WFI – Ingolstadt School of Management

Renewable Energy Carrier Generation in Developing Countries – Analyzing the Social Impact of Power-to-X Gigaplants in Morocco

Erneuerbare Energieträger Gewinnung in Entwicklungsländern – Analyse der sozialen Auswirkungen von Power-to-X Giga-Anlagen in Marokko

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Abstract

The world currently faces a problem with covering the global energy demand sustainable in the future. One solution is generating renewable energy carriers in ideal geographical locations, mostly sited in developing countries. These economies still struggle with severe social problems. This study aims to evaluate whether renewable energy carrier generation projects can have a social benefit or if entering this market rather results in a social damage of the local population of developing countries. To be able to make a statement concerning this issue, this thesis answers the following question: What is the social impact of renewable energy carrier generation projects in developing countries? Based on a review of literature on most severe social issues in developing economies and complementary observations during a research trip to Morocco, a Social Return on Investment analysis on a Power-to-X plant in Morocco was performed to measure the social impact. It demonstrated that renewable energy carrier generation projects deliver a high positive social impact with the opportunity of many diverse benefitting outcomes for the locals. On the basis of these results, it is recommended that energy investors use part of their revenue to invest into social development of the producing countries.

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CO_2	Carbon dioxide
HDI	Human Development Index
IVC	Impact Value Chain
NGO	Non-governmental Organization
PtL	Power-to-Liquid
PtX	Power-to-X
SCBA	Social Cost-Benefit Analysis
SIA	Social Impact Assessment
SIN	Social Impact Navigator
SROI	Social Return on Investment

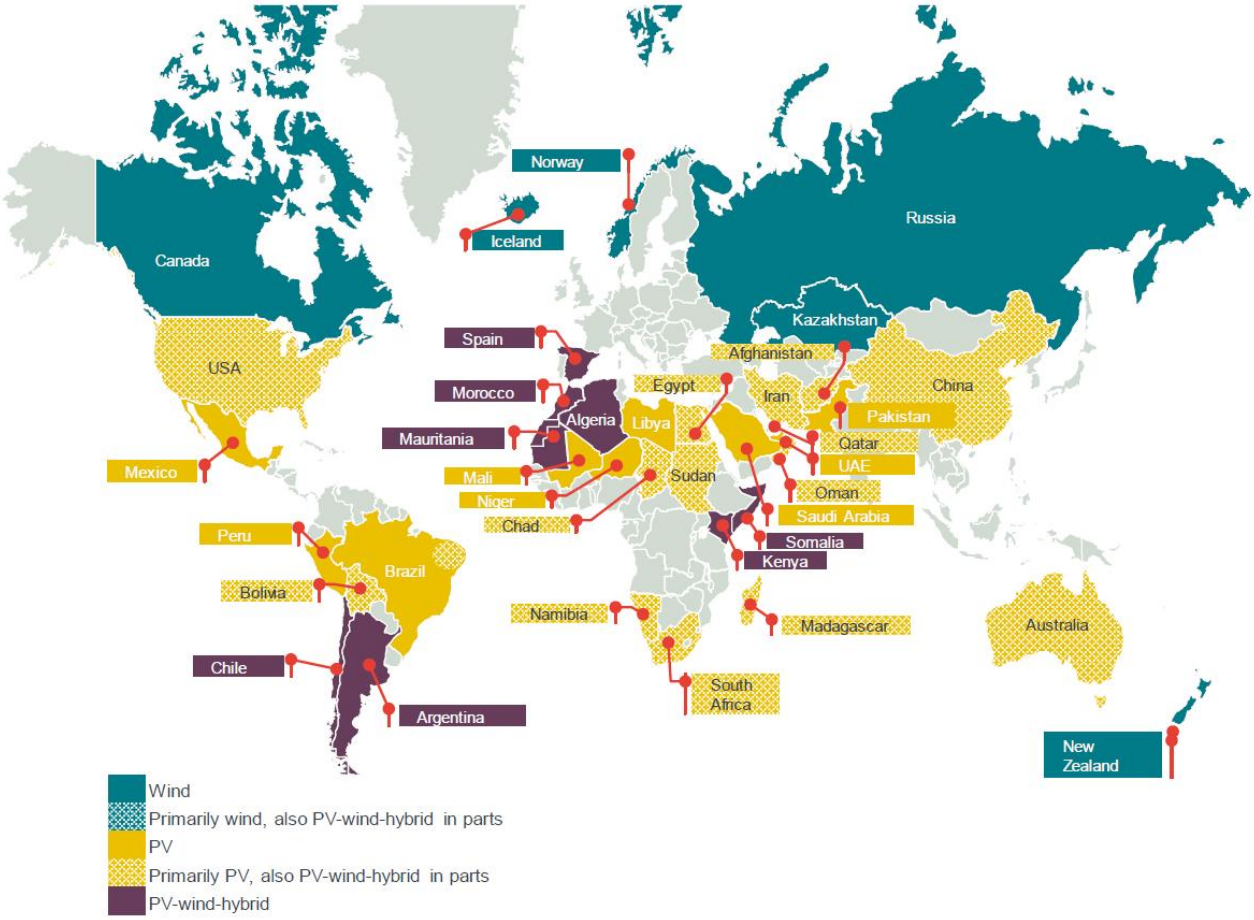
1. Introduction

1.1. Renewable energy carriers – a chance for social change

Emissions have to be cut into half from 1990 to 2050 in order to keep the increase in global average temperature below 2°C above pre-industrial levels, which many countries agreed to in Paris 2015 (United Nations, 2015). The increasing use of renewable energies as a carbon-neutral energy source, will be a key element in reaching this goal. A large part of these countries is located in less ideal geographical locations for renewable energies and will not be able to cover their energy demand sustainable on their own. The dependency on imports will therefore continue. In addition, some fields of application cannot be reached with direct electrification. In Germany a 'National Hydrogen Strategy' launched in 2019 to use new possibilities of energy carriers. This strategy aims to promote the development of climate-neutral hydrogen technologies and market-based structures for distribution. Thereby it is supposed to show how to keep industry, transport and energy systems of Germany competitive, while achieving the climate goals and exploring new markets. Green hydrogen can be produced from renewable energies in regions with high wind and solar potential. The transformation of energy from electricity in other carriers makes it possible to store, transport and as required use it for versatile purposes. Figure 1 shows, that these regions often lie within developing economies, offering them a chance to position themselves as an exporter of renewable energy carriers, while evolving the own country towards more prosperity. Within the frame of the 'National Hydrogen Strategy', discussions with African partners about the possibilities on site have already started (Bundesministerium für Bildung und Forschung, 2019).

While different ministries of the world discuss about new solutions for the worldwide energy demands, citizens of developing countries especially in rural areas often still face problems with social primary care. These people struggle with access to basic services, provision of food and water, severely little income and poverty every day (Calton et al., 2013). The bad living conditions are not only a problem of existing generations but carry on to the next as well. In the last years global attention drew towards these people as an unexplored market. This has attracted businesses, seeing an opportunity of a growing market and placing their companies there to gain from cheap conditions. The effect is often more a capturing and exploiting of new markets rather than creating social value on site for those otherwise trapped in poverty. Attention must shift away from identifying which market niches to exploit next towards including the local population in business for a mutual benefit (Calton et al., 2013).

Figure 1: *Countries with Strongest Renewable Energy System Potential (Frontier Economics, 2018)*



Ideal locations for the production of green hydrogen or other renewable energy carriers are often located in these rural neglected areas, as they deliver not only perfect renewable energy conditions, but also space. The technology producing hydrogen among other things by using renewable energies is called Power-to-X. The X describes the diverse sustainable energy carriers, like diesel, gas, hydrogen or gasoline possible to produce through syntheses (Eichhammer et al., 2019). The constellation of Power-to-X plants including desalination plants, renewable energies and syntheses makes a variety of outcomes, like employment or access to water and energy for the local population feasible. Looking at what the locals need and what could be delivered through the plant shows synergies. To sum up, for Power-to-X plants, which are necessary to meet the energy demand of the world, the ideal location has a high wind and solar potential, space and additionally access to water through proximity to the ocean. For the local population in these regions the plant can deliver a contribution to primary care and therefore help to eradicate poverty.

