SUPPORTING THE DEVELOPMENT OF A GREEN GROWTH ECONOMIC STRATEGY IN GEORGIA

TECHNICAL REPORT

EaPGREEN
Partnership for Environment and Growth

This project is funded by the EU

OECD BETTER POLICIES FOR BETTER LIVES

UNECE

UN environment

UNIDO

Geneva-Tbilisi

2018

ACKNOWLEDGEMENTS

Supporting the Development of a Green Growth Economic Strategy in Georgia has been developed within the "Greening Economies in the Eastern Neighbourhood" (EaP GREEN) programme, under the coordination of the United Nations Environment Programme (UN Environment).

The UN Environment coordination team included Rie Tsutsumi, Nina Schneider, Alex Leshchunskyy, Beatrice Bulwa, Giorgi Mukhigulishvili and Lesya Nikolayeva.

Andrea M. Bassi, an independent consultant, carried out the scenario analysis and drafted the report. Philip Gass, of the International Institute for Sustainable Development, contributed to the preparation of the report.

UN Environment would like to thank Irma Kavtaradze, Deputy Minister of Economy and Sustainable Development of Georgia for the guidance.

UN Environment would further like to thank all the contributors in the country who supplied the data, information and comments, and participants of Green Economy consultation workshop (28 April 2017) and modelling validation workshop (28 March 2018), which took place in Tbilisi, Georgia.

Editor: Geoff Hughes, Zoï Environment Network.

Translator of the Executive Summary into Georgian: Rusudan Apakidze-Kraveishvili, Translation Bureau Dialog 2006 Ltd.

Photo: Roberto Strauss, https://creativecommons.org/licenses/by/2.0/

DISCLAIMER

TABLE OF CONTENTS

ABBREVIATIONS

BAU – Business as usual

CBA – Cost Benefit Analysis

GDP – Gross Domestic Product

GE – Green Economy

GEOSTAT – National Statistics Office of Georgia

GEL – Georgian Lari

GHG – Greenhouse Gas emissions

GJ – Giga Joule

GoG – Government of Georgia

kWh – Kilowatt hour

MoESD - Ministry of Economy and Sustainable Development

NBSAP-2 – National Biodiversity Strategy Action Plan

O&M – Operation and Maintenance

SD – System Dynamics

TWh – Terawatt hour

UNFCCC – United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

This study simulates two main scenarios for Georgia's economic development until 2040, and analyses the results:

- A business as usual (BAU) case assumes the continuation of historic trends and incorporates all current policies and interventions
- A set of green economy (GE) scenarios simulates additional interventions in the agriculture, building and tourism sectors

An integrated model assesses the outcomes of green economy policies on investments, avoided costs and added benefits, and estimates the effects of the policies on GDP, job creation, and both government and household accounts.

The GE interventions in the model require a total investment of GEL 24.7 billion between 2018 and 2040 with the largest shares going to the building and tourism sectors for energy efficiency measures. Investments of GEL 2.2 billion in the agriculture sector support the installation of efficient irrigation infrastructure and the conversion of cropland to sustainable farming practices.

The transition to more efficient technologies yields cumulative avoided costs – from energy efficiency measures in buildings, the downscaling of wastewater treatment facilities, and lower capacity requirements for the generation of electricity – of almost GEL 3.8 billion by 2040, and cumulative additional benefits of GEL 29.3 billion in labour income and social and environmental benefits of reducing emissions from energy consumption.

Real GDP reaches GEL 69.4 billion in 2040 In the BAU scenario, and GEL 74.0 billion in the GE scenario. The cumulative difference in GDP between the scenarios totals GEL 61.7 billion by 2040. The model projects real GDP to grow on average by 3.8 per cent per year between 2017 and 2040 in the BAU scenario, and by 4.0 per cent per year in GE scenario.

Government revenues grow on average by 6.0 per cent per year in the BAU scenario, and 6.2 per cent in the GE scenario. Annual government revenues reach approximately GEL 40.8 billion by 2040 in the BAU scenario and GEL 42.9 billion in the GE scenario.

GE interventions reverse the BAU increase in unemployment in 2020, but starting in 2030 – after the end of the implementation of GE policies – unemployment rises (in the absence of new interventions). Private consumption reaches GEL 103 billion by 2040 in the BAU scenario, and GEL 108 billion in the GE scenario – about 5 per cent higher. Disposable household income was GEL 27.3 billion in 2015. By 2040, it increases to GEL 128.7 billion per year in the BAU scenario and to GEL 135.2 billion in the GE scenario.

The models for the agriculture, building and tourism sectors are customized for Georgia. These sectors were chosen for their current relevance to the economy, for the potential that GE interventions have in improving the performance of these sectors, and for their tight interconnectedness.

The investments required for the transition to more sustainable buildings total GEL 19.2 billion between 2020 and 2040, and include upgrades in technology, the construction of new buildings and the retrofitting old buildings. Employment from the construction of buildings remains unchanged compared to the BAU scenario.

By 2040, a higher share of energy-efficient buildings causes the annual electricity demand for buildings in the GE scenario to be 11.7 per cent lower than in the BAU scenario. The increase in green buildings reduces the electricity consumption per square metre by 7.9 kWh per year, and higher energy efficiency contributes to cumulative savings of GEL 3.3 billion in the operating costs of buildings by 2040.

The increased energy efficiency in buildings contributes to a 6.4 per cent reduction in annual CO_2 emissions compared to the BAU scenario, and water demand for buildings reaches 267.6 billion litres per year in 2040, 9.2 per cent lower than in the BAU scenario.

In the agriculture sector, the analysis focuses on the improvement of production and water management practices to increase land productivity and the area that is irrigated.

The transition to sustainable agriculture practices requires investments of GEL 496 million between 2020 and 2040, while investments in more efficient irrigation capacity total GEL 2.2 billion. The total amount of agricultural land remains unchanged in the GE scenario relative to the BAU case, but the share of sustainable agriculture grows from 0.1 per cent in 2017 to 20 per cent in 2030. This increase in sustainable agriculture land increases the agriculture share of real GDP by GEL 193.4 million in 2040. Cumulatively, the greening of the agriculture sector generates an additional GEL 2.6 billion in real value added between 2020 and 2040.

The expanded use of sustainable farming practices results in total annual agriculture production that is 1.9 per cent higher than in the BAU scenario. In addition, the higher carbon sequestration capacity of soil under sustainable practices leads to an increase in the annual CO_2 absorption from land use. The cumulative CO_2 absorption equates to a GEL 312.7 million reduction in the social cost of carbon.

The use of drip irrigation in sustainable agriculture contributes to significant reductions in water demand. Overall, the GE scenario yields an 8.1 per cent reduction in water consumption for the period 2020-2040, leading to the possible irrigation of 23,600 additional hectares.

The analysis of the tourism sector focuses on improvements to infrastructure, the expansion of ecotourism and the increased use of local food by the industry. Tourism is forecast to remain an important sector in the economy with a projected increase in the total number of overnight stays of 80.2 per cent between 2016 and 2040, mainly driven by international arrivals.

The additional investments required to achieve higher efficiency in the GE tourism scenario total GEL 1.1 billion cumulatively by 2040. The share of green hotels reaches 15 per cent in 2040, while total demand for floor space increases by 1.1 million m^2 as a consequence of the increase in average length of stay.

In 2015 the tourism sector’s contribution to real GDP was GEL 2.2 billion, and is projected to reach GEL 4.7 billion by 2040. By 2040, the additional value added by green hotels increases real GDP from tourism by 5.8 per cent compared to the BAU scenario, or GEL 2.3 billion cumulatively.

Employment in the tourism sector is projected to increase from 179,100 jobs in 2014 to 561,700 jobs in 2040 as a result of the increasing construction of hotels to meet the demand. By 2040, the transition to green practices generates 32,600 additional jobs.

The high efficiency of the newly constructed green hotels yields annual savings of GEL 2.4 million in operating costs in the hotel sector, and the reduction in energy consumption and the shift to more sustainable and reliable heating systems contributes to emission savings. The reduction in electricity consumption contributes to reducing total investments in power generation capacity by GEL 80.9 million compared to the BAU scenario, and the reduction in total CO_2 emissions from buildings reduces the annual social costs of carbon in 2040 by GEL 460,000.

რეზიუმე

წინამდებარე კვლევა ასახავს 2040 წლამდე საქართველოს ეკონომიკური განვითარების ორ მთავარ სცენარს და შედეგების ანალიზს:

- ჩვეულებრივი ბიზნესი (BAU) ითვალისწინებს ისტორიული ტენდენციების გაგრძელებას და მოიცავს არსებულ პოლიტიკას და ინტერვენციას
- მწვანე ეკონომიკის (GE) სცენარები უზრუნველყოფს სოფლის მეურნეობაში, სამშენებლო და ტურიზმის სექტორში დამატებითი ინტერვენციების სიმულაციას

ინტეგრირებული მოდელი აფასებს მწვანე ეკონომიკის პოლიტიკის შედეგებს ინვესტიციებზე, თავიდან გვაცილებს ხარჯებს და აწესებს დამატებით შეღავათებს და აფასებს გავლენას მთლიანი შიდა პროდუქტის პოლიტიკაზე, სამუშაო ადგილების შექმნასა და მთავრობისა და შიდა მეურნეობის ანგარიშებზე.

GE ინტერვენცია მოდელში მოითხოვს 24.7 მილიარდი ლარის ინვესტიციას 2018 წლიდან 2040 წლამდე პერიოდში, საიდანაც უდიდესი წილი მიმართული იქნება სამშენებლო და ტურიზმის სექტორში ენერგო ეფექტურობის ღონისძიებებზე. 2.2 მილიარდი ლარის ინვესტიცია მიმართული იქნება სოფლის მეურნეობის სექტორში ეფექტური საირიგაციო ინფრასტრუქტურის შექმნასა და სახნავ-სათესი მიწის მდგრად მეურნეობად გადაქცევის ხელშესაწყობად.

მეტად ენერგო-ეფექტურ ტექნოლოგიებზე გადასვლის შედეგად მივიღებთ: კუმულაციური ხარჯების თავიდან აცილებას - მშენებლობაში ენერგო ეფექტური ღონისძიებებიდან, ჩამდინარე წყლების გამწმენდი ნაგებობების მასშტაბის შემცირება და ელექტროენერგიის წარმოებისთვის დაბალი სიმძლავრის მოთხოვნები - თითქმის 3.8 მილიარდი ლარით 2040 წლამდე და 29.3 მილიარდი ლარის ოდენობის კუმულაციურ დამატებით შეღავათს შრომის ანაზღაურებასა და სოციალურ და გარემოსდაცვით შეღავათებში, რომელიც მიიღება ენერგიის მოხმარების ემისიის შემცირებით.

რეალური მშპ აღწევს 69.4 მილიარდ ლარს 2040 წელს BAU სცენარით და 74.0 მილიარდ ლარს GE სცენარით. სცენარებს შორის მშპ-ში კუმულაციური განსხვავება შეადგენს 61.7 მილიარდ ლარს 2040 წლამდე. მოდელის პროგნოზირებით რეალური მშპ-ს საშუალოდ გაიზრდება 3.8

პროცენტით წელიწადში 2017 წლიდან 2040 წლამდე BAU სცენარით და წელიწადში 4.0 პროცენტით GE სცენარით.

მთავრობის შემოსავლები BAU სცენარით წელიწადში საშუალოდ 6.0 პროცენტით გაიზრდება, GE სცენარით კი 6.2 პროცენტით. BAU სცენარით მთავრობის წლიური შემოსავალი 2040 წლისთვის მიაღწევს დაახლოებით 40.8 მილიარდ ლარს, ხოლო GE სცენარით 42.9 მილიარდ ლარს.

GE ინტერვენციები BAU-სგან განსხვავებით გაზრდის უმუშევრობას 2020 წელს, მაგრამ 2030 წლიდან დაწყებული - GE პოლიტიკის განხორციელების შემდეგ - უმუშევრობა გაიზრდება (ახალი ინტერვენციების არარსებობის შემთხვევაში). პირადი მოხმარება 2040 წლისთვის მიაღწევს 103 მილიარდ ლარს BAU სცენარით, GE სცენარით კი 108 მილიარდ ლარს, რაც დაახლოებით 5% -ით მეტია. 2015 წელს სუფთა შემოსავალი შეადგენდა 27.3 მილიარდ ლარს. 2040 წლისთვის BAU სცენარით სუფთა წლიური შემოსავალი გაიზრდება 128,7 მილიარდ ლარამდე, ხოლო GE სცენარით კი 135,2 მილიარდ ლარამდე.

სოფლის მეურნეობის, სამშენებლო და ტურისტული სექტორის მოდელები მორგებულია საქართველოზე. ამ სექტორების შერჩევა მოხდა მათი ეკონომიკისთვის ამჟამინდელი მნიშვნელობის გათვალისწინებით, იმ პოტენციალისთვის, რომელიც GE ინტერვენციებს გააჩნია ამ სექტორების მუშაობის გაუმჯობესებისთვის და მათ შორის მჭიდრო ურთიერთობის ჩამოყალიბებისთვის.

ინვესტიციების ოდენობა, რომლებიც საჭიროა უფრო მეტად მდგრად მშენებლობაზე გადასასვლელად, შეადგენს 19.2 მილიარდ ლარს 2020-2040 წლებში და მოიცავს ტექნოლოგიურ განახლებას, ახალი შენობების მშენებლობას და ძველი ნაგებობების რესტავრაციას. მშენებლობაში დასაქმება უცვლელი რჩება BAU სცენარისგან განსხვავებით.

2040 წლისთვის, ენერგო-ეფექტური ნაგებობების დიდი წილი GE სცენარით იწვევს ელექტროენერგიის 11.7 პროცენტით ნაკლებ მოთხოვნას, ვიდრე BAU სცენარით. მწვანე ნაგებობების ზრდა ამცირებს ელექტროენერგიის მოხმარებას კვადრატულ მეტრზე წელიწადში 7.9 კვტ.-ით, ხოლო უფრო მაღალი ენერგო-ეფექტურობა 2040 წლისთვის უზრუნველყოფს 3.3 მილიარდი ლარის დანაზოგს შენობის საოპერაციო ხარჯებში.

შენობების გაზრდილი ენერგო-ეფექტურობა უზრუნველყოფს წლიურად CO_2 ემისიების შემცირებას 6.4 პროცენტით BAU სცენართან შედარებით, ხოლო შენობების წყალზე მოთხოვნა 2040 წელს მიაღწევს წელიწადში 267,6 მილიარდ ლიტრს, რაც 9.2 პროცენტით ნაკლებია BAU სცენართან შედარებით.

სოფლის მეურნეობის სექტორში, ყურადღება გამახვილებულია წარმოებისა და წყლის მართვის პრაქტიკის გაუმჯობესებაზე მიწის პროდუქტიულობისა და სარწყავი მიწის ფართობის გაზრდის მიზნით.

მდგრადი სოფლის მეურნეობის პრაქტიკის დანერგვა მოითხოვს 2020-დან 2040 წლამდე 496 მილიონი ლარის ინვესტირებას, ხოლო ინვესტიციები უფრო ეფექტურ სარწყავ სისტემებში

შეადგენს 2.2 მილიარდ ლარს. სასოფლო-სამეურნეო დანიშნულების მიწის მთლიანი მოცულობა უცვლელი რჩება GE სცენარით განსხვავებით BAU სცენარისგან, მაგრამ მდგრადი სოფლის მეურნეობის წილი 2017 წელს 0.1% -დან 2030 წლამდე 20% -მდე იზრდება. მდგრადი სოფლის მეურნეობის მიწის ზრდა ზრდის სოფლის მეურნეობის წილს მთლიან შიდა პროდუქტში 2040 წელს 193.4 მლნ ლარით. კუმულატიურად, სოფლის მეურნეობის სექტორის გამწვანება 2020-დან 2040 წლამდე დამატებით ახდენს 2.6 მილიარდი ლარის გენერირებას.

მდგრადი მეურნეობის პრაქტიკის გაფართოვება განაპირობებს ყოველწლიურად სასოფლო-სამეურნეო პროდუქციის ზრდას, რაც 1.9 პროცენტით მეტია, ვიდრე BAU სცენარით. გარდა ამისა, მდგრადი პრაქტიკის დროს ნიადაგის ნახშირბადის მაღალი სეკვესტრაციის სიმძლავრე იწვევს ყოველწლიურად CO_2 აბსორბციის გაზრდას მიწის გამოყენებისას. CO_2-ს კუმულაციური აბსორბცია უზრუნველყოფს 312.7 მილიონ ლარით ნახშირბადის სოციალური ხარჯის შემცირებას.

მდგრად სოფლის მეურნეობაში წერტილოვანი ირიგაცია ხელს უწყობს წყლის მოთხოვნის მნიშვნელოვან შემცირებას. საერთო ჯამში, GE სცენარი უზრუნველყოფს წყლის მოხმარების 8.1 პროცენტით შემცირებას 2020-2040 წლებში, რასაც მოჰყვება 23,600 დამატებითი ჰექტარის შესაძლო ირიგაცია.

ტურიზმის სექტორის ანალიზი ითვალისწინებს ინფრასტრუქტურის გაუმჯობესებას, ეკოტურიზმის გაფართოებას და ინდუსტრიის მიერ ადგილობრივი კვების პროდუქტების მოხმარების გაზრდას. ტურიზმი ეკონომიკის მნიშვნელოვან სექტორად რჩება. პროგნოზის მიხედვით, 2016 - 2040 წლებში 80.2 პროცენტით გაიზრდება ტურისტების რაოდენობა, რომლებიც ღამე დარჩენით იქნებიან, რაც ძირითადად, შემოსული საერთაშორისო ტურისტების ხარჯზე იქნება მიღწეული.

უფრო მაღალი ეფექტიანობის მისაღწევად GE ტურიზმის სცენარში საჭიროა დამატებითი ინვესტიციები, რაც კუმულატიურად 2040 წლისთვის შეადგენს 1.1 მილიარდ ლარს. მწვანე სასტუმროების წილი 2040 წელს შეადგენს 15 პროცენტს, ხოლო სართულიანობის მთლიანი მოთხოვნა გაიზრდება 1.1 მლნ კვ.მ-ით ტურისტის ქვეყანაში ყოფნის საშუალო ხანგრძლივობის გაზრდის შედეგად.

2015 წელს, ტურისტული სექტორის წილმა რეალურ მშპ-ში შეადგინა 2.2 მილიარდი ლარი, 2040 წლისთვის კი 4.7 მილიარდ ლარს მიაღწევს. 2040 წლისთვის, მწვანე სასტუმროების დამატებითი ღირებულება გადააჭარბებს რეალურ მშპ-ს ტურიზმიდან 5.8 პროცენტით BAU სცენარისგან განსხვავებით ან 2.3 მილიარდი ლარით კუმულატიურად.

პროგნოზის თანახმად, ტურიზმის სექტორში დასაქმება 2014 წელს 179,100 სამუშაო ადგილიდან 2040 წლისთვის გაიზრდება 561,700 სამუშაო ადგილამდე მოთხოვნის დასაკმაყოფილებლად სასტუმროების მშენებლობის შედეგად. 2040 წლისთვის, მწვანე პრაქტიკაზე გადასვლა უზრუნველყოფს 32,600 დამატებითი სამუშაო ადგილის შექმნას.

ახლად აშენებული მწვანე სასტუმროების მაღალი ეფექტურობა გამოიწვევს ყოველწლიურად სასტუმრო სექტორში 2,4 მილიონი ლარის საოპერაციო ხარჯების დაზოგვას და ენერგიის

მოხმარების შემცირებას. უფრო მდგრად და საიმედო გათბობის სისტემებზე გადასვლა უზრუნველყოფს ემისიების შემცირებას. ელექტროენერგიის მოხმარების შემცირება ხელს შეუწყობს ელექტროენერგიის წარმოებაში ინვესტიციების შემცირებას 80.9 მილიონ ლარით BAU სცენარისგან განსხვავებით. ამასთან, შენობებიდან CO_2 ემისიის შემცირება უზრუნველყოფს 2040 წელს ნახშირბადის ყოველწლიური სოციალური ხარჯების შემცირებას 460,000 ლარით.

