxes (excluding taxes directly related to the use of capital and labor)
$TIW_{l,j,reg,t}$	Government revenue from payroll taxes on type *l* labor in industry *j*
$TIWT_t$	Total government revenue from payroll taxes
$TIX_{i,t}$	Government revenue from export taxes on product *i*
$TIXT_t$	Total government revenue from export taxes
$TPRCTS_t$	Total government revenue from taxes on products and imports
$TPRODN_t$	Total government revenue from other taxes on production
$TR_{nh,nhj,t}$	Transfers from agent *agj* to agent *ag*

$YDH_{h,reg,t}$	Disposable income of type *h* households
YG_{t}	Total government income
YGK_{t}	Government capital income
$YGTR_{t}$	Government transfer income
$YH_{h,reg,t}$	Total income of type *h* households
$YHK_{h,reg,t}$	Capital income of type *h* households
$YHL_{h,reg,t}$	Labor income of type *h* households
$YROW_{t}$	Rest-of-the-world income

Rates, Intercepts, and Other Variable Parameters

The following are parameters that are formally treated as exogenous variables.

$sh0_{h,reg,t}$	Intercept (type *h* household savings in region *reg*)
$sh1_{h,reg,t}$	Slope (type *h* household savings in region *reg*)
$ttdh0_{h,reg,t}$	Intercept (income taxes of type *h* households in region *reg*)
$ttdh1_{h,reg,t}$	Marginal income tax rate of type h households in region reg
$ttic_{i,t}$	Tax rate on commodity *i*
$ttik_{k,j,reg,t}$	Tax rate on type k capital used in industry *j* in region *reg*
$ttim_{i,t}$	Rate of taxes and duties on imports of commodity *m*
$ttip_{j,reg,t}$	Tax rate on the production of industry *j* in region *reg*
$ttiw_{l,j,reg,t}$	Tax rate on type *l* worker compensation in industry *j* in region *reg*
$ttix_{i,t}$	Export tax rate on exported commodity *i*

Parameters

$aij_{itot,j,reg}$	Input output coefficient
α	Tobin *q*
A^{K_PRI}	Scale parameter (private investment funtion)
A^{K_PUB}	Scale parameter (public investment funtion)
$B^{KD}{}_{j,reg}$	Scale parameter (CES—composite capital)
$B^{LD}{}_{j,reg}$	Scale parameter (CES—composite labor)
$B^{C}{}_{h,reg}$	Scale parameter (CES—composite water)
$B^{DI}{}_{j,reg}$	Scale parameter (CES—composite water)
$B^{M}{}_{i}$	Scale parameter (CES—composite commodity)
$B^{VA}{}_{j,reg}$	Scale parameter (CES—value added)
$B^{X}{}_{j,i}$	Scale parameter (CET—exports and local sales)
$B^{XT}{}_{j,reg}$	Scale parameter (CET—total output)
$\mathrm{B}^{\mathrm{XTR}}{}_{\mathrm{j,i}}$	Scale parameter (CET—total output)
$\beta^{KD}_{k,j,reg}$	Share parameter (CES—composite capital)
$\beta^{LD}_{l,j,reg}$	Share parameter (CES—composite labor)
$\beta^{C}_{iw,h,reg}$	Share parameter (CES—composite water)
$\beta^{DI}_{iw,j,reg}$	Share parameter (CES—composite water)
β^{M}_{i}	Share parameter (CES—composite commodity)