1.2. Social impact of renewable energy carrier generation

The necessity of new sustainable technologies to meet the global energy needs and the unequal distribution of demand and natural energy resources lead to the requirement of a global exchange system. Developing countries with ideal geographic locations for renewable energy production can export their excess energy to industrial countries with a high demand. Several studies have shown how the involved economies could benefit from a global PtX market. Importing countries benefit from the 'green' character of energy, while delivering the technology for it. The dependence on energy imports stay but would be much more spread on several countries. Exporting developing economies get an opportunity to raise a source of income by entering a new market. While there are several studies, which have evaluated the overall impact of a global Power-to-X market on the involved economies, the social impact on the population of the exporting developing nations has been neglected. To fill this gap, this thesis focusses on evaluating whether renewable energy carrier generation projects can have a social benefit or if entering this market rather harms the local population of developing countries. The aim is to answer the following question: What is the social impact of renewable energy carrier generation projects in developing countries?

1.3. Structure of thesis

The above stated research question is answered by drawing on literature about the social problems in developing countries. The most significant factors influencing the lives of the local population are carved out and further researched. They represent the topics, which have to be addressed and solved. According to Figure 1 Morocco shows a high potential in producing renewable energy, essential for the operation of a Power-to-X plant. Meanwhile especially the rural population in this country faces several of the most significant social problems analysed before. Therefore, Morocco serves as an example for placing renewable energy carrier generation projects in developing countries. To find the most fitting method for evaluating the social impact, several possibilities are evaluated on the basis of selected criteria. A Power-to-X plant is taken as an example of renewable energy carrier generation projects. The technology background of Power-to-X is shortly introduced for a deeper understanding of the restrictions and possibilities for the social impact evaluation in the following chapters. The empirical study is done by performing a social impact analysis over a

Power-to-X plant in Morocco. The analysis is performed by following the steps of the chosen method concluding in the result of the study. In the course of the study the necessity to gain a deeper knowledge about the local population for the correct interpretation of results became clear. Therefore, besides the statistical data a research trip to Morocco gave further insides on the necessities of the locals and the social situation on site. The thesis closes with a discussion of the gained results and the limitations given followed by a comparison with the theoretical information researched before and an overall conclusion through a critical reflection.

2. Social problems in developing countries

Every year the World Bank releases a new classification of economies according to their income, separating them into four groups depending on the gross national income per capita: high-income economies, upper-middle-income economies, lower-middle-income economies and low-income economies. Countries of the last two groups are considered as developing countries (The World Bank, 2020). These regions experience economic, political, cultural and religious problems and have inadequate infrastructure, showing the significant differences between developing and developed countries. Citizens of these countries often face similar problems independent of the location on earth. The most serious features of life often include severely limited income, gender inequalities, poor nutrition, scarcity of potable water, lack of sanitation and limited access to basic health services and education (Calton et al., 2013; Dormekpor, 2015). These issues lie within the society and not only affect the present but also future generations. Many of these problems have to be seen as a global matter, since they are beyond the ability of the nation alone to address it. Reasons for social issues can be very diverse. Often though they tend to develop due to the depraved actions of people and organizations and neglection of negative consequences of these actions over a longer period (Sarkar & Pingle, 2018).

2.1. Poverty

"How to alleviate global poverty […] is among humanity's greatest challenges" (Radosavljevic et al., 2020, p. 1). To make the importance of alleviation of poverty even more clear it was set as the 'Sustainable Development Goal 1' in 2015. Target until 2030 is to eradicate extreme poverty for all people everywhere (United Nations, 2016). Defining poverty has a long history, starting with the insufficient available resources needed to maintain minimal levels of subsistence. However, studies have shown the multidimensional view of poverty including the impact of exclusion from social norms and customary activities. Today's definition is more expanding, reflecting the relative and broader nature of poverty (Pomati & Nandy, 2019).

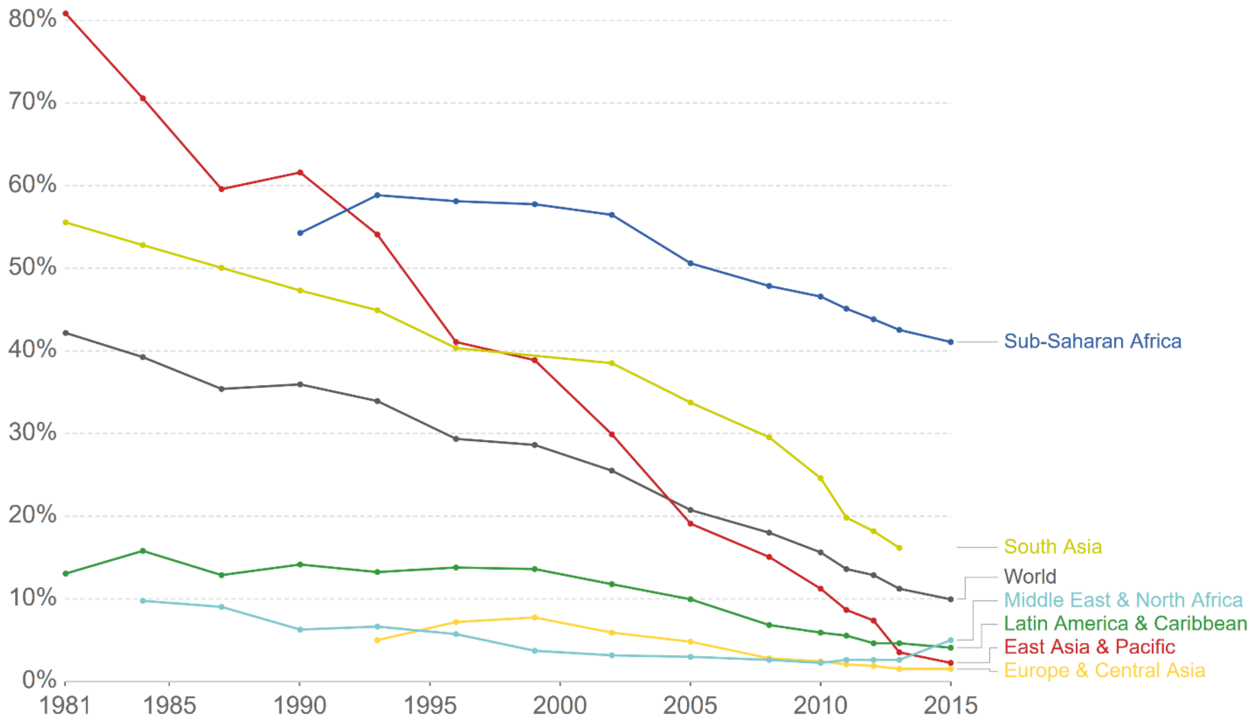
The United Nations define overall poverty as following:

> "a lack of income and productive resources to ensure sustainable livelihoods; hunger and malnutrition; ill health; limited or lack of access to education and other basic services; increased morbidity and mortality from illness; homelessness and inadequate

> housing; unsafe environments and social discrimination and exclusion. It is also characterised by a lack of participation in decision-making and in civil, social and cultural life. (United Nations, 1995, p. 2)"

This definition makes clear that the access to basic services for example should be reflected in any measurement and is therefore expanding the idea of resources beyond those owned by households. Poverty is life-encompassing characterized as capability deprivation from lack of economic opportunities, political freedom, social facilities and protective security (VanSandt & Sud, 2012). Many measurements also focus on composite indices. Taken for example the Human Development Index (HDI) developed by the United Nations Development Program. It seeks to size household wellbeing by aggregating a range of welfare-related aspects into an overall index. The countries are ranked according to their performance on life expectancy, education and income per capita. Composite poverty indices in general involve a range of individual indicators. Concluding several measurements, the indicators can be separated into three groups reflecting the individual level of deprivation and poverty. The first group housing quality includes hygiene and general health outcomes, such as access to safe drinking water, fuel lighting, electricity etc. Second is the ownership of assets, which can serve as a security for nutritional needs. The last group is human capital including schooling, educational attainment and employment (Steinert et al., 2018). To simplify the communication of the importance of poverty, measurements are using a monetary approach (Pomati & Nandy, 2019). The global poverty line has been set to US$1.90 a day per capita. According to the most recent estimates in 2015, around 10% of the world's population are living below this mark (The World Bank, 2019c).

Figure 2: *Extreme Poverty by World Region (Roser & Ortiz-Ospina, 2019, p. 7)*



Even though poverty rates have declined, the progress has been uneven. Figure 2 shows that in some regions the drop of extreme poverty has been much slower than in others. Geographically, most of the poor are living in the same regions of developing countries. The majority of the global poor are the rural population, are poorly educated and employed in the agricultural sector. (The World Bank, 2019c).

