APPLYING THE **WATER-ENERGY-FOOD** NEXUS APPROACH TO CATALYSE TRANSFORMATIONAL **CHANGE IN AFRICA**

RES4AFRICA
RENEWABLE ENERGY SOLUTIONS FOR AFRICA
FOUNDATION

OPENECONOMICS

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RES4Africa Foundation, promotes the deployment of large-scale and decentralized renewable energy in Africa to meet local energy needs. The foundation gathers the perspectives and expertise of a member network from across the sustainable energy value chain.

Our work: RES4Africa Foundation functions as a platform for members and partners of emerging markets to foster dialogue and partnerships, share knowledge and build capacity to advance sustainable energy investments in African countries.

Our mission: RES4Africa Foundation aims to create an enabling environment for renewable energy investments in emerging markets through three work streams:
• acting as a connecting platform for dialogue & strategic partnerships between members and partners to exchange perspectives and foster cooperation;
• providing technical support & market intelligence through dedicated studies and recommendations based on members' know-how to advance sustainable energy markets;
• leading capacity building & training efforts based on members' expertise to enable skills and knowledge transfer that supports long-term sustainable energy market creation.

Members: RES4Africa Foundation gathers a network of members from across the sustainable energy value chain including industries, agencies, utilities, manufacturers, financing institutions, consultancies, legal and technical services providers, research institutes, and academia.

Partners: RES4Africa Foundation works with local, regional and international partners, agencies and organizations to pursue its mission and promote renewable energy deployment in the region of focus.

OpenEconomics originates as a spin-off of a team of Italian researchers from the Department of Economics at the University of Rome Tor Vergata, which later joined an international group of professionals with a common experience supporting the World Bank and other development institutions.

Our team has a successful record as advisor of private companies, multilateral banks and national governments, and leverages on a broad experience in assessing investment's risks and opportunities in multiple sectors.
Plus, the Team has over 30 years of experience in supporting large organizations and government in matching private investments and development programs to improve the effectiveness of the public policies and reducing the risks related to investing in emerging economies.

OpenEconomics has a long experience in investment evaluation especially in transforming the industrial project from the point of view of the local stakeholders.
In line with the best practices adopted for the assessment of investment projects and economic policies by multilateral organizations, including the World Bank, we use a Dynamic Computable General Equilibrium (CGE) Model to simulate the structure of local economies based on the estimation of a detailed Social Accounting Matrix (SAM).

Enel Green Power is the Enel Group's global business line dedicated to the development and operation of renewables across the world, with a presence in Europe, the Americas, Asia, Africa and Oceania. Enel Green Power is a global leader in the green energy sector with a managed capacity of more than 43 GW across a generation mix that includes wind, solar, geothermal and hydropower, and is at the forefront of integrating innovative technologies into renewable power plants.

Enel Group since 2004 is a member of the UN organization Global Compact and in 2015 officially declared its commitment to support the United Nations Sustainable Development Goals number 4, 7, 8 and 13, nevertheless the hundreds of sustainability projects implemented around the world respond to the United Nations' call to action of all SDGs.

CEFA The seed of Solidarity is an Italian non-governmental organization that has been working for 45 years in order to overcome hunger and poverty. Committed to supporting and accompanying local communities in building sustainable development processes, CEFA is currently present in 12 developing countries in Africa and Latin America. Its main areas of intervention are integrated rural development and urban poverty alleviation, which include, but are not limited to, rural electrification, agro-processing and vocational training.

Active in Tanzania since 1976, CEFA is one of the most representative members of the country's mini-grid developers' community, with 3 successful projects implemented and over 30 years of experience. CEFA's commitment goes beyond the construction of infrastructures; it is in fact actively engaged in supporting the communities it serves in taking full advantage of the opportunities deriving from access to reliable and affordable renewable energy.

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ACRONYMS AND ABBREVIATIONS

BCR	Benefit Cost Ratio
CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
CGE	Computable General Equilibrium
ECBA	Economic Cost Benefit Analysis
EIRR	Economic Internal Rate of Return
ENPV	Economic Net Present Value
FCBA	Financial Cost Benefit Analysis
FNPV	Financial Net Present Value
NPV	Net Present Value
OPEX	Operating Expenditure
SAM	Social Accounting Matrix

EXECUTIVE SUMMARY

This document contains the premises, results and analysis of the impact evaluation of the Ikondo-Matembwe project, including the positive externalities on the socioeconomic system of Tanzania. The main aim of the study is to explore the potential economic contribution from the implementation of the pilot project and its scalability, in support of Africa's path toward a sustainable economic growth characterized by a high level of climate mitigation and social inclusion.

The project is a comprehensive and holistic set of activities aiming to bring access to un-polluting electricity from renewable resources, fresh and potable water and improve nutrition and food security of a target population. In order to analyse in some detail project feasibility and impact, a two level (microeconomic and macroeconomic) analysis has been carried out, which investigates the project economic effects as well as the externalities and the general benefits for the population and the investors involved.

An important part of the document is the presentation of the WEF Nexus transformational approach: this implies a new concept for development projects, focusing on long-lasting changes in target countries that, thanks to the project replicability, may bring about a lasting and beneficial transformation in the socioeconomic structure of a country.

From the point of view of the individual project, using the cost benefit methodology for marginal projects, we have found significant economic, social and environmental benefits for the community, which justify project's implementation and technological replicability in other similar areas. These benefits result in positive indicators for project feasibility.

TABLE 0.1: MICROECONOMIC PROJECT RESULTS (USD MILLION IN PRESENT VALUE)

PROJECT	ECONOMIC NPV USD
ENERGY	5,940,652
ENERGY AND FOOD	7,768,100
ENERGY AND WATER	10,651,791
ENERGY WATER AND FOOD	**12,479,239**

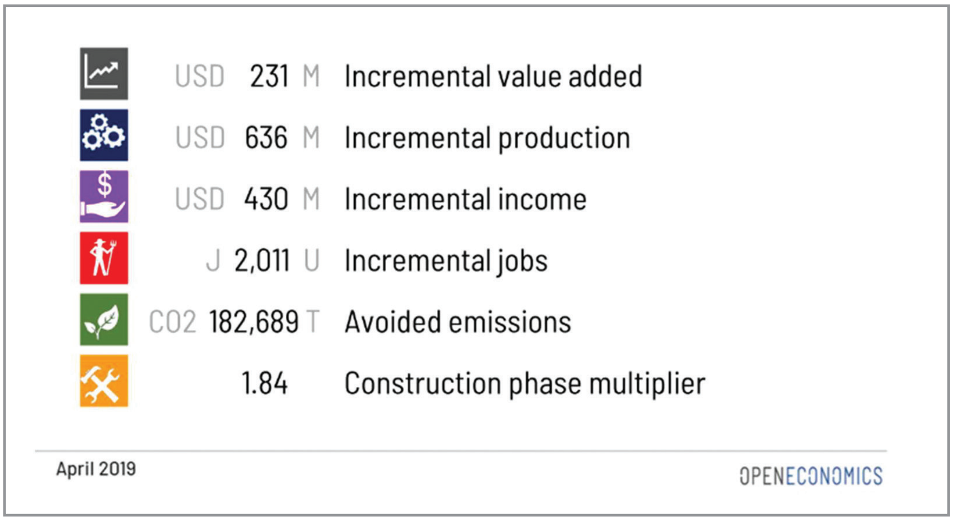
SOURCE: OPENECONOMICS ELABORATION

We have also found some interesting economies of scope, since implementing the three subprojects that compose the integrated project (Energy, Food and Water) is likely to achieve a greater impact in economic terms (an economic NPV of USD 5,940,652 of the Energy sub-project, an increase of USD 1,827,448 for the Energy and Food sub-project and an increase in NPV of USD 4,711,139 for the Energy and Water sub-project).

A further indicator analysed within the microeconomic cost-benefit analysis is the Benefit-Cost Ratio (BCR). BCR attempts to summarize the overall value for money of a project proposal. This indicator shows the relationship between the relative costs and benefits of an activity, expressed in monetary or qualitative terms. The BCR is calculated by dividing the proposed total cash benefits of a project by the proposed total cash costs of the project. If a project has a BCR greater than 1.0, the project is expected to deliver a positive net present value to its investors. Among multiple projects, the one that has a higher BCR will be preferred. The CEFA's project here presented, as resulted in the microeconomic analysis, has a BCR of 4,5, which means that the Ikondo-Matembwe will deliver an important positive net present value (NPV) and an internal rate of return (IRR) above the discount rate used. This suggests that the NPV of the project's cash flows outweighs the NPV of the costs and the project is therefore "consistent enough" to be considered.

The Nexus BCR is much higher than the sole energy component (that is 3.1) and this result confirms as the project integration allows to get wider benefits also thanks to the economies of scale that the enabling project (namely energy) setup to the comprehensive project. Once the scale-up is implemented, the transformative nature of the project results in more than proportional impacts on all the macroeconomic variables for both the project area and the whole country, giving not only a significant boost to the economy, but also putting the country on a clear course to reach its development targets.

FIGURE 0.1: MACROECONOMIC PROJECT RESULTS (USD MILLION IN PRESENT VALUE)



SOURCE: OPENECONOMICS ELABORATION

In the following pages, we will discuss in detail some of the reasons why a Nexus project shows consistent benefits and may be effective as a transformative policy instrument to achieve sustainable and inclusive economic growth in Africa.

1. THE WEF NEXUS MODEL AND THE TRASFORMATIONAL EFFECTS

The WEF Nexus model represents an innovative approach to sustainable development. The peculiarity of this brand-new approach lays in its distinctive essence, as it promotes the concept of "transformational engagement" recently promoted by the World Bank as the key tool to enhance the impact of the projects in long-lasting terms.
The WEF Nexus shares its holistic approach in providing access to essential resources for an appropriate human sustainable development. Access to clean water, modern and un-polluting energy services, nutrient and sufficient food is at the very core of the fight against global poverty and the efficient implementation of the Sustainable Development Goals. The Nexus approach generates value added thanks to the multi-sectoral shock induced by an activity specifically designed to transform the traditional environment and operating mode. It aims to enhance and secure the three most important natural resources, i.e. energy, water and food, and manage them in an integrated way. Most importantly, it is crucial to ensure the accessibility and affordability of basic resources to all sections of the population.

The WEF Nexus approach as introduced in the present document, focuses on Energy as the key enabling factor for a true inclusive development and promotes projects and policies characterized by their transformative nature. Why therefore Energy as the development backer? Energy scarcity is a burden leading to an inferior level of development both for households and entire communities, especially in remote and/or not easily accessible rural areas.

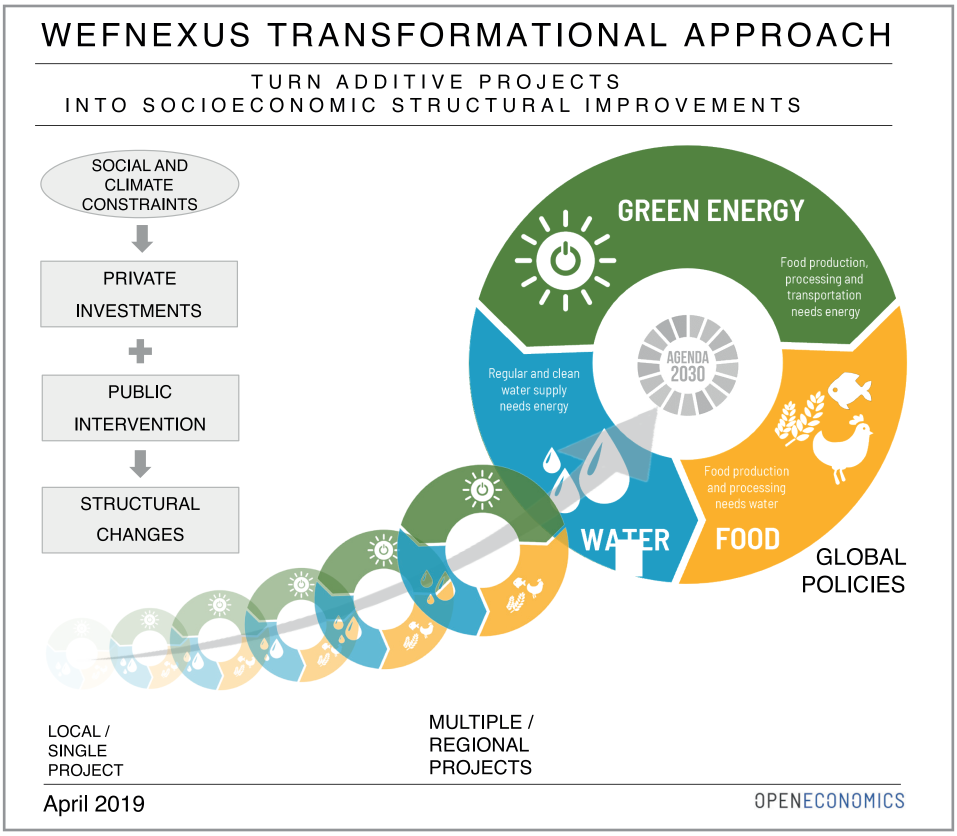
It is well recognised that energy is crucial for human development. This is distinctly true because without energy many basic services, such as water supply for human consumption and irrigation as well as food conservation and processing are precluded to most of the population. The role of Energy in the WEF model is essential as it is the starting element of the entire project design, the enabler of all the other related services and the solution to overcome critical constraints to development.
Energy, indeed, is intensively used in water treatment such as sanitization and potabilization of water, which implies the disinfection of water from pathogenic and other kinds of microorganisms. Water is clearly necessary for irrigating crops and irrigating crops means producing food but at the same time energy is needed in the whole supply chain of food. Thus, in a strongly interlinked world, an interrelated approach seems to be the most suitable and efficient.

Understanding the link among the resources is important to develop a proper methodology in operationalising the Nexus concept. However, so far very few projects have been properly addressed by the scientific community and an efficiently designing of theoretical assessment approach has yet to be realized.

1.1 THE TRANSFORMATIONAL ENGAGEMENT ACCORDING TO THE WEF NEXUS MODEL

The most important peculiarity of the WEF Nexus approach is that it aims to promote long-lasting change, by virtue of its transformative character and the integrated engagement that promotes for all project stakeholders.
Transformative engagement is identified as change that "improves fundamentally the lives of the poor and disadvantaged people"[1] in the context of the ambitious objectives of the international development community, inequality reduction and poverty eradication. More broadly, transformative projects promote radical modifications in project design and implementation to counter the recognized failure of many development projects to deliver lasting benefits over time and limiting themselves to achieve only temporary benefits for the stakeholders involved.
Although some economic transformation may have been brought by several projects, the element lacking to truly boost development and poverty reduction is a set of crucial changes, leading the economic and production structure of a community to move from an agricultural base to an industrial/manufacturing and services base.

FIGURE 1.1: THE WEF NEXUS APPROACH



SOURCE: OPENECONOMICS ELABORATION

[1] *(World Bank, 2016)*

The main aim of the WEF Nexus is to increase the emphasis on projects that can become deeply rooted and locally engaging in order to produce structurally transformative effects. By engagement we mean the ability to induce adoption and diffusion of transformative innovation across stakeholders, with large and effective spillovers, thereby replicating and scaling up the effects of individual projects, including broader changes that increase government effectiveness or stimulate private investment.

BOX NO.1: DIFFUSION AND ADOPTION AS A BASIS FOR A TRANSFORMATIVE PROJECT

The twin concepts of diffusion and adoption characterize the debate on the spread of technology and the role of innovation in the transformation of economic systems. One of the most clarifying models is dye to Rogers (1962), who defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system." According to Rogers (1995, p.79), diffusion is characterized by five stages: awareness, interest, evaluation, trial, and adoption. Thus, according to this interpretation, adoption is the final step of the diffusion process and is part of decision making, i.e. not only it is merely a component of diffusion, but it also characterizes the moment at which the decision maker acts to make the spread of technology happen.

While this interpretation of diffusion and adoption appears to be generally shared by the subsequent literature (Scandizzo, 2009), its operational validity hinges on its capacity to support a system of measurements. On one hand, in fact, diffusion seems to call for a measure directly related to the pervasiveness reached by technology over a given territory or population. On the other hand, adoption itself appears to be related to such a spread, even though its implicit reference to actions taken by individual agents calls for going beyond the mere coverage of the territory, to take into account some subjective element linked to the act of choice.

The Nexus approach is based on a comprehensive hypothesis on technological and social transformation that incorporates the idea that adoption and diffusion are two related processes referring respectively to collective spread and individual choice. More specifically, according to Scandizzo and Savastano (2010), the WEF Nexus approach considers adoption as the decision on the part of the individual farmer to adopt innovation under the influence of the project, and diffusion as the endogenous process by which individual adoption decisions influence each other and coalesce, thus causing the endogenous determination of the spread of the project induced technology as well as new transformative ways to organize and manage economic activities. This spread is a process, that, while initially relying on motivated adoption decisions, at some point claims its own momentum, based on interdependent activities, such as imitation, collective (herd) behavior, and external effects, such as marketing and transportation economies.

In sum, the Nexus approach seeks to scale up size and geography to catalyse more fundamental or transformational changes by promoting adoption and diffusion of new technologies and organizational and management forms (see BOX). Its goal is to implement projects that have longer-term effects through pragmatic mutation, leading first to adoption and then gradually to widespread diffusion of innovation and technical change.

Among the transformative changes promoted by the WEF Nexus approach, access to energy is the top enabler to adoption and diffusion, as new techniques for food production, processing and transportation need energy to be furthered. Similarly, water needs energy to be pumped and distributed to the target population and, at the same time to increase agricultural production through irrigation and the related modern techniques.

2. AN ECONOMIC APPROACH TO THE WEF NEXUS PROJECT

In order to advocate actions to drive Africa's renewable energy transition, it is fundamental to evaluate what kind of positive effects can be achieved throughout a RE-based holistic approach. In doing this, it is crucial to build up an impact assessment of the benefits and challenges that might arise from this specific designed activity, in order to further and promote sustainable institutional programmes and policies.

The main aim and core element of the impact assessment is to predict economic effects at an early stage of an investment planning and design, in order to find ways and means to reduce adverse impacts, shape investments to suit the local needs and present the predictions and options to decision-makers. Impact can therefore be defined as a measure of the changes and its assessment seeks to establish a causal connection between inputs and changes in terms of magnitude or scale or both.

Impact analysis is becoming crucial from an institutional point of view, as governments are relying more and more on efficient business models and policies that have positive impacts locally. This is therefore the key role of impact assessment by providing a sensible quantitative analysis. Ex ante impact analysis is vital to undertake local needs assessment and to plan the activities involved in the policy cycle. This is because it offers a prospective analysis of what the impacts of an intervention will stimulate so to advocate policymaking. In addition, it contributes to address broader evaluation questions and, in many evaluation designs, it is used with other qualitative techniques in order to reach pragmatic conclusions.