"აღმოსავლეთ სამეზობლო ქვეყნების ეკონომიკების გამწვანების“ (EaP GREEN) პროექტის ფარგლებში განხორციელდა შემდეგი კვლევა: "მწვანე ეკონომიკის ზრდის პოლიტიკის სტრატეგიის შემუშავების ხელშეწყობა საქართველოში". EaP GREEN პროექტი დაფინანსებულია ევროკავშირის მიერ. მას მხარს უჭერს რამდენიმე ქვეყანა. პროექტი ერთობლივად ხორციელდება ეკონომიკური თანამშრომლობისა და განვითარების ორგანიზაციის (OECD), გაეროს გარემოს დაცვის პროგრამის (UN Environment) და გაეროს სამრეწველო განვითარების ორგანიზაციის (UNIDO) მიერ. კვლევის განხორციელებას კოორდინაციას უწევდა გაეროს გარემოსდაცვითი პროგრამა (UN Environment) და საქართველოს ეკონომიკისა და მდგრადი განვითარების სამინისტრო.

INTRODUCTION

The development of a green economy (GE) in Georgia can effectively support the attainment of national development targets in the Green Growth Policy Paper (Ministry of Economy and Sustainable Development of Georgia, In Press). While that policy paper provides a qualitative assessment of how the green economy concept can be applied through the implementation of policies that would stimulate green growth and hence allow the country to achieve stated targets in a more cost effective manner, this report provides a quantitative assessment of the avoided costs and added benefits emerging from the implementation of green economy interventions.

This study is a collaborative effort between the Ministry of Economy and Sustainable Development (MoESD) and UN Environment. The main goal is to inform the preparation of the National Green Economy Strategy, providing insights on the likely social, economic and environmental outcomes of green economy policy implementation. The study analyses the building, tourism and agriculture sectors, and tests the improvement of energy efficiency in buildings, the expansion of sustainable tourism, and the use of sustainable agriculture practices. Synergies are explored among these sectors, with emphasis on energy and water management and the provision of food.

The macroeconomic and sectoral models rely on System Dynamics (SD), a methodology that enables the explicit capture of sectoral dynamics and cross-sectoral relations and the identification of potential entry points for policy intervention. The models forecast policy outcomes across economic sectors over time.

A range of scenarios are simulated to estimate and analyse the outcomes of GE policies on the performance of the respective sector and on their combined effects across sectors. The results of the analysis are presented for several monetary and physical indicators. Monetary indicators are grouped in three main categories: investments, avoided costs and added benefits. An extended analysis of costs and benefits, which includes the economic valuation of social and environmental policy outcomes, is provided to support budgetary allocations across various green economy interventions, both in the context of the National Green Economy Strategy and the annual sectoral and national budgetary exercises.

1. GEORGIA'S ECONOMIC, SOCIAL AND ENVIRONMENTAL PROFILE

1.1. Economy

In 2016, Georgia's GDP was GEL 35.6 billion, with a GDP growth rate of 2.7 per cent. Between 2000 and 2016, Georgia's GDP grew on average by 5.4 per cent per year (World Bank, 2017). In 2017, severe external shocks to Georgia's economy resulted in economic growth missing expectations. The International Monetary Fund (IMF) projects real GDP growth for 2017 to be 3.5 per cent, with GEOSTAT recording a preliminary value of 5.0 per cent.

Private sector investment has been the main driver of economic growth in the last decade. The share of private sector investments in GDP increased from around 12.5 per cent in 2010 to roughly 25 per cent in 2016. During the same period, public investments decreased from 9 per cent in 2010 to roughly 7 per cent in 2016 (GoG, 2017).

The key sectors contributing to economic growth and job creation are services, manufacturing and construction. Since 2009, these sectors have recorded average annual growth rates of 8.8 per cent (services), 8.7 per cent (manufacturing), and 7.4 per cent (construction) (GoG, 2016a).

According to the World Bank, the composition of GDP shows a shift towards a services-oriented economy. In 2002, the contribution of the agriculture, industry, and services sectors were, respectively, 22 per cent, 22 per cent and 56 per cent. By 2014, agriculture's share in GDP decreased to 9 per cent, while the share of industry and services increased to 24 per cent and 67 per cent respectively (World Bank, 2017).

Employment by sector has followed the composition of GDP. Compared to 2006, the share of employment provided by industry increased from 9 per cent to 10 per cent, and services increased from 35.6 per cent to 39.1 per cent. During the same period, agricultural employment has decreased from 55.3 per cent to 50.9 per cent (World Bank, 2017).

The unemployment rate in Georgia has been decreasing steadily since 2009, going from 16.9 per cent to 11.8 per cent in 2016, the lowest point in the past 13 years (GEOSTAT, 2017a). In this respect, agriculture remains an important sector, as it provides food and generates jobs for more than half of Georgia's workforce. Around 80 per cent of the workforce working in the agriculture sector is self-employed, which indicates that many farmers still engage in subsistence farming and produce food for their own consumption or local markets. Furthermore, the lack of advanced mechanization contributes to low productivity in the sector, and hence high employment (GCAD, 2015). In 2014, roughly 51 per cent of jobs were provided by the agriculture sector, followed by 39 per cent in services and 10 per cent in the industry and manufacturing sector.

Between 2000 and 2016, Georgia's GDP per capita (Purchasing Power Parity, constant 2011 international $) grew on average by 6.8 per cent per year, increasing from $3,264 per person in 2000 to $9,267 per person in 2016 with an intervening drop after the 2008 crisis from $6,408 in 2008 to $6,255 in 2009.

In 2014, Georgia ranked eighth out of 189 countries in the World Bank's "Doing Business" assessment, two positions better than in 2013 (GCAD, 2015). Several incentive programmes have been developed to draw investment into Georgia, especially in the agriculture sector (GoG, 2016b). As a testament to a business-friendly environment, Georgia's tourism sector has shown strong growth in the last decade, both in terms of tourism arrivals and investment.

1.2. Society

Georgia's population in 2016 was 3.7 million people and its annual growth rate was 0.06 per cent. The share of people living in urban areas slightly increased from around 52.3 per cent in 2002 to 53.8 per cent in 2016 (World Bank, 2017).

Georgia's literacy rate of people aged 15 and older remained constant at 99.6 per cent through the last decade (World Bank, 2017). The net school enrolment rates were at gender parity with 99 per cent for boys and 98 per cent for girls in primary education and 95 per cent for both boys and girls in secondary education. School dropout rates from secondary education are generally higher for boys than for girls. Especially in later years (grades 9 to 11), the rate at which boys drop out from secondary education is almost twice as high as the rate for girls (UNESCO, 2017). Despite good access to education, one of the main challenges for the education sector is a growing mismatch between curricula and the skills required in the workplace (GCAD, 2015).

The share of population with access to improved sanitation facilities is steadily decreasing from 95.7 per cent in 2000 to 86.3 per cent in 2015. During that period, access to improved sanitation facilities in urban areas slightly decreased from 96.4 per cent to 95.2 per cent, while access in rural areas decreased significantly, from 94.9 per cent to 75.9 per cent (World Bank, 2017).

1.3. Environment

Georgia has forests, fresh waters, wetlands, semi-deserts, steppes and high mountains as well as marine and coastal ecosystems. Georgia's forests are rich in biodiversity and have unique tree species in the Pan-European region.

Many of Georgia's ecosystems face anthropogenic pressures including logging and deforestation, soil erosion, water pollution, desertification, eutrophication and climate change (UNECE, 2016). Georgia's biodiversity is especially vulnerable to economic interventions in vulnerable areas, partially as a consequence of the deregulation of Georgia's environmental framework. According to the Bertelsmann Stiftung foundation, the current use of natural resources is unsustainable, and a lack of foresight and the prioritization of economic benefits over sustainability considerations have resulted in severe environmental degradation, especially in agricultural, mountainous and coastal regions (BTI, 2016).

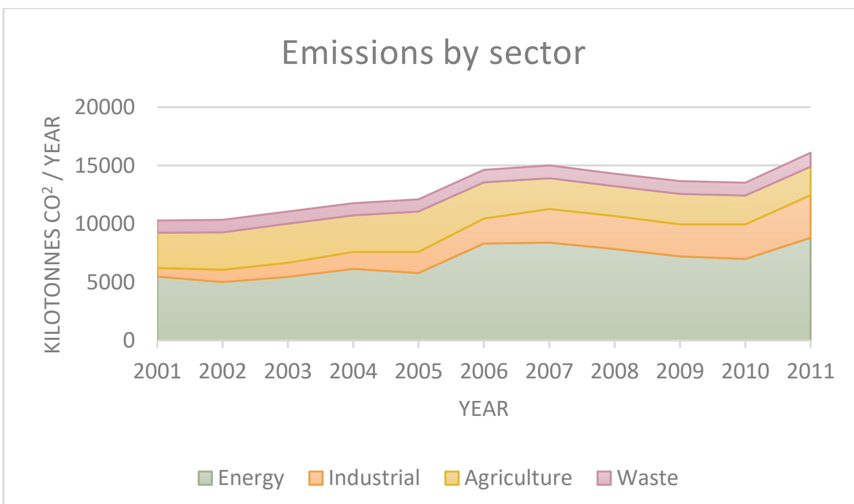
Georgia has approximately 2.5 million hectares of forest, around 41.6 per cent of its land area (World Bank, 2017). Forests contain most of the biodiversity of the country and are the predominant ecosystem in Georgia (UNECE, 2016). Almost all of Georgia's forest area consists of natural forests and are made up of close to 800 types of trees and bushes (GoG, 2016c). Forests contribute to soil protection, water protection, recreation and other ecosystem services. Specifically, they provide non-timber forest products that sustain the livelihood of the population and serve commercial purposes (UNECE, 2016). Among the main threats to Georgia's forests are pests and disease, illegal logging, intense grazing and unsustainable forest management (UNECE, 2016). In addition to these, climate change was recently identified as a pressure on Georgia's forest sector (GoG, 2016c).

To curb some of the pressures and set the preconditions for sustainable development, Georgia has established several policy frameworks. The most important of these is the National Biodiversity Strategy Action Plan (NBSAP-2) 2014-2020 (UNECE, 2016). The first NBSAP was implemented in 2005 and featured a 10-year strategy of conservation and sustainable use of biological diversity and a 5-year plan of concrete actions. In 2011, the process of updating the NBSAP began with technical project assistance from GIZ. The NBSAP-2 provides an overview of Georgia's biodiversity together with the vision and the overall national targets for safeguarding biodiversity (CBD, 2014).

According to its Third National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), Georgia's annual CO_2 emissions increased from 10,864 kilotons in 2000 to 16,094 kilotons in 2011, and to 16,679 kilotons in 2013 (GoG, 2016b).

Figure 1 provides an overview of Georgia's total CO_2 emissions by sector. Emissions from land use and land use change – excluded from this graph – amounted to a net sequestration of 7,094 kilotons in 2011 (GoG, 2016c). This indicates a net removal of 4,624 kilotons of CO_2 emissions in 2011 from primary sectors, estimated as total sequestration (7,094 kilotons) minus emissions from agriculture and pasture land (2,470 kilotons). Despite an increase in hydroelectricity between 2008 and 2011, the energy sector is, with a share of roughly 50 per cent in total emissions, by far the largest emitter of greenhouse gas (GHG) emissions (GoG, 2016c).

Figure 1: GHG emissions by sector (2001 – 2011) (GoG, 2016c)



Multiple programmes aimed at increasing the share of renewables have been launched through the last decade – the Programme on Promotion of Renewable Energies II, for example. The aim of these programmes is to stimulate investments in small-scale, low-carbon energy generation capacity (OECD, 2016). The implementation of these programmes focuses on providing low-cost energy to Georgia's population.

2. METHODOLOGY AND MODELING APPROACH

2.1. System Dynamics and Green Economy modeling

The methodology for the creation of the quantitative sectoral and macroeconomic models is System Dynamics (Forrester, 1961; Sterman, 2000), an approach that uses causal relations, feedback loops, delays and non-linearity to represent real-life complexity. SD models run differential equations through the explicit representation of stocks and flows.

In the context of a green economy assessment, the use of SD facilitates the accounting of the various benefits that can accrue over time through the implementation of GE policy interventions across economic sectors (Probst & Bassi, 2014; UNEP, 2014).

The creation of an SD model follows an iterative five-step process (Sterman, 2000):

1. Problem identification
2. Dynamic hypotheses (system mapping)
3. Formal model development
4. Validation
5. Simulation of alternative scenarios

These five steps are closely related to the five steps of the integrated policymaking cycle developed by UNEP (2009), and show how SD can be used to inform various stages of the decision-making process. Specifically, SD highlights the role of feedback loops in shaping trends and allows for the anticipation of potential synergies and side effects. Coupled with scenario analysis, SD can be used to test exploratory scenarios and existing policy proposals. As such, SD models do not optimize performance; instead, these models simulate “what if” scenarios. The result is an assessment of the likely outcomes of policy implementation (desired and undesired), which can inform the formulation of complementary policy options for long-term sustainability.

2.2. Overview of the Green Economy model for Georgia

2.2.1. Overview of the model

The GE model developed for Georgia includes a macroeconomic module and three sectoral models – for buildings, tourism and agriculture. These are needed to carry out in-depth assessments of sectoral performance, and are able to generate valuable inputs for the development of green economy strategies by sector. The macroeconomic module can test the cross-sectoral coherence of the sectoral interventions proposed (e.g. possible side effects of sectoral interventions) and can assess the outcomes of policy interventions at the national level (e.g. contribution to GDP and job creation).

The macroeconomic module includes several indicators, such as government accounts (primarily revenues, expenditures and debt), household accounts (income and consumption) and a high-level disaggregation of GDP (for agriculture, industry and services). As a result, the model can estimate the contribution of sectoral GE policies on sectoral and national GDP, as well as on job creation, and on both government and household accounts.

Specifically, government accounts provide an overview of government expenditures and revenues, which are used to determine the net operating balance (whether there will be a deficit or a surplus for a given year) and funding available for government consumption and investments. Household accounts estimate total household revenues and disposable income and keep track of private consumption and savings. Projected changes in these accounts provide the basis for an assessment of the extent to which GE policy interventions contribute to an improvement of economic performance for households. When coupled with estimates of emissions and food security, to cite two examples, the GE model can assess how policy affects well-being outcomes. GDP is estimated at a high level of aggregation for agriculture, industry and services; construction and tourism are included as sub-sectors of industry and services. These sectoral modules keep track of investments, capital accumulation, employment, and the potential impact of other factors (e.g. energy expenditure) on productivity.

More detailed sectoral models for agriculture, buildings (construction) and tourism are fully customized for Georgia. These sectors were chosen for their current relevance in the Georgian economy, for the potential that GE interventions have in improving the performance of these sectors, and for their tight interconnectedness. In fact, the building sector is a key pillar of the tourism sector. In addition, tourism, and especially ecotourism, relies on local agricultural production, creating strong synergies with rural areas and mountainous regions of the country. Further, specific policy interventions can be tested at the sectoral level. The agriculture sector provides information on total land use by crop, crop yields (for sustainable and conventional production), water requirements and use of fertilizers. Policies affecting any of these factors can be tested with the model. The construction sector includes demand for conventional and energy-efficient floor space, both for new construction and retrofitting. In addition, the operational parameters of buildings (e.g. type of heating, A/C, lighting) are used to assess the GE potential of the building sector.[1] The tourism sector provides information about domestic and international tourist arrivals, value added, and employment generated by the tourism sector. It also estimates the sector's food demand and the number of hotels needed to accommodate incoming tourists.

2.2.2. Indicators of investment, avoided cost and added benefits

An integrated methodology assesses the outcomes of GE policy implementation on three main components: investments, avoided costs and added benefits. The example of energy-efficient buildings, which reduce negative impacts of human activity and improve adaptation and resilience, illustrates this approach.

Investments

From a private sector perspective, investments refer to the monetary costs of implementing a decision. For building operators, complying with energy efficiency standards might entail, for example, purchasing efficient appliances. Contractors will consider the costs for energy-efficient construction, certification fees for new buildings and auditing for existing ones. From a public sector point of view, investments refer to

---

[1] The model for buildings was created using the Sustainable Asset Valuation (SAVi) approach developed by International Institute for Sustainable Development (IISD).

the allocation and/or reallocation of financial resources with the aim of reaching a stated policy target such as creating the enabling conditions for the investment in windows with high thermal insulation.

Avoided costs

The estimation of potential avoided costs considers the results of the successful implementation of an investment or policy. In the case of energy efficiency in buildings, these avoided costs refer to direct savings derived from reduced energy expenditures for heating, cooling and electricity, or to health costs avoided as a result of reduced emissions (UNEP, 2012a).

Added benefits

Among the added benefits are the monetary value of economic, social and environmental benefits deriving from investment or policy implementation, focusing on short-, medium- and long-term impacts across sectors and actors. In the case of energy-efficient buildings these include job creation and premium prices for certified buildings. These are additional benefits that would not accrue in a business as usual scenario.

3. SCENARIOS AND ASSUMPTIONS

This study simulates two main scenarios and analyses the results:

- A business as usual case that the continuation of historic trends, includes all policies and interventions currently active and enforced, but excludes policies planned but not yet implemented
- A set of green economy scenarios simulates additional interventions in the agriculture, building and tourism sectors

The specific interventions and assumptions simulated in the GE scenarios are discussed below and in the results section.

Agriculture

The GE scenario for agriculture assumes a transition towards the adoption of ecological agriculture practices.

provides an overview of the model assumptions for the Green Economy scenario.

Specifically, the share of agriculture land that is sustainable is assumed to increase from 0.1 per cent in 2017 to 20 per cent in 2030. Ecological agriculture is expected to increase yield per hectare by 10 per cent and to profit from premium prices, generating 20 per cent more added value than conventional agriculture. Finally, the GE scenario assumes that sustainable agriculture is 10 per cent more labour-intensive than conventional agriculture.

Table 1: Green Economy assumptions for Agriculture

Variable	Value
Desired fraction of sustainable farmland in 2030	20%
Impact of sustainable farming on yields	10%
Additional value added of sustainable produce	20%
Additional employment from sustainable farming	10%

Buildings

The GE scenario for buildings assumes an accelerated rate of green construction for both new buildings and retrofits. The goal is to achieve a 30 per cent green building share of the total stock by 2030. Practically, the GE scenario assumes that demand for new buildings is going to be oriented towards green buildings, that if this demand is not sufficient, the remodeling of buildings reaching the end of their useful lives will follow green building standards, and that if the first two items are not sufficient to reach the 2030 target, existing buildings will be retrofitted (e.g. through the allocation of energy efficiency incentives). Table 2 provides an overview of the model assumptions for the green economy scenario in the building sector.

Table 2: Green Economy assumptions for Buildings

Variable	Value
Desired fraction of new constructions sustainable	2010: 0% 2020: 0% 2030: 30%

Tourism

The GE scenario for the tourism sector assumes that 50 per cent of new construction in the tourism sector will be energy-efficient and that energy-efficient hotels generate 20 per cent more added value than conventional hotels (due to price premiums from ecotourism). In addition, the GE scenario assesses the possibility of sourcing 50 per cent of the food to meet the tourism demand from local sustainable farms, and estimates the resulting changes in land and labour requirements, production, and value added in the agriculture sector. The GE scenario also assumes a doubling of the number of tourists from such markets as the European Union, Asia, and North America between 2018 and 2025. Tourists from these markets are expected to spend more. Finally, this scenario assumes that the average length of stay increases from 5.0 days in 2016 to 5.3 days in 2025.

Table 3 provides an overview of the model assumptions for the Green Economy scenario for the tourism sector.