The diversity of causes of poverty also gives many options for tackling it. Broad economic stability, competitive markets and public investments in infrastructure are recognized as important requirements for a reduction in poverty. One factor is the correlation between poverty and economic growth. Low economic growth comes with high poverty rates. In the past countries with faster economic growth managed to significantly reduce monetary poverty. Results show a close connection between the income of the poor and the average national income with a correlation coefficient of 1.09 in the periods of normal growth (Guiga & Rejeb, 2012). But on the opposite simply fostering the national growth of economy does not necessarily lead to a decrease of poverty depending on the distribution of income. Inequalities, for example in education contribute to a persistence of poverty, leading to intergenerational effects. This iterative process starting from not having access to basic services as education, followed by a low income, ends with also leaving the descendants without opportunities to get access to education. This persistence also has a negative effect on economic growth, which again fosters high poverty rates. Solutions have to be found to get out of this circle (Andrade Rosas & Jiménez-Bandala, 2018).

One theory is focussing on the poverty reduction through inclusive development efforts. These efforts can be drawn from political economy for financial inclusion, the use of technology, especially the introduction of telecommunications, and market-based strategies. Market-based approaches focus on the increase of productivity and income through for example new business opportunities with new creation of jobs and opening up new markets. Studies and social projects have shown that using an inclusive development approach can help to reduce poverty nationally and globally (Chibba, 2008). Focussing on inclusive development means necessarily including the effects of business activity – negative and positive – in the considerations. The creation of new jobs through business activity can lead to a higher household income and from this to a higher consumption. Negative aspects can also include the neglect of rural areas and agriculture, which leads to an even bigger gap between rich and poor and with it the decrease of food production. These inequalities are not necessarily visible on the basis of national measurements, since the national income rate still rises (Singer, 2006).These negative effects can be prevented through measuring on a subnational level, taken the urban and rural differences in poverty into account. With this information specific measures can be taken to address the local situation (Steinert et al., 2018).

2.2. Inequalities and rural-urban migration

Poverty differences can be seen in all sectors, starting from discrepancies between gender, age, place of residence or hometown, going down to households where children and women suffer more than men. Between communities, rural areas are much more affected than urban areas. 81% of the poor are concentrated outside cities, while only 58% of its population is rural (Guiga & Rejeb, 2012). Economic growth must not necessarily result in a reduction of poverty and rise of living conditions for all. In contradiction it can lead to even bigger inequalities, not benefitting the poor. Goal Number 10 of the United Nations Sustainability Goals focuses on the reduction of inequality within and among countries (United Nations, 2016). A special focus lies on income inequality referring to a highly dispersed distribution of income among a population resulting in unequal access to opportunities and severe social problems (Di Lorenzo & Scarlata, 2019). These social problems including among many others education, health care, social status and poverty show that economic inequality encompasses a range of factors. On the long run these differences lead to a threat to social and economic development of the society. On an individual basis inequality leads to psychological problems and health issues through unequal access to basic resources. On the society level it us followed by distortions in capital and labour markets, which result in resource misallocation and efficiency declines. Additionally it raises mistrust and cohesion in the society fuelling political instability, which reduces economic investments (Andrews & Htun, 2018; Berrone et al., 2016; Camera et al., 2019).

Previous studies have identified large gaps in levels of income and deprivation or employment between urban and rural households. In almost all countries the living conditions faced by the rural poor are far worse than those faced by the urban poor.

Figure 3: *Rural Poverty by Region (The World Bank, 2018b, p. 113)*

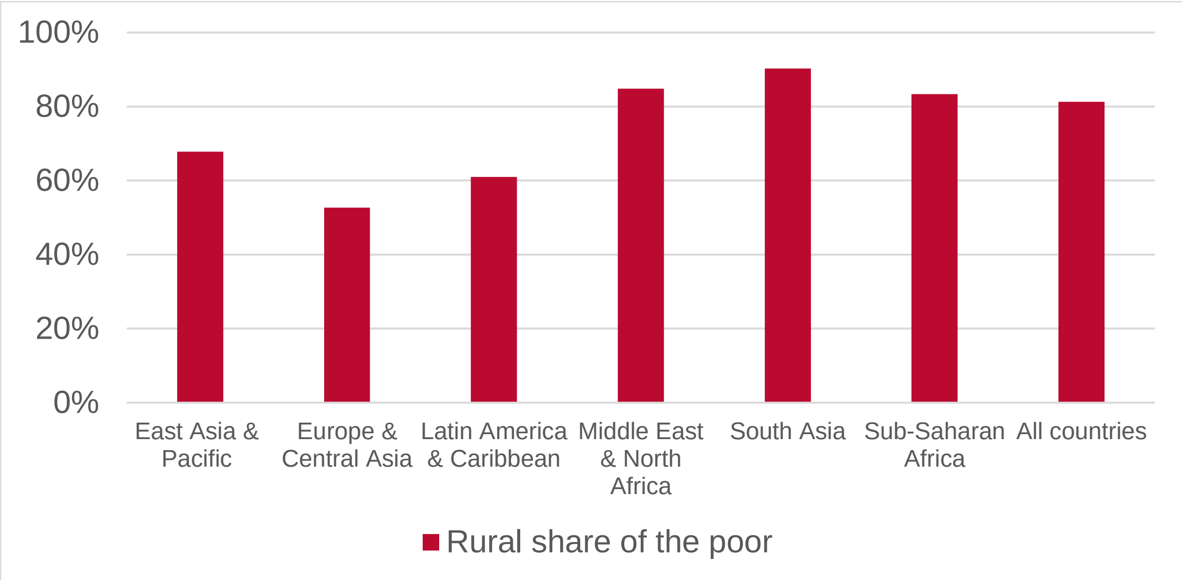


Figure 3 shows a clear tendency towards a high share of the poor population living in rural areas. This trend is especially apparent in regions with a high number of developing nations. High levels of rural poverty have led to a rapid population growth and migration to urban areas (Khan, 2001). Estimations say two-thirds of the world populations will reside in urban areas in 2050 with the bulk of this urban growth taking place in developing countries (Østby, 2016).

Reasons for the rural-urban migration are multidimensional. The urban area can be seen as representative for the industrial sector using capital and labour to produce manufactured goods. On the opposite the rural area represents the agricultural sector using land, labour and capital to produce food. Potential migrants consider the various labour market opportunities available to them in both regions and choose the one which maximises their expected wage gains. Industrial enterprises are mostly located in urban areas due to lack of support services and industries and infrastructure in rural areas. This leaves the people there with only a few to none alternatives for employment except agriculture. Farming needs little investment in human capital, therefore wages are very low, often only on the subsistence level. They have no labour union representation and depend on the fluctuating market prices (Agesa & Agesa, 1999). In arid countries climate change is an additional push to migration since food and cash crop production is decreasing due to longer periods of droughts (Duda et al., 2018). The urban economy is better developed with more employment opportunities in the formal and informal sector characterized by above subsistence wages and job security. These jobs offer a higher wage, but also require a higher educational level. That is why educated people are more likely to migrate than uneducated, as they have a higher probability to get a better paid job. The required educational level also explains the gender differences in migration. Mostly young men tend to move to cities, while women, which often have a poorer education, stay behind. In summary a lower education means lower expected employment opportunities and lower differences in expected wage gains as a result of migration (Agesa & Agesa, 1999).

Problems due to high rural-urban migration rates occur in both areas. Labour markets cannot absorb the fast-growing population, which is why many people end up in informal jobs with low wages and bad living conditions. Additionally, rising food prices and other economic circumstances due to the fast growth lead to public violence in huge cities. Left behind rural population faces losses in agricultural labour leading to a lower production and income. Overall due to migration the agrarian regions age and lose young productive workers, ending in higher food and resource instability nationwide and even more poverty in these regions (Duda et al., 2018; Østby, 2016). Solutions to these problems can emerge from fostering the inclusive and sustainable rural transformation. The provision of basic services can significantly increase the economic wellbeing of individuals at the bottom of the income distribution chain. Securing critical resources, such as food and water through enhancing agricultural growth leads to higher incomes. Supporting farming gives most households access to food in their fields and markets, resulting in improved food security and poverty through higher income. This in turn means lower incentives to move to urban centres (Berrone et al., 2016; Imai et al., 2017).