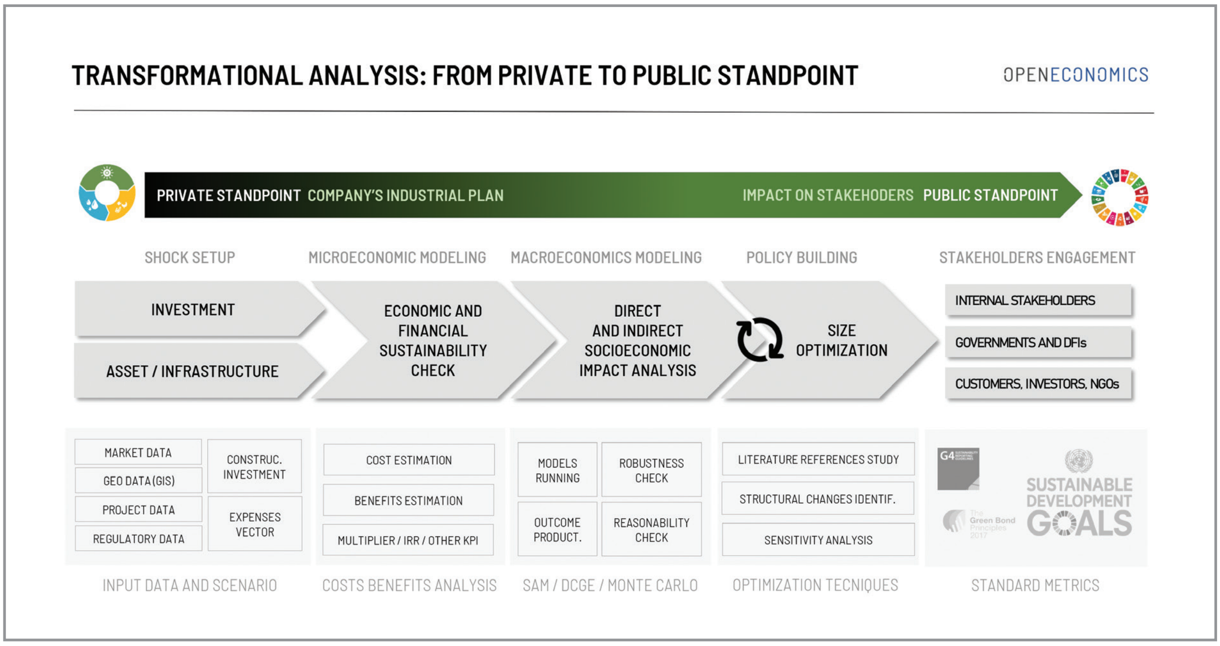
Moreover, the scientific-based analysis offers a concrete value added to investors, presenting a favourable business model with significant potentiality for investments towards local communities.
In this sense, an impact assessment evaluation is vital both for the investor or the institution responsible for delivering services and for the local society as a whole. Throughout the economic impact assessment, it is possible to evaluate the impact brought by in terms of Principles of Sustainability enclosed in the Social, Economic and Environmental Impacts.

The methodology is structured according to an integrated approach useful for the estimation of the different types of impact. There are 3 different kind of economic impacts:
- Direct
- Indirect
- Induced

Direct impacts are those that enable us to evaluate the outputs for a specific sector targeted by the business model. Therefore, when investing in energy, the direct impacts will flow on the energy sector itself.
Indirect impacts include all the outputs within the value chain of the sectors where capital goods are purchased or where productive capacity is increased as a consequence of the project. For example, if we consider the investment in energy, the indirect impact will outreach energy suppliers upstream and energy customers downstream. Upstream suppliers are those responsible for the energy production, such as those sectors involved in building energy infrastructures, mainly construction and machinery sectors. The downstream beneficiaries are those sectors that need energy to fuel their businesses. Indirect impacts can

be briefly defined as the growth of production, value added or consumption within the productive chain of the invested sector.
Induced impacts are occurring in those sectors outside the value chain. The Nexus model activates a whole range of economic benefits, as energy supply will increase the demand for energy and therefore also the production of energy. In order to boost the production of energy it will be necessary to invest new capital in the energy sector and hire new workers. This leads to an income increase for the workers which in turn will be spent on other sectors, increasing general expenditures.

FIGURE 2.1: OPENECONOMICS METHODOLOGY



SOURCE: OPENECONOMICS ELABORATION

BOX NO.2: CBA AND CGE ANALYSIS

Within the microeconomic impact assessment, a Cost-Benefit Analysis (CBA) will be employed to perform the financial and economic evaluation of the project. The CBA is a technique traditionally used in the evaluation of investment projects by the main institutional bodies (European Union, World Bank and many others), for its efficacy and for its scientific foundations, which concerns the planning of the whole project through its entire generation cycle from identification to implementation and management, with the aim to improve the allocation of public and private resources.
While CBA is effective in evaluating the project direct impact, indirect and induced impacts can be estimated only by using a combination of macro and micro economic techniques that require the formulation of a general equilibrium model. This type of model is able to analyse and evaluate the project impact under the conditions of scaling up and replicability provided by its adoption and diffusion beyond the initial location and implementing attempts. The CGE model, and the associated social accounting matrix (SAM) allow to quantitatively examine the project impact by taking into account all relationships of exchange and interdependence among the different agents of the economic system (Government, companies, families, etc.). This in turn enables the analysis to evaluate indirect and induced impacts both in the short and in the long run as effects on variables such as value added, production and employment, and their structural components.

The WEF Nexus approach is based on a project structure that can generate indirect effects not only through the interdependence of value chains, but also through the innovation-imitation mechanisms characteristic of the adoption-diffusion process. If successful, the final effect can be a quantum leap in the innovations proposed by the project business model, thus determining large-scale transformative effects capable of producing significant progress in achieving the sustainable growth targets set by the SDGs.
The macroeconomic assessment based on the CGE model enables to simulate multiple scale up scenarios to identify the triggers of change in the economic structure and, consequently, the implicit transformative potential of the project. This will allow to identify the characteristics (technological, sizing, territorial extension and business model) that can facilitate the adoption of the project (or its model) on a larger scale.

3. PRESENT CASE STUDY: THE CEFA'S IKONDO-MATEMBWE PROJECT

Following the approach explained in the previous chapter, in what follows we present an analytical case study, named Ikondo-Matembwe project as designed by the CEFA Onlus (Comitato Europeo per la Formazione e l'Agricoltura).

3.1 PROJECT BACKGROUND

Project Location

The project, as assumed by CEFA, covers an area of 8 villages, sited in five rural wards of Tanzania (Matembwe, Ikondo, Lupembe, Ukalawa and Kidegembye) in the Njombe Rural District. A ward is a local administrative area, typically used for electoral purposes. Wards are usually named after neighbourhoods, thoroughfares, parishes, landmarks, geographical features and in some cases historical figures connected to the area. The Njombe Rural District is a former district of the Iringa Region of Tanzania and is located -9.081716, 35.247725°. The total population of the area is 20,928 inhabitants, with an overall number of households of 4,435.

Within the Njombe Rural District people rely on farming, with agriculture being the largest sector of the local economy. A share of 67% of the households has a farming activity and agriculture is crucial for their food provision and living. Agriculture is also the main reason for income, especially through the cultivation of local harvests such as beans, tea or maize. Another important means of livelihood for the local population is livestock. Beef is the largest meat product followed by lamb/mutton in mainland, while chicken and pork are mainly produced in rural areas thanks to the lower prices of the meat.

As the population is dependent on agriculture and livestock, and still uses traditional techniques on non-irrigated land, the income generated from these activities is particularly low; approximately 68 percent of Tanzania's 44,9 million citizens live below the poverty line of $1.25 a day and 32 percent of the population is malnourished.[2] Furthermore, Tanzania faces high environmental challenges because of unsustainable harvesting of its natural resources, unchecked cultivation, climate change and water- source encroachment.

The project examined tackles the agriculture issue by using a range of technologies based on improved seeds, machinery, and other modern inputs, thereby displaying a significant impact on production by increasing yields and labour productivity. Poor nutrition remains a persistent problem with a 16% of children population that are underweight and 34% experience stunted growth as a result of malnutrition.[3] Malnutrition is also due to maternal de-nourishment, poor infant feeding practices, hygiene practices and poor healthcare services.

Another criticality within the target area is access to water. Water supply and sanitation are poorly accessible to the population. Although the National Government has embarked on a major sector reform process since 2002, access to potable and drinking water is still difficult for local population as water points are poorly managed and far from main aggregation centres. A decentralisation in the water supply has been carried out since the local government authorities and is carried out by 20 urban utilities and about 100 district utilities,

[2] *(Global Hunger Index, 2018)*
[3] *(USAID, 2018))*

as well as by Community Owned Water Supply Organisations in rural areas.

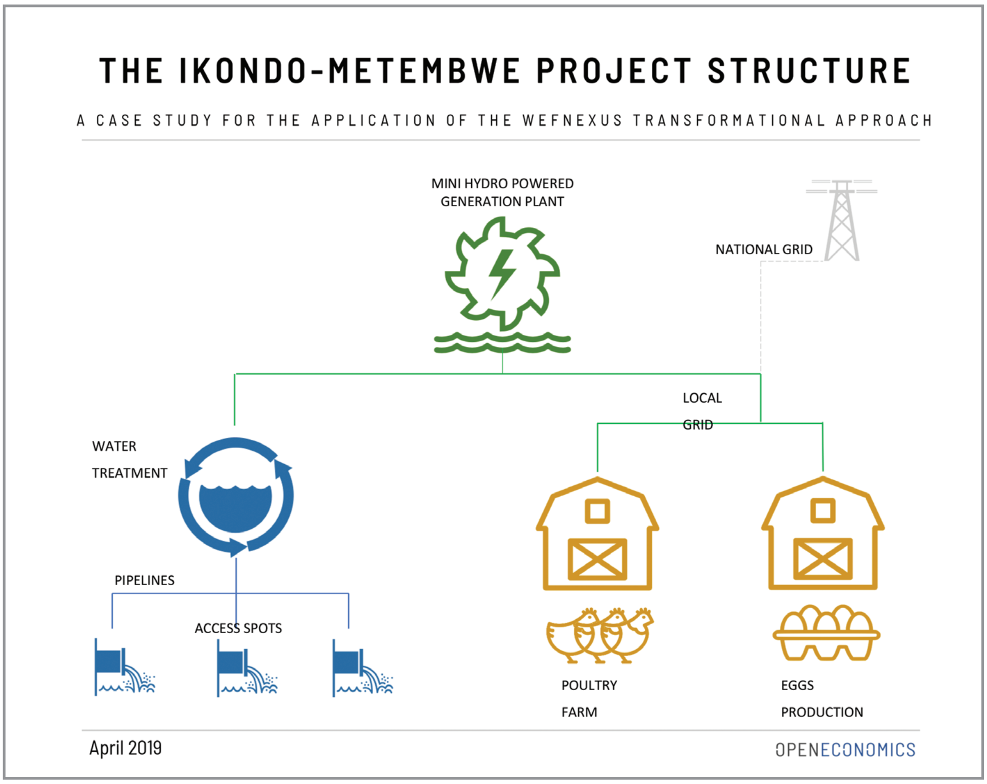
Project Structure

CEFA's project presented within the study covers two community-scale hydro-powered energy access projects.

The Ikondo-Matembwe electric infrastructure is based on two interconnected hydro power plants that have a total generation capacity of 550 kW of electric supply and is able, through a local grid that currently counts 1,102 connections, to provide access to energy to the entire target population, approximately 890 households, 186 businesses and 26 public services. The older plant features a 120 kW turbine, whereas the newer one installed two turbines for a total capacity of 430 kW. The two plants are interconnected and distribute electricity through around 65 km of medium voltage lines, serving through a dedicated distribution network the whole target households and businesses. In addition, the Ikondo-Matembwe mini-grid is owned and managed by the Matembwe Village Company Ltd (MVC).

MVC is a rural-based multi-utility operating in the sectors of energy and water provision, agro-forestry, animal-feed and livestock production. Focusing on the energy sector, MVC provides reliable and affordable clean energy to three groups of local users: households, private enterprises and public service providers. In November 2016 the Ikondo-Matembwe mini-grid was connected to the national grid, making MVC the second biggest client in terms of consumption with its animal-feed factory and the hatchery.
Electricity is the crucial element within the presented WEF Nexus model of the project as it is the enabler par excellence. Thanks to electricity it has been possible to supply around seven aqueducts providing water. Water is depurated and pumped thanks to electricity. Plus, the installation of water access spots gives the possibility to supply with fresh water the entire targeted population.

FIGURE 3.1: THE IKONDO-MATEMBWE PROJECT



SOURCE: OPENECONOMICS ELABORATION

In the Ikondo-Matembwe project area, the electricity activated by the hydro plant enables the increasing in the production of an animal feed factory and a poultry hatchery. This business and the related activities are fostered by the abundant and reliable energy supply that provides electricity, at a lower price and for a longer period of time of the former energy-generating solution, permitting an increase in agricultural and processing activities, such as poultry feeding and seed production.

4. THE MICROECONOMIC SETUP OF THE PROJECT

The microeconomic analysis is a powerful tool for empirical analysis and evaluation of certain benefits deriving from the specific project, according to the Nexus model.

An investment project is characterized by a set of productive activities that, through capital formation, is involved to certain economic-financial objectives at times deferred over time. Every time a productive input of a company is used, consequences are generated on the production or consumption of units that are different from the decision-making unit that gave rise to the production itself, thus generating external economies (or diseconomies).

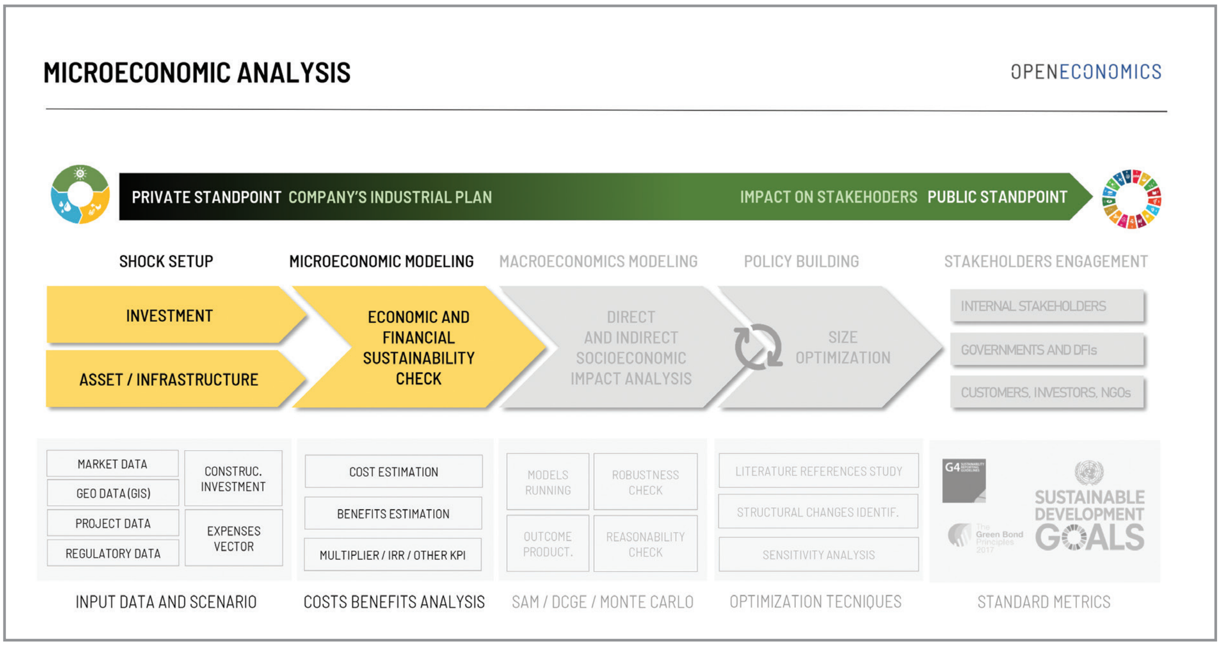
These have the peculiarity of the repercussions on other companies, on consumers and also on the prices paid and received, with the possibility of generating both benefits and external costs, impacting on the environment, infrastructure and the economic system in general. In this context, a thorough analysis of the effects of the investment project becomes crucial, evoking an approach to the evaluation of the investments considering two distinct and successive moments.

The first of these consists of the identification and measurement of the effects, or rather of the physical and institutional changes that the project generates within the environment in which it is inserted. This identification will be proposed to the policy maker as a set of distinct consequences of the project. The second moment of evaluation consists in attributing an economic value, first of all to each of the consequences generated by the project and together through appropriate homogenization and aggregation procedures.

BOX NO. 3: PROJECT INTERNAL AND EXTERNAL EFFECTS

An investment project is characterized by a set of productive activities that, through capital formation, is involved to certain economic-financial objectives at times deferred over time. Every time a productive input is used, consequences are generated on the production or consumption of units that are different from the decision-making unit that gave rise to the production itself, thus generating indirect effects as well as external economies (or diseconomies). These affect other agents, consumers and also prices paid and received, with the possibility of generating both benefits and external costs, impacting on the environment, infrastructure and the economic system in general. In this context, a thorough analysis of the effects of the investment project becomes crucial, requiring an approach to the evaluation of the investments based on two successive phases: (i) identifying project effects, defined as the physical and institutional changes that the project generates within the environment in which it is inserted, and (ii) valuing these effects by attributing them a monetary value. According to the ECBA method, the external effects concern the subjects who are not a proper part of the project, whose boundaries must therefore be defined by first identifying the institutions and the individual and collective subjects that characterize it.

FIGURE 4.1: MICROECONOMIC MODELING



SOURCE: OPENECONOMICS ELABORATION

4.1 PROJECT COSTS

In the following pages we present the results of the Economic Cost Benefit (ECBA) analysis of the Ikondo-Matembwe project. Project feasibility results will be showed through the Economic Net Present Value (ENPV) and the Economic Internal Rate of Return (EIRR). The project lifespan is divided in three years of construction and twenty years of operations. The discount rate used is 5% in line with the recommendations of the World Bank for the country in question.

Investment Costs

The total investment cost for the Ikondo-Matembwe project is USD 3,781,131 split in its components of energy, water and food/livestock according to the following figures:

TABLE 4.1: ENERGY CAPEX

CAPEX RELATED TO THE ENERGY COMPONENT	USD	%
Project management and development - Human Resources (local)	110,880	3.8%
Project management and development - Human Resources (expat)	165,984	5.6%
Project management and development - Local transports	212,016	7.2%
Project management and development - Other	28,616	1.0%
Project management and development M&E activities	8,960	0.3%
Supporting activities for local communities	66,696	2.3%
Legal and authorization costs	11,200	0.4%
Land purchase	8,400	0.3%
Generation plant and distr. Line- Human Resources (local)	142,464	4.8%
Generation plant and distr. Line- Human Resources (expat)	107,520	3.6%
Generation plant - Asset costs	1,246,168	42.2%
Distribution line - Asset costs	544,320	18.4%
Last- mile connections - Asset costs	246,848	8.4%
Local Office costs	50,400	1.7%
TOTAL	2,950,472	100%

SOURCE: OPENECONOMICS ELABORATION ON PROJECT DATA

TABLE 4.2: WATER CAPEX

CAPEX RELATED TO THE WATER COMPONENT	USD	%
Supporting Activities for Local Communities	11,200	3.3%
Legal and authorization costs	5,600	1.7%
Pumping plant and distr. line - Human Resources (Local)	77,952	23.1%
Pumping plant and distr. line - Human Resources (Expat)	40,320	12.0%
Pumping & distribution pipe - Asset costs	202,160	59.9%
TOTAL	337,232	100%

SOURCE: OPENECONOMICS ELABORATION ON PROJECT DATA

TABLE 4.3: FOOD CAPEX

CAPEX RELATED TO THE FOOD COMPONENT	USD	%
Supporting activities for local communities	33,600	6.8%
Legal and authorization costs	9,520	1.9%
Land purchase	50,512	10.2%
Plant - Human Resources (Local)	78,624	15.9%
Civil works and buildings - Asset costs	177,072	35.9%
Plant machinery and equipment - Asset costs	144,099	29.2%
TOTAL	2,950,472	100%

SOURCE: OPENECONOMICS ELABORATION ON PROJECT DATA

Operating and Economic Costs

The costs considered in the economic CBA were disaggregated following the investment costs for energy, water and food/livestock components.