Table 3: Green Economy assumptions for Tourism

Variable	Value
Desired fraction of new hotels sustainable from 2030	50% of new construction
Value added by green hotels	20%
Share of food for tourism sourced domestically	50%
Average length of stay 2016 2025	 5.0 days 5.3 days
Increase in international visitors from higher spending markets	+100% by 2025

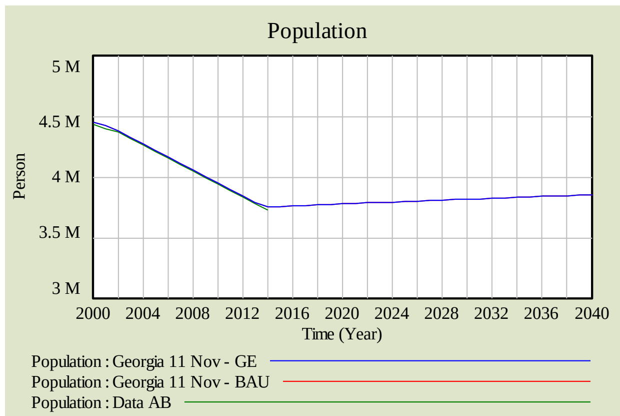
4. ANALYSIS OF RESULTS

4.1. Macroeconomic trends

This section presents the macroeconomic analysis, shows how sectoral performance can contribute to national development, and presents the impacts of green economy interventions on GDP, employment and income, energy consumption, water use for domestic needs and irrigation, and carbon emissions. Selected indicators are presented in Table 5.

The BAU scenario projects Georgia's population to increase slightly. By 2040, the population is expected to be roughly 3.9 million people – a 2.5 per cent increase compared to 2016. Figure 2 shows the development of Georgia's population (blue line) compared to historical data (red line, which overlaps with the blue simulation). The assumption of a stable trend for population was based on the trend of recent years, and on the basis of the high population scenario of the UN World Population Prospects.[2]

Figure 2: Population

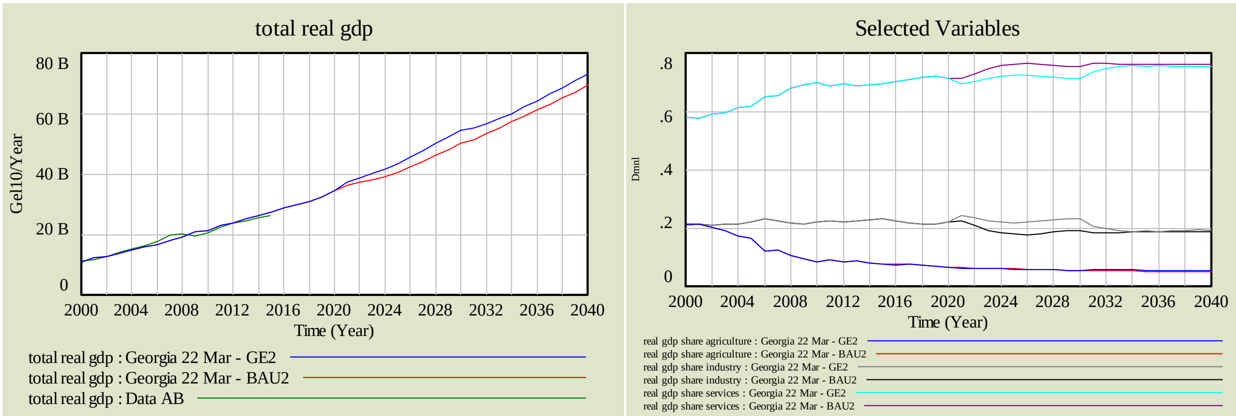


In the BAU scenario, Georgia's real GDP is expected to reach GEL 69.4 billion in 2040, with a real GDP per capita of GEL 18,000 compared to GEL 9,120 in 2016 (World Bank, 2017). In the GE scenario GDP is projected to increase to GEL 74.0 billion by 2040. The cumulative difference in GDP between the BAU and the GE scenario totals GEL 61.7 billion by 2040. Between 2017 and 2040, Georgia's real GDP is projected to grow on average by 3.8 per cent and 4.0 per cent per year in the BAU and GE scenarios respectively, but most of the gain in the GE scenario is observed between 2018 and 2030 (which are the years in which policies are implemented). IMF forecasts a real GDP growth rate of 4.0 per cent in 2018 and 5.5 per cent in 2022 (IMF, 2017); the GE model projects a real GDP growth rate of 4.2 per cent in 2018 and 5.2 per cent in 2022. The contributions of GE interventions become visible in 2020 leading to reduced costs and higher value added, with the latter in the range of 5.8 per cent above the BAU case between 2020 and 2040.

Figure 3 illustrates the development of real GDP in the BAU and GE scenarios compared to historical data (left), and the contribution of agriculture (dark blue), industry (grey) and services (light blue) to GDP (right).

[2] Available at https://esa.un.org/unpd/wpp/ and last accessed on October 15, 2017.

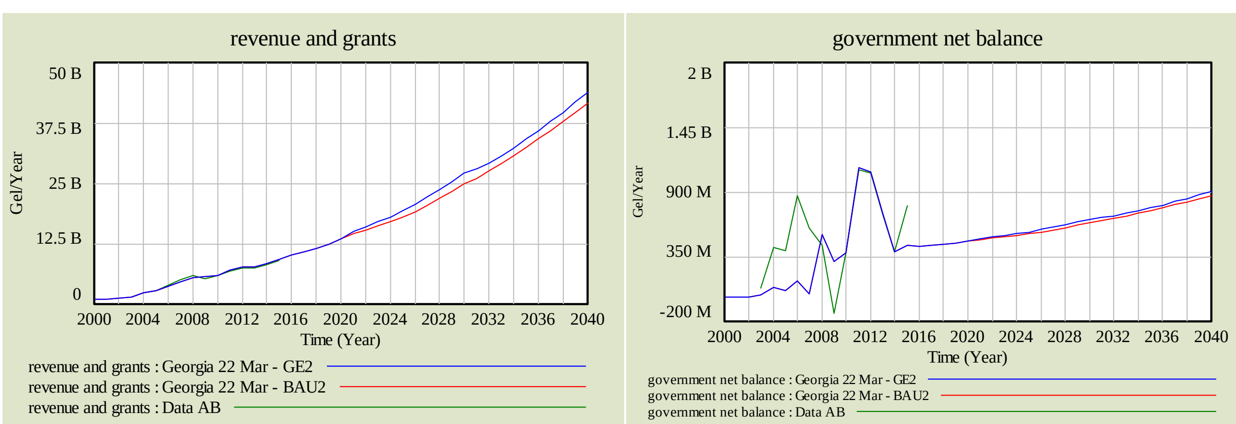
Figure 3: Real GDP and sectoral contributions to GDP



While industry and services show projected growth, the expected decrease in the contribution of the agriculture sector to GDP is consistent with the historical trend (World Bank, 2017), both in the BAU and GE scenarios. The differences between the BAU and GE cases between 2020 and 2030 are primarily driven by retrofits for buildings, which increase the contribution of the industry sector to GDP more than agriculture and services. In fact, the policy ambition in the industrial sector is much higher in the GE case than the scenarios simulated for agriculture and services (i.e., tourism).

Figure 4 illustrates the development of government revenues and the government net balance. Government revenues and grants in the BAU and GE scenarios increase to respectively GEL 41.7 billion and GEL 43.8 billion in 2040, a difference of GEL 2.1 billion. Between 2018 and 2040, government revenues grow on average by 6.0 per cent per year in the BAU scenario, and by 6.2 per cent in the GE scenario. The improved performance of the GE scenario is primarily driven by the higher economic growth forecast in the GE case. As a result, the net balance in the GE scenario remains positive and is on average 3.4 per cent higher than the BAU case between 2018 and 2040. A budget surplus in both scenarios indicates the capacity to reduce debt and/or allocate additional investments to stimulate growth, aside from the purchase of financial and non-financial assets.

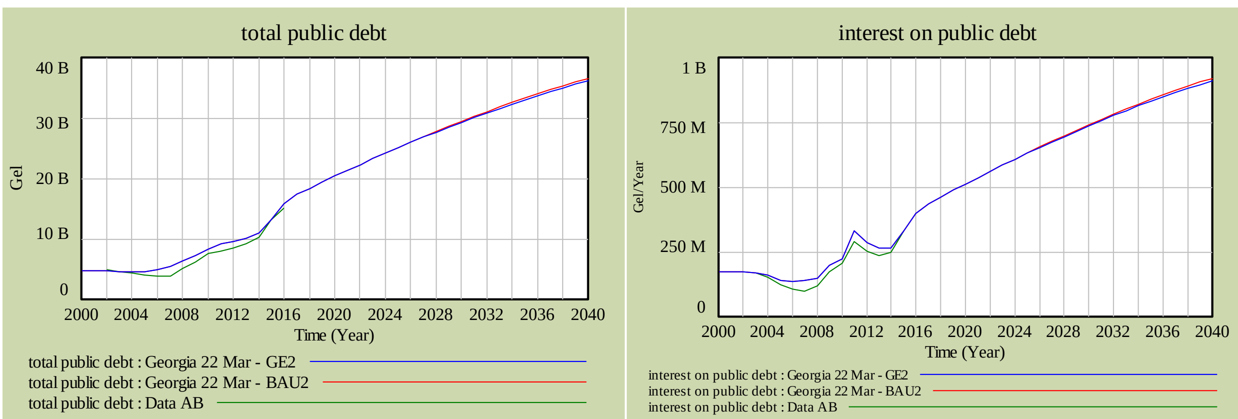
Figure 4: Government revenues and grants and Government net balance



Despite the positive outlook for government finances, total public debt in the BAU scenario is expected to increase to GEL 36.6 billion in 2040, primarily due to the assumption that the government will continue to purchase financial and non-financial assets following the trend of the last decade (roughly GEL 1.5 billion per year). In the GE scenario, public debt totals GEL 36.2 billion by 2040, which is GEL 0.4 billion lower than in the BAU scenario. The increase in public debt in both scenarios contributes to an increase in annual interest payments, from GEL 329.8 million in 2015 to GEL 920.4 million (BAU) and GEL 909.9 million (GE) in 2040 (using an interest rate of 2.5 per cent).

Figure ***1*** shows the development of total public debt and interest payments on public debt in the BAU scenario compared to the historical figures.

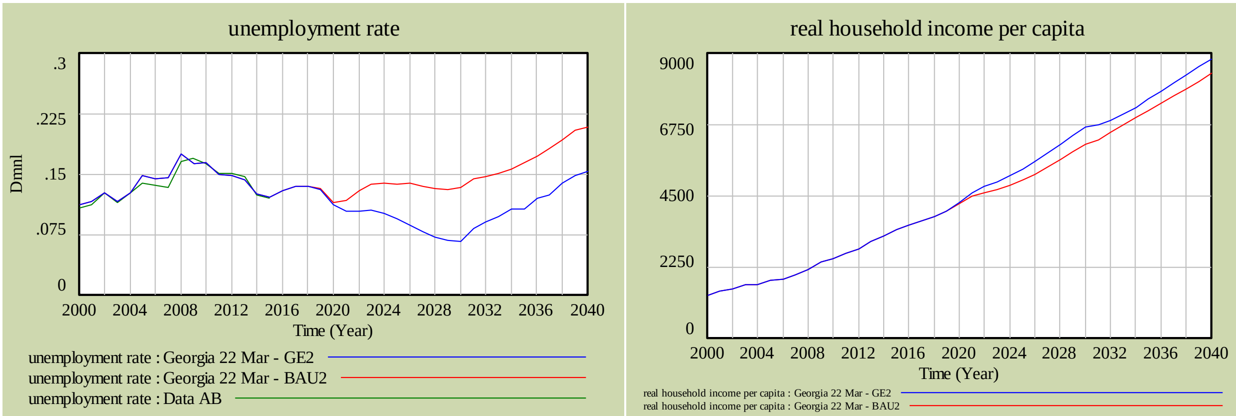
Figure 1: Total public debt and Interest on public debt



Georgia's economic development benefits its population by generating additional labour and income. For the period between 2018 and 2040, the GE scenario produces an unemployment rate that is 4.6 per cent lower on average than under the BAU scenario. Figure 6 compares the unemployment rate of both scenarios to historical data. It shows that GE interventions are forecast to reverse the BAU increase in unemployment in 2020, but that starting in 2030 – after the end of the implementation of GE policies – unemployment will rise (unless new interventions are planned).

Further, Figure 6 shows that real household income per capita is projected to increase from GEL 390 per capita in 2015 to GEL 8,380 per capita (BAU) and GEL 8,800 per capita (GE) in 2040.]

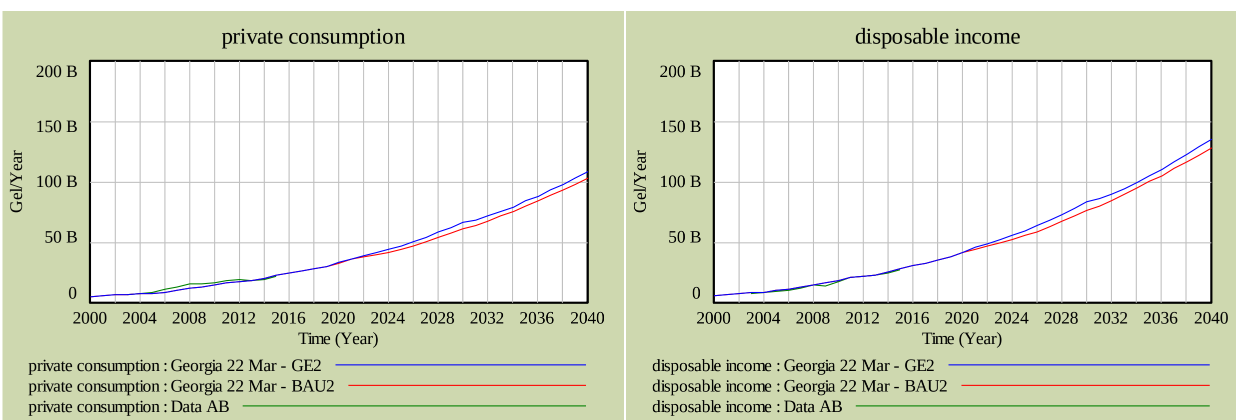
Figure 6: Employment rate and Real income per capita



The economic development of Georgia leads to an increase in personal income and purchasing power. Private consumption in the BAU scenario reaches GEL 103 billion by 2040. In the GE scenario, private consumption reaches GEL 108 billion by 2040, or about 5 per cent higher than in the BAU scenario. Figure 7 shows the growth in total disposable income and total private consumption for the BAU and GE scenarios, compared to historical data. Between 2004 and 2015, disposable income grew on average by 11.6 per cent per year, and consumption expenditures by 11.4 per cent (GEOSTAT, 2014; 2015; 2016; 2017b). Between 2016 and 2040, the annual growth rates for both total disposable household income and consumption expenditures in the BAU and GE scenarios are projected to be 6.1 per cent and 6.3 per cent respectively.

By 2040, disposable household income increases from GEL 27.3 billion in 2015 to GEL 128.7 billion per year in the BAU scenario and GEL 135.2 billion in the GE scenario (GEOSTAT, 2017b).

Figure 7: Private consumption and Disposable income



Investments

The implementation of all GE interventions requires a total investment of GEL 24.7 billion between 2018 and 2040, corresponding to 4.9 per cent of GDP between 2018 and 2030 and 2.4 per cent of GDP between 2018 and 2040.

This investment leads to value creation, with cumulative GDP being higher than the BAU case by GEL 61.7 billion. Table 4 provides an overview of the investments required for each of the sectoral GE scenarios, and the combined implementation of GE interventions. It also provides information on avoided costs and added benefits, and shows that the simultaneous implementation of all GE interventions leads to outcomes that are larger than the sum of sectoral interventions, due to the effects of macroeconomic feedback loops.

The GE scenarios change the extent to which sectors respond to investments. For instance, the target in the GE scenario to increase sustainable buildings leads to an increase in retrofits that would occur in the BAU case (where demolition and reconstruction are the primary drivers of the sector). In light of this, if we were to consider only the extra cost of retrofits in the GE scenario relative to the BAU case, rather than the full cost as shown in Table 4, the total investment in the buildings sector in retrofits would decline to approximately GEL 3.8 billion in the buildings scenario and to GEL 3.3 billion in the combined GE scenario. The net investment savings (or reduced investments) in these two green economy scenarios relative to the BAU case occur in part because of the lower cost of retrofits relative to new construction. That being said, the report presents as a main result the total investment in order to provide an idea of the amount of funding required (from private and public sources) to implement the green economy targets analysed.

Table 4: Summary table on Investments, avoided costs and added benefits GE scenarios

Indicator	Unit	Scenario			
		Tourism	Buildings	Agriculture	Combined GE
Cumulative difference in GDP GE vs. BAU	M GEL	10,190.0	47,500.2	3,633.5	61,655.1
Investment					
Buildings					
Construction	M GEL	841.5	-13,612.8	0.0	-11,499.2
Technology	M GEL	35.5	2,020.5	0.0	2,123.8
Retrofits	M GEL	98.2	30,826.3	0.0	31,333.6
Agriculture					0.0
Irrigation	M GEL	47.6	0.0	2,184.4	2,231.0
Organic farming	M GEL	8.7	0.0	496.0	504.6
Sum of additional investments	M GEL	1,031.5	19,234.0	2,680.4	24,693.8
Avoided costs					
Operating Costs	M GEL	-87.6	3,328.8	-36.3	3,130.9
Investments in Power Generation	M GEL	80.9	489.2	0.0	535.0
Investments in Wastewater treatment	M GEL	96.7	0.0	0.0	96.7
Total avoided costs	M GEL	90.0	3,818.0	-36.3	3,762.7
Added benefits					

Additional labour income	M GEL	5,817.9	18,000.4	4,216.6	28,519.8
Avoided social cost of carbon	M GEL	-14.3	522.2	7.0	505.1
Additional carbon sequestration	M GEL	0.0	0.0	312.7	312.7
Social costs of emissions	M GEL	20.2	-232.0	6.5	-203.5
Total added benefits	M GEL	5,803.6	18,522.6	4,536.3	29,337.6
Sum avoided costs and added benefits	M GEL	5,893.6	22,340.6	4,500.0	33,100.3
Net benefit of GE intervention	M GEL	4,862.0	3,106.6	1,819.7	8,406.4

The building and tourism sectors require the largest share of investments to realize the energy efficiency ambitions. Overall, a total investment of GEL 20.3 billion is required between 2020 and 2040 for these two sectors. During the same period, GE interventions in the agriculture sector require total investments of GEL 2.2 billion for the installation of efficient irrigation infrastructure, and 496 million to convert and maintain 20 per cent of Georgia's cropland under sustainable farming practices. Avoided costs and added benefits are assessed for the period between 2020 and 2040 for all investments.

Avoided costs

The transition to more efficient technologies yields cumulative avoided costs of almost GEL 3.8 billion, which is equivalent to savings of GEL 188 million per year. Extending the timeframe of the analysis for the lifetime of the investments would increase this figure. Of the total avoided costs, GEL 3.1 billion are realized from reductions in operating costs; energy efficiency measures in buildings yield cumulative reductions of GEL 3.3 billion, equal to average savings of GEL 166.4 million per year. The use of efficient irrigation technologies realizes additional savings of almost GEL 68.2 million by reducing energy requirements for irrigation. However, savings in energy expenditure are cancelled out through higher O&M costs, yielding a net saving of GEL 36.3 million over 20 years (2020-2040). The transition to more sustainable hotels allows for downscaling wastewater treatment facilities (WWTF), which realizes GEL 96.7 million in cumulative avoided investment and O&M costs for WWTF capacity. Finally, the implementation of energy efficiency measures through the three sectors contributes to GEL 535 million avoided investment costs in electricity generation capacity.