2.3. Access to clean water

Not only income equality leads to less reason to move to urban centres and lower poverty, but also access to basic services like clean water play a fundamental role in the enhancement of living conditions. Despite improvements in the last years, access to safe drinking water is still a daily struggle to one third of the world population (Thompson, 2010). This entry delivers people water security, which has been defined as “the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies” (Grey & Sadoff, 2007, p. 545). Water insecurity is one of the major problems in developing countries leading to many other concerns. The World Health Organization (2019) stated that 2.2 billion people in 2017 lacked safely managed water services. Safely managed water services are defined through the usage of improved water sources located on premises, available when needed and free from contamination. Looking at the amount of people, water security is a global issue. If one looks at the overall availability of water, it is clear that the amount would be sufficient for the whole population, merely the distribution is a problem. Thus the water crisis can be seen as a supply chain dilemma (Nwankwo et al., 2007). Distribution of freshwater resources between and within countries is highly unequal and 80% of humanity lives in regions where water security is threatened (Zakar et al., 2012).

Figure 4: *World Population with Access to Improved Drinking Water in 2015 (Ritchie & Roser, 2020, p. 4)*

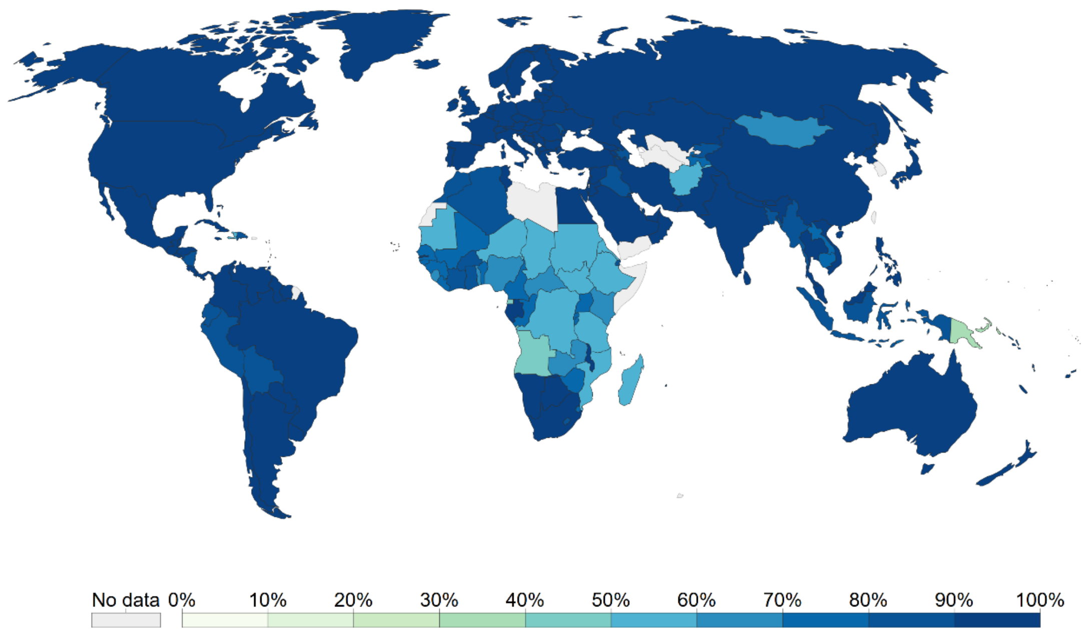


Figure 4 shows the share of the population with access to improved drinking water in 2015. The map shows a strong indication of unequal distribution of improved drinking water. The share of the population in developing countries mostly on the African continent facing these problems is much higher than in western countries. This has several reasons: In most countries the difficulty is not the availability of water but the availability of usable water. The usability is not only dependent on the volume but more importantly on the quality consistent with the usage requirements (Nwankwo et al., 2007). This economic scarcity means having no financial possibilities to regularly exploit the existing water sources, which could be overcome by building basic infrastructure. The second problem - mostly found in semi-arid to arid regions - is the availability of natural resources of water. Climate conditions in these areas include long droughts and short and heavy rainfalls. This influences the availability, quality and quantity of current water resources making them even scarcer (Jemmali, 2018).

Especially in these regions, where agriculture is the main income, high demands of water are used for crop production. It consumes more water than any other human activity leading to an extensive use of renewable water resources for irrigation plus over-pumping of groundwater. This again leads to declining groundwater and severe environmental degradation. Another reason for the rising water stress level is the growing population linked to socioeconomic development in developing countries leading to a higher demand. As a result, the agricultural sector is under even greater pressure to produce more food, which further increases the consumption of irrigation water. Additionally rising standards of living in urban centres lead to a higher calorific intake through a more meat-based nutrition, which requires a several times higher amount of water than grain production (Jemmali, 2018; Zakar et al., 2012).

The result of water scarcity is the collection of water from unsafe sources where water is contaminated. The consumption leads to water-borne diseases, mostly diarrheal illnesses.

> “Some 829.000 people are estimated to die each year from diarrhoea as a result of unsafe drinking-water, sanitation and hand hygiene. Yet diarrhoea is largely preventable, and the deaths of 297.000 children aged under 5 years could be avoided each year if these risk factors were addressed” (World Health Organization, 2019, p. 2).

Many governments have not identified the access to safe water as the highest priority for achieving economic productivity and human health especially in rural areas. Improvements in water supply quality could significantly minimize the negative health impacts (Arvai & Post, 2012). Ill people cannot contribute effectively to economic and social growth resulting in a lower productivity. Caring for sick children due to contaminated water also limits the time available to perform the wage-earning work (Thompson, 2010). This is considered to be women’s responsibility. Collecting water counts as a household-based obligation, which as well falls into the duties of women. Without water infrastructure women spend many hours collecting water for domestic use. Gathering water means travelling far distances to the next well, pond or other sources making it in some cases a part-time trip. Most households do not own motorized vehicles, so the water collection is done by head loading limiting the amount of water able to carry. Some women travel several times a day or send more than one household member, often children to the water source. The time spend on home production, which includes water collection diverts time from potentially income-generating activities leading to a lower household income. Thus the time spent on gathering leads to further poverty under the poor. (Meeks, 2017). The summary of problems related to no access to clean water can be demonstrated in a vicious cycle. Starting from the limited availability leading to a disproportionate fraction of communal, individual and financial resources diverted to the provision of water. This retards the wealth creation and economic growth followed by continuing poverty. Thus it is impossible to achieve poverty alleviation without access to clean potable water (Nwankwo et al., 2007).

> “In fact the term ‘developing country’ may make the most sense if defined as a country in which the majority of its citizens do not have access to potable water and improved sanitation, given how fundamental this indicator is to all other development metrics” (Nwankwo et al., 2007, p. 93).

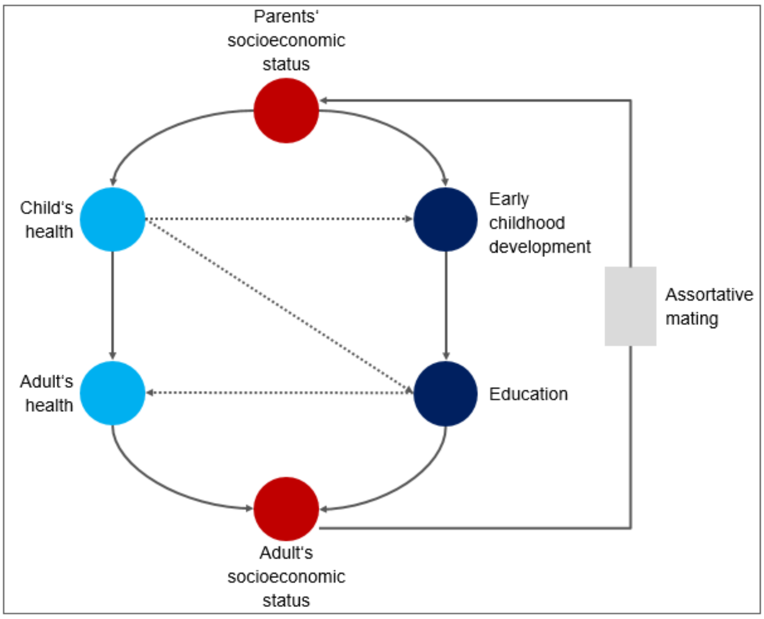
An adequate supply of water for both domestic and agricultural use is required for development and growth. Benefits derive among others from improved human health such as increased worker productivity and a decreased burden on the health care system. Improvements in household technologies can help shift time allocation from basic household tasks related to water collection to increased market production. In rural areas this means more time spent on the farmland and more water available for irrigation purposes leading to a higher crop production. A household access to a safe water source means eliminating not only the risks of collecting from dangerous sources and therefore reducing sickness from water-related diseases but also reducing the time of collection as a constraint to wage-earning activities (Meeks, 2017; Nwankwo et al., 2007; Thompson, 2010).