For the energy-related project, households pay an electricity tariff of 0.06 USD/kWh, public services pay a tariff of 0.043 USD/kWh and private business pay a tariff of 0.11 USD/kWh. Considering all the beneficiaries of clean energy due to the project, the total cost would be USD 742,406 in net present value for the entire project life. For the water-related activity, households would pay 0.0010 USD/litre after project implementation. Considering a consumption of 95.70 litres per day, the total cost would amount to USD 1,872,198 in net present value for the project lifespan. Regarding food /livestock activity, households would pay for livestock (poultry) and fodder. Considering a unit amount of USD 0.68 per animal and USD 21.35 per 50 kg of fodder, the total amount is USD 871,038 in net present value for the entire project lifespan.

The operating and maintenance costs refer to administration, audit and insurance, as well as ordinary and extraordinary maintenance. For the energy part, these costs are calculated at USD 396,253 for the entire project life; for water at 57,179 USD in net present value and for food/livestock at USD 395,029 in net present value.

4.2 ESTIMATES OF THE PROJECT NET BENEFITS

The benefits produced by the Electrification components in the Project

Energy is widely known for being vital for human development; however, an estimated 1,1 billion people in the world currently lack access to electricity.[4] Most of these people live in isolated rural areas, where the development of projects for electrification is not economically viable due to geographical dispersion, difficult access to these areas, and the low payment capacity of local people.

Literature has extensively shown that there are several benefits from providing access to electricity supply in non-connected rural areas, such as: improvement in people's health, in education, in the productive processes of the communities, environmental benefits, as well as per the facilitation in communication. Electricity, furthermore, is a basic general-purpose technology that allows the productive usage of a large set of production techniques, including mechanization, irrigation and other modern inputs that are vital to agriculture. Electricity, therefore, plays a very important role in the social, economic and environmental life of the collectivity.

The most common use of electrification is lighting, either for domestic or community use, while the second is television, which brings both entertainment and, together with radio, plays a crucial educational role to its users.
Households commonly generate energy through conventional resources such as kerosene, wood and generators, which can result very expensive and polluting. Electricity's core benefit is the reduction in the cost of energy to the users, resulting in a consumer surplus, defined as the difference between what consumers are willing to pay and what they can actually pay.

The large body of literature on the benefits of rural electrification claims that rural electrification greatly contributes to the welfare growth of rural households. To quantify electrification's benefits, we explore the benefits of electricity use to understand how these immediate outcomes may have impacted welfare indicators[5]:

- *Lightening*
- *TV and Radio*
- *Time savings*
- *Education*
- *Health*
- *Productivity increase*
- *Cost Saving*
- *Environment*

Lightening

The benefit from lightening derives from the switch from the use of conventional and polluting resource to generate light (such as kerosene lanterns) to a cleaner and more efficient resource such as electricity.

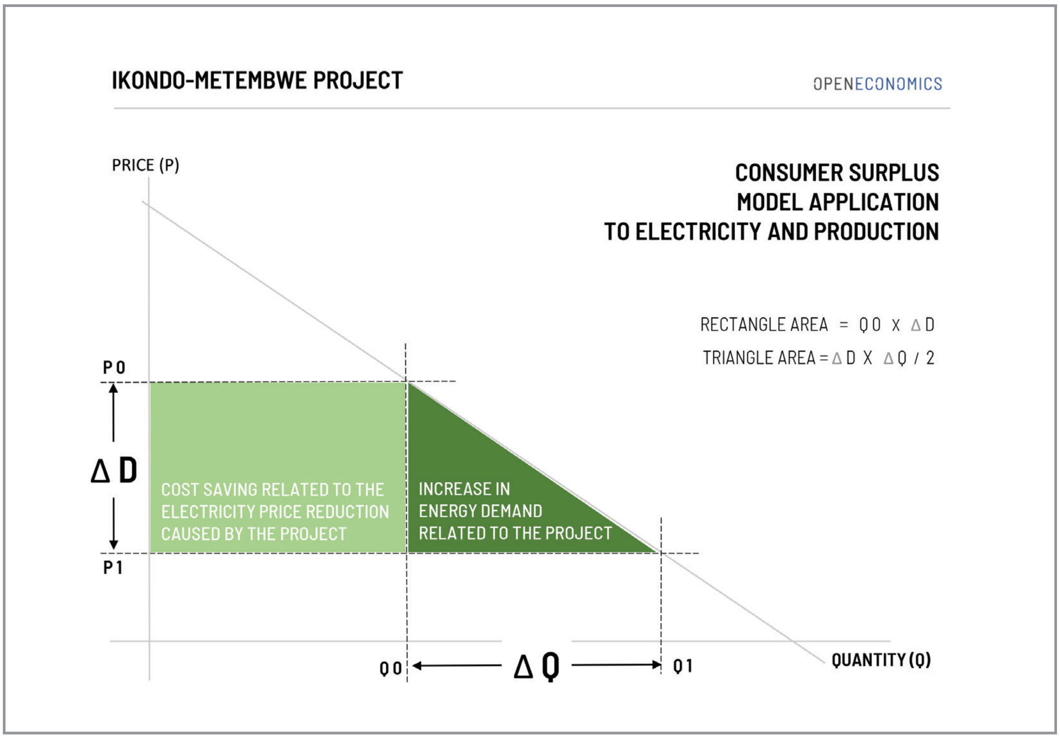
[4] *(International Energy Agency, 2017)*
[5] *For further info regarding methodology please refer to: The World Bank. (2008). The Welfare Impact of Rural Electrification: A reassessment of the Costs and Benefits. The International Bank for Reconstruction and Development / The World Bank.*

Electricity shift from kerosene lanterns to electric lamps brings to a concrete improvement in deliverable energy, in terms of:

- *Affordability: defined as the share of monthly household income that is spent on utility services.*
- *Reliability: which implies fulfilling basic consumer demand for electricity, while being flexible enough to increase output during possible peaks.*
- *Security: which implies the uninterrupted availability of energy sources at an affordable price.*

This benefit can be measured with a quantity defined as Consumer Surplus. Consumer Surplus is a measure of the welfare that people gain from consuming goods and services. It is defined as the difference between the total amount that consumers are willing and able to pay for a good or service (indicated by the demand curve) and the total amount that they actually do pay.

FIGURE 4.2: ELECTRICITY CONSUMER SURPLUS OF THE IKONDO-MATEMBWE PROJECT



SOURCE: OPENECONOMICS ELABORATION ON PROJECT DATA

The rectangle area represents the saving costs for consumers using conventional sources in order to generate energy, considering that clean energy such as electricity is less expensive. The triangle area represents the increasing demand of new consumers for clean energy, thanks to the availability of electricity enhanced by the project. In our analysis, the assumptions behind the estimates of consumer surplus for energy (based on demand elasticities) were taken both from project data and literature. The kWh tariff electricity use for households, public services and business consumer after the implementation of the project are respectively: 0.060 USD/kWh; 0.043 USD/kWh and 0.105 USD/kWh, while electricity consumption at the base year corresponds to 106 kWh/year; 142 kWh/year and 728 kWh/year.[6]

In the scenario without the project, consumers use a mixture of kerosene and diesel to generate electricity. At the base year, the cost of diesel is 0.11 USD/kWh and for business consumer is around 6% higher. Yearly kWh consumption from fossil fuel is 53 kWh for households; 71 kWh for public services and 364 kWh for business

[6] *Project data.*

consumers. According to the data mentioned and following the positive trend of connected consumers, total consumer surplus turns out to be equal to USD 44,261 in net present value for 20 years of project lifespan. The rectangle area, corresponding to cost savings, is equal to USD 29,507 in net present value, while the triangle area, corresponding to the new demand is equal to USD 14,754 in net present value.

Tv and radio benefits

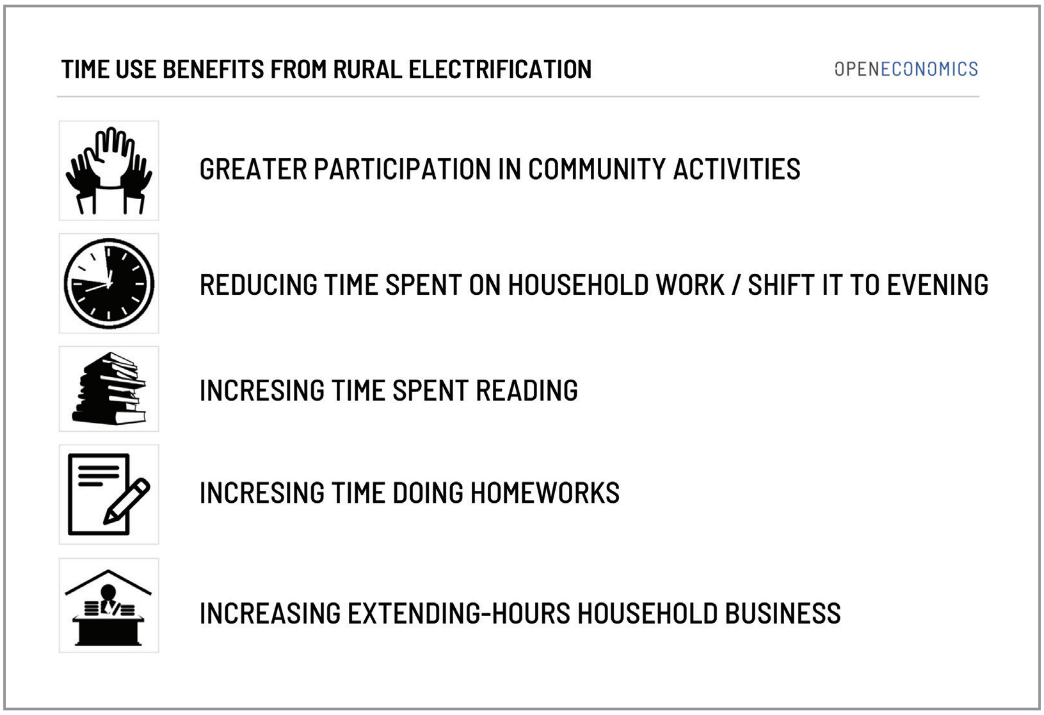
As previously stated, the second most common use of electrification supply is television and radio. The World Bank estimated that close to half of all the electrified households in rural areas have televisions. A similar portion shows that all homes have radios. Both TV and radios are not strictly related to grid connection as both devices can be battery-powered. However, electricity results to be cheaper than battery supply and therefore households are encouraged to enjoy Tv and radio's services for longer time.
The method for assessing the electrification benefits of radio and television considers as units of consumption:

- *For tv watching: hours of television watched per month.*
- *For radio reception: hours of radio listened per month.*

Time savings

Rural electrification helps to reduce time allocated to fuel-collection by household members and increases time allocated to other activities, as detailed in figure 4.3 below.

FIGURE 4.3: TIME SAVINGS BENEFITS FROM RURAL ELECTRIFICATION



SOURCE: OPENECONOMICS ELABORATION

Participation in community activities is commonly understood as the collective involvement of local people in assessing their needs and organising strategies to meet those needs. It helps ensure the more equitable distribution of community benefits, by facilitating access to these benefits by politically or economically weak groups. It also helps people to develop problem solving skills and becoming a more responsible attitude toward their health and welfare.

Education

The most important benefits for education that result from access to electricity are:
- *Improvement of the quality of school facilities using equipment that works with electrical power.*
- *Increased time for study, thanks to lighting in homes, or in schools.*

Typically, in isolated rural areas, schools lack the necessary basic equipment, including adequate furniture or books. In addition, there is a failure of teachers in working in remote locations, which lead to frequent teachers and student's absenteeism. Electricity availability makes rural positions more appealing to teachers, leading to an improvement in teaching quality and methods thanks to electricity-powered educational tools that might be installed in schools.

Thus, one of the possible reasons for higher educational levels is that enhancement of electricity causes improved school quality, thereby encouraging students to attend school for a longer period, enabling them to improve their knowledge and grades. Higher education levels have a strong linkage with future income; people with higher education achievements benefit from higher income than those with lower education. Electricity can therefore improve future household income. On the other hand, access to electricity supply in homes allows to extend time spent studying.

Health

The most important health benefits resulting from improved access to electricity can be summarized as follows:
- *Improvement in sanitary facilities.*
- *Improvement in family's health through the improvement of indoor air quality, thanks to the avoidance of polluting cooking fuels.*
- *Greater health and welfare knowledge thanks to the information available on television, radio and internet.*
- *Improvements in nutrition derived from greater knowledge as well as the fact of being able to refrigerate food.*

Among the health benefits, one of the major impacts is on indoor air quality improvement. Rural electricity can promote better health by reducing indoor air pollution through changes in lighting source. The use of traditional solid fuels puts families on exposure to contaminated air inside their homes, with consequent dangerous health risks.

Women's comprehension of health and family planning provides very strong evidence that access to TV significantly increases this knowledge. Women becomes more encouraged to use modern anticonceptional. Nutrition is another outcome affected by TV enhanced awareness, both because of health knowledge proxies for nutrition knowledge and because infirmity is the direct result of poor nutrition.

We have estimated the benefits of TV and radio, time savings, education and health thanks to the data present in literature reviews, related to rural households. The estimates have shown a monthly value per household of USD 7.46 for the benefits related to TV and Radio, USD 5.40 for time saving, USD 0.10 for health and USD 12.46 for education. Considering the overall benefits, the estimates are equal to USD 1,840,444 in net present value for TV and radio, USD 1,537,276 for time saving, USD 24,670 for health and USD 3,073,987 for education.

Productivity Increase

Rural electrification provides better means of working, boosting productivity of small business in the target area. For project's purpose, we have calculated the increment of productivity related to the local economy, considering the profit increment compared to a scenario without clean energy. When electricity is available from renewable resources, in fact, production costs are lower, and the service is more efficient, increasing profit for businesses in the area. In the case of mill, due to project's clean energy, the average profit would be around USD 102 per month, while in the scenario without clean energy, the profit would be around USD 76 per month, with an average difference of USD 26. Adapting this profit difference on yearly basis and considering the entire lifespan of the project, the benefit would amount to USD 883,864 in net present value.

Cost Saving

A shift from fossil fuel-powered energy to renewable energy sources leads to a cost saving due to improvement in energy efficiency. As per the project, assuming in the no project scenario a yearly use in the base year of kerosene/diesel for a total of 53 kWh/year for households; 71 kWh/year for public services and 364 kWh/year for business consumer and a cost of diesel of 0.11 USD/kWh, the saving cost for the entire lifespan of the project is USD 400,710 in net present value.

Environmental benefits

Off-grid installation, unlike transmission and distribution projects, displaces existing non-renewable sources with clean and efficient energy. Therefore, the installation of renewable energy generation capacity displaces existing non-renewable energy sources. Main benefits are averted CO2 emissions, the value of which should be included in the benefit stream.

In this regard, a shift from conventional fossil fuel source to clean energy allows a consistent reduction of CO2 emission. Considering the same amount of fossil fuel consumption for lighting benefits, shifting to renewable source energy avoid emissions for a total of 3447 ton of CO2 for the entire duration of the project. Considering a price of USD 0.028 per Kg of CO2, the benefit of emission reduction is equal to USD 47,363 in net present value for the entire project lifespan.

In the following table it is possible to have an overlook of the overall benefits deriving from access to electricity relatives to the Ikondo-Matembwe project:

TABLE 4.4: BENEFITS FROM ACCESS TO ELECTRICITY

BENEFITS	ESTIMATIONS (PRESENT VALUE USD)
LIGHTENING	44,261
TV AND RADIO	1,840,444
TIME SAVINGS	1,537,276
EDUCATION	3,073,987
HEALTH	24,670
PRODUCTIVITY INCREASE	883,864
COST SAVING	400,710
ENVIRONMENT	47,363
TOTAL	**7,852,576**

SOURCE: OPENECONOMICS ELABORATION

The benefits produced by the Water component in the Project

Water distribution is strictly linked to sanitation systems, and improvement in this sector brings to a decrease in potential environmental and health risks. The low percentage of Tanzanian population that have access to improved sanitation means that more than 50 percent of faecal waste is currently disposed without treatment, leading to contamination of groundwater and recurrent incidences of diseases such as diarrhoea and cholera.

Many international studies[7] show that benefits of an improved access to water are large and widespread. Among the most relevant, the following are worth mentioning:
- *Health benefits*
- *Time savings*
- *Opportunity cost of absenteeism*
- *Water Consumer Surplus*

Health benefits

Efforts to improve water, sanitation and hygiene interact with each other to boost overall health. Access to sanitation, such as simple latrines in communities, prevents drinking water contamination from human waste and reduces infections.[8]

Health benefits are among the most relevant positive outcomes when it comes to an access-to-water activity. Poor sanitation imposes significant cost on population health that urge important mitigation acts. Health benefits can be furtherly analysed within two different categories:
a) Avoided diarrheal diseases incidence
b) Value of loss of life avoided

a) Avoided diarrheal diseases incidence: following the data provided by the Institute for Health Metrics and Evaluation, Tanzania has a high incidence of diarrhoea diagnosis. In addition, diarrheal diseases are among the top 10 causes of premature death in 2017 [9] and about 14,174 deaths in Tanzania occurred from diarrhoea in children under age five in 2012.[10] Diarrhoea affects about 13 percent of the population under five years and about 2 percent of the population above five years.[11]

Improvement in water and sanitation have a clear link to impact in avoidance of both morbidity and mortality associated with diarrheal diseases, which are brought by several types of bacteria and parasites that are ingested through contaminated food or water.

The reduced diarrheal incidence has been calculated based on the treatment cost per case and the number of people that are affected. According to the data available, the adult population affected by diarrheal disease is 2% of the population, while the percentage of child population affected is 13%.[12]

[7] *(World Bank, 2003)*
[8] *(WHO, 2008)*
[9] *(Institute for Health Metrics and Evaluation, 2017)*
[10] *(WHO, 2012)*
[11] *Ibidem*
[12] *(World Bank, 2016)*

Among the population affected , it is estimated that around 98% of the cases are outpatient and the remaining 2 % require hospitalized care and can be considered as inpatients.[13] The cost for outpatient care for diarrheal disease per patient is estimated at USD11 and for an inpatient care at USD 33.[14]
In the target population, we estimate that 676 children and 1404 adults would be affected, with a total avoided diarrheal disease incidence of USD 192,150 in net present value for the entire life of the project.

b) Value of loss of life avoided: in order to understand the importance of access to water, scholars generally rely on the concept of the disability-adjusted life year (DALY).

The DALY is a measure of overall disease burden, expressed as the number of years lost because of ill-health, disability, or early death. It is estimated that 863 DALYs are lost per 1000 children under the age of five in Tanzania. [15] The estimation of the value of loss of life avoided is estimated by multiplying the estimate of the number of children affected by diarrhoea by the estimated DALY, at the average wage of USD 11,913,44 per annum, which corresponds to a total of USD 1,340,148 in Net Present Value for the entire life of the project.

Time savings

Improved access to water and sanitation can help the target population in developing a more time- efficient daily life. One of the benefits linked to water and sanitations activities is, therefore, time savings.

The average daily water collection time for a 20-liter jerry can in urban Tanzania is estimated to be 20 minutes. Hence, per year a person spends about eight days collecting water to guarantee a personal consumption of 30 liters per day. Time savings are equivalent to about Tsh 77,500 per year of potential wages forgone. To estimate the benefits arising from time saving, beneficiaries from household connections are assumed to spend no time collecting water and those benefiting from stand posts are assumed to spend half of the time than without the project as the water source is closer to their homes.[16]

Considering an average wage of USD 11,913,44 the time savings equivalent per year is USD 35,307,52. Therefore, the total benefit of time savings are estimated at USD 1,770,103 in net present value for the entire life of the project.