$\beta^{VA}_{j,reg}$	Share parameter (CES—value added)
$\beta^{X}_{j,i}$	Share parameter (CET—exports and local sales)
$\beta^{XT}_{j,i,reg}$	Share parameter (CET—total output)
$\beta^{XTR}_{j,i,reg}$	Share parameter (CET—total output)
$\delta_{k,j,reg}$	Depreciation rate of capital k in industry *j*
η	Price elasticity of indexed transfers and parameters
$\text{frisch}_{h,reg}$	Frisch parameter Linear Expenditure System (LES) function)
γ^{gvt}_{i}	Share of commodity *i* in total current public expenditures on goods and services
γ^{INVPRI}_{i}	Share of commodity *i* in total private investment expenditures
γ^{INVPUB}_{i}	Share of commodity *i* in total public investment expenditures
$\gamma^{LES}_{isw,h,reg}$	Marginal share of commodity *isw* in household *h* consumption budget
$\text{io}_{\text{j,reg}}$	Coefficient (Leontief—intermediate consumption)
$\lambda^{RK}_{nh,k}$	Share of type *k* capital income received by agent *nh*
$\lambda^{RKh}_{h,reg,k}$	Share of type *k* capital income received by agent *h*
$\lambda^{TR}_{nh,nhj}$	Share parameter (transfer functions)
$\lambda^{WL}_{h,reg,l}$	Share of type *l* labor income received by type *h* households
n_{time}	Population growth rate
n1	Population growth rate for the first period
$\phi_{k,j,reg}$	Scale parameter (allocation of investment to industries)
$\phi^{rds}_{jw,iw,regj,reg}$	Share of *jw* industry output in product *iw* produced by *reg* and supplied to *regj*
pop_{time}	Population index
$\rho^{KD}_{j,reg}$	Elasticity parameter (CES—composite capital)
$\rho^{LD}_{j,reg}$	Elasticity parameter (CES—composite labor)
$\rho^{C}_{h,reg}$	Elasticity parameter (CES—composite water household demand)
$\rho^{DI}_{j,reg}$	Elasticity parameter (CES—composite water intermediate demand)
ρ^{M}_{i}	Elasticity parameter (CES—composite good improted and locally produced)
$\rho^{VA}_{j,reg}$	Elasticity parameter (CES—value added)
$\rho^{X}_{j,i}$	Elasticity parameter (CET—exports and local sales)
$\rho^{XT}_{j,reg}$	Elasticity parameter (CET—total regional output)
$\rho^{XTR}_{j,i}$	Elasticity parameter (CET—total sectoral output)
$\sigma^{INV}_{k,j,reg}$	Elasticity (investment demand)
$\sigma^{KD}_{j,reg}$	Elasticity (CES—composite capital)
$\sigma^{LD}_{j,reg}$	Elasticity (CES—composite labor)
$\sigma^{C}_{h,reg}$	Elasticity (CES—composite water household demand)
$\sigma^{DI}_{j,reg}$	Elasticity (CES—composite water intermediate demand)
σ^{M}_{i}	Elasticity (CES—composite good imported and locally produced)

$\sigma^{VA}_{j,reg}$	Elasticity (CES—value added)
$\sigma^{X}_{j,i}$	Elasticity (CET—exports and local sales)
$\sigma^{XT}_{j,reg}$	Elasticity (CET—total regional output)
$\sigma^{XTR}_{j,i}$	Elasticity (CET—total sectoral output)
σ^{XD}_{i}	Price elasticity of the world demand for exports of product *i*
$\sigma^{Y}_{isw,h,reg}$	Income elasticity of consumption
$tmrg_{i,ij}$	Rate of margin *i* applied to commodity *ij*
$tmrg\_X_{i,ij}$	Rate of margin *i* applied to exported commodity *x*
$vo_{j,reg}$	Coefficient (Leontief—value added)

Variables that Are Fixed in the Model Closure

$C^{MIN}{}_{isw,h,reg,t}$	Minimum consumption of commodity *i* by type *h* households
CAB_t	Current account balance
e_t	Exchange rate (price of foreign currency in local currency)
$PWM_{i,t}$	World price of imported product *i* (expressed in foreign currency)
$PWX_{i,t}$	World price of exported product *i* (expressed in foreign currency)
$IND_{k,pub,reg,t}$	Volume of new type *k* capital investment to sector *j*
$KD_{k2,j,reg,t}$	Demand for type *k* capital by industry *j*
$KS_{k1,reg,t}$	Supply of type *k* capital
$LS_{l,reg,t}$	Supply of type *l* labor
$VSTK_{i,t}$	Inventory change of commodity i

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