2.4. Socioeconomic situation in Morocco

Developing countries face many struggles, which often to a certain extend can be solved by improving access and the quality of basic services like clean water. Morocco is classified as a lower-middle income economy and hereby a developing country (The World Bank, 2020). The country sited in the North African region faces many of these problems elaborated in the chapters above. The king instigated several reform programs like a poverty alleviation program, the National Initiative for Human Development, a regionalization agenda and economic liberalization to face these problems. Despite the governmental efforts and the growing economy every year, the impact on the population differs greatly between urban and rural areas. Rural areas record large discrepancies in several fields. The economy in these areas rely heavily on resource-based activities like volatile rainfed agriculture and accounts for three-quarters of employment. An additional reason for the dependency on rain for agriculture are the semi-arid climate conditions leaving Morocco as one of the most water-scarce countries in the world (Hofste et al., 2019). Many workers are exposed to poor working conditions, including a lack of social protection and lower pay. The agricultural minimum wage lies 30% lower than the minimum wage for non-agricultural activities. The farms are mostly family run and the products are sold on the local market to barely provide the whole family. Women are the care-providers of the family, while men are seen as the wage-earning protector. This gendered view underpins women's full participation in community and economic life leaving them dependent on largely unpaid family work, especially in agriculture and household activities (Taqeem Initiative, 2018). Limited access to education beyond primary level – average years of schooling was 3.8 years for girls and 6.4 years for boys in 2018 –, lack of basic services and limited access to better paid jobs weigh additionally heavy on the opportunities for rural women (The World Bank, 2018c).

The HDI ranks Morocco 121st out of 189 countries with a score of 0.676 compared to the world score of 0.731, putting it in a medium human development category. Education is carrying the highest weight on the score. Compared to other Arab states, which are close to its HDI rank and population size, Morocco scores well in life expectancy, showing the improvement of the health conditions in the last years. It is far behind in mean years of schooling and Gross National Income (GNI). Data shows that prospects in adult life for children differs vastly depending on the human development score of the country they are born in. These circumstances are setting them on different and unequal paths in terms of health, education, employment and income prospects, almost beyond their control (Conceição, 2019). Figure 5 shows the different stages of the lifecycle. The red ones represent the final outcomes. The arrows underline the influence of origin on the future life. The dashed lines refer to interactions of health on early childhood development and prospects for education.

Figure 5: *Education and Health along the Lifecycle (Conceição, 2019, p. 10)*



The multidimensional poverty shows that 18.6% are considered multidimensional poor, while only 1% are below the extreme income poverty line of 1.90 $ per day. The difference shows that even people living over the extreme poverty line still suffer deprivations in other dimensions. 90% of this multidimensional poverty resides in rural areas. Morocco scores especially low in years of schooling, access to water and sanitary assets and used cooking fuels (United Nations, 2019). This was confirmed in the conversation with Amal Zniber (see Appendix 3.2.). According to the Haut Commissariat au Plan (2014a) 62.2% of the rural population is without access to safe drinking water and 27% still use firewood and 11% animal waste as fuel for cooking, while almost everyone has access to electricity. Both are considered to be unclean cooking fuel (The World Bank, 2019d). These differences explain the high urbanization rate of 2.14% annual rate of change (United Nations, Department of Economic and Social Affairs, Public Division, 2018).

Even though Morocco has almost eradicated extreme monetary poverty in the last years, it still faces big multidimensional deficits considering the supply of basic services especially the important factors safe water, education and clean cooking fuel. In addition to the high amount of low-paid rainfed agriculture it leads to rural-urban migration, leaving large areas empty. These facts again highlight the importance of an all-round view of poverty and necessity to eradicate these multidimensional deficits to fully eradicate poverty.

3. Methodical approach

3.1. Importance of social impact measurement for businesses

In the past businesses were mainly responsible to stockholders for increasing profit, but with changing times corporations today have to take responsibility for many social, political and environmental aspects as well. Examples are working conditions, product protection or influence on local population (Edmunds, 1977). Business practices, even far away from the home market like most developing countries, can still be a topic for customers, governments, suppliers or shareholders (Knox & Maklan, 2004). The Study from Knox and Maklan (2004) shows a strong relation between the corporate social behaviour and the strength of the corporate reputation, through addressing stakeholder concerns. Additionally the social pressure about the transparency and accountability of actions rose, demanding a demonstration of results in addressing complex social problems such as poverty and inequality (Ebrahim & Rangan, 2014). This demonstration requires a full measurement of social performance and impact.

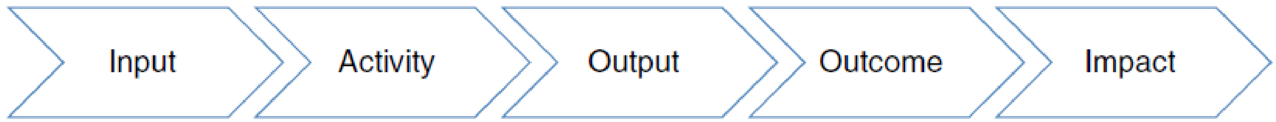
The term ‘impact’ has not been consistently defined. According to Varga and Rosca (2019) the different definitions can be categorized in three lines of thinking.

> “Some consider it as the broad, far-reaching results of social intervention, others define it as the occurred social change which is proven to be attributed to the intervention, while others … explain impact as the effects of social intervention which are sustained changes on people, organizations, environments and systems” (Varga & Rosca, 2019, p. 496).

Furthermore, many differentiations can be drawn in the type of impact, looking at indirect or direct and intentional or unintentional. Social impacts cover several categories including changes in way of life, culture expressed through people’s shared beliefs, customs and values, community, political system, environment, health, personal and property rights or fear and aspirations (Larsen, Hansen, & Nielsen, 2018). An overall model used by several impact assessment analyses is the impact value chain (IVC) (Varga & Rosca, 2019). It demonstrates the chronological sequence of cause and effects of events and happenings. The impact value chain analyses the steps happening before, which caused the impact, tracing it back to the starting activity.

Inputs can be described as “the resources required to develop the project including human, financial, organizational or material resources” (Wuppertal Institute & Germanwatch, 2015, p. 76). Activities include all actions that are performed during the project, which convert inputs into outputs. Outputs are direct products and services delivered through the activities. In the model the Impact Measurement Working Group (2014) defined impact as “changes or effects on society or the environment that follow from outcomes that have been achieved” (p.6). This definition misses the attribution to the intervention or activity triggering the impact as “the portion of the total outcome that happened as a result of the activity of the venture, above and beyond what would have happened anyway” (Clark et al., 2004, p. 7). This kind of approach is needed for the following evaluation of assessment methods.

Figure 6*: The Impact Value Chain Framework (Impact Measurement Working Group, 2014, p. 6)*

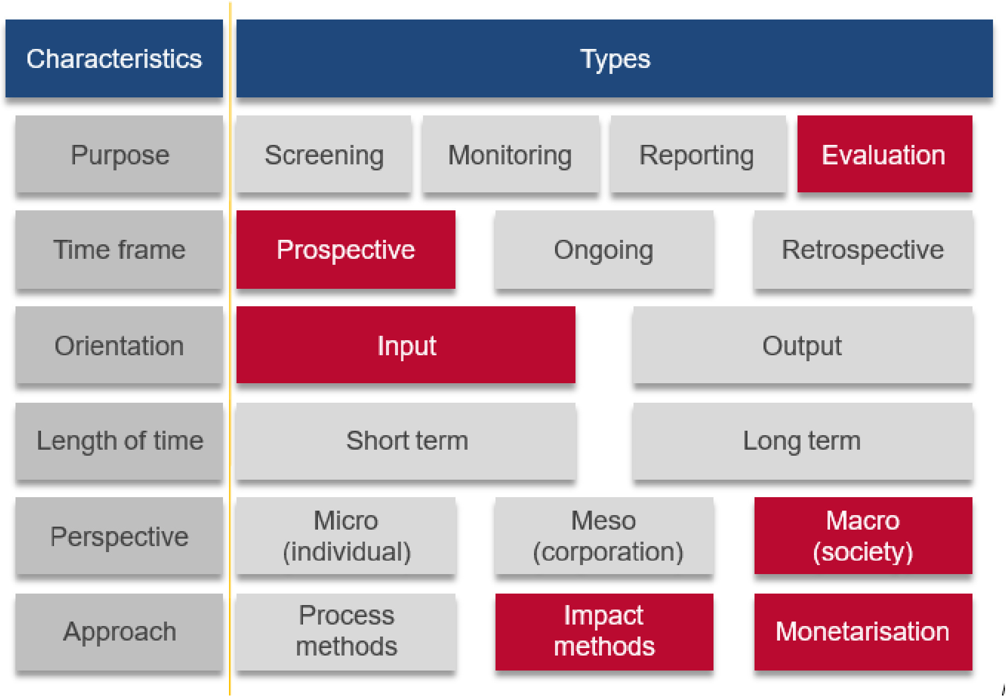


Moving further to the right of the IVC, shown in Figure 6, the reach of the changes become wider and farther and often need a longer period of time to show. At the same time the actor has less control of the results, consequently the more difficult it becomes to observe, understand, measure and attribute the changes resulting from one’s activity. Still in order to create better evaluations it is important to move from measuring outputs and outcomes to measuring impact (Varga & Rosca, 2019).