Opportunity cost of absenteeism

The opportunity cost of absenteeism measure evaluates the economic improvement among population because of water and sanitation upgrading. The impact of a diarrhoea case in the population is valued on the minimum wage basis, assuming that the number of school days missed per episode of sickness is three for the outpatient cases and five for the inpatient cases.[17]

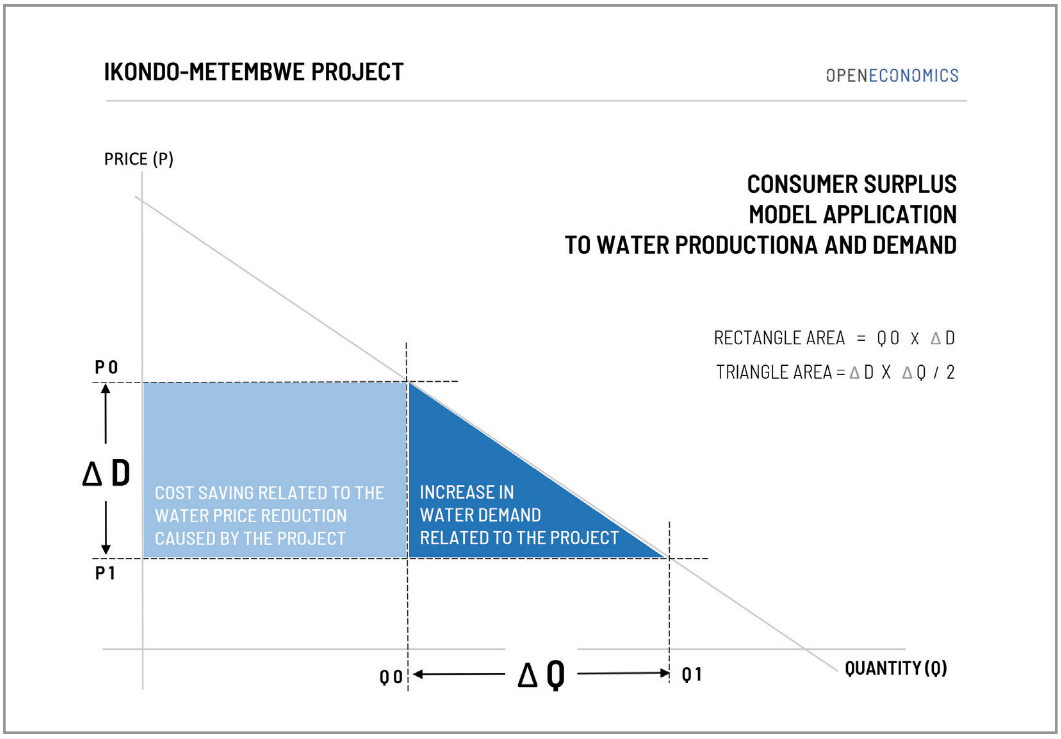
The evaluations have been made considering the opportunity cost of not attending school for children among 5 and 18 years old, and adult population at working age. Assuming the average days of absence per year at school for a child is four and for adults is three, [18] the opportunity cost of absenteeism is valued based on the average wage of USD 11,913. The corresponding opportunity cost for a child can be estimated as USD 15,885, while for an adult is USD 11,913 per year. The total benefit from reducing the opportunity cost of absenteeism is estimated at 239,305 USD in net present value for the entire life of the project.

[13] *(Open Data Tanzania, 2014)*
[14] *(World Bank, 2016)*
[15] *(WHO, 2010)*
[16] *(World Bank, 2017)*
[17] *(WHO, 1994)*
[18] *(WHO, 2014)*

Water consumer surplus

The Water Consumer Surplus measures the economic gain obtained by consumers because they are able to purchase a product for a price that is less than the highest price that they would be willing to pay. As per the project scenario, access to water enhances collection efficiency, with the possibility to save a series of water-related costs. In a scenario where water is unavailable, water consumption is assumed to be 87 litre per day per household, with a cost of USD 0.0022 per litre. Within the project scenario, consumption of water would increase by 10%[19]; for a total amount of 95 litre per household daily, while the cost of collection would decrease to USD 0.0010 per litre. The Consumer Surplus is calculated with the same method used to estimate the energy consumer surplus, as shown in figure 4.4 below.

FIGURE 4.4: WATER CONSUMER SURPLUS



SOURCE: OPENECONOMICS ELABORATION

As per above, the light blue rectangle area represents cost savings for consumers who already collect water, while the blue triangle area represents the increased demand of new consumers due to improved access (from lower price and/or opportunity cost) to water enhanced by the project. The estimation of the rectangle area amounts to USD 2,087,619 in net present value for the entire life of the project, while the triangle area would be USD 104,381 in net present value. The total surplus is thus estimated at USD 2,191,999 in net present value for the entire project lifespan. Table 4.5 below reports the overall benefits deriving from the project effects on improving access to water.

[19] *(World Bank, 2016)*

TABLE 4.5: BENEFITS FROM ACCESS TO WATER

BENEFITS	ESTIMATIONS (PRESENT VALUE USD)
AVOIDED DIARRHEA INCIDENCE	192,150
OPPORTUNITY COST OF ABSENTEEISM	239,305
VALUE OF LOSS OF LIFE AVOIDED	1,340,148
TIME SAVINGS	1,770,103
WATER CONSUMER SURPLUS	2,191,999
TOTAL	**5,733,706**

SOURCE: OPENECONOMICS ELABORATION

The benefits produced by the Food component of the project

Malnutrition is one of the most serious problem in many countries today, dramatized by its combination with other forms of poverty and the global inequality in food distribution. Malnutrition imposes high economic and social costs on countries and investing in improving nutrition is not only a crucial global mission but can also yield high economic benefits. Tanzania is estimated to lose Tsh 815bn (USD 512m) in yearly revenue from malnutrition which mainly decimates young children. A recent survey shows that about 69% of the Tanzanian children are anaemic, 42% are stunted, 35% are iron deficient, 33% are vitamin A deficient and 16% are underweight.[20]

The main project benefits from enhanced food security can be summarized under the following headings:
- *Improved farmers income from crop production benefits*
- *Improved farmers income from poultry and egg production*
- *Nutrition and Food Security*

Improved farmers income from crop production

Most people of working age in Tanzania are engaged in the cultivation of maize and/or beans. The project will yield positive outcomes that will improve farmers income from maize and beans production, as the key ingredient of Tanzanian food supply.

In the scenario without the project, debe[21] yield of these two crops is respectively 15 debe per acre for beans and 30 debe per acre of maize. Once clean energy and water become available due through the project, production increases up to 25 debe per acre for beans and 50 debe per acre for maize. Considering revenues and costs of production, the profit difference with and without project would be around USD 47 for one acre of land for beans and around USD 43 for one acre of land for maize. In this context, the benefit of all farmers involved in the project is estimated to be USD 1,235,122 in net present value for the entire project life.

Improved farmers income from poultry and egg production

Most households in Tanzania are also growing poultry for egg production and home consumption. Based on an estimate of 14 additional chickens per farmer as a consequence of the enhanced access to electricity and water, the average difference in income between the scenario without and with the project is estimated to be USD 23 per farmer per year, for a total benefit of USD 322,073 in net present value.

[20] *(BMC Pediatrics,2017)*
[21] *A debe is a bucket of 20 litres and is considered a commonly used measure for agricultural output in rural Tanzania*

Nutrition and Food Security

Food security is defined as a state in which "all people at all times have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life".[22] Household nutrition and food security is reported in term of Food Consumption Score (FCS) and Household Food Insecurity Access Score (HFIAS) .[23]

In order to estimate health benefits, we considered project induced variations in the FCS and the HFIAS index respectively of +20% and -20%[24], according to the percentage of children under 5 years whose nutrition improves within the project area. Considering 0.68 number of children under 5 age per household, and 51%[25] of malnourished children for Tanzania and the average wage as the opportunity cost for malnutrition, the total benefit would be USD 1,902,891 in net present value over the entire project life. Table 4.6 below reports the overall benefits deriving from the enhanced access to water induced by the project:

TABLE 4.6: BENEFITS FROM IMPROVEMENT IN FOOD ACCESS

BENEFITS	ESTIMATIONS (PRESENT VALUE USD)
IMPROVED FARMERS CROP PRODUCTION AND INCOME	1,235,122
IMPROVED FARM POULTRY AND EGG PRODUCTION AND INCOME	322,073
NUTRITION AND FOOD SECURITY	1,902,890
TOTAL	**3,460,086**

SOURCE: OPENECONOMICS ELABORATION

4.3 IKONDO-MATEMBWE PROJECT RESULTS

The Financial Cost-Benefit analysis

The purpose of the financial cost-benefit analysis is to assess the financial viability of the proposed project, testing whether the project is financially attractive for the investor or the investors involved. In the financial benefit-cost analysis, the unit of analysis is an individual stakeholder or a group of stakeholders and not the entire economy. In contrast, the economic cost-benefit analysis evaluates the project from the viewpoint of an entire (typically national) community.

The profitability of a project to the stakeholder considered is indicated by the project's Financial Net Present Value (FNPV). A positive FNPV indicates a profitable project from the point of view of the private party who has to undertake it, i.e. if the project generates sufficient funds to cover its cost to the stakeholder considered, including loan repayments and interest payments.

[22] (Gibson, 2012)

[23] The Food Consumption Score (FCS) aggregates household-level data on the diversity and frequency of food groups consumed over the previous seven days, which is then weighted according to the relative nutritional value of the consumed food groups. Based on this score, a household's food consumption can be further classified into one of three categories: poor, borderline, or acceptable. The food consumption score is a proxy indicator of household caloric availability.

Household Food Insecurity Access Score (HFIAS) is a tool to assess whether households have experienced problems in food access in the preceding 30 days. It allows the extent and severity of food insecurity at household level to be assessed and is a useful measure for comparing food access across different population groups. (WFP, 2015; UNSCN, 2017).

[24] (World Bank, 2016)

[25] (UNICEF 2009)

Table 4.7 below shows project revenues, project's investment costs and project net benefits for the entire project lifespan from the point of view of a private investor (a utility or a power producing company) that would own the energy producing asset:

TABLE 4.7: PROJECT FINANCIAL ESTIMATIONS

PROJECT	REVENUES PRESENT VALUE USD	INVESTMENT COST	FNPV USD
ENERGY	792,120	2,907,431	-2,115,311

SOURCE: OPENECONOMICS ELABORATION

Revenues are based on electricity sales and connection fees. Households are assumed to pay a tariff of 0.06 USD/kWh, social services of 0.04 USD/kWh and business of 0.11 USD/kWh. Connection fees for the base year are assumed to be around USD 128 and the national grid to be able to collect a tariff of 0.04 USD/kWh.

Considering project data, the results of the financial Cost-benefit Analysis are negative, with a Net Present Value of USD -2,115,311.60 and an FIRR of -4%. The FIRR is also the discount rate at which the present value of the net benefit stream in financial terms becomes zero.

The results of the FCBA imply that from the point of view of the private stakeholder, which in this case is the utility owning the asset, the project is not feasible, as it will not be convenient for the investor to implement such a project in terms of profit. The financial gap, as highlighted within the data analysis, corresponds to 72% of the project CAPEX.

Even though the project is not attractive from the point of view of the energy investor, it could be beneficial from the point of view of society at large. The Economic Cost Benefit Analysis (ECBA) can thus be used to ascertain whether the project would be beneficial from the broader point of view of the community involved and, more generally of the entire country.

4.4 THE ECONOMIC COST-BENEFIT ANALYSIS OF THE PROJECT

To carry out the Economic Cost Benefit Analysis, two different scenarios have been considered for the three project's components: (i) simultaneous implementation and, (ii) implementation at different times.
In the second scenario, the energy part alone is the main component with the major investment costs. This implies two distinct alternatives for water and livestock, consisting, respectively in the combination of (i) energy and water and (ii) energy and livestock. This scenario has been compared with an alternative case where all components are implemented together. The rational for this comparison is that energy is the activating component for the water supplied to the village, bringing about crucial economic benefits to the target population. In addition, energy is also the activating component of the livestock factor, as farmers need energy to improve their ability to use improved cultivation techniques. As per the livestock subcomponent, energy gives the opportunity to increase production through hatchery activities, through the use of electric equipment. This boosts productivity through an enhanced value chain and also improves the environment and the wellness conditions of the animals.
In terms of project results, the Energy project alone ENPV turns out to be USD 5,940,652, while the

Energy and Water project combination and the Energy and Food project yield respectively an ENPV of USD 10,651,791, and of USD 7,768,100. Therefore, the project with the highest Economic NPV is the integrated WEF Nexus Project, consisting of Energy, Water and Food, with an ENPV for USD 12,479,239. Simultaneous implementation of the three projects thus produces the largest impact in economic terms.

TABLE 4.8: PROJECT RESULTS

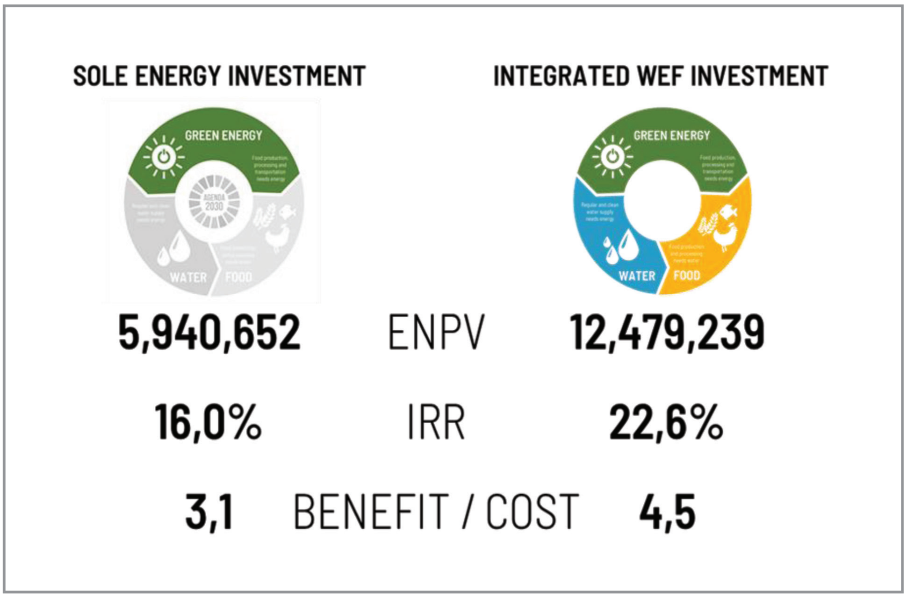
PROJECT	ECONOMIC NPV USD
ENERGY	5,940,652
ENERGY AND FOOD	7,768,100
ENERGY AND WATER	10,651,791
ENERGY WATER AND FOOD	12,479,239

SOURCE: OPENECONOMICS ELABORATION

Although there appears to be only a small difference in terms of ENPV and economic benefits between the Energy and Water project and the complete Ikondo-Matembwe project, it must be considered that without Energy, the other two projects would not be adopted, as the investment costs would be much higher than those as assumed in the project. This is because energy is crucial for all activities and in the absence of the energy project component, it would have to be produced at much higher costs. This conclusion can be seen also through the lenses of a project expansion; the Energy project opens the possibility to further develop the Water and Food components.

Further indicators of project performance are the Internal Rate of Return (IRR) of 16% with a Benefit Cost Ratio (BCR) of 3,1 for the Energy project, and an IRR of 22,57% and a BCR of 4,5 for the Energy, Water and Food integrated project.

FIGURE 4.5: ENERGY AND INTEGRATED INVESTMENT IRR AND COST-BENEFIT RATIO



SOURCE: OPENECONOMICS ELABORATION

The BCR indicator is indicative of the peculiarity of the integrated project compared to the sole energy investment. The 1,4 points differential among the two projects has a clear explanation: energy is the enabler

of the integrated project, if energy is not activated, the other two components would not be enabled. This is significant as in this case with a little investment quantified for the energy sector, it is possible to collect high benefits from the energy, water and food components.
In addition, whilst the Nexus approach brings about mostly positive externalities, it is true that negative externalities might arise as well. If a positive externality is a benefit enjoyed by a third party, a negative externality implies a cost for the mentioned as result of an economic transaction. A traditional case of negative externality is the case of pollution, imposes costs on society and individual reducing, therefore the possible project benefits.

The identification and quantification of these negative externalities and especially their conversion into monetary terms is important when evaluating the economic benefits and costs of a project although they are very difficult to compute.

As per the WEF Nexus, negative externalities do not arise and the very few ones are not major negative externalities but only marginal ones. As per the mentioned, a kind of negative externality might be related to the reduction of diesel sales, brought by the switch undertaken by the project to produce energy from this conventional source into a RE based technology.

Another externality that might be related to the project is related to the land expropriation and land right issue. Although it is a crucial advocacy aspect, it cannot be related to this project as it is assumed that those land that will be deployed to develop it are uncultivated, public lands with no economic value that will not affect neither farming nor farmers as agriculture is well known to be the main economic activity in rural areas.

5. MICROECONOMIC CONCLUSIONS AND MACROECONOMIC PRELUDE

The aim of this study was to evaluate the effects that the innovative Nexus project can have on a specific area. In doing this, a microeconomic impact assessment was developed to evaluate economic, social and environmental costs and benefits, in order to further and promote sustainable institutional programmes and policies.

From project results it is possible to state that investing at the same time in all the three components would give better performances in terms of economic results for the local stakeholders, compared to the implementation of the Energy project alone.
The evaluation model developed addresses the positive impacts and benefits deriving from the Ikondo-Matembwe project that enables to achieve concrete improvements in the wellbeing of the local population. The starting point of the study is the provision of sustainable energy and improved access to it through the generation from renewable sources such as water, with energy being the enabling factor empowering the other component of the integrated approach, permitting a dynamic mechanism that power up the other two components of the project.

The results of the ECBA project validate its desirability from the society point of view and its economic and financial feasibility. Total ENPV, which is estimated at USD 12,479,239, covers the entire financial GAP of the financial analysis and delivers important positive results for all project stakeholders.
The integrated Ikondo-Matembwe project can therefore be financed by the public counterpart and for this reason, lays the foundations for a further feasibility analysis based on a scale-up of the technology in remote and disconnected areas of the country.

The economic benefits of the project and the potential impact on the well-being of the population and area considered suggests that the project may be productively replicated at regional and national level. The transformative nature of a project lies in its potential to change the production technology at regional basis. The mix of technology, project dimension, business model and area considered may help to lay the basis of a structural change into the economy, that together with governmental financial support can enable the conditions for sustainable development. The analysis of the project's scale-up and its transformative effects nature will be assessed through the macroeconomic model, that will allow to focus on the territorial impacts in terms economic, social and environmental values, as well as on the Sustainable Development Goals, backing its foundation for a comprehensive consideration of the collective well-being of the country and hence in line with the most appropriate economic policy.