Added benefits

In total, the GE interventions generate cumulative additional benefits worth GEL 29.3 billion between 2020 and 2040. The added benefits assessed for the GE interventions are the generated labour income, and social and environmental benefits of reducing emissions from energy consumption. By 2040, the GE interventions are projected to create an additional 113,600 jobs and generate cumulative additional labour income of GEL 28.5 billion. While total energy demand and emissions increase in the GE scenario due to higher GDP growth, a reduction in CO_2 emissions is forecast, as well as a net reduction relative to the BAU case for the building and the agriculture (irrigation) sector. Specifically, the GE case forecasts savings of 6.9 million tonnes of CO_2 until 2040, or 343,830 tonnes per year on average. This corresponds to GEL 505.1 million cumulatively between 2020 and 2040 with a social cost of carbon at GEL 74/tonne (US $31/tonne) (Nordhaus, 2017). Furthermore, the conversion to sustainable agriculture generates cumulative additional benefits of GEL 312.7 million by 2040 through increased carbon absorption.

Sustainable land-use practices increase carbon sequestration on average by 207,200 tonnes per year and sequester an additional 4.1 million tonnes of CO_2 by 2040.

In addition to the financial indicators, the GE scenario yields multiple social and environmental benefits. The transition to more efficient technologies enables Georgia to realize significant water and energy savings. Total water consumption between 2020 and 2040 is 5.3 per cent lower compared to the BAU scenario. Cumulative water savings total 1.2 billion m^3, which is equivalent to average annual water savings of roughly 60.3 million m^3. The cumulative savings in electricity consumption from buildings total 30.3 TWh by 2040, and average 1.5 TWh over 20 years. On average, these savings represent a 6.4 per cent reduction in annual demand from buildings. With the end of the transition in 2040, the annual energy demand from buildings is 9.8 per cent lower than in the BAU scenario.

APPLICATION OF ENERGY EFFICIENCY MEASURES EXCLUSIVELY IN AN URBAN CONTEXT

The return on investment in energy-efficient technologies in buildings is relatively small, due to a high usage of inexpensive biomass for heating in rural areas. An additional analysis on the impacts of energy efficiency improvements in buildings was conducted, based on the assumption that efficiency improvements in buildings are predominantly implemented in urban areas. To assess the impact of energy efficiency measures in an urban context, an energy mix of 50 per cent gas and 50 per cent electricity for heating is assumed for both scenarios. All other assumptions remain equal.

The analysis reveals that, between 2020 and 2040, total investments of GEL 1.9 billion in energy-efficient technologies are required to upgrade 30 per cent of the building stock. Capital investment in the construction of buildings remains the same as in the GE building scenario (GEL 17.2 billion). Based on the assumed energy mix for heating, the energy efficiency measures yield cumulative savings of GEL 5.9 billion by 2040. Compared to the previous GE scenario, total cumulative investments in energy efficient technologies are GEL 3.2 million lower, while cumulative savings in energy expenditure are GEL 816.4 million higher.

Table 5: Summary of macroeconomic results

Variable	Unit	2015	2020	2025	2030	2035	2040
Population	People						
BAU		3,755,604	3,778,661	3,797,600	3,816,635	3,835,765	3,854,991
GE		3,755,604	3,778,661	3,797,600	3,816,635	3,835,765	3,854,991
GDP	M GEL10/Year						
BAU		27,470	34,443	40,659	50,069	59,196	69,417
GE		27,470	34,482	43,423	54,550	62,228	72,948
GDP growth rate	%						
BAU		4.6%	5.2%	3.4%	4.1%	3.5%	3.3%
GE		4.6%	5.2%	4.2%	4.4%	3.4%	3.2%
Government revenues	M GEL/Year						
BAU		9,369	13,524	18,070	24,842	32,459	41,699
GE		9,369	13,539	19,278	27,038	34,107	43,805
Government expenditure	M GEL/Year						
BAU		8,925	13,043	17,526	24,204	31,716	40,828
GE		8,925	13,058	18,718	26,370	33,341	42,905
Total public debt	M GEL						
BAU		13,114	20,368	25,100	29,452	33,311	36,584
GE		13,114	20,368	25,051	29,283	33,028	36,169
Unemployment rate	%						
BAU		12.2%	11.5%	13.8%	13.3%	16.4%	20.8%
GE		12.2%	11.3%	9.9%	7.4%	11.6%	16.2%
Real household income per capita	GEL10/Person/ Year						
BAU		3,420	4,256	4,993	6,112	7,184	8,378
GE		3,420	4,260	5,331	6,656	7,551	8,803

4.2. Sectoral dynamics

4.2.1. Buildings

The building model estimates the energy consumption in the building sector by energy sources, the cost of interventions and operations, and GHG emissions. It also projects life cycle emissions based on estimates of cement and steel consumption.

The main indicators analyzed include required investments; savings on energy expenditures and avoided costs for electricity generation and fuel imports; and added benefits such as job creation and reductions in water use and emissions. Selected results, for key performance indicators, are presented in Table 7.

4.2.1.1. GE opportunities from the Green Growth Policy Paper

The INDC submission and the Third National Communication to the UNFCCC present the need for energy efficiency improvements (Ministry of Environment and National Resources Protection of Georgia, 2015). The following policy actions are the most relevant in the context of green growth:

- Reduce energy imports and increase energy independence, through both demand and supply measures
- Improve regulatory mechanisms and optimize supply to create a business environment that attracts direct foreign investment
- Incorporate the goal of reducing GHG emissions and other environmental impacts into the evaluation of energy projects

Competitive energy prices are key to the energy sector's ability to enable economic growth. In a green economy approach, however, the emphasis shifts from price to consumption, and to the level of expenditure resulting from consumption. In this approach, energy expenditure is a more important indicator than energy price.

The government of Georgia has already started planning for the introduction of energy efficiency regulations for buildings (the adoption of the Construction Code and energy performance indicators, for example). Policies are already in place to incentivize remodeling and retrofitting efforts. When the cost of renovation is over 25 per cent of the value of the building, the government and the municipality provide support.

Table 6: Assessment of selected green economy interventions in the energy sector (excerpt on energy efficiency from the Green Growth Policy Paper)

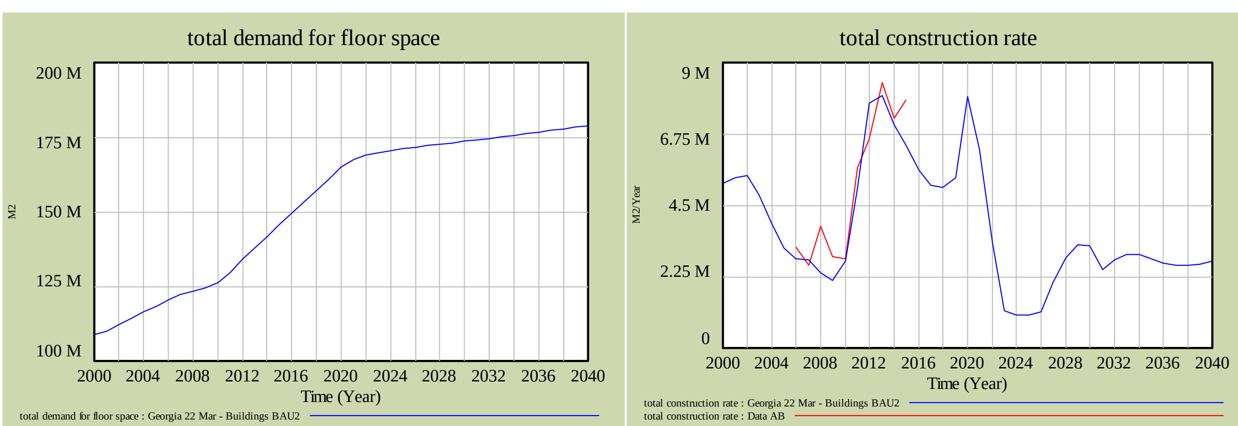
Goal	Policy	Multi-criteria analysis		
		Investment	**Avoided cost**	**Added benefit**
	Incentives for production and servicing	Public incentive (G), purchase of machinery (P), capacity-building (P)	Import of RE capacity (P)	Improved balance of payments (G), employment creation (H), GDP growth (P, G)
Energy efficiency	Incentives for building retrofits and efficient appliances	Public incentive (G), purchase of products or retrofits (P, H)	Electricity and energy bills (H, P), cost of fossil fuel use (H, P), public generation capacity (G)	Lower emissions (G), employment creation (H), higher savings/consumption (H, G)

H = households; P = private sector; G = government

4.2.1.2. Simulation results: BAU

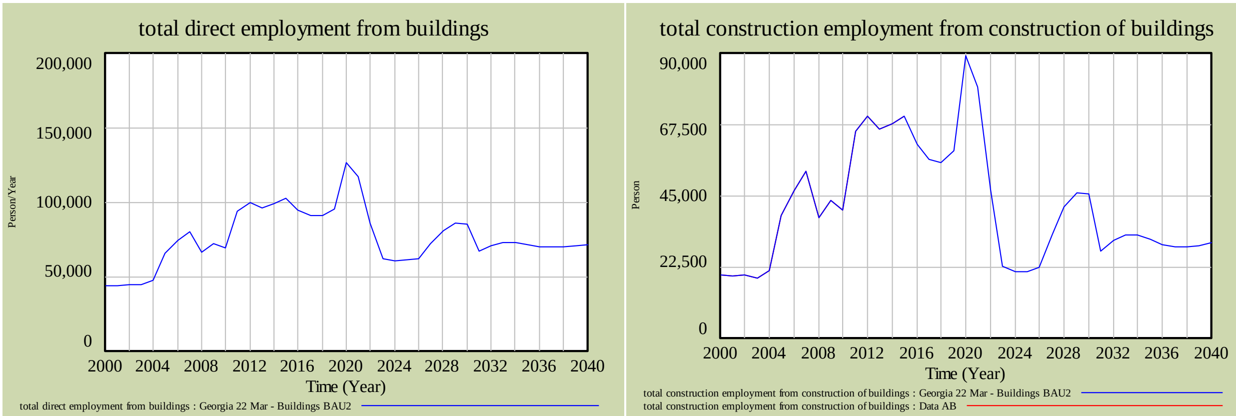
In the BAU scenario, the total demand for floor space is projected to increase by about 0.6 per cent between 2018 and 2040 as a result of low population growth. Figure 8 illustrates the development of demand for floor space in the BAU scenario (left), and compares the construction rate of the BAU scenario to historical data (right). The success of the incentives provided for the renovation of buildings is evident. In fact, despite the slow growth of total demand for floor space, total annual construction approximates 2.7 million square metres in the long run as a result of reconstruction and retrofits, with a peak in 2013 at over 7 million square metres. Further, the projected peak is reached in 2020 as a consequence of a modest increase in demand for energy-efficient buildings (the share is assumed to increase to 10 per cent by 2030). On average 1.5 per cent of the building stock is replaced annually in the BAU scenario.

Figure 8: Demand for floor space (left) and total construction rate (right) - BAU scenario



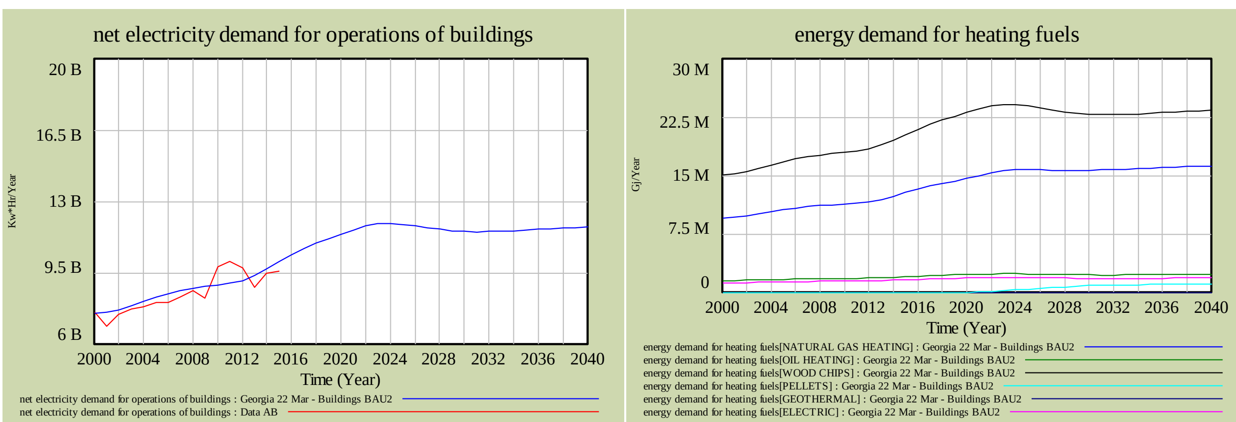
After 2030, the employment generated by buildings is estimated at roughly 77,900 jobs, of which 50.7 per cent stem from the operation of buildings (due to low construction rates). Employment from the construction of buildings during peak construction periods can reach an employment share of 70 per cent. Figure 9 illustrates the development of total employment from buildings and specifically for construction.

Figure 9: Total employment and Employment from construction of buildings - BAU scenario



The electricity demand for buildings is projected to increase slightly as a consequence of the increase in the building stock. The total annual net demand for electricity from buildings is expected to reach 42.3 million GJ (or 11.8 TWh) by 2040. The increases in energy demand for heating are a consequence of new construction and the switching of fuels. The development of the total electricity demand (kWh/year) and energy demand for heating fuels (GJ) from buildings are shown in Figure 10.

Figure 10: Electricity demand and Energy demand from buildings - BAU scenario



The energy demand for heating fuels depends in part on the share of energy-efficient buildings. In the BAU scenario, fuel wood, gas and oil (Figure 10) are assumed to be the main heating sources, and they increase the most as a consequence of the construction peak between 2010 and 2014. By 2040, demand for heating fuels for buildings in the BAU scenario totals 44.7 million GJ.

By 2040, 10.6 per cent of the building stock is expected to be energy-efficient in the BAU scenario. Due to more energy-efficient technology, the greening of the building stock causes per square metre energy consumption to decrease from 71.2 kW per m² in 2010 to 67.3 kW per m² in 2040 (Figure 11). The water demand from buildings hovers around 295 billion litres per year in 2040. Total per square metre electricity consumption and water demand from buildings are displayed in Figure 11 (right).

Figure 11: Energy consumption per m² (left) and water demand from buildings (right) - BAU scenario

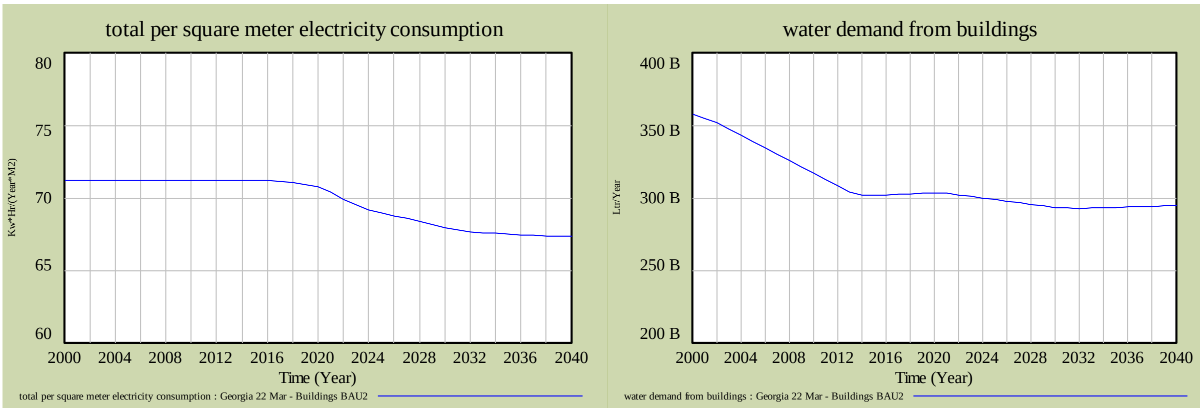
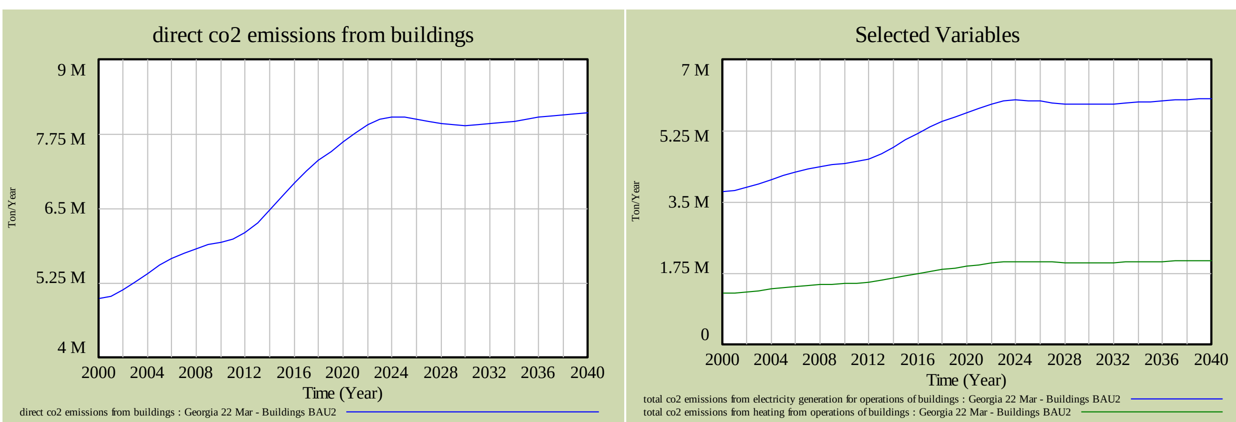


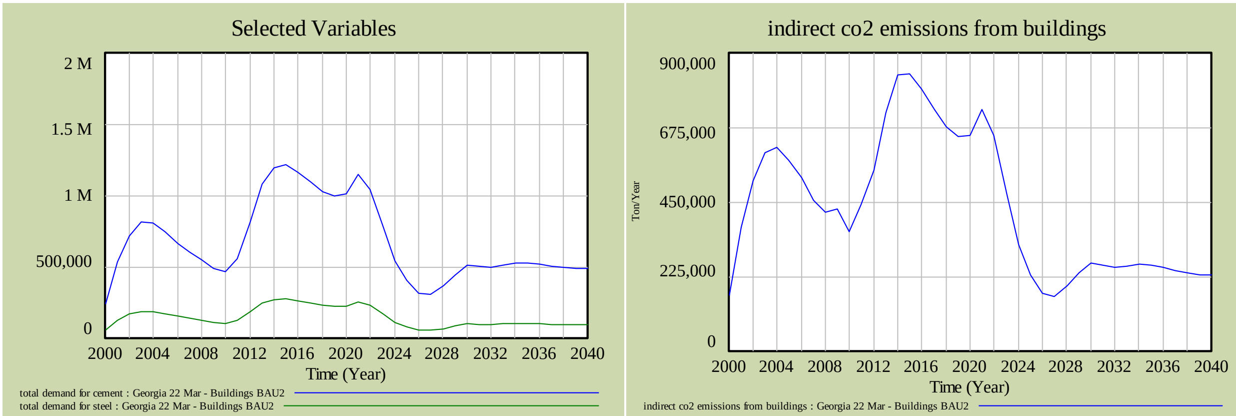
Figure 12 provides an overview of total direct CO_2 emissions from buildings. Annual CO_2 emissions from buildings are expected to reach 8.1 million tonnes per year in 2040. The figure on the right shows CO_2 emissions from electricity generation compared to heating-related CO_2 emissions. The BAU scenario indicates that electricity consumption in buildings (including electricity used for heating) produces almost three times more CO_2 emissions than fossil fuel use for heating.

Figure 12: Direct CO_2 emissions from buildings (left) and CO_2 emissions from buildings operations and heating (right) - BAU scenario



The construction rate drives the demand for construction materials. In the long run, demand for steel and cement reaches 90,000 tonnes and 470,000 tonnes per year respectively. Figure 13 provides an overview of the demand for cement and steel in the BAU scenario, and the emissions from the production of these materials.