3.2. Methods and tools for social impact analysis

The literature gives several options of tools and methods for the measurement of social impact. Compared with profitability, where a general understanding of the measurement exists, there is no common agreement on the measurement of social impact (Varga & Rosca, 2019). One agreement which can be made is the base of the measurement. All tools and analyses are based on the impact value chain, explained above. To find the optimal method for different requirements a classification is necessary. Clark et al. (2004) refers to a categorization according to the approach into process methods, impact methods and monetization methods. The approach combined with other important characteristics, like purpose, time frame, orientation, length of time frame and perspective forms the classification tool. (Maas & Liket, 2011) In a next step several internationally accepted tools are analysed and evaluated after those characteristics. On the basis of these categorizations a preselection of possibly fitting methods could be drawn. The project specifications give following highlighted types of characteristics.

Figure 7: *Types of Characteristics of the Analysed Project (Own Illustration)*



As a result of the highlighted types in Figure 7, a selection of methods analysed in the following chapters could be drawn. Seven methods scored a minimum of 5 matches and higher. Out of these, four methods were chosen. The Social Cost-Benefit Analysis, Social Impact Assessment, Social Impact Navigator and the Social Return on Investment will be further examined and evaluated as tools for the following impact analysis (see Appendix 1).

3.2.1. Social Cost-Benefit Analysis

„Today's social, economic and environmental challenges render the social and financial allocation of available resources increasingly important" (Vörös, 2018, p. 402). These challenges can be tackled through a social cost-benefit analysis (SCBA). The basic purpose of the analysis is to provide a mechanism by which decisions concerning the allocation of these scarce resources include the preferences of the members of society who will be affected by the decision. A general cost-benefit analysis seeks to answer the question whether an investment project is worth implementing and which of several feasible technical alternatives should be chosen. Combined with the social aspect the methodology focusses on a larger community, town or country affected by the investment, speaking of the main stakeholders of the project. It requires the monetization of all relevant costs and benefits of the project arising at the social level. These are then being compared in a simple calculation using the benefit-cost ratio indicator (Maas & Liket, 2011, p. 196):

$$Benefit - cost\ ratio = \frac{discounted\ value\ of\ revenues\ and\ positive\ impacts}{discounted\ value\ of\ costs\ and\ negative\ impacts}$$

Especially benefits can be hard to track in financial transactions, since most of them are indirect effects, which result from complex mechanisms of action and are therefore fairly difficult to quantify. This basic calculation shows, the conceptual framework draws mainly on the general equilibrium theory and the concept of the consumer surplus, which plays a key role in the measurement of social benefit (Jones-Lee & Aven, 2009; Vörös, 2018).

The ‘willingness to pay approach’ serves as an indication of the value and benefit of a certain good or service to the individual relative to other potential objects of expenditure. Benefits can be quantified more easily using this indicator. It is constrained by the ability to pay, for example the income of the person. The same counts for the ‘willingness to accept’ approach serving as an indicator for the quantification of the social cost (Jones-Lee & Aven, 2009). Most criticism on this approach is the large influence of the behaviour and cognitive abilities of the respondent. As any questionnaire the ‘willingness to pay’ and ‘willingness to accept’ approach faces the problem of several biases and assumptions. Regarding the interviewees it has to be assumed that everyone is perfectly informed and gives honest answers without any strategic behaviour or goal behind it. Additionally, only a few stakeholders can be questioned, serving more as a sample. Several other biases such as the non-response bias or interviewer-caused biases have to be taken into account as well. Overall it is difficult in this approach to guarantee the objectivity of the given answers considering the many possible external influences (Hausman, 2012).

The advantage of the SCBA lies clearly in the simplicity using the monetization as a common measurement. It enables to consider external effects that are manifested only indirectly in monetary transactions. Likewise it gives a clear insight in who gets the benefits and who actually bears the costs due to the impact of a certain action (Vörös, 2018).

Decisions over projects are made on very complex impact systems, looking for example at the social system of a country, on the basis of a single or only a few figures and indicators. Several problems and effects on these systems are general methodological problems and are independent of any field of application. Additionally, some effects, especially social benefits like more gender-equality, are difficult to quantify. Social benefits often appear in secondary markets as indirect effects, which cannot be fully captured by the estimated consumer surplus in the primary market (Vörös, 2018). Still official SCBA guidelines suggest no consideration of any indirect effects (European Commission, 2015; Vörös, 2018).

A high share of secondary outcomes is due to multiplier effects. Projects can be underrated through false or no consideration of multiplier effects and therefor shape the judgement over the return of a project significantly. Considering the equilibrium theory every amount of money spend in any sector has a certain multiplier effect due to the additional final demand, which appears in the lifecycle of the examined economy. The effect on the local economy depends thereby on the extent to which the incoming supply chain relies on it. As any spending creates final demand a consideration of the multiplier effect can only be used through the comparison of two projects (Vörös, 2018).

The general principle of SCBA is the use of periodically determining the least expensive way to provide benefits or to reduce negative impacts to all stakeholders. It cannot be used in regular business decisions due to this fact. Another disadvantage lies in the nature of the SCBA, which frames benefits and costs as trade-offs and does not facilitate planning or prioritizing the optimization of financial and social value creation (Lingane & Olsen, 2004).

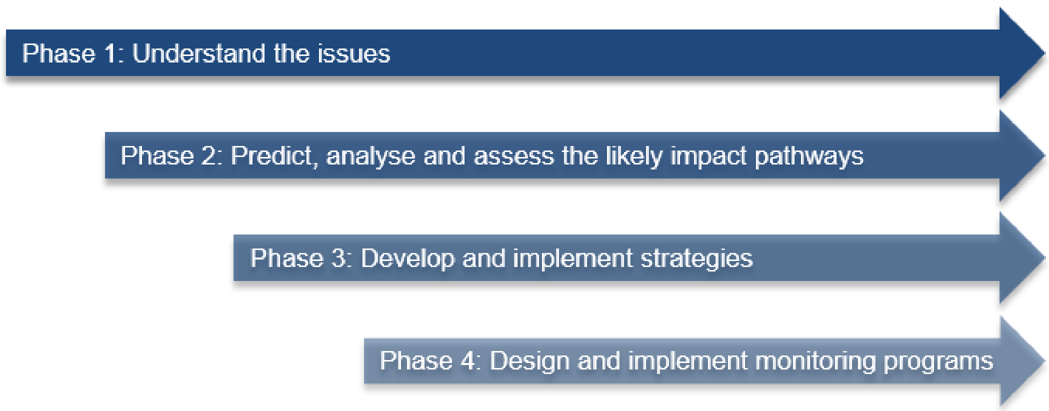
In regard to the disadvantages listed above the social cost-benefit analysis cannot be further considered for the analysis in this thesis. Especially the indirect effects are of great importance for developing countries and have to be taken into account. The other main aspect is the criticism of the willingness to pay and willingness to accept approach, having to take the biases into account. Especially in rural areas in developing countries the education and information standard of the population is not high enough to be able to make a decision over such a project. It would be unfair to expose such a decision on them. Therefor no objective quantification and valuation is possible through this approach.