6. THE MACROECONOMIC SETUP OF THE PROJECT

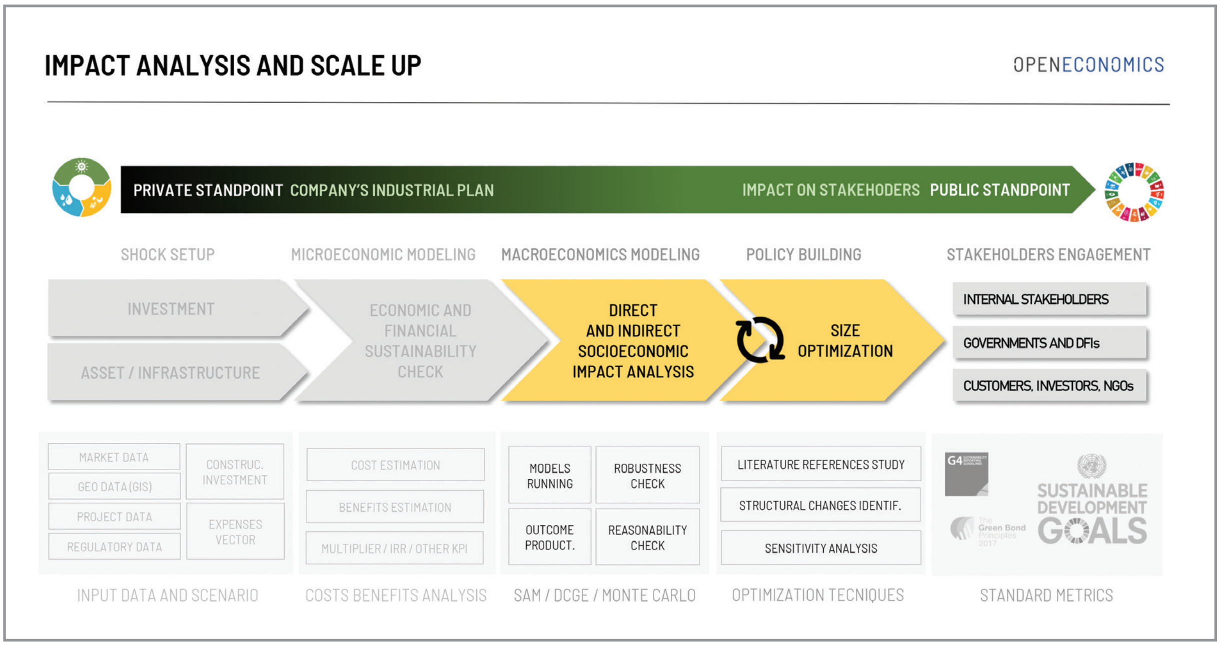
6.1 METHODOLOGICAL PREMISE

The macro impact analysis of the Ikondo-Matembwe project has been carried out by using a Dynamic CGE model backed by a Social Accounting Matrix (SAM) .[26] This methodology constitutes an evaluative international best practice of increasing use by international organizations and multilateral agencies, including, in particular, the World Bank. This model is part of the latest generation of analytical tools applied in the evaluation of the indirect and induced effects of large investment projects and their macroeconomic impacts. CGE models are believed to be one the most reliable tool to investigate the policy options for an economy; advantage of using CGE lays on the General equilibrium assumption, assisting the adjustment of policy issues.

The general equilibrium represents a condition where all markets are in a state of equilibrium from the point of view of demand and supply, according to the Walrasian general principles. It concerns three different circles of causation: between demand and supply of goods and services on one hand, and prices and incomes on the other; between the formation of incomes from demand and supply of factors of production and their prices, and between the initial resource endowment and the redistribution caused by productive choices and institutional transfers.

CGE incorporates all the interactions that are market-based, and results generated, suggesting which kind of policy would be more appropriate for a certain economy. It simulates the behaviour of the observed economy, in response to external stimuli of various nature, entity and temporal extension created by the considered investment. The factor behind the more appropriateness of CGE than all its linear predecessors is that it eliminates the linearity constraint found in all the previous models. Such methodology can simulate the functioning of the economy on the basis of the interdependent relations among local stakeholders and among all market's components.

FIGURE 6.1: MACROECONOMIC MODELING



SOURCE: OPENECONOMICS ELABORATION

[26] *For methodological details see 26 Scandizzo P.L., Ferrarese C. (2017), A CGE model for Tanzania, The World Bank Technical Report, Washington DC*

The starting point of the CGE and the corresponding SAM is the circular flow of income both in the village economy and in its country wide surroundings, which involves all the economic agents and their linkages. The main actors are households, owners of the factors of production and, at the same time, consume the goods produced. Differently from the simple SAM model, CGEs consider price and elasticity effects, according to structural and behavioural equations that have a microeconomic foundation.

The model is able to calculate indirect and induced effects on the economy, where the former represents impact on the value chain of project's economic sector reference (energy and infrastructure sectors), while induced effects are the economic, social and environmental effects on the other sector of the economy influenced through interlinkages between sectors and institutions.

During the construction period, investments act on the economic system as a complex increase in expenditure towards the sectors producing capital goods. An investment, in fact, consists of purchasing capital goods (i.e. assets whose existence survives the period of production, conventionally fixed in a year). The purchase of these goods activates a supply chain that starts from the sectors that supply the capital goods. These suppliers turn to other suppliers in a process that can involve many sectors and leads to the generation of the so-called indirect effects of the investment. This produces an increase in expenditure that contributes to an income increase for those within the involved sector, increasing the purchasing power of targeted stakeholders.

At the end of the construction period, one or more productive sectors can become the owners of the increase of capital stock carried out by the investment: thus, their productive capability increase as a direct consequence of the investment. If the investment has at its main aim in increasing human and social capital, it can be attributed to the beneficiary institutions (families, businesses, Government).

At the core of the CGE model lies a Social Accounting Matrix (SAM). The SAM is necessary to integrate all statistical information enabling a detailed estimation of sector and agents' interdependencies and the related cascade of causes and effects leading from an intervention to its desired effects. It describes the economic interrelations among productive sectors and institutions following the logics of the circular flow of income from production activities to the distribution circuit of income to institutional sectors.

Within the analysis, the SAM constitutes the statistical and accounting reference framework that systemically collects all the available estimates of consumptions, income formation and distribution and productive activities for a specific economy.

6.2 MACROECONOMIC DATA

The simulations and the applications of CGE model developed in this study needs to be calibrated to a specific SAM that requires an ad hoc structured database. To this purpose, a calibrated SAM for Tanzania at a base year 2016 was estimated.

The 2016 SAM has been estimated from the most recent GTAP[27] matrix as a starting data base. This data base, which has been updated using official national and international statistics, has allowed us to develop an analysis of the complex economic structure of the country, as well as of the interconnections between productive sectors and institutions. At the national level, in the case of Tanzania, reference is made

[27] The Global Trade Analysis Project (GTAP) is a global network of researchers and policy makers conducting quantitative analysis of international policy issues. They provide economic and quantitative data to support different type of analysis

to the Tanzania National Bureau of Statistics, which offers updated statistics at an economic, social and environmental level necessary for updating the SAM.
Data from regional and international development banks, such as the International Monetary Fund, World Bank and the African Development Bank, were also used, which present a series of updated data on the various development issues in the country, such as household income, system data sanitary etc.
The CGE model uses SAM as a starting database for the country's economic structure and, by applying a system of equations, variables and parameters that describe the behaviour of economic actors, is able to simulate the process of adjustment to new balances resulting from the reaction of economic agents to different measures of economic policies, including a public investment program. In this context, the model enables to simulate the reaction of economic agents and to evaluate how the indirect effects of spending within a sector can affect the most important economic variables, such as production, prices and employment and their structural components.

6.3 THE 2016 SAM FOR TANZANIA

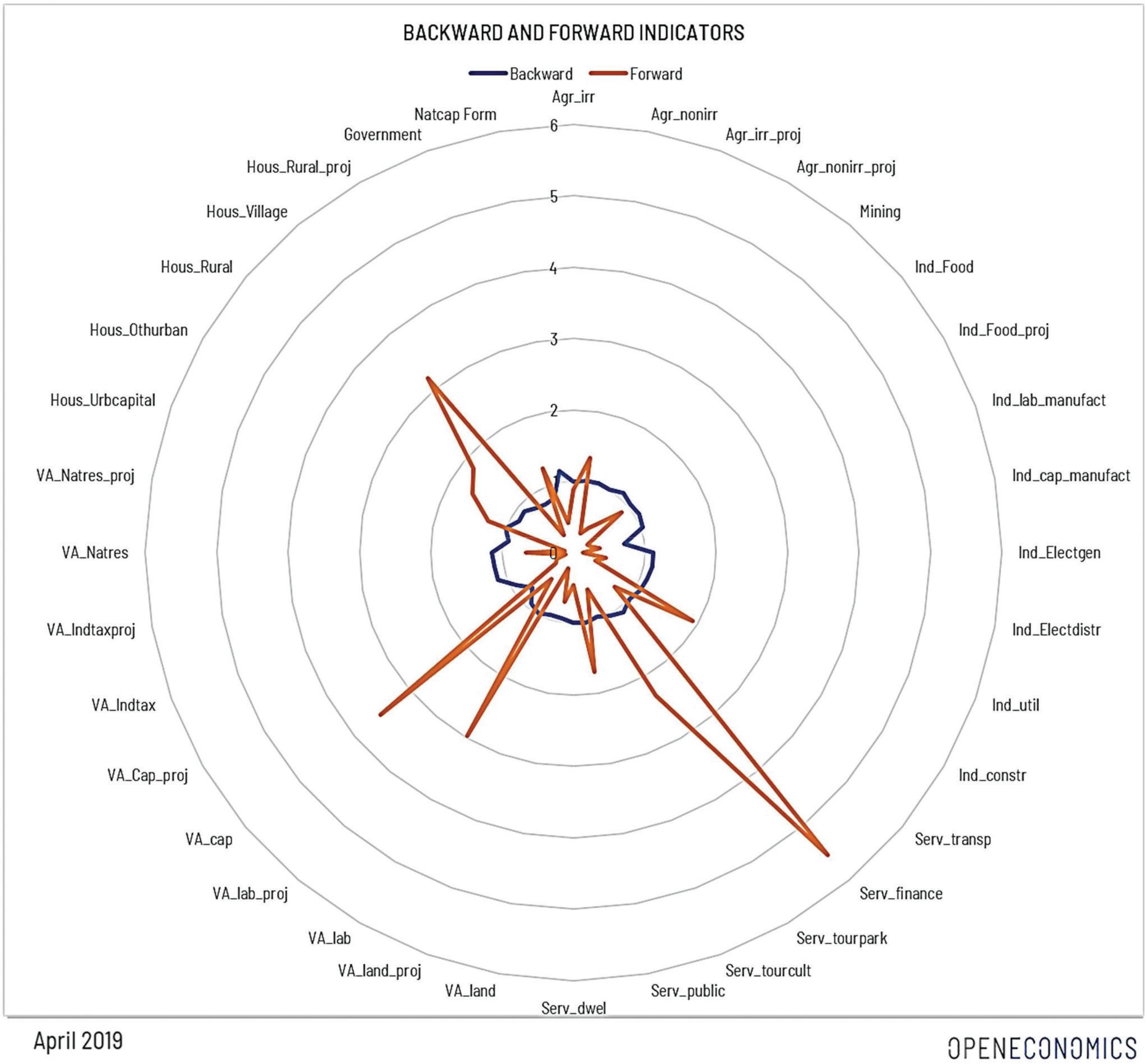
The SAM for Tanzania integrates data on production activities, use and distribution of capital, allowing an in-depth estimation of the interdependent effects that an external shock provoke on the economic and financial flows. From the economic data collection described above, the SAM has been estimated using an entropy-based algorithm which allowed to use the different data available and consistently balance the different accounts.

The SAM contains twenty-two sectors of production, including detailed accounts of energy, agriculture and water. To better understand the project's impacts on the sites where the scale-up is based and on the rest of the Tanzanian economy, agriculture and food production appear both in a set of accounts referring to project site and in one for the rest of the country.
Value added accrues to eight factors of production, namely labour, capital, land and environmental resources, also in this case divided between the project site and the rest of the economy. Institutional accounts include Government, Households and the Rest of the World. Household accounts include separately rural and urban families and project and non-project sites residents. Finally, capital formation is divided into produced (standard) and non-produced (natural) capital formation, accounting for investment or depletion of natural resources.

Figure 6.2 below shows the Rasmussen indexes of backward and forward linkages computed from the matrix. These indexes describe the direct and indirect connections between the different actors of the economy, whose accounts are represented in the SAM. The indexes of backward linkages are based on the average multipliers (from the columns of the SAM inverse) and can be interpreted as the increase in output of the entire system of industries needed to cope with an increase in the final demand for the products of one industry by one unit (Rasmussen, 1957). The indexes of forward linkages are instead based on the row multipliers and quantify the extent to which the system of industries draws upon a given industry. They are indexes of sensitivity of dispersion, as they measure the increase in the production of an industry driven by a unit increase in the final demand for all industries in the system. Both indexes are normalized by dividing the average multiplier for each sector by the average multiplier for all sectors.
The magnitude of the multipliers depends on the number of the accounts considered exogenous and are lower the larger such a number, while the Rasmussen indexes, being normalized with the average multiplier, indicate only the relative importance of a sector linkage as compared to the mean. The multipliers used in the

table correspond to the hypothesis that the capital formation account is exogenous. Under this hypothesis, as the figure shows, the Rasmussen indexes of backward multipliers, which average 1 by construction, range from a minimum of 0.73 for capital-intensive manufacturing to a maximum of more than 1.17 for hydro sector. This means that if the demand of one sector increases 100 per cent, the average impact on the demand for the products of the other sectors is between a minimum of 73% and a maximum of 117% of the average. The results show that the country enjoys a stronger than average backward connectivity for many sectors, and that the hydropower sector is one of these. The indexes of forward linkages, on the other hand, measure the degree of participation of each sector/institution to the overall economic activity, that is, on average, how much a sector demand increases in response to an equi-proportional increase in all sectors. They are much more diverse than the backward indexes, with especially large values for some sectors such as service sector and tourism. The lowest value of 0.12 is for small industry sectors, while the highest value of 5.54 is for service sector.

FIGURE 6.2: BACKWARD AND FORWARD INDICATORS



SOURCE: OPENECONOMICS ELABORATION ON SAM DATA

6.4 SCALABILITY SETUP AND KEY INDICATORS

The estimation for the scalability has been based on "ELECTRIFICATION PATHWAYS FOR NIGERIA, TANZANIA AND ZAMBIA" [28] tool. This is a geospatial analysis supporting the planning, implementation and monitoring of basic services delivery in developing countries, as reflected by an increase in use in a number of geographies and sectors.

Within the energy sector, the use of GIS data and associated analytical tools can be useful in conducting strategic planning as well as prioritizing and rationalizing energy investment. The web-based open source application presented here allows the users to select scenarios based on electricity consumption targeted (Tiers of access) and spatially related fuel costs towards identifying the least cost electrification technology for every settlement at a 1 by 1 km resolution.
The technology decision depends on several spatial parameters, including: population density, distance from existing and planned transmission infrastructure, proximity to road network, night-time light, as well as energy resource availability.

For each location, seven electrification technologies are compared, and the least cost system is selected depending on the tiers of access aimed for. In other words, the technology offering the lowest levelized cost of electricity generated throughout its lifetime, is considered as the best electrification solution. Results are available for each settlement.

The model provides 5 options for level of electricity consumption that are named as Tiers of access. Simulations by using the tools show that the higher the Tier, the more grid extension increases. In this analysis it is assumed that the Tier also represents an indicator of the economic development in the target population and it is thus assumed that it represents a proxy of the potential productivity level.
A conservative approach is applied to choose the Tier for this analysis: even if the reference scenario (Matembwe-Ikondo) starts with a Tier 2 and reaches the Tier 3 during the operational phase, a Tier 3 is selected in the model to identify the more promising areas for a successful project. Although several electrification technologies can be inspected, the present analysis only focuses on the following renewable technologies:
- Hydro Mini-Grid
- Wind Mini-Grid
- Photovoltaic Mini-Grid

In order to identify the number of plants for the scale-up planning, it is assumed that the same generation capacity installed in the project Ikondo-Matembwe will be replicated all around the country in every suitable off-grid site, according to the results of the tool. Firstly, 550 kw hydro power plant is the reference size chosen and equally performing wind and photovoltaic plants are sized considering an equal yearly electricity production. Secondly, the total hydropower capacity given by the tool in each District is calculated and, lastly, the result, for each District, is divided by the reference size and rounded down to obtain the number of plants, paying attention in differentiating by hydro, wind and photovoltaic potential capacity. The number of plants that could be built in each district have been evaluated considering the following aspects:

- Hydro Mini-Grid: total hydropower capacity divided by the standard size of 550 kW.
- Wind Mini-Grid: total wind power capacity divided by the standard size of 550 kW and by 8760/3000 (ratio of hydro and wind equivalent hours).
- Photovoltaic Mini-Grid: total photovoltaic power capacity divided by the standard size of 550 kW and by 8760/2160 (ratio of hydro and solar equivalent hours).

[28] *The tool and data for the scalability has been assessed and provided by FS4MGO International Research Group*

As per the Project's scale up, 16 regions have been projected to be involved in the replicability process, as shown in Figure 6.3 below.

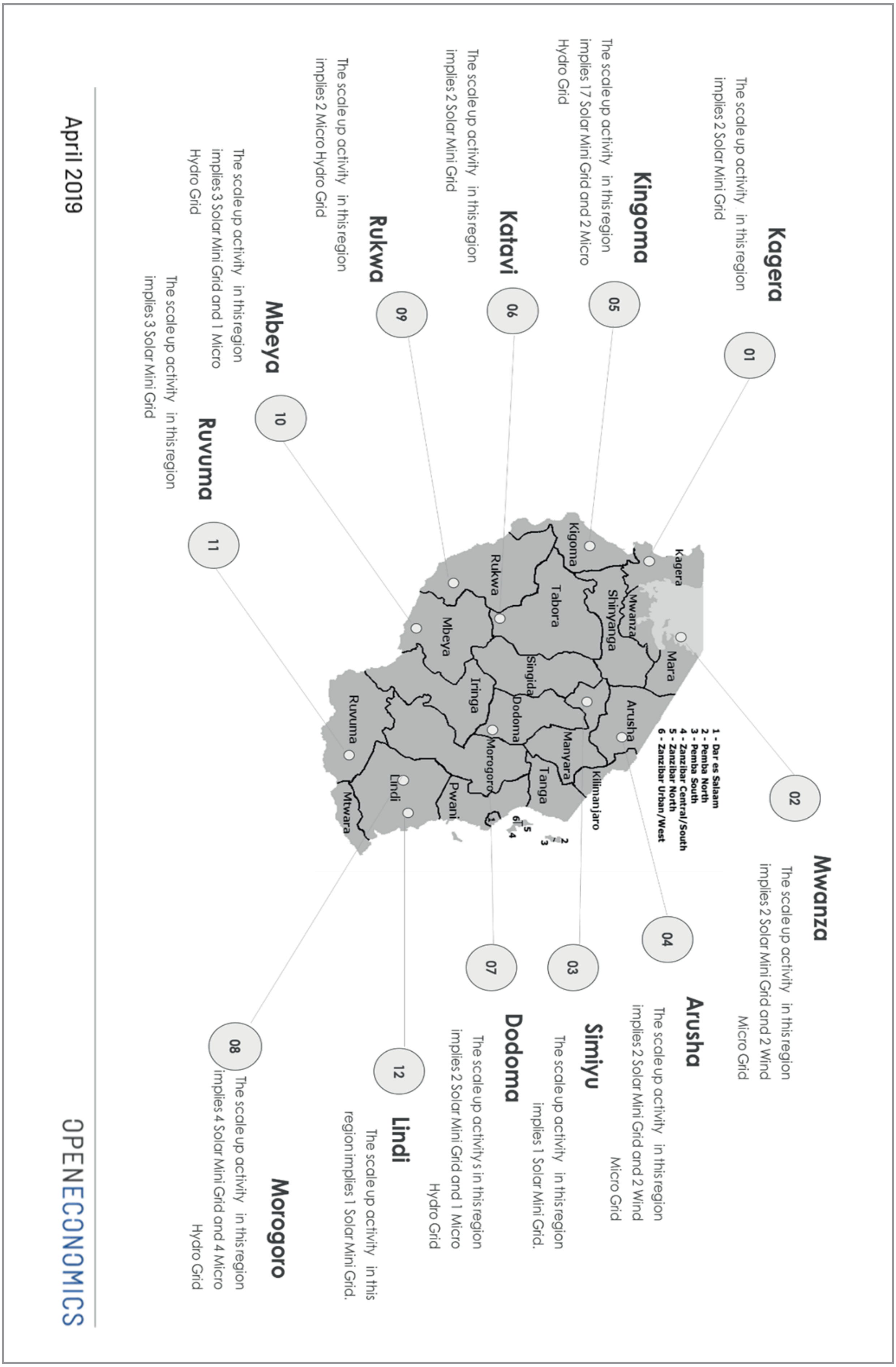


TABLE 6.1: OVERLOOK OF THE SCALE UP ACTIVITIES

REGION	TYPE OF ACTIVITY	NUMBER OF INTERVENTIONS
KAGERA	Solar Micro Grids	2
MWANZA	Solar Micro Grids Wind Micro Grids	2 2
SIMIYU	Solar Micro Grids	1
ARUSHA	Solar Micro Grids Wind Micro Grids	2 2
KIGOMA	Solar Micro Grids Micro Hydro Grids	17 2
KATAVI	Solar Micro Grids	2
DODOMA	Solar Micro Grids Micro Hydro Grids	2 1
MOROGORO	Solar Micro Grids Micro Hydro Grids	4 4
RUKWA	Micro Hydro Grids	2
MBEYA	Solar Micro Grids Micro Hydro Grids	3 1
RUVUMA	Solar Micro Grids	3
LINDI	Solar Micro Grids	1
TOTAL	**Solar Micro Grids** **Micro Hydro Grids** **Wind Micro Grids**	**39** **10** **4**

SOURCE: OPENECONOMICS ELABORATION

The total number of projects to implement was determined as per 39 Solar Micro Grids, 10 Micro Hydro Grids and 4 Wind Micro Grids, for an overall total of 53 installations, with investment costs (including the water and food component) as presented in table 6.2 below.