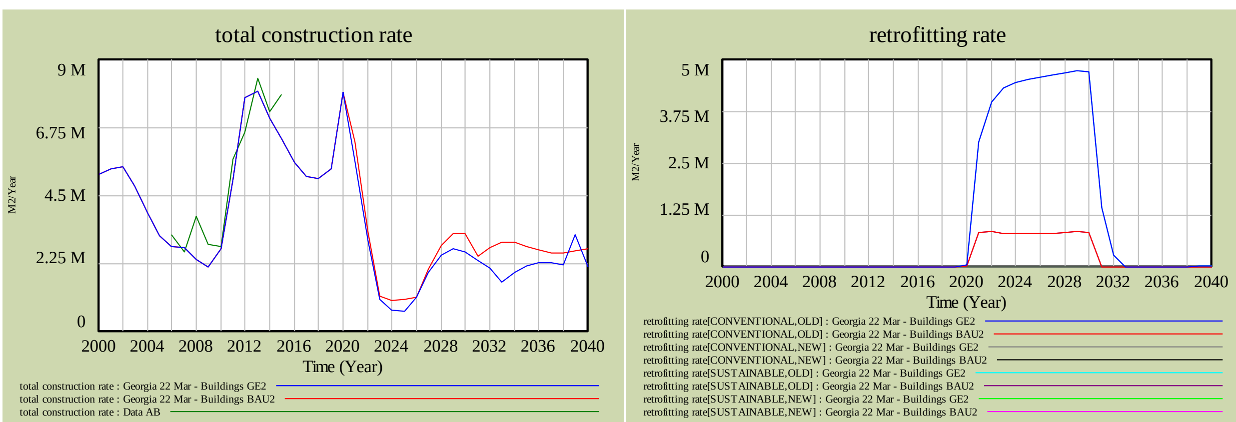
Figure 13: Demand for cement and steel from buildings (left) and indirect CO_2 emissions from buildings (right) - BAU scenario



4.2.1.3. Simulation results: GE

The demand for living space is assumed to be equal in both scenarios. Differences in the construction rate starting from 2020 are caused by higher ambition for sustainable buildings and by the retrofitting of old buildings to facilitate this transition. Figure 14 compares the construction and the retrofitting rates of the BAU scenario to the respective rates of the GE scenario. The reduced construction rate in the GE scenario results from the high retrofitting rates.

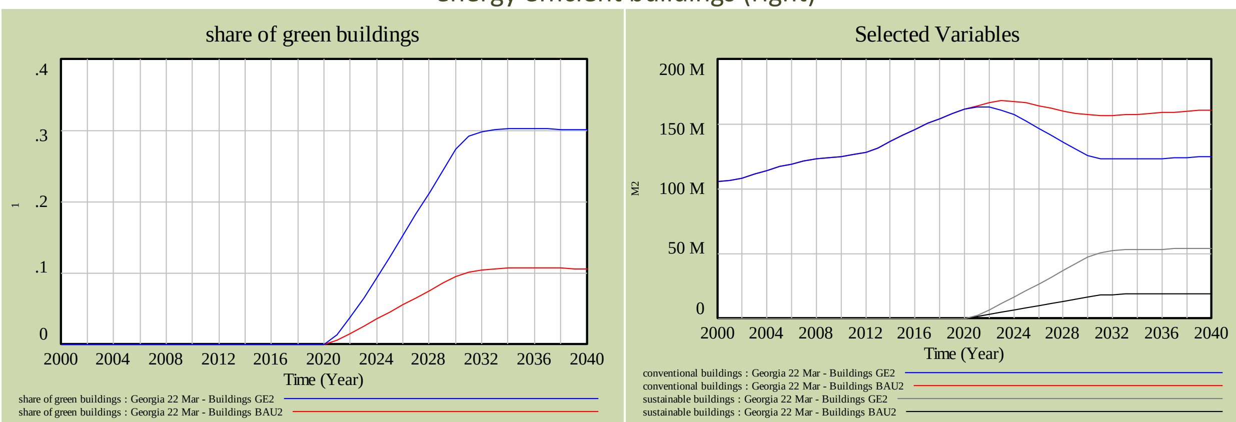
Figure 14: Total construction and retrofitting rate and Sustainable floor space



As a result of new sustainable construction and retrofits, the stock of efficient buildings reaches 53.7 million square metres in 2040, three times as high as in the BAU scenario (17.9 million square metres). By 2033, the share of energy-efficient buildings is projected to reach 30.1 per cent. Figure 15 compares the development of conventional and energy-efficient building stocks in the GE and BAU scenarios.

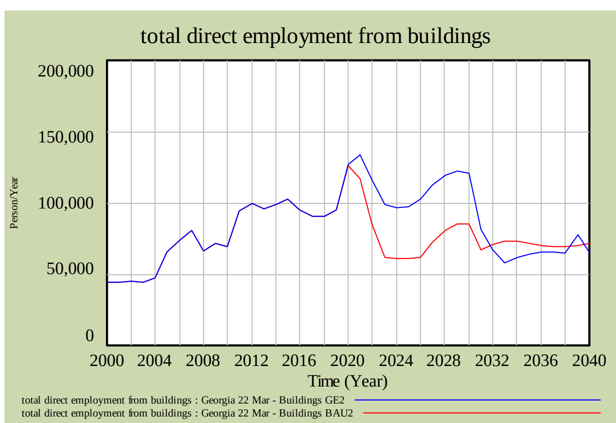
The required additional investments for the transition to more sustainable buildings total GEL 19.2 billion between 2020 and 2040, and include upgrades in technology such as light bulbs and appliances (GEL 2.0 billion) and the construction of new buildings and the costs of retrofitting old buildings (GEL 17.2 billion). The estimated capital cost is primarily for retrofits rather than new construction. This is because of the short time available to reach the stated target of sustainable buildings, which, due to limitations in the construction of new buildings, is satisfied primarily by retrofits. Also, it is assumed that a retrofit increases the average lifetime of buildings, contributing to a 7.8 million square metre reduction in total construction between 2020 and 2040. The reduction of investment in new buildings, relative to the BAU case, totals GEL 13.0 billion (GEL -8.5 billion for conventional and GEL -4.5 billion for energy-efficient) during 2020-2040, while cumulative investments in the retrofitting of buildings increase by GEL 30.6 billion to GEL 37.4 billion. Compared with the BAU scenario, this change represents a 5.1 per cent reduction in investments in new constructions and a 457 per cent increase of investments in retrofits.

Figure 15: Share of green buildings (left) and development of conventional and energy efficient buildings (right)



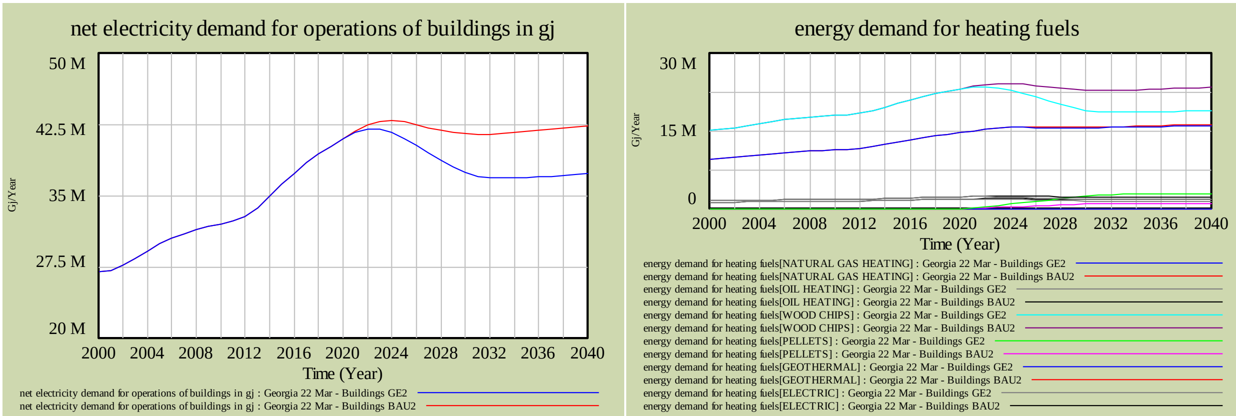
Employment from the construction of buildings remains unchanged compared to the BAU scenario. In the long run, the total number of jobs increases to roughly 91,400 jobs, which is an increase of 13,500 jobs compared to the BAU scenario. Figure 16 illustrates the development of employment from buildings and employment from construction of buildings in both scenarios.

Figure 16: Total employment from construction and O&M of buildings – BAU and GE scenarios



In 2040, a higher share of energy-efficient buildings causes the annual electricity demand for buildings in the GE scenario to be 11.7 per cent lower than in the BAU scenario. This is equivalent to annual energy savings of approximately 5 GJ. Further, the demand of heating fuels shifts towards safer, low-carbon energy sources. As a result of more efficient technologies, the energy demand for heating fuels in the GE scenario totals 40.9 million GJ, which is 3.8 million GJ lower than in the BAU scenario. Figure 17 illustrates the development of electricity and energy demand from buildings in the GE and the BAU scenarios.

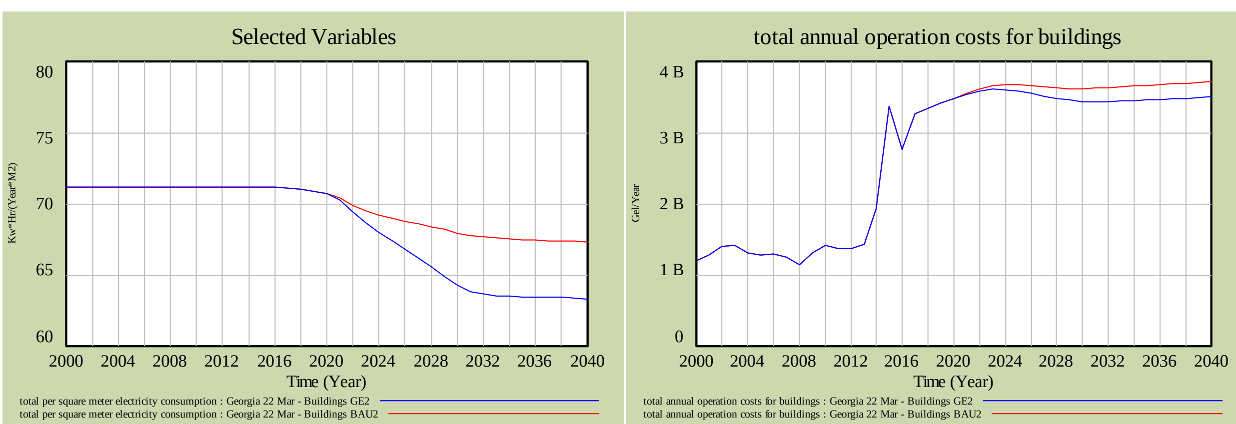
Figure 17: Electricity demand from buildings and Energy demand for heating fuels



The increase in green buildings reduces the electricity consumption per square metre by 7.9 kWh per year by 2040, from 71.2 kWh in 2015 to 63.3 kWh in 2040. By 2040, the reduction in per square metre electricity consumption and more efficient heating technologies yield savings of GEL 210.5 million in annual operating expenditures, which represents a cost reduction of 5.7 per cent. Figure 18 illustrates the development of per square metre electricity consumption and total energy expenditure from buildings in the two scenarios.

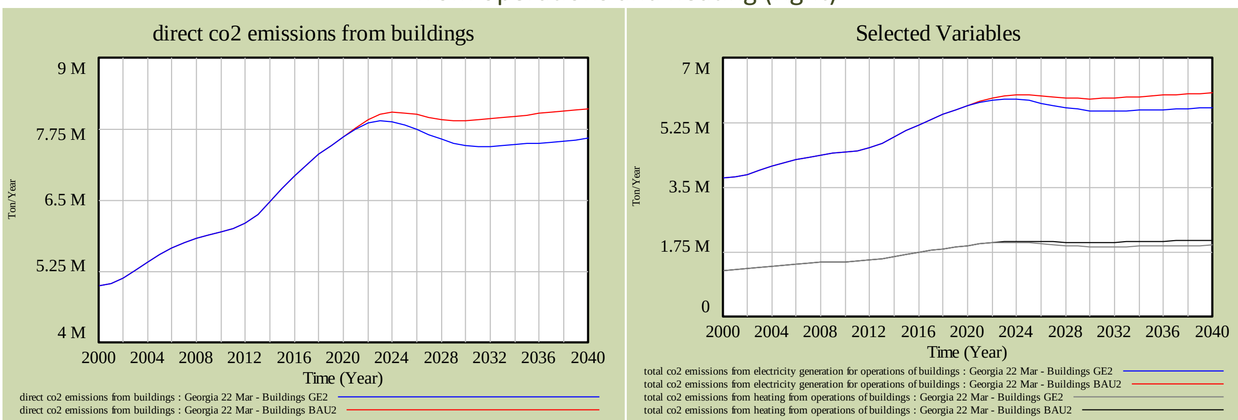
Higher energy efficiency contributes to cumulative savings of GEL 3.3 billion in the operating costs of buildings by 2040. Further, the reduced electricity consumption in the GE scenario leads to capital savings in power generation amounting to GEL 489.2 million between 2020 and 2040 compared to the BAU scenario.

Figure 18: Per m^2 energy consumption (left) and total electricity costs in buildings (right) - GE scenario



By 2040, the increased energy efficiency in buildings contributes to a 6.4 per cent reduction in annual CO_2 emissions compared to the BAU scenario. In 2040, CO_2 emissions from buildings are 522,500 tonnes lower compared to the BAU scenario, yielding cumulatively around 7.4 million tonnes of CO_2 in avoided emissions. In the GE scenario, annual CO_2 emissions from buildings range around 7.6 million tonnes per year between 2020 and 2040, compared to 8.1 million tonnes per year in the BAU scenario. Emissions from both heating and electricity are lower compared to the BAU scenario. By 2040, annual CO_2 emissions from heating and electricity in the GE scenario are forecast to be 6.6 per cent and 6.4 per cent lower than in the BAU scenario. Figure 19 compares direct CO_2 emissions from buildings, and for heating and electricity in the GE and BAU scenarios.

Figure 19: Direct CO_2 emissions from buildings (left) and CO_2 emissions from operations and heating (right)



Lower energy requirements and electricity savings reduce GHG emissions and hence the social costs of carbon from buildings. Compared to the BAU scenario, the social costs of carbon from buildings are approximately GEL 38.4 million lower in the 2030-2040 period, or GEL 522 million cumulatively.

Water demand from building reaches 267.6 billion litres per year in 2040, which is 9.2 per cent lower than in the BAU scenario. Annual water savings are approximately 27.2 billion litres. The recycling rate of construction materials increases as a result of the efficiency of buildings. In particular, the demand for cement and steel is reduced considerably. By 2040, the average annual demand for cement and steel is 16,900 and 77,700 tonnes lower per year respectively when compared to the BAU scenario. Between 2020 and 2040, retrofits and the recycling of materials yield an avoided production of 1.4 million tonnes of cement and 310,000 tonnes of steel. As a result of avoided cement and steel production, a cumulative reduction of 758,000 tonnes of CO_2 is achieved between 2020 and 2040 in the GE case when compared to the BAU scenario.

Figure 20: Demand for construction materials (left) and avoided CO_2 emissions from material savings (right)

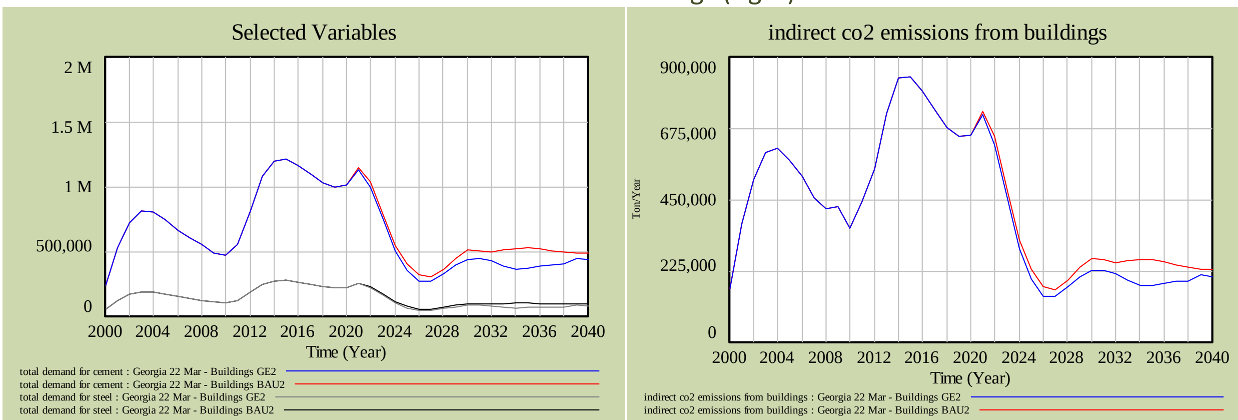


Table 2: Summary of buildings results

Variable	Unit	2015	2020	2030	2040
Real construction GDP	M GEL10/Year				
BAU		1,686	1,412	916	682
GE		1,686	1,420	1,802	610
Share of energy efficient buildings	%				
BAU		0.0%	0.0%	9.5%	10.6%
GE		0.0%	0.0%	27.4%	30.1%
Energy consumption	GJ/m²				
BAU		71.2	70.8	68.0	67.3
GE		71.2	70.8	64.3	63.3
CO_2 emissions from buildings	M Tonne/Year				
BAU		6.7	7.6	7.9	8.1
GE		6.7	7.6	7.5	7.6
Total employment	People/Year				
BAU		102,320	126,161	85,387	71,303
GE		102,320	126,514	120,516	64,254
Total additional investment GE vs. BAU	M GEL/Year	0	27.2	25,398.9	18,874.3
Energy cost savings GE vs. BAU	M GEL / Year	0	0	393	492
Avoided power generation investments GE vs. BAU	M GEL	0	0.0	341.1	489.2

Reduced social cost of carbon GE vs. BAU	M GEL/Year	0	0	9	10
Reduced water use GE vs. BAU	m^3/Year	0	0	24,577,802	27,217,756
Reduced cement use GE vs. BAU	Tonne/Year	0	0	74,594	51,568
Reduced steel use GE vs. BAU	Tonne/Year	0	0	16,210	10,202

4.2.2. Agriculture

Two of the main national goals for the agriculture sector are improved food security (including access and affordability), and an increase in added value.

The analysis focuses on two main strategies to increase production and productivity – the improvement of production practices that increase land productivity, and the improvement of water management to increase the area that is irrigated.

The outputs of the model include agriculture production and land productivity, leading to an estimate of revenues and costs of production, and finally value added and profitability (i.e., contribution to GDP). The model also estimates production inputs to assess the sustainability of the agriculture sector. Indicators include land and water use and the utilization of fertilizers and the resulting amount of nutrient loading reaching watercourses. On the social side, indicators include job and income creation. Additional indicators for the environment include carbon sequestration. Results for these indicators, for the BAU and GE scenarios, are presented in Table 9.

4.2.2.1. GE opportunities from the Green Growth Policy Paper

The Green Growth Policy paper identifies the enabling conditions for sustainably managing the agricultural sector on the supply side:

- Investments for technologies that make agricultural activities more resource-efficient
- Incentives for ecological farming practices that preserve soil fertility and biodiversity (e.g. certification)
- Post-harvest storage
- Research and development on crops and farming practices

The national goals related to sustainable agriculture are presented in the report "Strategy for Agricultural Development in Georgia 2015-2020" (Ministry of Agriculture of Georgia, 2015). Specifically, this document highlights the need to improve infrastructure (to reach markets more quickly), to encourage climate-smart agriculture practices, and to eliminate rural poverty through sustainable development of agriculture and rural areas.