3.2.2. Social Impact Assessment

When focussing more on the qualitative effects, the Social Impact Assessment (SIA) is regarded as a technique for predicting the social impacts. In the past it was mainly seen as part of an Environmental Impact Assessment, but since it failed to adequately address the social issues the SIA was developed as a gradual extension. “However, its focus on the social well-being of societies has become an area of increasing concern, leading SIA to an accelerated development” (Nigri & Michelini, 2019). In general SIA includes analysing, monitoring and managing the intended and unintended social consequences of planned interventions, including governmental policies, programs or industrial projects, independent of being positive or negative. Its overall goal is to bring about a more sustainable environment with a focus on enhancing the maximization of positive outcomes, being more important than minimising the negative impacts (Vanclay, 2003).

The process of SIA consists of four phases according to Vanclay et al. (2015) highlighting the iterative nature and aiming at a continuous improvement. The four phases shown in Figure 8 can be seen as sequential, but also overlapping. Being in the nature of an iterative process, initial assumptions and preliminary understandings may need to be modified and updated after some time.

Figure 8 : *The Phases of Social Impact Assessment (Vanclay et al., 2015, p. 7)*



All phases consist of several specified tasks, which can be used as a guidance of establishing good and best practice in SIA. In the following paragraphs these tasks of each phase are being shortly summarized. In phase 1 the first rough framework is set by preparing a community profile of the social area of influence and a stakeholder analysis, including needs and different interests. The involved communities are informed about their likely impact and proposed benefits to help them understand the whole picture. In a last step the scope for the analysis is set with a first identification of thematic sections, which are of potential concern. Examples for indicative thematic sections are education, land tenure and use, community, infrastructure, economy or demographics (Vanclay et al., 2015). The likely impacts in all varieties, considering indirect ones as well are being analysed in phase 2 including the effect they will have on the host communities. Next is the determination of the reaction of the affected groups. Afterwards these impacts have to be prioritized according to their significance (Vanclay et al., 2015).

In the next phase strategies are being built up to develop ways to treat these impacts. Benefits and project-related opportunities have to be enhanced. Ways to address the negative sites through for example compensation, avoidance or mitigation have to be identified. The next step is communicating these changes, implementing appropriate feedback and grievance mechanism and optionally develop an impact and benefits agreement between the communities and developers. To hold this agreement in the future an ongoing social performance plan has to be established with partnerships in industry, government and civil society (Vanclay et al., 2015).

The last phase mainly frames the implementation of monitoring systems, to observe change over time. Periodic reviews and evaluations help to track the status of the social performance plan (Vanclay et al., 2015). The 26 tasks listed in the instructions serve as a guideline and can vary according to context. The end result in any case should be a social impact management plan and related documents which provide a recommendation of behaviours and actions managing the social issues created by a project (McCombes et al., 2015).

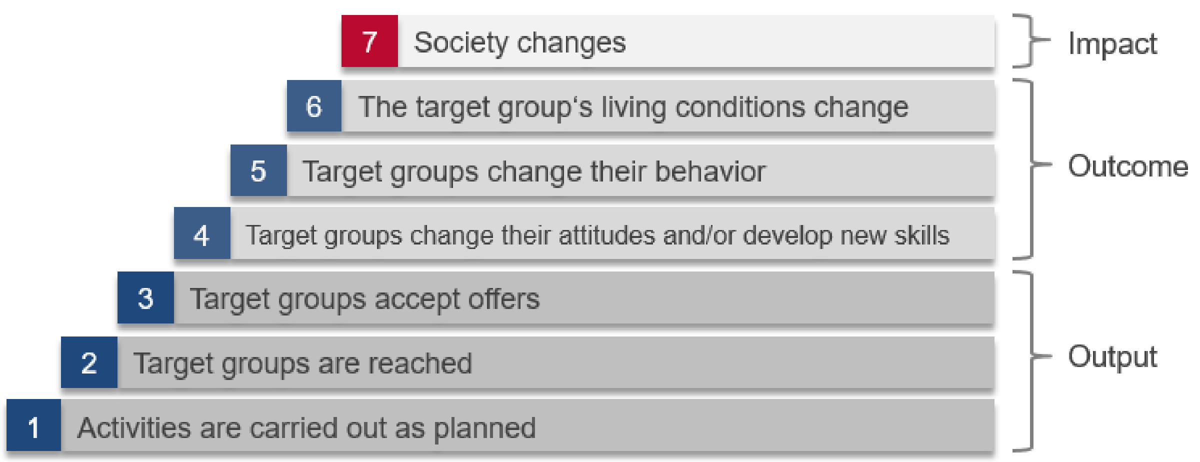
In order to avoid conflicts the stakeholders are involved very early in the process of the SIA. The assessment is providing an arena for a necessary dialogue amongst the effected citizens regarding the issues concerning them. For the corporation it gives the opportunities to deal early with social consequences in the planning process to avoid surprises in the future. Altogether it is still not possible to totally avoid conflict when individual emotions and intentions are involved (Larsen et al., 2018). This participatory approach can have many advantages through allowing the accounting of specific characteristics of the affected communities. On the other hand this can lead to additional difficulties and risks like the integration of conflicting views or the danger of presenting exaggerated and biased opinions in the planning phase slowing down the process unnecessarily (Wuppertal Institute & Germanwatch, 2015).

SIA generally serves as a one-off activity for the purpose of securing project approval, including the community as well as the management of the corporation. Often the educational level of management and local community differs extremely, therefor it is difficult to use the same explanation tool for all groups (Wilson, 2017). For the addressed management a clearer measurement in terms of monetized impacts and for the community an easy understandable list of impacts with explanations concerning them would be most beneficial. The limited practical application of SIA lies therefor in the missing normative framework and the lack of appropriate consistent tools (Wuppertal Institute & Germanwatch, 2015). The different needs of addressed groups make the SIA an unsuitable tool for the following analysis. A rather combined application of participatory and technical measurement approaches would be recommended to provide robust findings on social impacts.

3.2.3. Social Impact Navigator

The Social Impact Navigator (SIN) is a guide for impact-oriented projects or organizations. It offers a solid foundation when organizers want to scale the project. It makes you plan and implement your project in an impact-oriented way and analyse your results. Results can have different meanings, it is important to understand these differences to consider all of them for further activities (Kurz & Kubek, 2016). The different stages of results are shown in Figure 9 following the logic of the impact value chain.

Figure 9: *The Results Staircase (Kurz & Kubek, 2016, p. 5)*



This analysis shows the correlation between the outputs and the impacts. The outputs are a requirement for achieving impacts but are no effects themselves. Originally the SIN was designed for non-profit organizations seeking to analyse and document the effects produced by their projects, but the guide can easily be used by non-profit organizations as well wanting to measure the impact of their work. The goal of the SIN is giving simple steps on planning and implementing an impact-oriented way in the project. The steps in the process have an iterative structure, which is why they are often demonstrated in a cycle. The three main parts with their sub-steps are explained in the following (Kurz & Kubek, 2016).

Part 1: Planning Results

In this part the basis for the project work is being done. The local and global social challenges and the target group needs are worked out through a needs assessment and a problem tree. The needs assessment helps to identify the key stakeholders and tailor the project to the right target group. Following perspectives are being addressed in the needs assessment:

- "Societal challenges and the situation in the target area
- Target groups and their needs
- Identify and involve stakeholders
- Previous offerings and gaps in support
- The problem's causes and effects" (Kurz & Kubek, 2016, p. 13).

The causes and consequences of a problem can additionally be analysed through a problem tree. The core problem of the target group and the core problem on societal level are in the middle with its causes as the roots and the effects as the branches of the tree (Kurz & Kubek, 2016). The problem tree is converted into a solution tree in step two. The core problem is transformed into an objective and with it the causes and effects are turning to positive aspects. On the tree many possible paths to reach the goal are possible, from which the ones fitting for the project have to be chosen (Kurz & Kubek, 2016). The last big step in part one is the logic model. Again the logic model is based on the impact value chain and can be demonstrated as a flowchart or as a staircase, seen in Figure 9 (Kurz & Kubek, 2016).

Part 2: Analysing Results

This part demonstrates the social impact analysis itself. The data preparation takes place through monitoring and evaluation throughout and after the project. In the beginning the evaluation can already be used to compare the project objectives and the identified needs along the logic model. As in the other analyses indicators have to be formulated and the data has to be collected. The last step then is the processing of data and the analysis itself using a simple spreadsheet. Recommendations can already be drawn from this (Kurz & Kubek, 2016).