TABLE 6.2: ACTIVITIES AND RELATED INVESTMENT COSTS

PROJECT	UNITARY COST USD	REPLICATIONS	TOTAL INVESTMENT COSTS USD
SOLAR MICRO GRIDS	3,500,000	39	136,500,000
MICRO HYDRO GRIDS	2,950,472	10	29,504,720
WIND MICRO GRIDS	3,300,000	4	13,200,000
WATER PROJECT	337,232	53	17,873,296
FOOD PROJECT	493,427	53	26,151,631
TOTAL			**223,229,647**

SOURCE: OPENECONOMICS ELABORATION ON FS4MGO DATA

The components of the capital expenditure include the following economic sectors:

- *Capital-Intensive Manufactures*
- *Construction*
- *Transportation & Communication*
- *Private Financial & Other Services*

Among the Capital-Intensive Manufactures, all the costs related to the machineries and installations of the three project components (Energy, Water and Food) are included. Among these, civil works pertain to the Construction sector, while transport costs are attributable to the Transportation and Communication sector, while all design and business services are associated with the Private Financial & Other Services sector.

A further step was necessary in order to determine the costs locally incurred in the construction phase. The analysis conducted through the OE projects database showed that the 49% of the energy projects costs are met locally, while those for the water components are equal to 42% and foods accounts to 71%.

Table 6.3 below shows in detail the components related to local costs.

TABLE 6.3: LOCAL COSTS RELATED TO THE PROJECTS COMPONENTS

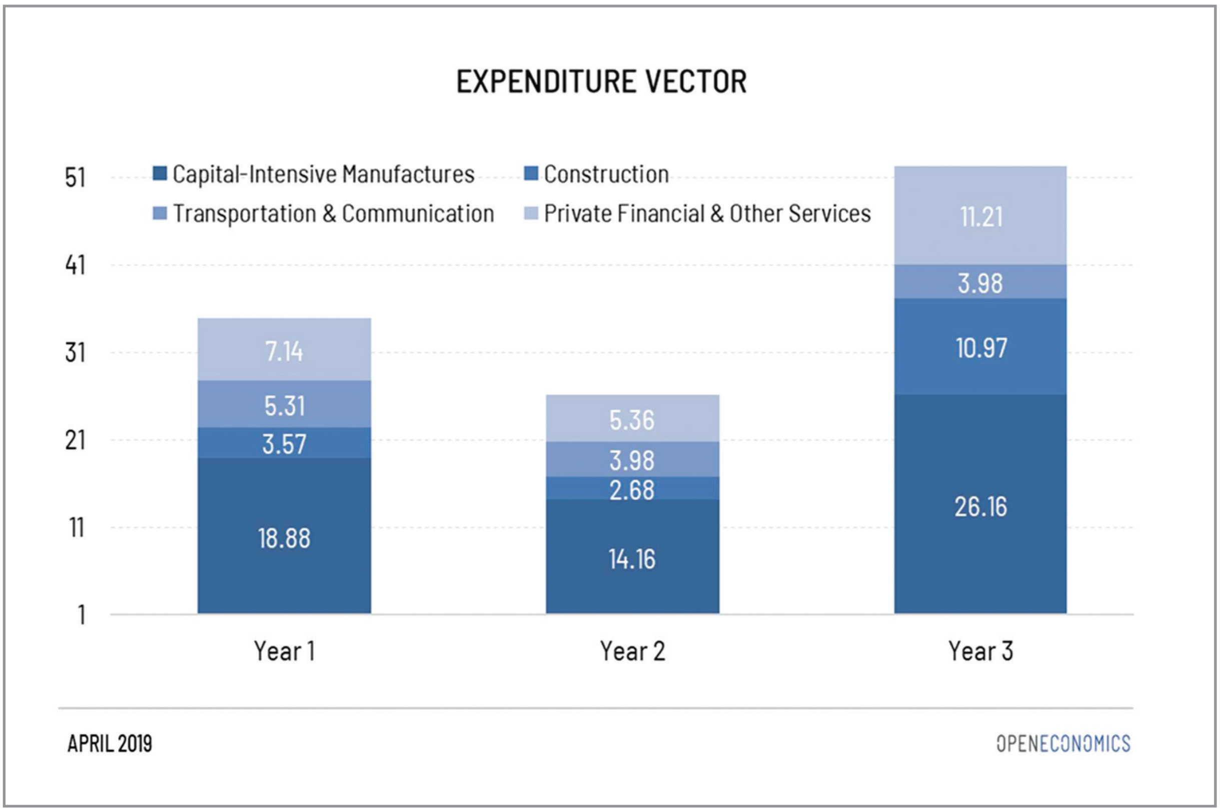
COMPONENTS	ENERGY	WATER	FOOD
CAPITAL-INTENSIVE MANUFACTURES	39%	23%	56%
CONSTRUCTION	57%	66%	100%
TRANSPORTATION & COMMUNICATION	100%		
PRIVATE FINANCIAL & OTHER SERVICES	63%	100%	100%
TOTAL	49%	42%	71%

SOURCE: OPENECONOMICS ELABORATION

The expenditure vector

The expenditure vector for the investment period, set at three years with the water and food projects always carried out in the third year, is detailed in Figure 6.4 below.

FIGURE 6.4: EXPENDITURE VECTOR FOR THE INVESTMENT PERIOD USD MILLION



SOURCE: OPENECONOMICS ELABORATION

6.5 INVESTMENT PERIOD RESULTS

The dynamic General Economic Equilibrium (CGE) model used allows to generate internally consistent economic scenarios, according to international best practices and the broad principles of standard economic theory.

The CGE system of equations takes into account the relationships of interdependence among agents of an economic system and is able to reproduce both the direct and indirect effects of investment spending and the consequent increases in production capacity on the most important economic variables, such as production, prices and employment and their structural components (sectors, production factors and institutions).

As previously highlighted, the investments referring to the activities carried out during the construction period, consist of capital good expenditures. The key procedure for the evaluation of these costs consists of the definition of a "shopping list", technically defined as expenditure vector, which, in the construction period, corresponds to the quantification of the costs incurred to carry out the intervention.

At the operational level, all the costs related to the project are expressed coherently with an international sectoral classification (called NACE2 and in line with the statistical system of the European Union), according to which the evaluation model has been built up.

The effects of the construction period on the GDP

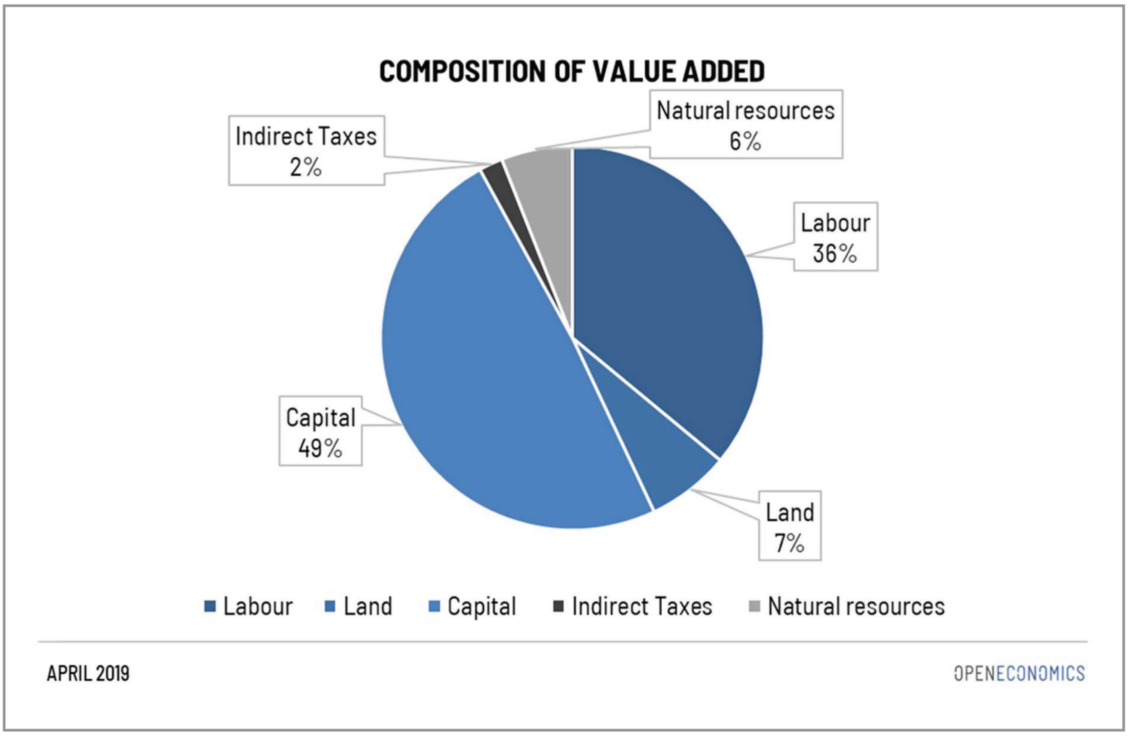
Considering the impact generated by the construction activities (including all capital goods acquired) in the first 3 years of the project, the estimated effect on Tanzania's GDP is above USD 197 million in net present value at the discount rate of 5%. As shown in Table 6.4 and Figure 6.5 below, out of this increase, USD 71.5 million of value added would accrue to labour and around USD 97.5 million to capital. The remaining part is assigned to land, indirect taxes and natural resources.

TABLE 6.4: EFFECTS ON GDP IN THE CONSTRUCTION PERIOD OF THE PROJECT

FACTORS	MLN USD IN PRESENT VALUE	%
LABOUR	71.49	36.2%
LAND	13.62	6.9%
CAPITAL	97.54	49.5%
INDIRECT TAX	2.99	1.5%
NATURAL RESOURCES	11.58	5.9%
TOTAL MLN USD IN CURRENT VALUE	**197.2**	**100%**

SOURCE: OPENECONOMICS ELABORATION

FIGURE 6.5: COMPOSITION OF VALUE ADDED GENERATED DURING THE CONSTRUCTION PROJECT (PRESENT VALUE)



SOURCE: OPENECONOMICS ELABORATION

The overall multiplier of discounted (PV) value added is equal to 1.84, which implies that for every dollar invested in the project, a PV equivalent of USD 1.84 is generated in the country over the three years of the construction period. The multiplier effect comes about because injections of new demand for goods and services into the circular flow of income stimulate further rounds of spending – in other words "one person's spending is another's income". The value-added multiplier therefore provides an estimate of the additional value added to the product or service as a result of this economic activity. Value added includes employee compensation, tax on production and imports, proprietary and other property income.

Summing the value added of all businesses in a state is equivalent to the Gross State Product. In order to evaluate the weight of this multiplier, it is possible to compare it with similar projects, in this case the evaluated ones are those deployed by The World Bank.[29] The following table shows the multipliers of three related projects in Tanzania.

TABLE 6.5: THE WORLD BANK PROJECTS MULTIPLIER

COUNTRY	TYPE OF INVESTMENT	SECTOR	DONOR	CONSTRUCTION PERIOD (YEARS)	MULTIPLIER
TANZANIA	Low Energy investment growth	ENERGY	THE WORLD BANK	1	1.54
TANZANIA	Medium Energy investment growth	ENERGY	THE WORLD BANK	1	1.46
TANZANIA	High Energy investment growth	ENERGY	THE WORLD BANK	1	1.73
AVERAGE					**1.57**

SOURCE: OPENECONOMICS ELABORATION

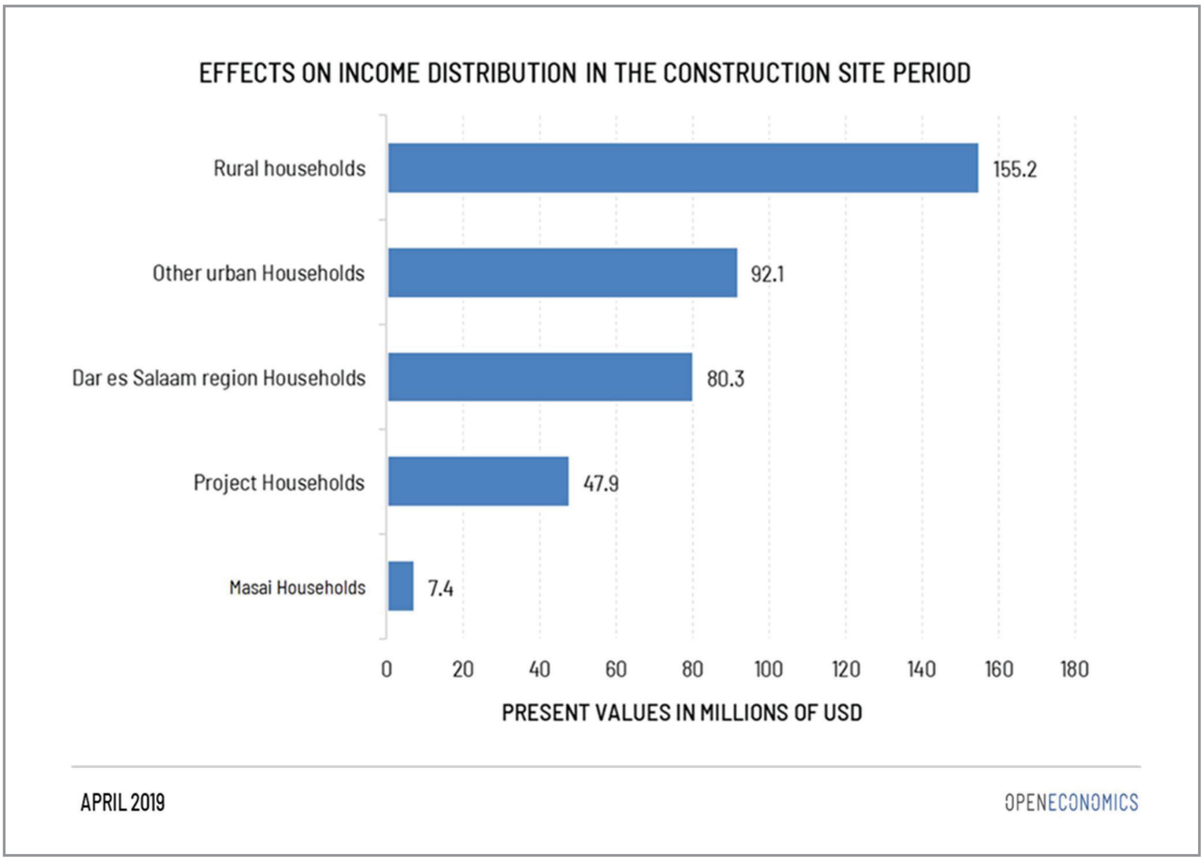
As shown in the table, the average multiplier as computed for three projects implemented by The World Banks is 1.57 (as above, 1 dollar invested is equivalent to 1.57 generated in the country over the construction period).

At a first glance, it is possible to notice how the WEF Nexus multiplier, equivalent to 1.84 is higher than the World Bank projects average multipliers (in this case also the highest). With a difference of 0.27, the WEF Nexus project as structured has a higher impact in term of wealth generated in the country in the construction phase. This data is particularly important when it comes to evaluate the added valued brought by a project within one country as it allows a higher return from the investment and higher benefits for the whole economic local system and involved stakeholders.

Effects on Income distribution

With regard to the distribution of income, the construction period allows for an overall increase in the present value of household incomes of USD 383 million (Figure 6.6 below). Main beneficiaries are rural households (USD 155.2 million) followed by other urban households (USD 92.1 million), Dar es Salaam region households with USD 80.3 million and Project households with an overall USD 47.9 million. At the last position of the chart there are the Masai households with a USD 7.4 million.