Table 8 presents a supply-side policy for the agriculture sector and summarizes the investments required to implement the policies in question, the avoided costs, and the added benefits resulting from implementation.

Table 8: Assessment of a green economy intervention in the agriculture sector (excerpt from the Green Growth Policy Paper)

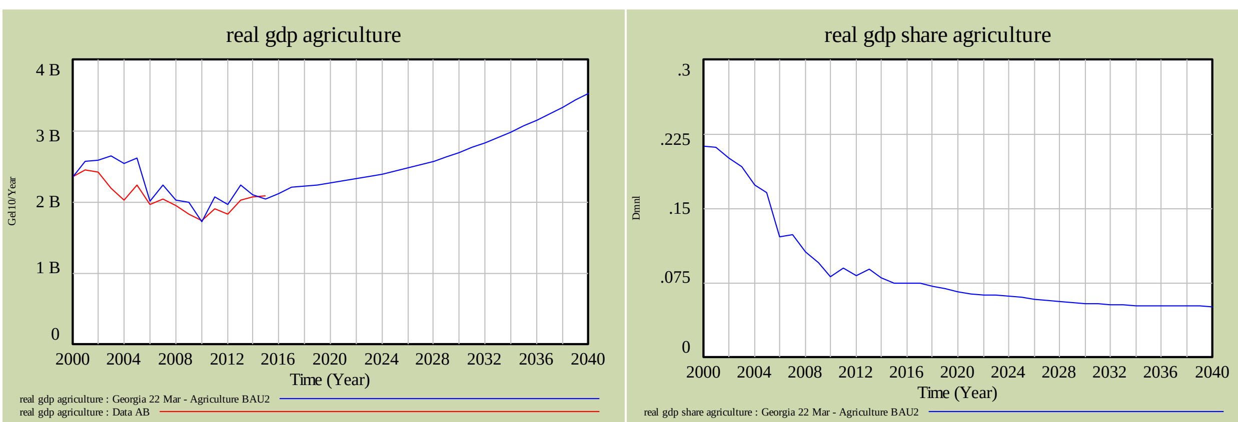
Goal	Policy	Multi-criteria analysis		
		Investment	**Avoided cost**	**Added benefit**
Reducing pressure on the environment	Incentives for ecological farming practices	Training activities (G), Compensation for short-term productivity decline (P)	Loss of ecosystem services (P, G), Costs of chemical fertilizers and pesticides (P), Water pollution (G)	Employment (H), Higher land productivity (P), Climate resilience (P), Access to foreign markets (P), Food quality (H)

H = households; P = private sector; G = government

4.2.2.2. Simulation results: BAU

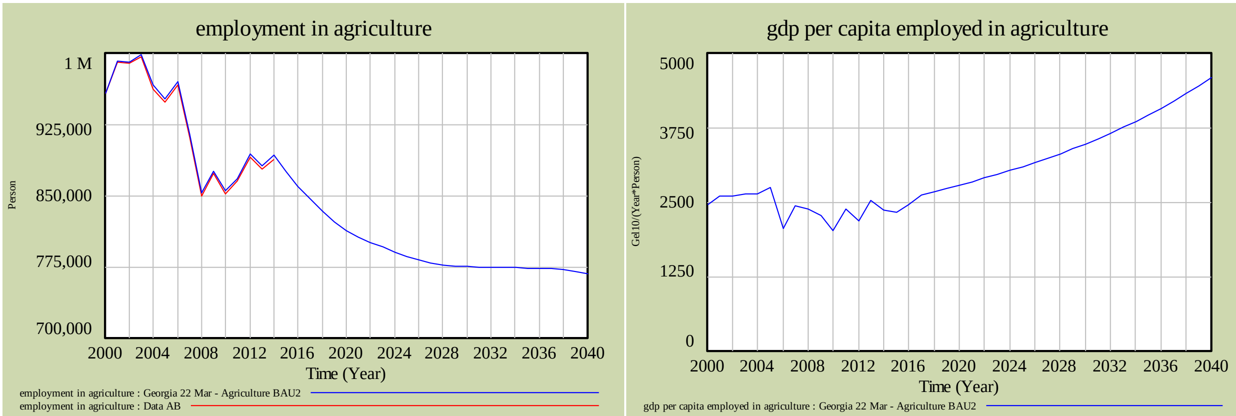
The agriculture share of real GDP is projected to reach GEL 3.5 billion in 2040, compared to GEL 2.0 billion in 2015. Despite providing jobs for almost 40 per cent of Georgia's population, the productivity of the agriculture sector is expected to remain low in the BAU scenario due to the lack of investment, unfavorable external conditions and limited mechanization (GCAD, 2015; BTI, 2016). The agriculture share of GDP is projected to decrease from around 9 per cent in 2015 (World Bank, 2017), to approximately 5 per cent in 2040. Figure 21 shows the agriculture share of real GDP compared to its historical performance, and the sector's contribution to GDP over time.

Figure 21: Real GDP and Real GDP Share Agriculture - BAU scenario



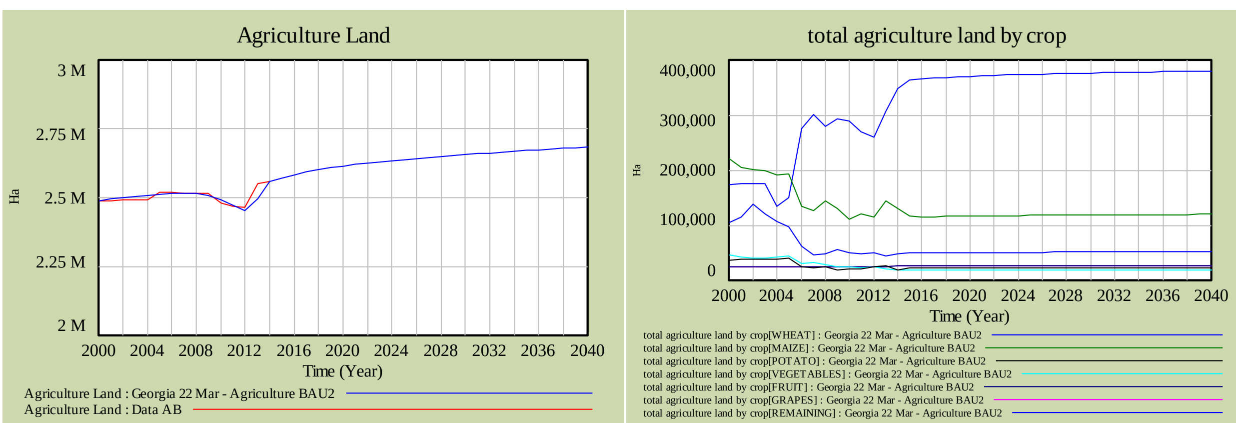
Despite its decreasing contribution to GDP, the agriculture sector continues to provide employment to almost 40 per cent of Georgia's population. The real GDP per person working in agriculture increases from GEL 2,468 in 2016 to GEL 4,594 in 2040. Figure 22 illustrates the total number of jobs provided by the agriculture sector and the real GDP per person employed in agriculture. By 2040 employment in the agriculture sector is projected to decrease to roughly 768,000 jobs, primarily due to baseline improvements in labour productivity.

Figure 22: Employment in agriculture and GDP per capita agriculture - BAU scenario



Overall, agricultural land increases in order to support a growing demand for food production. As a consequence of slow population growth, the total amount of agriculture land is expected to increase by roughly 84,000 hectares, or 0.1 per cent, from 2.6 million hectares in 2018 to 2.7 million hectares in 2040. The expansion of agricultural land is mainly driven by population growth, an increasing need for subsistence farming, and export businesses for products that enjoy an international reputation (e.g. wine). The development of total agricultural land in the BAU scenario is depicted in Figure 23 (left). In addition, an overview of land used for selected crops is provided (right).

Figure 23: Total Agriculture Land and Agriculture land by crop - BAU scenario



In the BAU scenario, the share of sustainable land use practices in 2011 was 0.1 per cent. Figure 24 illustrates the share of sustainable agriculture land over time in the BAU scenario.

Figure 24: Share of sustainable agriculture and Sustainable production by crop - BAU scenario

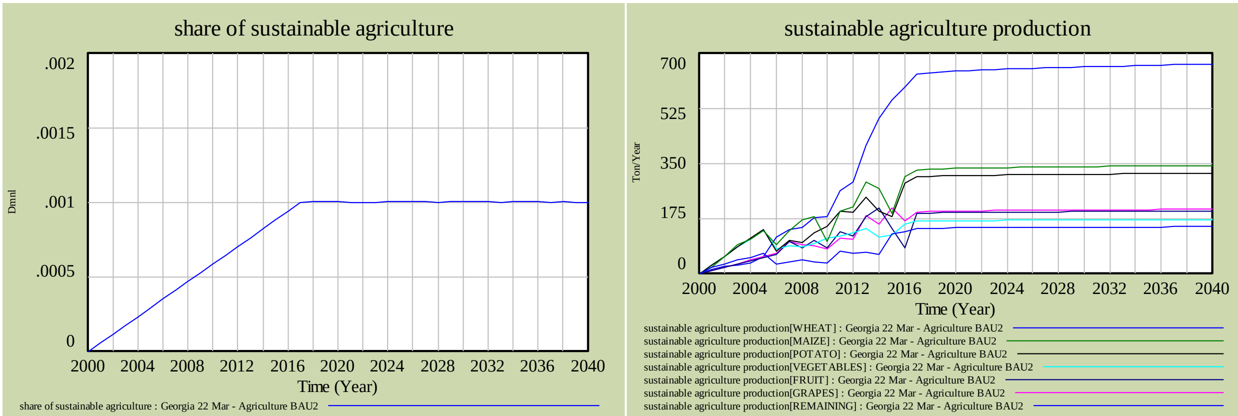
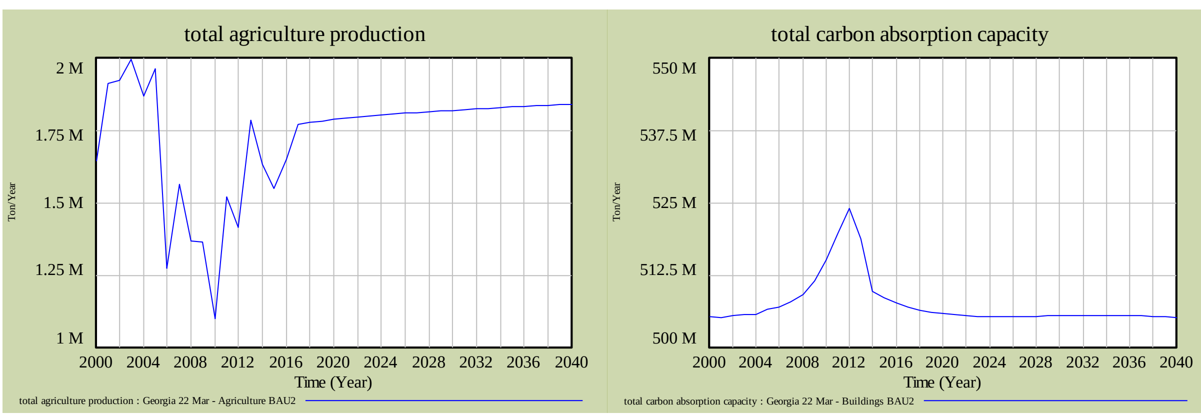


Figure 25 illustrates total agriculture production and the annual CO_2 absorption rate from land use (including fallow and forest land) in the BAU scenario. Total agricultural production in the BAU scenario totals around 1.8 million tonnes on average over the years, and is forecast to remain higher than in 2000, partially due to the stabilization of the population trend. By 2040, the CO_2 stock from land use in the BAU scenario is 505.3 million tonnes.

Figure 25: Total agriculture production and Total CO_2 stock from land use - BAU scenario

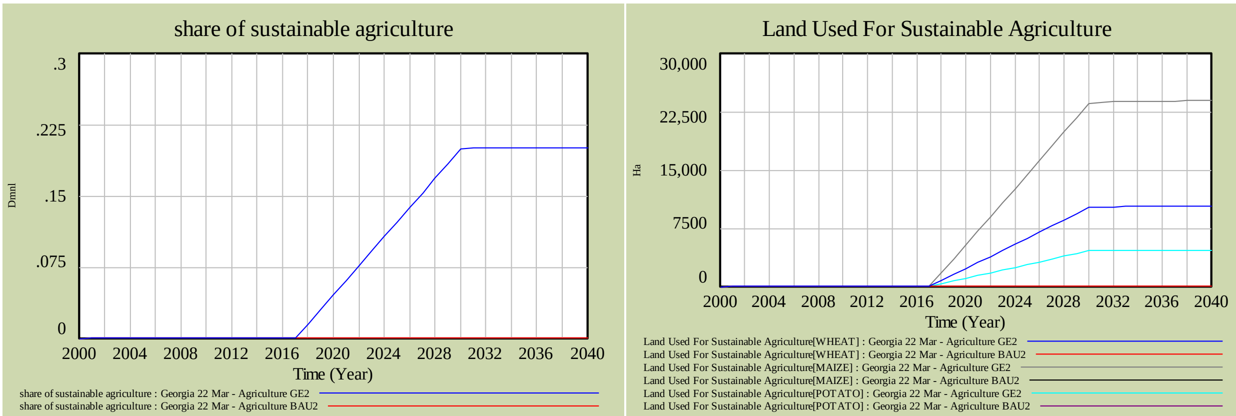


4.2.2.3. Simulation results: GE

The total amount of agricultural land and the land used by crop type remain unchanged in the GE scenario relative to the BAU case. On the other hand, in the GE scenario the share of sustainable agriculture grows from 0.1 per cent in 2017 to 20 per cent in 2030. Figure 26 illustrates the increase in land under sustainable farming practices (left) and the number of hectares under sustainable practices for growing wheat, maize and potatoes (right). By 2040, the area of wheat, maize and potatoes under sustainable farming is projected to increase to 10,350 hectares, 24,000 hectares and 4,700 hectares respectively.

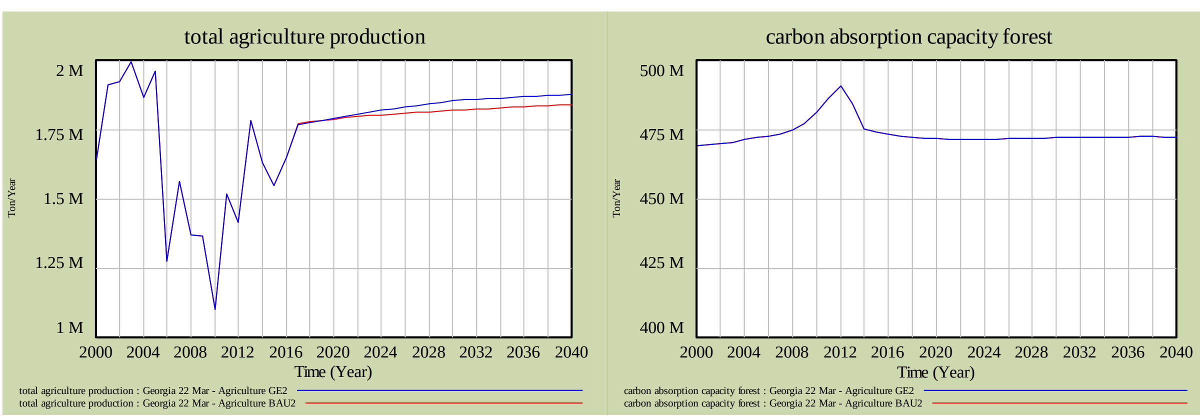
The transition to more sustainable agricultural practices requires investments of GEL 496 million between 2020 and 2040, while investments in more efficient irrigation capacity during the same period total GEL 2.2 billion. Compared to the BAU scenario, the increase in sustainable agriculture land increases the agriculture share of real GDP by GEL 193.4 million (5.5%) in 2040. Cumulatively, the greening of the agriculture sector generates an additional GEL 2.6 billion in real value added between 2020 and 2040.

Figure 26: Share of agriculture land and Land used for sustainable agriculture



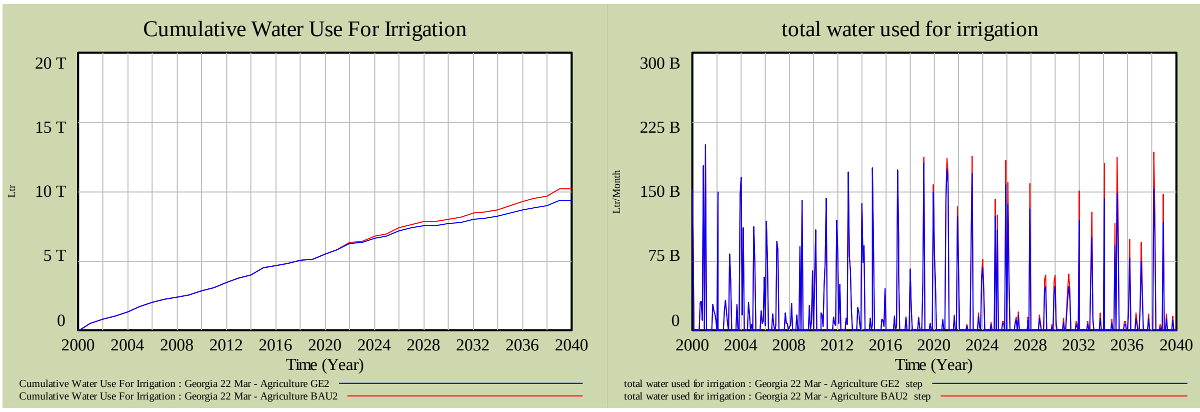
Total agriculture production benefits from the increase in productivity caused by the expanded use of sustainable farming practices. By 2040, total annual agriculture production is projected to be 1.9 per cent higher than in the BAU scenario. In addition, the higher carbon sequestration capacity of soil under sustainable practices leads to an increase in the annual CO_2 absorption from land use by approximately 262,750 tonnes compared to the BAU case. The additional CO_2 absorption reaches 4.1 million tonnes cumulatively in 2040. This translates to a reduction in the social cost of carbon of GEL 312.7 million, or GEL 16.6 million per year on average. Figure 27 shows total agriculture production and annual CO_2 absorption rates compared to the BAU scenario.

Figure 27: Total agriculture production and Total CO_2 stock from land use



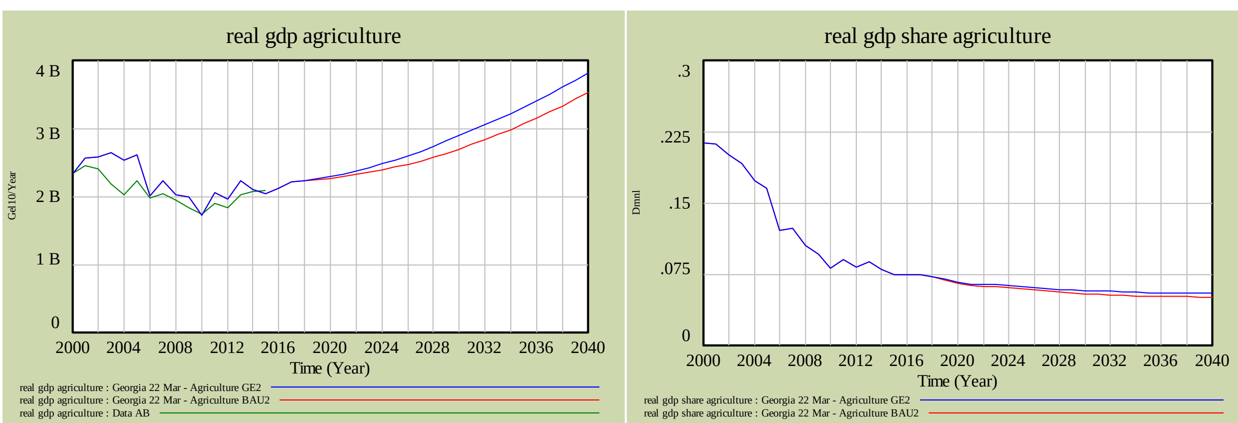
The use of drip irrigation in sustainable agriculture contributes to significant reductions in water demand. Overall, the GE scenario yields cumulative water savings of 823.1 million m³, which represents an 8.1 per cent reduction in water consumption for the period 2020-2040 compared to the BAU scenario. This translates to average annual water savings of 41.1 million m³, possibly leading to the irrigation of 23,600 additional hectares in water-scarce areas.