FIGURE 6.6: EFFECTS ON INCOME DISTRIBUTION IN THE CONSTRUCTION SITE PERIOD (PRESENT VALUES IN MILLIONS OF USD)

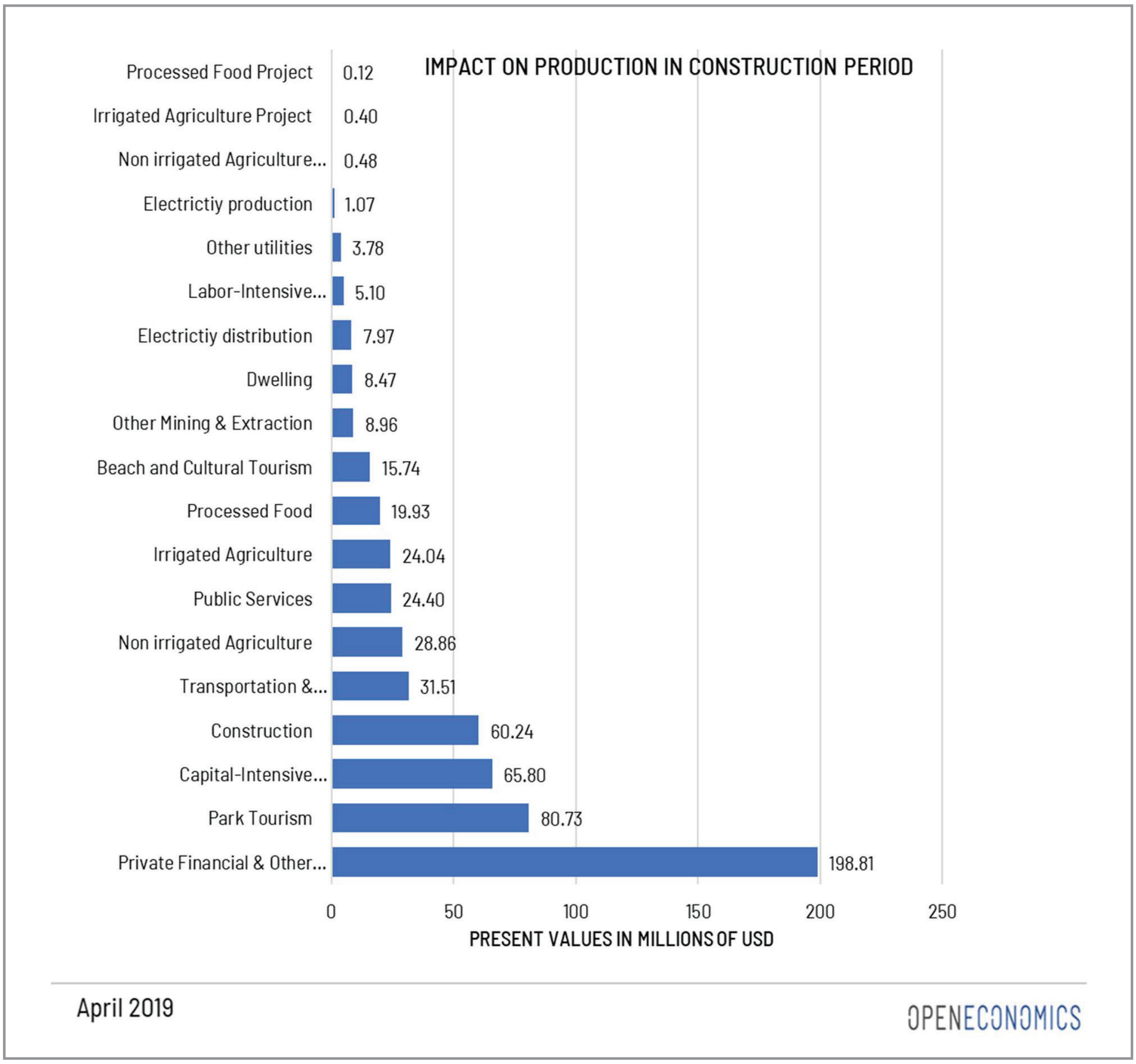


SOURCE: OPENECONOMICS ELABORATION

Effects on Production

In general, the model projects a higher increase for the service sectors compared to the industrial ones. Among the industrial sectors, the highest growing sectors are those related to construction and capital-intensive manufactures with respectively 60 and 66 USD million in present value (PV). Agriculture also receives a high impact, with 24 USD million in PV for irrigated agriculture and 29 USD million in PV for non-irrigated agriculture. The overall PV of the effect on production in the construction phase is above USD 580 million.

FIGURE 6.7: IMPACT ON PRODUCTION IN CONSTRUCTION PERIOD (PRESENT VALUES IN MILLIONS OF USD)



SOURCE: OPENECONOMICS ELABORATION

Effects on Public Accounts

The estimated overall PV increase of fiscal net revenue is more than USD 45 million (considering the amount as per the project lifetime in 2019 values), with a distribution by source presented in Table 6.5 below.

TABLE 6.5: EFFECTS ON PUBLIC ACCOUNTS IN CONSTRUCTION PERIOD (PRESENT VALUES IN MILLIONS OF USD)

TAXES	MLN USD IN CURRENT VALUE	%
DIRECT TAXES AND OTHER INCOMES	42.03	93%
INDIRECT TAX	2.99	7%
TOTAL	**45.03**	**100%**

SOURCE: OPENECONOMICS ELABORATION

The structural and overall impacts of the project

The simulation of long-term effects through the CGE makes possible to assess the structural changes in the Tanzanian economy, deriving from the operations of the set of projects included in the NEXUS scale up, once the construction phase is concluded and their longer-term effects are displayed on the country. The evaluation of the long-term project effects thus assumes that the adoption rate of the technological improvements promoted by the project is sufficient to generate a change in the productive system not only in the original target area, but also in wider region of the rest of the country. For this purpose, in the estimation of the model, some of the technological characteristics of key sectors of the Tanzanian rural economy have been modified according with the technology diffusive effects foreseen from the Nexus project scale up. Considering the replicability of the project, the adoption rate and the speed of diffusion foreseen by the scheme presented in the previous paragraphs, our simulations envisage three moments of technological change in the sectors covered by the interventions (agriculture, food production and electricity).

The capital created by the investment in the construction period is assigned for the operational period to the productive sectors whose production capacity is increased as a consequence of the project. Where the project has the effect of increasing human and social capital, these increases are assigned to the institutions that are assumed to benefit from it (households, companies, government, etc.).

In general, the sector that becomes the owner of the capital created by the investment project must be considered as affected by an exogenous change (the production capacity and the productivity increase generated by the corresponding investment in the construction period).

The evaluation of the operational impact consists of estimating the effects of the increase in production capacity (including any related productivity increase) as an exogenous variation (created independently of the endogenous accumulation dynamics based on the behaviour of the operators) which continues throughout the economic life of the investment.

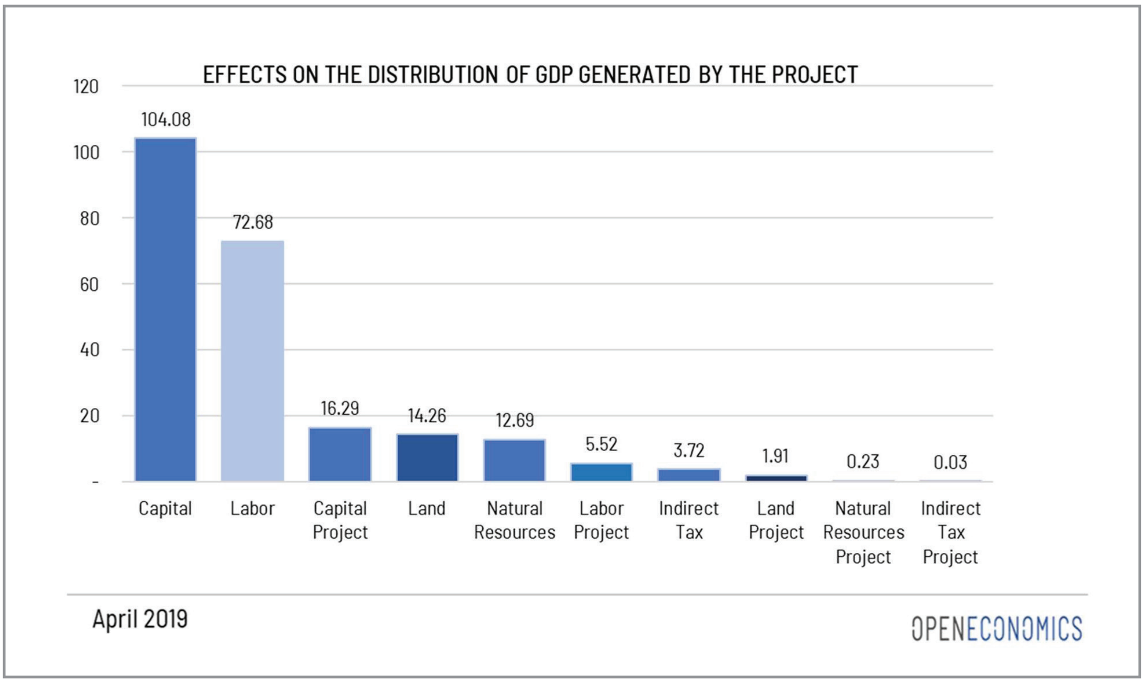
More specifically, the variation induced by the NEXUS scale up in its operational period is estimated as an increase in productive capacity and productivity of the project sectors. This entails a variation of the so-called technical production coefficients which is in turn from the results of the micro analysis performed for the individual project components.

The short and long-term overall effects on Gross Domestic Product

The multi-year scenario generated by the economic model deployed shows that the Nexus project, over its lifespan, can generate additional wealth in the Tanzanian territory, measured in terms of Gross Domestic Product (GDP), equal to approximately USD 231 million in present value (PV).

This figure quantifies the aggregate impact of the project, for the entire duration of its production cycle (20 years) expressed at constant 2019 prices and in Present Value at the same year, which means taking into account the progressive reduction in value of the cash flows with the increase of their time distance from the initial reference year (2019).
Figures 6.8 and 6.9 show how the GDP generated by the project is distributed among the different production factors and its own evolution over time.

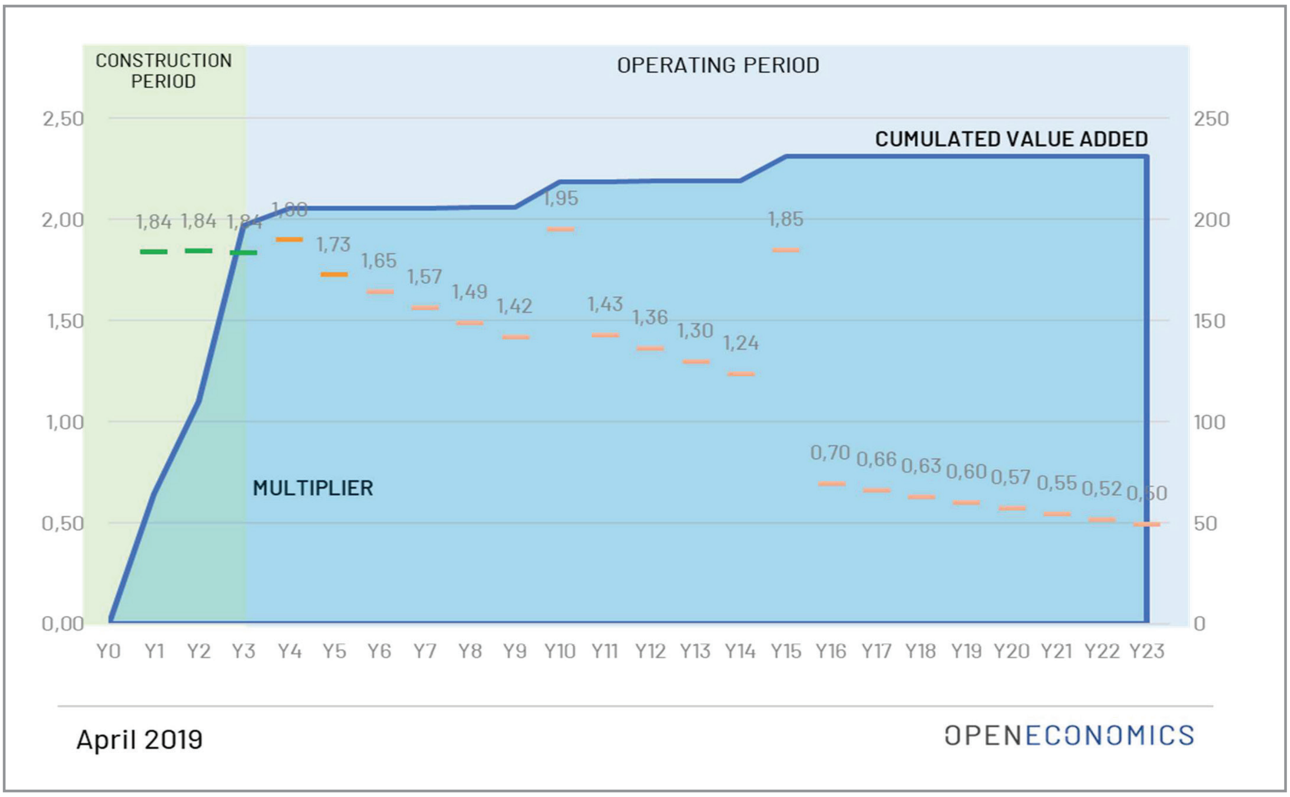
FIGURE 6.8: EFFECTS ON THE DISTRIBUTION OF GDP GENERATED BY THE PROJECT (USD MILLION IN PRESENT VALUE)



SOURCE: OPENECONOMICS ELABORATION

Altogether, more than 89% of the value added would be produced within the national territory with around 11% in the areas covered by the projects. Moreover, 52% of the value added produced would come from capital, while 34% comes from labour. These results are obtained as the difference between the designed project scenario and the counterfactual one, i.e. in the absence of scale up projects. The evolution over time of the value added clearly shows the moments of technological growth in which the economy makes the so-called "jump" in efficiency following the adoption of the pilot project and by a gradually increasing the number of rural villages involved.

FIGURE 6.9: EVOLUTION OF THE VALUE ADDED (USD MILLION IN PRESENT VALUE)

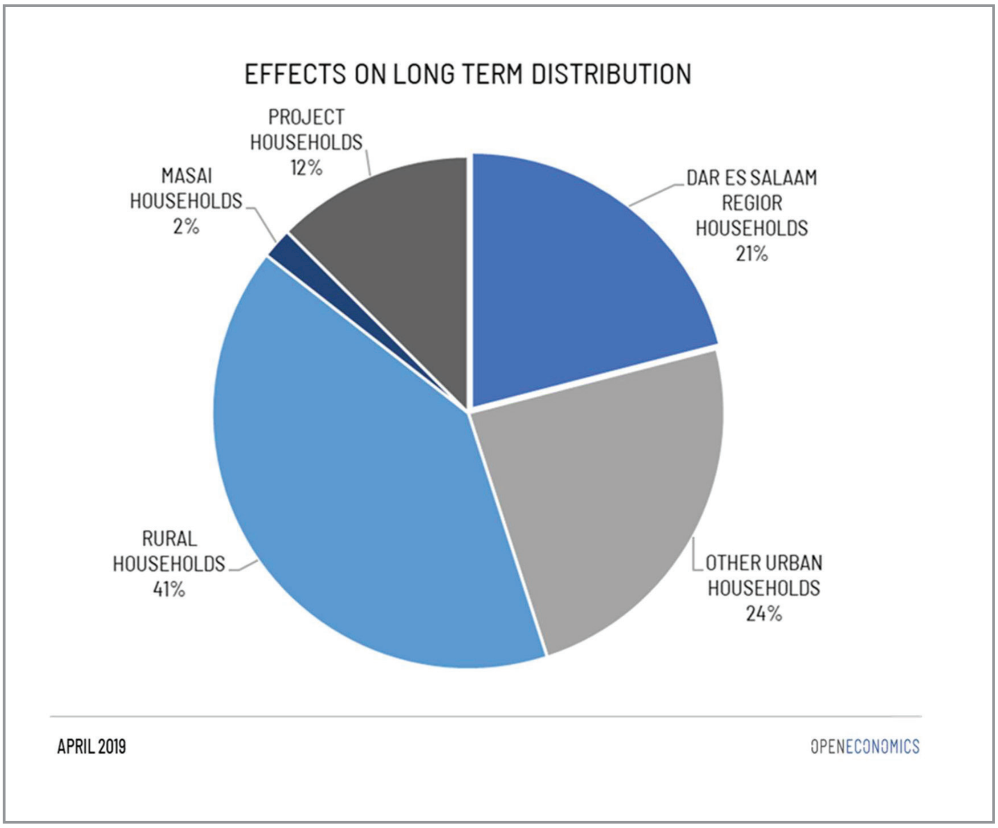


SOURCE: OPENECONOMICS ELABORATION

Impact on income distribution

The overall effect on household incomes exceeds USD 380 million. Considering the indirect and induced effects that are generated in the Tanzanian economy, the cluster of families that is mostly interested in the project is rural families that collect 41% of total income increases. Particularly relevant is the effect on the incomes of the households residing in the area of the scaled-up project. In fact, in spite of the fact that they account for only 1% of total incomes, these households are able to capture more than 12% of the overall effects of the project. This figure shows also how a rural development project may lead to a significant redistribution of incomes, reducing the differences between the more and less developed areas.

FIGURE 6.10: EFFECTS ON LONG-TERM INCOME DISTRIBUTION (PERCENTAGE)

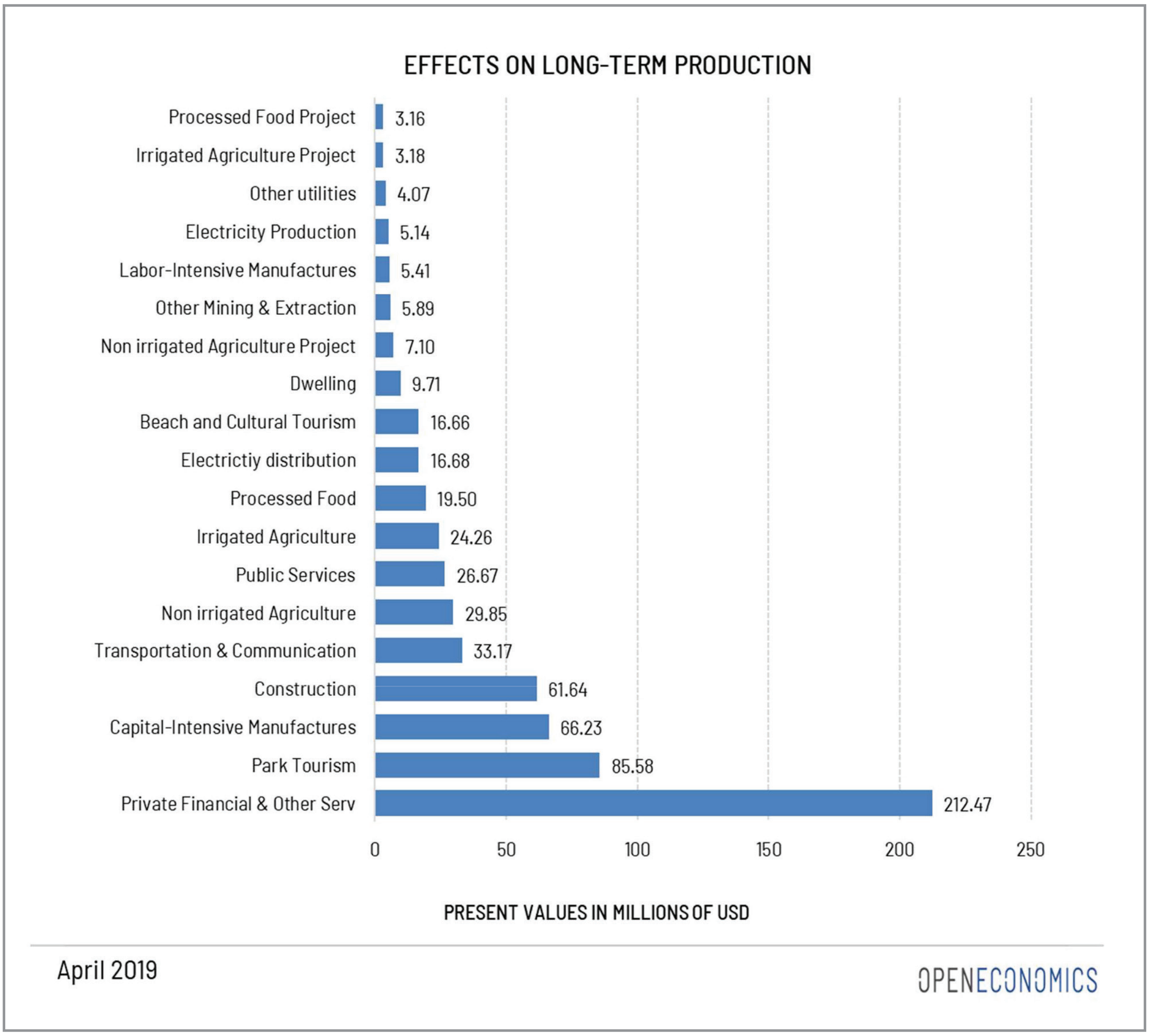


SOURCE: OPENECONOMICS ELABORATION

Effects on Production

Similarly, to the construction period, production effects are concentrated in the service sectors. Among the industrial sectors, the highest effects are those related to construction and the agricultural activities. The overall value of the impact on production is above USD 636 million, although this number should be considered an overestimate because of double counting the production of intermediates.
The results presented in Figure 6.11 show that project effects in the target areas are positive especially for the agriculture sector.

FIGURE 6.11: EFFECTS ON LONG-TERM PRODUCTION (PRESENT VALUES IN MILLIONS OF USD)



SOURCE: OPENECONOMICS ELABORATION

Effects on Public Accounts

The estimate of the overall effect on public finances is more than USD 51 million (considering the amount as per the project lifetime in 2019 values), with a distribution by source of revenue presented in Table 6.6.

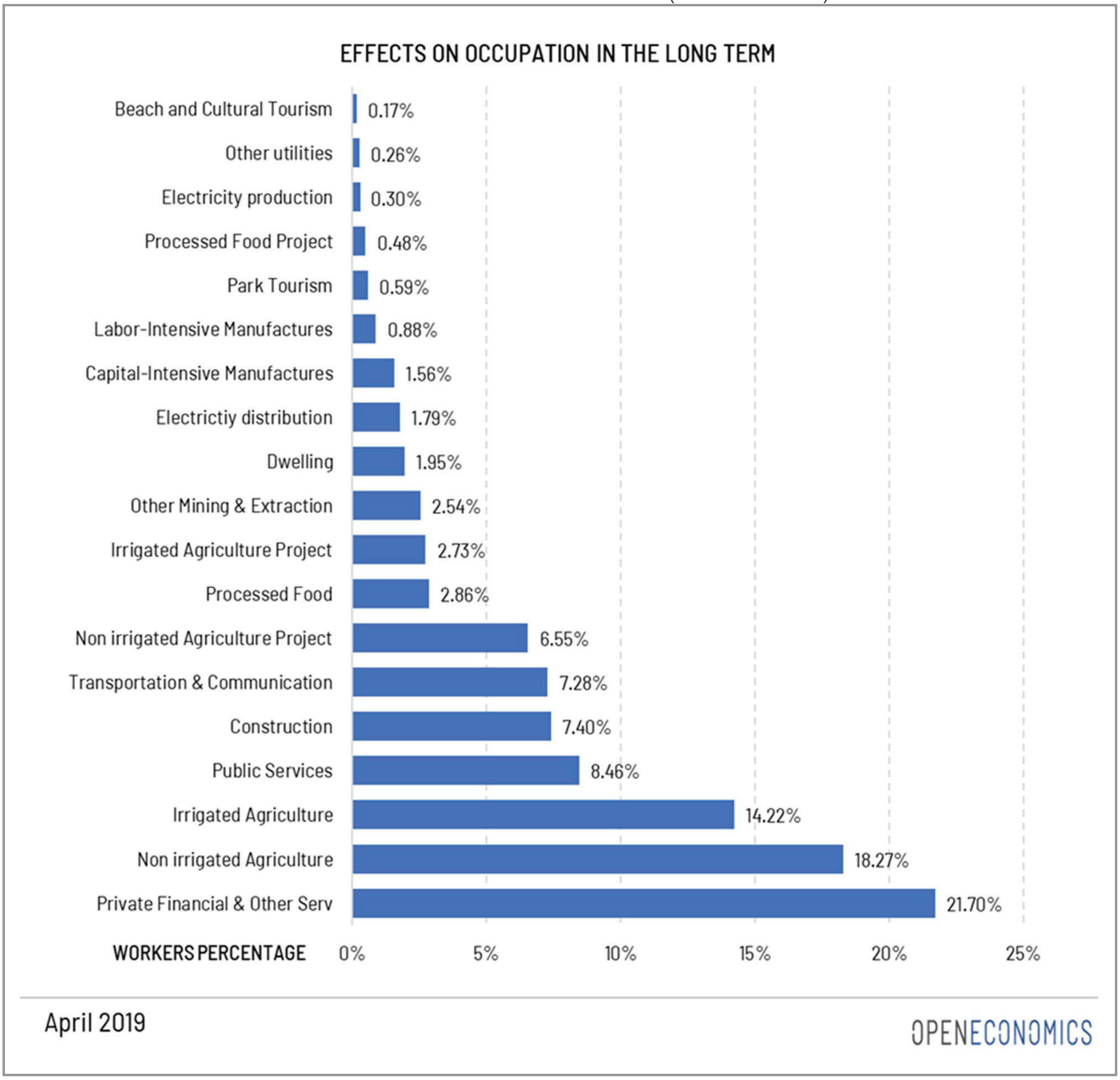
TABLE 6.6: EFFECTS ON TAXES IN THE LONG RUN (CURRENT VALUES IN MILLIONS OF USD)

TAXES	MLN USD IN CURRENT VALUE	%
DIRECT TAXES AND OTHER INCOMES	47.5	93%
INDIRECT TAX	3.8	7%
TOTAL	**51.22**	**100%**

SOURCE: OPENECONOMICS ELABORATION

Occupational Impact

FIGURE 6.12: EFFECTS ON EMPLOYMENT IN THE LONG TERM (PERCENTAGE)

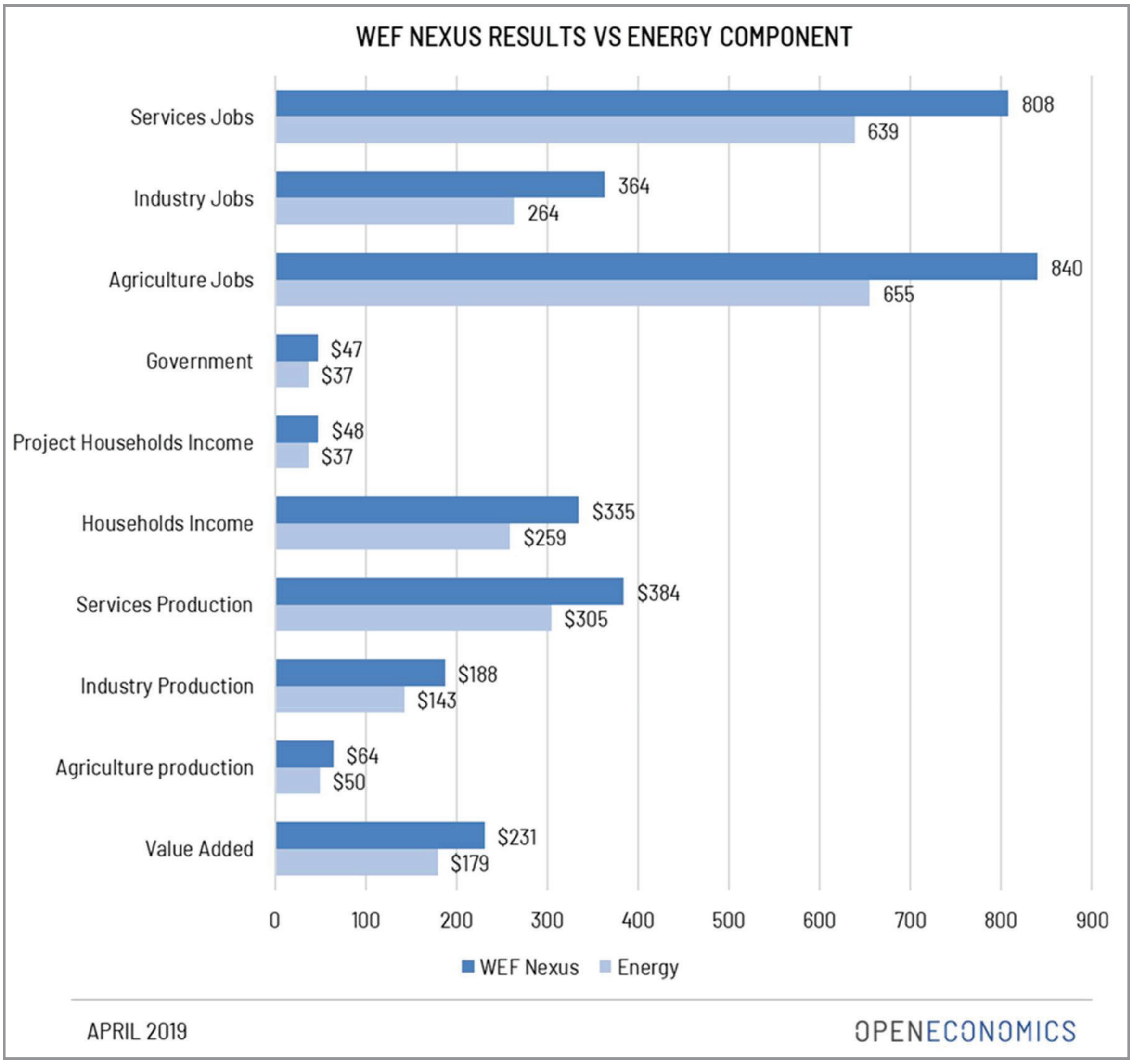


SOURCE: OPENECONOMICS ELABORATION

Employment benefits deriving from the project are sizable with 2,011 new permanent jobs created (or saved) directly or indirectly, through multiplier effects by the project. Due to the present Tanzanian economy structure, the majority of jobs will be created within the Private Financial services (21.7%) with 436 full time jobs, and the agricultural sector, within Non irrigated Agriculture (18%) with 367 jobs and irrigated agriculture (14%) with 286 jobs.

WEF Nexus vs Energy Project

FIGURE 6.13: WEF NEXUS RESULTS COMPARED TO THE ENERGY COMPONENT RESULTS (UNITS AND USD MILLION)



SOURCE: OPENECONOMICS ELABORATION

The socioeconomic impact of the integrated project scale up confirms the results of the pilot project. If the outcomes of the comprehensive project are compared with those related to the sole energy component, it is possible to verify the impact differences that are more favourable to the integrated solution. As said, the WEF nexus results complete the range of benefits brought by the stakeholders and wide up the recipients including among the direct beneficiaries (therefore those mostly impacted by the project) all the local communities englobed in the initiative. The figure above clearly shows the principle results given by the evaluation, comparing the energy component outcomes with those related to the integrate project as described in this document. Services jobs, Industry and Agriculture jobs are express in unit while all the other indicators are expressed in USD million.

7. FOCUS ON THE SUSTAINABLE DEVELOPMENT GOALS

The scaled-up NEXUS project has the potential to contribute significantly to the achievement of the UN Sustainable Development Goals.

SDG 1: End poverty in all its forms everywhere

$ 95.34 M

INCREASE IN INCOME OF LOW INCOME HH

While Tanzania has achieved a significant reduction in extreme poverty since 1990, pockets of the worst forms of poverty persist and the government recognizes that ending poverty requires universal social protection systems aimed at safeguarding all individuals throughout the life cycle. The SDG 1 has been evaluated taking into account the increase in income of low-income households. Low income households are defined as those whose members live on less than $1.25 a day. Considering the percentage of poor urban households in Tanzania, equal to 15% and the poor rural households in Tanzania, equals to 33%, it has been estimated an increase in income for the first group of USD Mln 25,86 and an increase for the second group of USD Mln 69.48. The overall increase for both rural and urban poor households is therefore equal to USD Mln 95.34.

SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

$ 10.35 M

INCREASE IN FOOD CONSUMPTIONS

SDG 2 seeks sustainable solutions to end hunger in all its forms by 2030 and to achieve food security. The aim is to ensure that everyone everywhere has enough good-quality food to lead a healthy life. Achieving this Goal will require better access to food and the widespread promotion of sustainable agriculture. Considering the cluster of families, as per the macroeconomic analysis, the project contribution to the SDG2 has been estimated by the amount of food consumption increases for poor households. With an increase of USD Mln 0.84 for the Dar es Salaam region households, of USD Mln 1.35 for urban households, of USD Mln 6.67 for rural households, plus the increase of US Mln 0.21 for the Masai families and of USD Mln 1.28 for Project households. The overall contribution to SDG2 is estimated at a PV of USD Mln 10.35 over the project lifetime.

SDG 3: Ensure healthy lives and promote well-being for all at all ages

3 GOOD HEALTH

$ 2.63 M

INCREASE IN HEALTH EXPENDITURE

Goal 3 seeks to ensure health and well-being for all, at every stage of life. The aim is to improve reproductive and maternal and child health; end the epidemics of HIV/AIDS, malaria, tuberculosis and neglected tropical diseases; reduce non-communicable and environmental diseases; achieve universal health coverage; and ensure universal access to safe, affordable and effective medicines and vaccines.

The contribution of the project to this goal measured by the overall increase in health expenditure is estimated to be USD Mln 2.63. This estimate has taken into account the health expenditure for the family's clusters as presented in the paper which includes: an increase of USD Mln 0.35 for the Dar es Salaam region households, USD Mln 0.51 for the urban households, USD Mln 1.3 for the rural households and USD Mln 0.04 for the Masai households. Considering the Rural Households included in the project area, investing in the scaled-up NEXUS project would be improve health conditions for 1,109,184 persons.

SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

4 QUALITY EDUCATION

2,443 U

ADDITIONAL YEARLY NO. OF CHILDREN IN PRIMARY EDUCATION

Goal 4 aims to ensure that all people have access to quality education and lifelong learning opportunities. This Goal focuses on the acquisition of foundational and higher-order skills at all stages of education and development; greater and more equitable access to quality education at all levels as well as technical and vocational education and training. For this goal, the project is able to generate an increase in the expenditure related to education, implying that a higher number of children is enabled to attend primary education, with a projected increase of 2,443 children attending school in each year of project life.

SDG 6: Ensure availability and sustainable management of water and sanitation for all

6 CLEAN WATER AND SANITATION

1,109,184 U

ADDITIONAL NO. OF LOW-INCOME PEOPLE ACCESSING WATER

Sustainable Development Goal 6 goes beyond drinking water, sanitation and hygiene to also address the quality and sustainability of water resources, critical to the survival of people and the planet. The 2030 Agenda recognizes the centrality of water resources to sustainable development, and the vital role that improved drinking water, sanitation and hygiene play in progress in other areas, including health, education and poverty reduction. Considering the initial target population of 20,928 inhabitants in the first year, we estimate that 1,109,184 additional people will have benefited of improved access in water consumption in low income households by the end of the 20 years project lifespan.

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

542,826 U

ADDITIONAL NUMBER OF PEOPLE USING CLEAN ENERGY

Access to affordable, reliable and sustainable energy is crucial to achieving many of the Sustainable Development Goals – from poverty eradication via advancements in health, education, water supply and industrialization to mitigating climate change. Energy access, however, varies widely across countries and the current rate of progress falls short of what will be required to achieve the Goal. Redoubled efforts will be needed, particularly for countries with large energy access deficits and high energy consumption. We estimate that the project will cause an additional number of 542,826 persons to be able to use clean energy.

SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

2,011 U

ADDITIONAL PERMANENT JOBS

Sustained and inclusive economic growth is a prerequisite for sustainable development, which can contribute to improved livelihoods for people around the world. Economic growth can lead to new and better employment opportunities and provide greater economic security for all. Moreover, rapid growth, especially among the least developed and other developing countries, can help them reduce the wage gap relative to developed countries, thereby diminishing glaring inequalities between the rich and poor. We estimate that the project will lead to 2011 additional permanent jobs.

SDG 10: Reduce inequality within and among countries

25 %

SHARE OF INCREASE IN INCOME OF LOW INCOME HH

The international community has made significant strides towards lifting people out of poverty. The most vulnerable nations – the least developed countries, the landlocked developing countries and the small island developing states – continue to make inroads into poverty reduction. However, inequality persists, and large disparities remain regarding access to health and education services and other assets. As a contribution to this goal, we estimate the project will lead to a larger share (25%) of total income accruing to low income households.

SDG 13: Take urgent action to combat climate change and its impacts

CO2 182,689 T

AVOIDED EMISSIONS BASED ON COUNTRY'S MIX

Climate change presents the single biggest threat to development, and its widespread, unprecedented effects disproportionately burden the poorest and the most vulnerable. Goal 13 calls for urgent action not only to combat climate change and its impacts, but also to build resilience in responding to climate-related hazards and natural disasters.[10] As above, the project scale up will avoid 182,689 Tons of CO2.

[10] *This amount has been estimated considering the kWh use of diesel, equals to 116, 720 and the KG of CO2 per kWh, equals to 0,31*

8. CONCLUSIONS

This study analyses the structure of an integrated model for water, energy and food production, based on the idea of transformative change through simultaneous access to general purpose (energy and water) and specific (modern agricultural techniques) technology.

The results of the study are helpful to suggest transformative patterns of project design to address the challenge posed by development in many African countries, where access to energy and to other general purpose technology is still minimal, with negative impact on the quality of life and, at the same time, on the adoption of technological change from farmers and other local operators.

The analysis addresses the transformative impact that could be generated from locally based, but potentially transformative projects through the combination of three specific factors: (i) an enabling component based on ensuring access to sustainable energy and water through general purpose technologies, (ii) an adoption component based on productivity enhancing techniques of agriculture and food production, and (iii) a transformative component based on the replication, scaling up and diffusion of proposed solutions over a wider region. These three components are synergic as they enable greater production, but, at the same time, also fuel development of demand through increases in incomes, employment opportunities and improvement in the quality of life.

Our evaluation suggests that the success of the project depends on: (i) the interdependence built in the project structure, (ii) the complementarity of water, energy and food components, and (iii) the mechanisms of adoption and diffusion that would support the replication and the scaling up of the initial, local based project. As shown in the cost benefit analysis, adoption of the individual project is justified by its significant benefits to the population and production sectors directly affected, as well as in terms of improved economic, social and environmental conditions for the area of the original location. Those benefits are confirmed in the scale-up context, where investing in replicating the project model engenders a chain of diffusion of both general purpose and specific technologies and enhance cascading benefits in terms of value added, production and income distribution, allowing, at the same time, to yield significant contributions to sustainable development goals.

Tanzania's Development Vision 2025 seeks to transform Tanzania into a middle income and semi industrialized nation in 25 years. To achieve this goal, it is crucial that effective stakeholders are engaged in investment devoted to encouraging economic growth and social cohesion. Planning an appropriate resources allocation strategy aimed to achieve social goals through a quantum jump in technology adoption is crucial to foster development actions.

For this purpose, the results of our study suggest the following policy recommendations:

Animation and participation: the diffusion of project patterns and its transformative success depends on a dynamic process of adoption and diffusion that can only occur if communities embrace the project goals and solutions and participate in adapting them to the local context through adaptation and innovation. Activities of animation and participation of local communities may thus be crucial actions to achieve widespread adoption of the new technologies and the business model fostered by the project.

Increase policy synergies among key sectors: transformative investment requires a holistic approach aiming to link general purpose and enabling technologies with product and process innovations fuelled by higher level of human and non-human capital.

Improving information on the project: in order to ensure project success both in its initial and scaled up mode, it is vital ensure an adequate amount of information of the stakeholders involved as well as all local population on the goals, the logic, the features and the NEXUS project. Both project stakeholders and people not directly involved in fact have a potential role in promoting the success of the projects and investments in a specific area, so that by providing adequate information it is possible to improve the efficiency of the actions performed and engender the transformation that the project aims to achieve. Information should be diffused, accessible, of high quality, and such as to engender engagement and confidence. Governments may also help in this, by furthering knowledge sharing activities using specific programs as well as the media.

Promote trans-boundary activities: in a globalised world, decisions cannot be taken alone. Regional and international integration is crucial in order to promote trans-boundaries activities to enhance and spread the benefits deriving from a WEF nexus project while promoting optimal resource use and equitable distribution.

Create a favourable environment for investment: WEF nexus projects are positive both for those implementing them and for local societies. For this reason, Governments should create a favourable environment for investments by supporting business through an enabling regulatory environment, reducing bureaucratic obstacles to private initiative and foster market competition and innovation.

Create a gender and children-equality environment: enhancing WEF related investments means promoting a gender equal environment. As water and fuel collection are currently feminine tasks, the WEF nexus project promises to improve the quality of life of girls and women. In addition, in order to increase long run incomes and opportunities, project implementation should be combined with policies that ensure that children will not be forced to work to contribute to the family wealth, but can attend school, widening their skills and knowledge.

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