Figure 28: Cumulative water use from irrigation and Annual water use for irrigation



The implementation of sustainable farming practices benefits the economic performance of the agriculture sector. In the GE scenario, the agriculture share of real GDP by 2040 is forecast to be GEL 287.1 million higher than in the BAU scenario, representing an 8.1 per cent increase for the year 2040. Cumulatively, agriculture GDP is forecast to be GEL 5.2 billion higher than the BAU case. The growth of GDP translates into a 0.4 per cent increase in the share that the agriculture sector holds in total real GDP (Figure 29). The transition contributes on average GEL 121.8 million in real value added per year between 2020 and 2040, and projects agriculture GDP to be 5 per cent higher compared to the baseline. The transition to sustainable farming practices increases total agriculture production in 2040 by 35,700 tonnes, or roughly 2 per cent above BAU levels.

Figure 29: Real GDP and Real GDP Share Agriculture



As a result of higher labour requirements for sustainable agriculture, the GE scenario forecasts the creation of 17,500 additional jobs by 2040. This increases the share of employment of the agriculture sector in total employment by only 1.1 per cent, but provides additional income for rural communities.

Table 3: Summary of agriculture results

VARIABLE	Unit	2015	2020	2030	2040
REAL GDP AGRICULTURE	M GEL10/Year				
BAU		2,036	2,262	2,697	3,528
GE		2,036	2,285	2,839	3,722
REAL GDP SHARE AGRICULTURE IN TOTAL REAL GDP	%				
BAU		7.4%	6.6%	5.4%	5.1%
GE		7.4%	6.6%	5.7%	5.3%
EMPLOYMENT IN AGRICULTURE	People				
BAU		875,067	813,426	775,453	767,920
GE		875,067	817,106	791,751	785,401
SHARE OF SUSTAINABLE AGRICULTURE	%				
BAU		0.01%	0.1%	0.1%	0.1%
GE		0.1%	4.6%	20.0%	20.0%
AVERAGE PRODUCTIVITY PER HECTARE	Tonne/Hectare				
BAU		2.5	2.8	2.8	2.8
GE		2.5	2.8	2.9	2.9
ADDITIONAL INVESTMENT IN ORGANIC AGRICULTURE GE VS. BAU	GEL/Year	0	6,700,084	30,079,167	30,566,334
ADDITIONAL INVESTMENT IN IRRIGATION TECHNOLOGIES GE VS. BAU	M GEL/Year	0	26	60.9	38.5
AVOIDED SOCIAL COST OF CARBON FROM INCREASED CARBON UPTAKE GE VS. BAU	M GEL/Year	0	2	8.0	8.2
AVERAGE ANNUAL REDUCTION IN WATER USE GE VS. BAU	M^3/Year	0	4,092,174	32,091,878	41,153,620
EMISSION REDUCTIONS FROM LAND USE CHANGE GE VS. BAU	Tonne/Year	0	57,600	258,560	262,752

4.2.3. Tourism

The analysis of the tourism sector focuses on the opportunities arising from greening infrastructure, diversifying the opportunities for ecotourism and relying on local food supplies.

The model assesses the required construction of sustainable buildings, the related job creation, and the impact on GDP, job and income creation, costs and revenues. The environmental considerations include wastewater and nitrogen loading, which can lead to harmful discharges in coastal areas. Key results are presented in Table 11.

4.2.3.1. GE opportunities from the Green Growth Policy Paper

National goals relating to the sustainable management of the tourism sector are presented in the reports "Georgia Tourism Strategy" (GoG, 2015) and "Green Georgia" (Ministry of Economy and Sustainable Development of Georgia, 2011). These documents anticipate that ecotourism will play an increasingly important role.

The Green Growth Policy Paper regards green growth as a way to allow the tourism sector to grow and at the same time help several other sectors (e.g. agriculture). On the other hand, the tourism sector needs support from other sectors: infrastructure (e.g. airports and roads), a healthy environment, a local supply of agricultural products, reliable energy and parks. Indeed, the tourism sector can thrive only if other sectors provide good services at affordable prices and if the environment is properly managed.

The "Georgia Tourism Strategy" (GoG, 2015) presents the guiding principles and strategic objectives that should guide tourism development in the country for the next ten years. Specific 2025 policy objectives are as follows:

- Increase the sector's direct GDP contribution to the 6.7 per cent level of total GDP
- Increase average spending per visitor from GEL 785 to GEL 1,225 (US $320 to US $500)
- Increase the number of people employed in the tourism sector by 85 per cent
- Extend the average length of stay to 5.3 days
- Increase foreign direct investment in the tourism industry by 63 per cent
- Double the number of visitors from the higher spending markets of EU, Asia, and North America

Table 4: Assessment of selected green economy interventions in the tourism sector

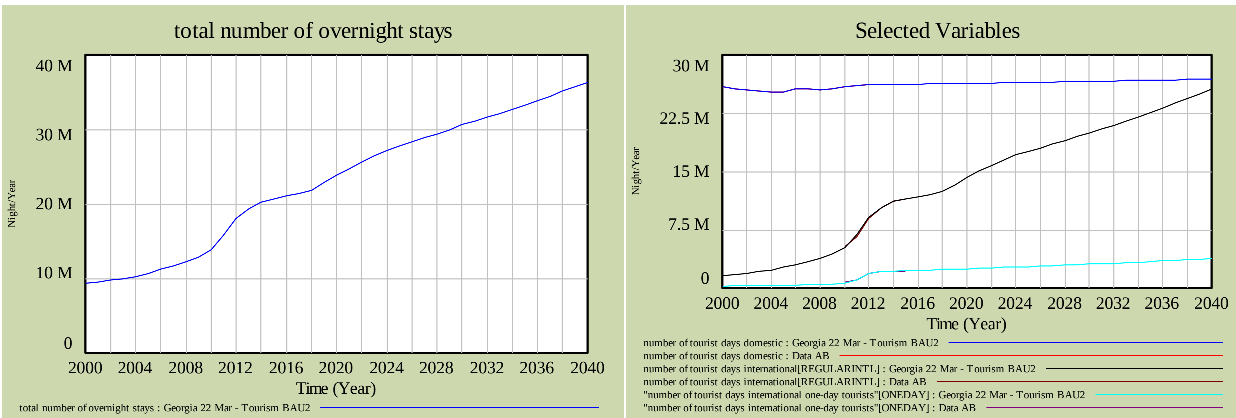
Goal	Policy	Multi-criteria analysis		
		Investment	Avoided cost	Added benefit
Reduce ecological footprint of tourism infrastructure	Investments in green infrastructure	Construction costs (G)	Energy costs (P), Climate resilience (P), Loss of ecosystem services (G)	Employment (H), Tourist arrivals (P), Local economic stimulus (H, P)
	Increase network of protected areas	Ecological assessment (G), Monitoring (G)	Illegal logging (G), Loss of biodiversity (G, P)	Employment (H), Recreational opportunities (H, P), Tourist arrivals (P)

H = households; P = private sector; G = government

4.2.3.2. Simulation results: BAU

Tourism is forecast to remain an important sector for the Georgian economy in the BAU scenario. The total number of overnight stays is projected to increase by 80.2 per cent between 2016 and 2040, mainly driven by international arrivals for multi-day recreational travel. One-day trips to Georgia and domestic multi-day tourism are expected to increase slightly in the future. Figure 30 shows the total number of overnight stays (left) and the total number of tourist days by tourist group (right).

Figure 30: Total number of overnight stays and Total number of days by tourist group - BAU scenario

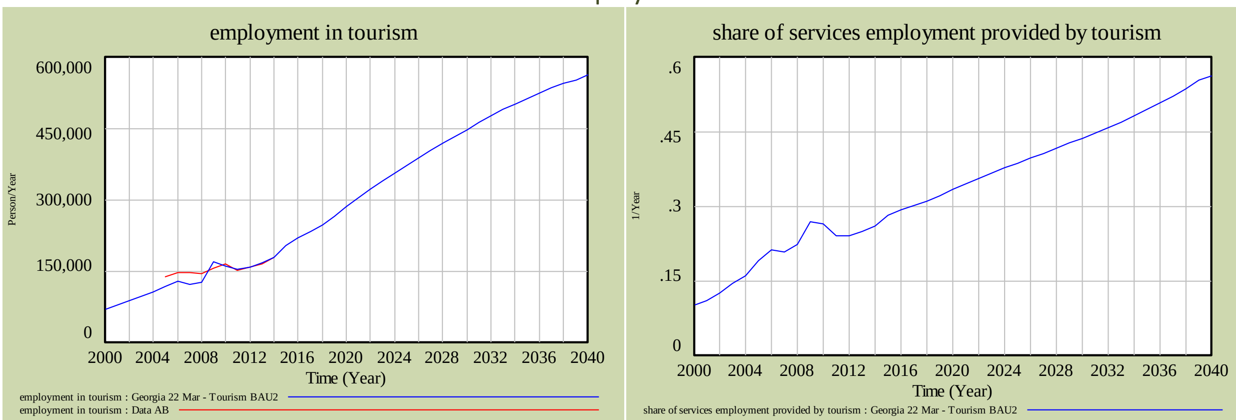


Tourism GDP is projected to almost triple between 2016 and 2040 (Figure 31), driven by the increase in tourist arrivals. In 2015 the tourism sector's contribution to real GDP was GEL 2.2 billion, and is projected to reach GEL 4.7 billion by 2040. Supported by the increase in tourists and value added per tourist, the share of tourism in real GDP increases from around 5.6 per cent in 2016 to 6.7 per cent in 2040 in the BAU scenario.

Figure 31: Tourism real GDP - BAU scenario

Employment in the tourism sector is projected to increase from 179,100 jobs in 2014 to 561,700 jobs in 2040. Figure 32 shows total employment in tourism in the BAU scenario, and illustrates the services and tourism shares of total employment. Figure 32 indicates that by 2040 roughly 56.2 per cent of all jobs in the services sector are provided by tourism-related activities.

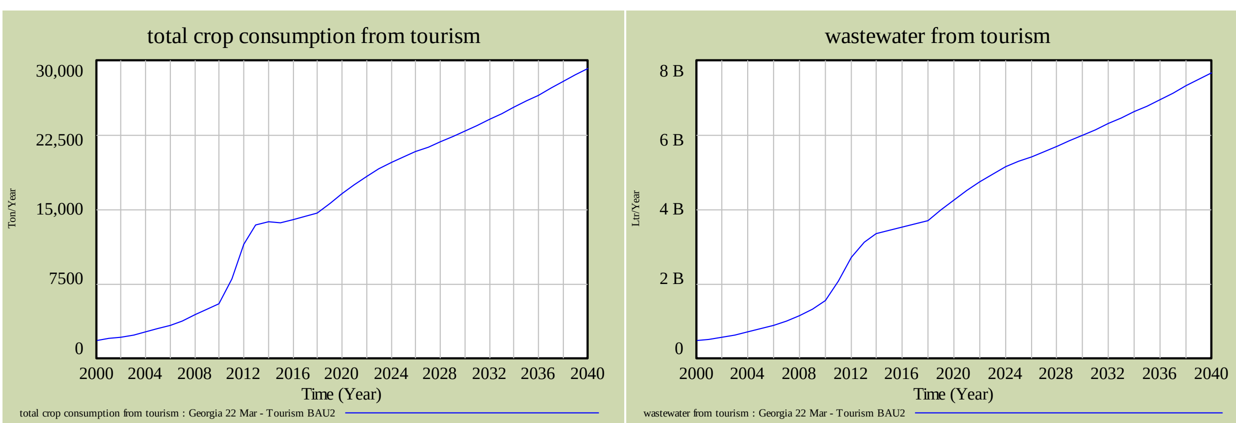
Figure 32: Employment in tourism and Employment share of tourism and services in total employment - BAU scenario



Overall, Georgia's tourism sector is forecast to provide accommodation for 64.6 million overnight stays per year by 2040, which is almost 3.5 times what the Georgian National Tourism Administration (GNTA) reported in 2015. The number of hotels increases as a consequence of higher demand for accommodation from tourists. The total number of hotels increases from 1,475 in 2015 (GNTA, 2016) to roughly 4,660 in 2040.

The total crop consumption from tourism in 2016 totaled about 14,000 tonnes and is forecast to more than double by 2040. Wastewater generation is calculated based on an estimate of UNEP (2011) and is projected to reach around 7.7 billion litres by 2040, compared to 3.5 billion litres in 2015. Figure 33 provides an overview of the annual crop consumption from tourism (left) and the wastewater generation from tourists (right) in the BAU scenario.

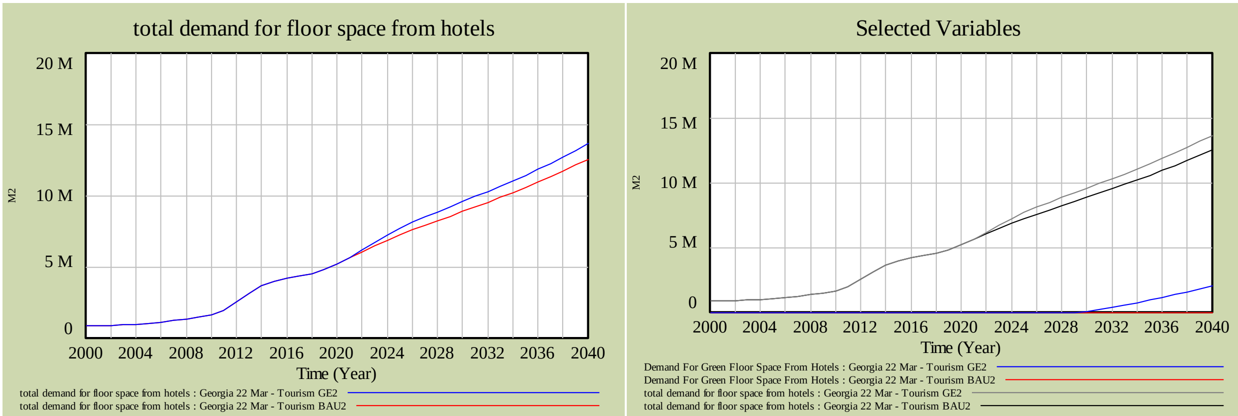
Figure 33: Total crop consumption and Wastewater from tourism - BAU scenario



4.2.3.3. Simulation results: GE

In the GE scenario, the share of green hotels reaches 15 per cent in 2040, while total demand for floor space increases by 1.1 million m² as a consequence of the increase in average length of stay per tourist. This means that by 2040, a total of 2 million square metres of hotel space are projected to be energy- and water-efficient. Figure 34 shows the projected growth of hotel space under the two scenarios.

Figure 34: Total demand for floor space from hotels and Green hotel area compared to total hotel area



The additional investments required to achieve higher efficiency in the GE tourism scenario total GEL 1.1 billion cumulatively by 2040. Investments in energy-efficient technologies total roughly GEL 35.5 million, while costs for new construction and retrofits reach GEL 939.7 million. The incremental increase in demand leads to the construction of about 1.9 million m² of energy-efficient building space, while only 88,400 m² are satisfied by retrofits. The sourcing of food locally would require cumulative investments of GEL 56.3 million in the agriculture sector, in addition to the investments in the building sector.

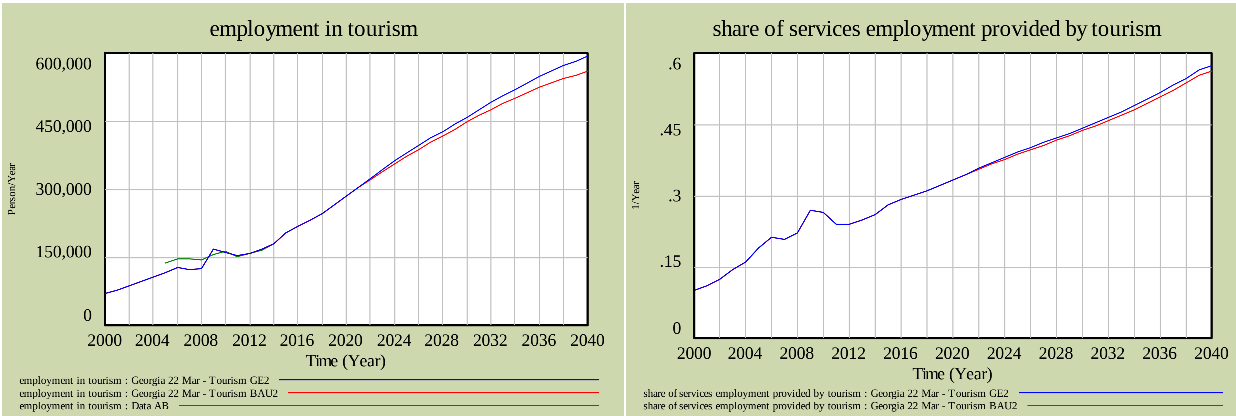
As a consequence of the timing of investments in energy-efficient hotels, Georgia's tourism sector does not realize savings between 2030 and 2040, but incurs GEL 87.6 million in cumulative operational expenditure. This is equivalent to average annual additional cost of GEL 8.8 million.

By 2040, the additional value added by green hotels increases real GDP from tourism by 5.8 per cent compared to the BAU scenario, or GEL 2.3 billion cumulatively. Figure 35 shows the tourism share of real GDP in the GE and BAU scenarios. The tourism share of real GDP in the GE scenario is forecast to reach 6.9 per cent in 2040, 0.2 per cent higher than in the BAU scenario.

Figure 35: Real Tourism GDP and Share of tourism in real GDP - GE scenario

Employment in tourism results from the increasing construction of hotels to meet the demand for overnight stays. By 2040, the transition to green practices generates 32,600 additional jobs, which increases the share of tourism-related activities in total service employment by 1.2 per cent to 57.4 per cent in 2040. Both indicators for both scenarios are displayed in Figure 36.

Figure 36: Employment in tourism and Employment share of tourism and services in total employment



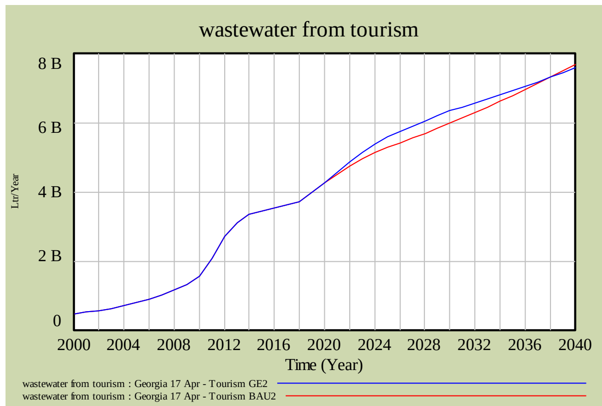
The high efficiency of the newly constructed green hotels yields additional benefits for the hotel sector. By 2040, the additional conversion of 2 million square metres yields annual savings of GEL 2.4 million in hotel operating costs, which is equivalent to savings of GEL 1.2 per square metre per year for green hotels. The green economy scenario captures an increase in total tourists, which leads to higher total operating costs for the sector. As a result, the benefits of green hotels would be more than the GEL 1.2 per square metre per year savings under the original assumptions. Furthermore, the reduction in energy consumption and the shift to more sustainable and reliable heating systems contributes to emission savings of approximately 6,300 tonnes per year by 2040 (Figure 37).

Figure 37: Total annual operation costs and Direct CO_2 emissions from buildings

Between 2020 and 2040 the operating expenditures of buildings increase by a cumulative GEL 87.7 million as a consequence of increasing tourist visits and length of stay. Net savings in operating expenditures from buildings start accruing after 2035 and average GEL 2.3 million per year between 2036 and 2040. The reduction in electricity consumption contributes to a reduction in total investments in power generation capacity by GEL 80.9 million compared to the BAU scenario. Further, the reduction in total CO_2 emissions from buildings reduces the annual social costs of carbon in 2040 by GEL 460,000 compared to the BAU scenario.

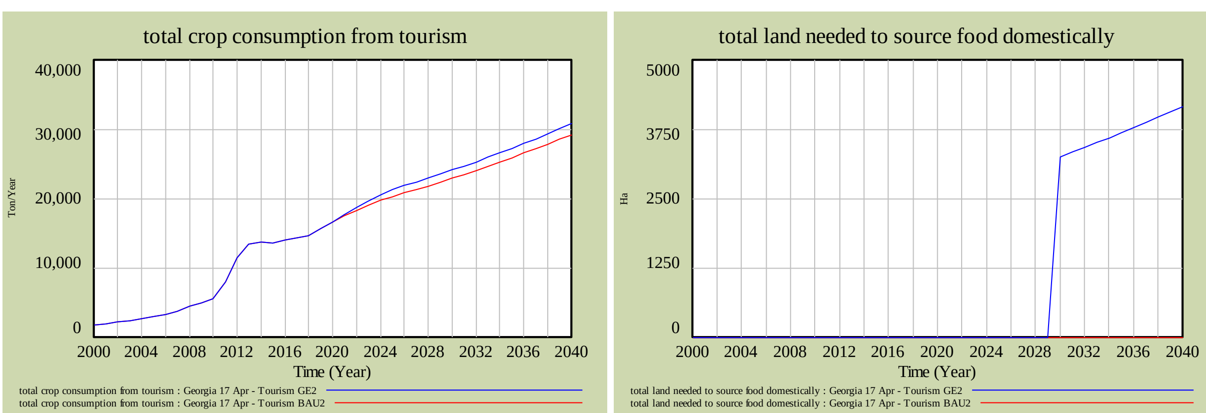
An additional benefit from green hotels is the reduction in total wastewater and in water demand as a result of more efficient facilities. The avoided investments in wastewater treatment capacity amount to GEL 96.7 million. In 2040, wastewater from tourism is projected to be 1.1 per cent, or 87.4 million litres per year lower than in the BAU scenario, despite the increase in tourist days, which increases demand in the medium and short term (Figure 38).

Figure 38: Wastewater from tourism



The GE scenario assumes that 50 per cent of the food demand from the tourism sector will be sourced domestically from sustainable agriculture. Meeting this demand will require an additional 4,160 hectares of farmland by 2040 compared to the BAU scenario. Between 2030 and 2040, total additional cumulative investments of GEL 56.3 million are required to source food from sustainable agriculture; GEL 47.6 million are invested in irrigation infrastructure, and GEL 8.7 million for the establishment and maintenance of sustainable agriculture land. The demand for crops from tourism and additional land requirements for both scenarios are illustrated in Figure 39.

Figure 39: Crop consumption from tourism and Land requirements for domestic sourcing



In 2040, the additional production in the tourism sector is projected to contribute GEL 3.4 million to the agriculture share of real GDP. The expansion of agricultural land is projected to generate approximately 1,750 additional jobs by 2040, a 0.2 per cent increase in total agriculture employment (Figure 40).

Figure 40: Additional value added and Additional employment from sourcing food domestically

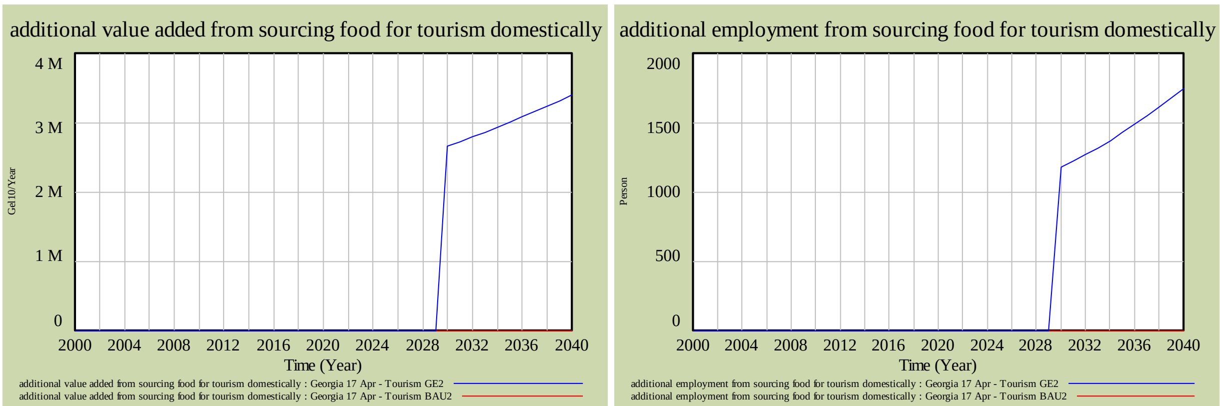


Table 11: Summary of tourism results

Variable	Unit	2015	2020	2030	2040
TOTAL NUMBER OF TOURISTS	M People				
BAU		16.4	17.3	19.1	21.1
GE		16.4	17.3	19.1	21.1
AVERAGE VALUE ADDED PER TOURIST	GEL10 / Year				
BAU		204.4	288.6	515.5	772.9
GE		204.4	288.6	515.5	796.0
REAL GDP TOURISM	M GEL10/Year				
BAU		1,516	2,025	3,224	4,661
GE		1,516	2,025	3,302	4,932
GDO SHARE OF TOURISM IN TOTAL GDP	%				
BAU		5.5%	5.9%	6.4%	6.7%
GE		5.5%	5.9%	6.6%	6.9%
TOURIST ACCOMMODATION CAPACITY	M Nights/Year				
BAU		20.3	26.6	45.6	64.6
GE		20.3	26.6	49.2	70.2
EMPLOYMENT IN TOURISM	People				
BAU		203,058	284,087	447,644	561,660
GE		203,058	284,098	458,491	594,269
SHARE OF ENERGY EFFICIENT HOTELS	%				
BAU		0.0%	0.0%	0.0%	0.0%
GE		0.0%	0.0%	0.1%	15.0%
LAND FOR LOCAL FOOD PRODUCTION	Hectare				
BAU		0	0	0	0
GE		0	0	3,256	4,159
ADDITIONAL INVESTMENT IN ENERGY-EFFICIENT BUILDINGS GE VS. BAU	M GEL/Year	0	0.00	-84.3	2,216.2
AVOIDED ENERGY COSTS GE VS. BAU	M GEL/Year	0	0.00	-13.7	2.4
AVOIDED SOCIAL COST OF CARBON GE VS. BAU	GEL/Year	0	0	-619,710	125,170
ANNUAL CO_2 EMISSION REDUCTION GE VS. BAU	M GEL10/Year	0	0	-30,986	6,259

5. CONCLUSIONS

The main goal for this study is to inform the preparation of a National Green Economy Strategy for Georgia. It does so by quantifying the outcomes of selected green economy interventions identified in the Green Growth Policy Paper, providing forecasts across sectors and economic actors, for the three dimensions of sustainable development, and over time.

The analysis was carried out with support from the Ministry of Economy and Sustainable Development, and through consultations with several Ministries, civil society groups and academia. This is a crucial aspect of this study, which uses a participatory modeling approach to set the boundaries of the model and effectively capture key indicators and feedback loops responsible for past and future sectoral and macroeconomic performance.

The three sectors analyzed – buildings, agriculture and tourism – show that important savings and additional benefits relative to the BAU scenario can be realized by investing in green economy interventions. Environmental performance also improves.

6. REFERENCES

AgriLIFE Extension. (2011). *Economics of irrigation systems.* Texas AgriLife Extension Service.

BRE. (2013). *Energy follow-up survey 2011.* BRE.

BTI. (2016). *Georgia country report.* Gütersloh: Bertelsmann Stiftung.

CBD. (2014). *National Biodiversity Strategy and Action Plan of Georgia.* Tbilisi: Convention on Biological Biodiversity, in collaboration with GIZ.

CEC. (2011). *North American power plant air emissions.* Montréal: Commission for Environmental Cooperation.

DoE. (2005). *Properly sized room air conditioners.* Manila: Consumer Welfare and Promotion Office, Department of Energy of the Philippines.

ESCO. (2017). *Electricity System Commercial Operator*. Retrieved from Electricity Market Operator: http://esco.ge/en

FAO. (1997). *Irrigation technology transfer in support of food security.* Rome: Food and Agriculture Organization of the United Nations.

Forrester, J. (1961). *Industrial Dynamics.* Cambridge, MA: MIT Press.

GCAD. (2015). *Country report: Georgia.* The Fund Georgia Center for Agribusiness Development.

GEOSTAT. (2014). *National Accounts of Georgia 2012 (Statistical publication).* Tbilisi: National Accounts Division of National Statistics Office of Georgia.

GEOSTAT. (2015). *National Accounts of Georgia 2013 (Statistical publication).* Tbilisi: National Accounts Division of National Statistics Office of Georgia.

GEOSTAT. (2016). *National Accounts of Georgia 2014 (Statistical publication).* Tbilisi: National Accounts Division of National Statistics Office of Georgia.

GEOSTAT. (2017a). *National Statistics Office of Georgia*. Retrieved from http://www.geostat.ge/index.php?lang=eng

GEOSTAT. (2017b). *National Accounts of Georgia 2015 (Statistical publication).* Tbilisi: National Accounts Division of National Statistics Office of Georgia.

GNTA . (2015). *Georgian tourism in figures 2014.* Georgia National Tourism Administration.

GNTA. (2014). *Georgian tourism in figures 2013.* Georgia National Tourism Administration.

GNTA. (2016). *Georgian tourism in figures 2015.* Georgia National Tourism Administration.

GNTA. (2017, 10 10). *Statistics portal of the Georgian National Tourism Administration*. Retrieved from http://stats.gnta.ge/Default.aspx

GoG. (2015). *Georgia Tourism Strategy.* Tbilisi.

GoG. (2016a). *Georgia economic outlook.* Government of Georgia.

GoG. (2016b). *Georgian agro-food sector - For your investment.* Ministry of Agriculture, Government of Georgia.

GoG. (2016c). *Georgia's third National Communication to the UNFCCC.* Government of Georgia.

GoG. (2017). *Economic outlook.* Ministry of Economy and Sustainable Development, Government of Georgia.

IEA. (2014). *World Energy Outlook 2014.* Paris: OECD/International Energy Agency.

IEA. (2017). *International Energy Agency - Georgia*. Retrieved from https://www.iea.org/countries/non-membercountries/georgia/

IMF. (2017). *World economic outlook 2017.* Washington D.C.: International Monetary Fund.

Ministry of Agriculture of Georgia. (2015). *Strategy for Agricultural Development in Georgia 2015-2020.* Tbilisi.

Ministry of Economy and Sustainable Development of Georgia. (2011). *Green Georgia.* Tbilisi, Georgia.

Ministry of Economy and Sustainable Development of Georgia. (In Press). *Green Growth Policy Paper.* Tbilisi: MoESD.

Ministry of Environment and National Resources Protection of Georgia. (2015). *Georgia's Third National Communication to the UNFCCC.* Tbilisi, Georgia.

MultiHeat. (2015). *MultiHeat*. Retrieved 01 11, 2017, from Energy Efficient Electric Heating, Infrared Heating Panels: http://www.multiheat-energysystems.co.uk/infrared-heating/50w-per-square-metre

Nordhaus, W. (2017). Revisiting the social cost of carbon. *PNAS*, vol. 11, no.7, 1518-1523.

OECD. (2016). *Financing climate action in Georgia.* Paris: OECD Green Action Programme.

Probst, G., & Bassi, A. (2014). *Tackling Complexity: A systematic approach for decision makers.* Sheffield, UK: Greenleaf Publishing.

Sauer, T., Havlík, P., Schneider, U., Schmid, E., Kindermann, G., & Obersteiner, M. (2010). *Agriculture and resource availability in a changing world: The role of irrigation.* doi:10.1029/2009WR007729: Water Resources Research 46.

Sterman, J. D. (2000). *Business Dynamics - Systems Thinking and Modeling for a complex world.* Irwin McGraw-Hill.

Turconi, R., Boldrin, A., & Astrup, T. (2013). Life cycle assessment (LCA) of electricity generation technologies: overview, comparability and limitations. *Renewable and sustainable energy reviews*, 28, 555-565.

UNECE. (2016). *Georgia Environmental performance reviews - Third review.* New York and Geneva: United Nations Economic Commission for Europe.

UNEP. (2009). *Integrated policymaking for sustainable development - A reference manual.* United Nations Environmental Programme.

UNEP. (2011). *Tourism: Investing in energy and resource efficiency.* United Nations Environment Programme.

UNEP. (2014). *Using models for Green Economy policymaking.* United Nations Environment Programme.

UNESCO. (2017, 10 12). *UNESCO Institute for Statistics*. Retrieved from http://uis.unesco.org/country/GE

World Bank. (2017). *World Bank Data*. Retrieved from https://data.worldbank.org/

APPENDIX 1 – DOCUMENTATION OF DATA SOURCES

Macroeconomy

Table A1 provides an overview of the key assumptions and variables used to set the parameters and calibrate the macroeconomic sector of the simulation model.

Table A1: Key assumptions for the Macroeconomic sector

Variable	Value	Source
Nominal GDP	Time series (GEL 31.76 billion in 2015)	(GEOSTAT, 2017a)
Real GDP	Time series (GEL 26.24 billion in 2015)	(GEOSTAT, 2017a)
GDP growth rate	Time series (2.5% in 2015)	(GEOSTAT, 2017a)
Employment by sector	Time series	(GEOSTAT, 2017a) (World Bank, 2017)
GDP by sector	Time series	(GEOSTAT, 2017a)
GDP deflator	Time series	(GEOSTAT, 2017a)

Public sector

Table A2 provides an overview of the key assumptions and variables used to set the parameters and calibrate the public sector of the simulation model.

Table A2: Key assumptions for the Macroeconomic sector

<table>
<tr><th>Variable</th><th>Value</th><th>Source</th></tr>
<tr><td>Government revenues</td><td>Time series</td><td rowspan="4">Statistical publication of SNA:
(GEOSTAT, 2014)
(GEOSTAT, 2015)
(GEOSTAT, 2017b)</td></tr>
<tr><td>Government expenditure</td><td>Time series</td></tr>
<tr><td>Government consumption</td><td>Time series</td></tr>
<tr><td>Gov. operating balance</td><td>Time series</td></tr>
<tr><td>Grants</td><td>Time series</td><td rowspan="2">Supplemented by GEOSTAT
(GEOSTAT, 2017a)</td></tr>
<tr><td>Subsidies and transfers</td><td>Time series</td></tr>
</table>

Population

Table A3 provides an overview of the key assumptions and variables used to set the parameters and calibrate the population sector of the simulation model.

Table A3: Key assumptions for the Population sector

Variable	Value	Source
Population	Time series (3.7 million in 2014)	(GEOSTAT, 2017a)
Birth rate	Time series (1.6% in 2015)	
Death rate	Time series (1.3% in 2015)	
Migration	Time series	Calibration
Demand for food by crop	Time series	(GEOSTAT, 2017a)

Agriculture

Table A4 provides an overview of the key assumptions and variables used to set the parameters and calibrate the agriculture sector of the simulation model.

Table A4: Key assumptions for the Agriculture sector

Variable	Value	Source
Total agriculture land	Time series (2.5 million ha in 2015)	(GEOSTAT, 2017a) (World Bank, 2017)
Agriculture land by crop	Time series	(GEOSTAT, 2017a)
Productivity per hectare by crop	Time series	(GEOSTAT, 2017a)
Labour productivity agriculture	Time series	(GEOSTAT, 2017a),
Irrigation efficiency	Flood: 25% Sprinkler: 64% Drip: 82%	(Sauer, et al., 2010)
Capital cost of irrigation systems *(USD per hectare)*	Furrow: $208.56 Sprinkler: $556.00 Drip: $1,200.00	(AgriLIFE Extension, 2011)
O&M costs of irrigation systems	Furrow: $24.00 Sprinkler: $34.00 Drip: $48.00	(FAO, 1997)

Tourism

Table A5 provides an overview of the key assumptions and variables used to set the parameters and calibrate the tourism sector of the simulation model.

Table A5: Key assumptions for the Tourism sector

Variable	Value	Source
Number of domestic tourists	Time series (11.9 million in 2015)	Georgia tourism in numbers (GNTA, 2014) (GNTA , 2015) (GNTA, 2016) GNTA statistics portal (GNTA, 2017)
Number of international tourists	Time series (Intl. One-day: 2.2 million in 2015; Intl. multi-day: 2.3 million in 2015)	
Avg. length of stay per tourist	Domestic: 2.2 days Intl. one-day: 1.0 days Intl. Multi-day: 5.0 days	
Number of hotels	Time series (1,475 in 2015)	
Total accommodation capacity	Time series (20.6 million in 2015)	
Avg. valued added per tourist	Time series (GEL 46.01 per person in 2015)	(GEOSTAT, 2017a) (GNTA, 2017)
Tourism labour intensity	Time series (0.00011 Jobs/GEL in 2015)	

Buildings

Table A6 provides an overview of the key assumptions and variables used to set the parameters and calibrate the buildings sector of the simulation model.

Table A6: Key assumptions for the Building sector

Variable	Value	Source
Lighting requirements per m²	Conventional: 15 W/m² Efficient: 10 W/m²	
Heating requirements per m²	Conventional: 50 W/m² Efficient: 40 W/m²	(MultiHeat, 2015)
Length of heating period	Conventional: 168 days Efficient: 134 days	(BRE, 2013)
Cooling requirements per m²	Conventional: 5.0 W/m² Efficient: 2.5 W/m²	(DoE, 2005) with calibration to local data
Conventional buildings		
Lighting technologies	Incandescent: 100% LED: 0%	
Heating technologies	Natural gas: 40% Oil heating: 5% Fuel wood: 50% Wood pellets: 0% Geothermal: 0% Electric heating: 5%	
Air conditioning technologies	Inefficient: 100% Efficient: 0%	
Appliances	35 kWh/m²/year	

Efficient buildings		
Lighting technologies	Incandescent: 0% LED: 100%	
Heating technologies	Natural gas: 60% Oil heating: 0% Fuel wood: 10% Wood pellets: 30% Geothermal: 0% Electric heating: 0%	
Air conditioning technologies	Inefficient: 0% Efficient: 100%	
Appliances	30 kWh/m²/year	

Energy

Table A7 provides an overview of the key assumptions and variables used to set the parameters and calibrate the energy sector of the simulation model.

Table A7: Key assumptions for the Energy sector

Variable	Value	Source
Demand for energy by source	Time series	(GEOSTAT, 2017a) (IEA, 2017)
Energy price by source	Time series	(GEOSTAT, 2017a)
Total energy demand	Time series (175,718 TJ in 2015)	(GEOSTAT, 2017a)
Electricity generation by source	Time series (Gas: 2.38 million MWh in 2015, Hydro: 8.45 million MWh in 2015)	(GEOSTAT, 2017a) (ESCO, 2017)
Power generation capacity	Time series (Gas: 911.2 MW in 2015 Hydro: 2,798.0 MW in 2015)	(GEOSTAT, 2017a)
Capital cost per MW of capacity	Gas: $450,000 Hydro: $2,080,000	(IEA, 2014)
Life cycle CO_2 emissions per MWh	Gas: 0.70 tonne/MWh Hydro: 0.01 tonne/MWh	(Turconi, Boldrin, & Astrup, 2013)
Pm2.5 and NOx emission factor gas	Pm2.5: 0.270 kg/MWh NOx: 0.378 kg/MWh	(CEC, 2011)