Part 3: Improving Results

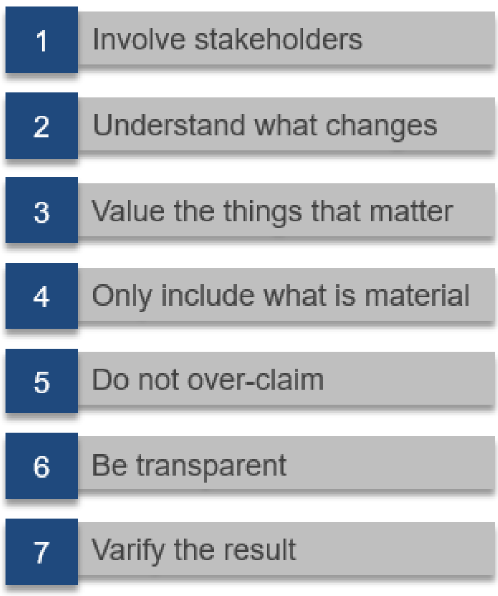
In order to fulfil the primarily cause of the SIN the results have to be used to improve processes in the organization and learn from it. Monitoring data is suitable to discuss in regular meetings allowing adjustments quickly. An evaluation is more qualified for deeper looks into the processes of the analysis and the objectives. Relevant stakeholders should be involved in the evaluation. Overall it serves as an internal improvement tool. For communicating the results the Social Reporting Standard (SRS) is recommended as a framework for a transparent official report (Kurz & Kubek, 2016).

The SIN does not specify a necessary quantification of the data, it is rather focused on keeping it qualitative. A benefit of the SIN is the early needs assessment. It gives an understanding of the challenges and the most urgent social issues needed to be addressed. From the beginning it is clear where the project should target at, so that all invest is going in the right direction. A disadvantage is the rather unclear communication of the impact of the activities. And similar to the SIA the clear result, end statement and additionally the external communication purpose is missing. The strong disadvantages are overweighing the benefits, which is why the SIN is not further considered.

3.2.4. Social Return on Investment

The traditional Return on Investment is used to compare companies within a given industry and to their own individual performance over time. It serves as a quick overview of the financial situation in a relative context. The Social Return on Investment (SROI) is a spin-off from original version "describing the social impact of a business or non-profit's operations in dollar terms, relative to the investment required to create that impact and exclusive of its financial return to investors" (Lingane & Olsen, 2004, p. 118). It is a monetization of the social benefits and costs relative to the financial costs of a company's operations, based on the net present value of these impacts in dollar terms. The outcome is the ratio of a philanthropic dollar or euro invested generating economic and social returns in excess of the initial value of that dollar or euro invested (Moody et al., 2015). The overall goal is to reduce inequality and environmental degradation and improve the wellbeing. The monetization hereby only plays a role as a common measurement representing the value of the impact. As a combination of SCBA and SIA it contains qualitative and quantitative information and can be carried out over a whole organization or just a specific project (Kroeger & Weber, 2014). SROI is timely independent and is applied evaluative, in a retrospective time frame or forecasting. Especially as a forecast it helps to show how investments maximize impact and set useful indicators for the measurement of the ongoing project (Nicholls et al., 2009). The SROI is based on seven principles shown in Figure 10. These principles underpin the execution of a SROI.

Figure 10*: The Principles of SROI (Nicholls et al., 2009, p. 9)*



During the SROI these principles serves as a guide. The sequence is divided into six steps.

Step 1: Establishing Scope and Identifying Stakeholders

This step is similar to the first step of the SIA. The scope of a SROI means setting the boundaries of what has to be considered and what is not feasible enough or does not support achieving the goal, set for the analysis. Limitations due to available resources and priorities for measurements have to be clear. The next stage in step 1 is the identification of stakeholders and deciding individually over their involvement in the process. The identification is prepared as listing down all possible stakeholders affected by the activities without setting restrictions. In this list now reasons for inclusion and exclusion should be drawn according to the significance of change happening to the stakeholder group. The last decision is on the methods of involvement of the included stakeholders, through for example email, phone or direct interviews or surveys helping you to understand the real effects and strength and weaknesses of your activities (Nicholls et al., 2009; Walk et al., 2015).

Step 2: Mapping Outcomes

For the mapping of outcomes, the impact map comes to support. The impact map is using the impact value chain in Figure 6 as a basis to draw a line between the used resources or inputs, the activities, outputs and outcomes for the stakeholders. The information for the impact map stems from the information given by the stakeholders. The impact map builds the base of the SROI, here all calculations are drawn. In this step only all information and descriptions are gathered, and no evaluations are made. Central to the impact map is the identification of the theory of change of the organization or the project. The theory of change means understanding the building blocks leading to the overall social goal of the project. Building blocks describe the information on what is the project socially doing, what are the contributions of it and the aimed benefits (Vieta et al., 2015).

Step 3: Evidencing outcomes and giving them a value

The described outcomes from the last step are now being evaluated through developed indicators. These are important to be able to measure if change has happened. Indicators then have to be filled with data from for example surveys, stakeholder, official documents, research or observation. Depending on the activity some outcomes will last longer than others, giving them more significance. All outcomes are then given a financial value to make further calculations possible (Nicholls et al., 2009; Walk et al., 2015).

Step 4: Establishing Impact

This section provides ways to assess whether the identified outcome can be traced back to the activity or is considered as deadweight or displacement. The separation gives insight on how much of the outcomes would have happened anyways. Attribution describes the percentage of how much of the outcome was caused by the contribution of the activity. Drop-off means the percentage of which the attribution and effect of the activity wares off after time. This is only applied for outcomes lasting longer than one year. It reduces the risk of over claiming and makes the activity more credible. Bringing these numbers together the calculation of the impact can be made (Nicholls et al., 2009; Walk et al., 2015).

Step 5: Calculating the SROI

For the final calculation several steps are needed. At first the value of the impact over the whole time frame, has to be accounted using the drop-off rate from step 4 for every year. Then the net present value can be measured adding up the costs and benefits of every year through discounting. Discounting is a process of measuring the time value of money. It is based on the assumption that people like to have their money today rather than tomorrow meaning the value of money sinks after time for the person today receiving it (Nicholls et al., 2009, p. 68).

$$Present\ Value = \frac{value\ of\ impact\ in\ year\ 1}{(1+r)} + \cdots + \frac{value\ of\ impact\ in\ year\ n}{(1+r)^n}$$

r: discount rate

The Net Present Value then subtracts the value of the inputs from the Present Value. The SROI ratio can be calculated from the Net Present Value or the Present Value, depending on the intended goal. The general calculation works with the Present Value (Nicholls et al., 2009, p. 68):

$$SROI\ ratio = \frac{Present\ Value}{Value\ of\ Inputs}$$

After the calculations it is important to know the extent to which your results would change depending on the assumptions made before. It helps to analyse which have the greatest effect on the result. The common approach is to calculate how much needs to be changed to get the ratio to 1€ or $ of value for 1€ or $ of input. It shows the sensitivity of the analysis to changes and how much amount of change is necessary to make the effect turn from negative to positive (Nicholls et al., 2009).

Step 6: Reporting, using and embedding

The results of the SROI should be presented to the stakeholders in a report. The way of communication depends upon the audience. In the report the path of the calculation as well as all quantitative and qualitative aspects should be made clear to give externals an overall understanding. In order to give the results a meaning it is important to not only report them but also use and implement them into the organization and decisions over the project (Nicholls et al., 2009).

One challenge is the cost and time required for a full SROI, since information systems are often not well developed for social measures. Referring to already performed SROIs, often a consultant is being involved (Mook et al., 2015). A SROI makes it additionally quite difficult to compare the social impact to very different projects. It is mostly used to compare similar activities and their social outcomes (Kroeger & Weber, 2014).

The SROI can help managers and board members understand the social – rather than just the financial – impacts of a project or organization. Especially in the planning phase it can help to assess the necessary determinants for a benefitting outcome for the community. The monetization in the process can still lead to problems such as the force to quantify human emotions, well-being or environmental balance. Coming to such quantifications means using a very subjective evaluation. As in the SIA the SROI includes a certain risk of different biases. Still due to the very complex process and constant valuation of all data the risk can be kept to a minimum (Vieta et al., 2015). The most important aspect about the SROI is not the result in the end, but rather the multidimensional path towards it. Possibly even more important than the monetized result is the qualitative information foundational to the understanding of the chain of events leading to the impact and the engagement with the stakeholders. The strong involvement of the stakeholders in the early phases helps to avoid certain conflicts, while through the specific process an over involvement of too many opinions and chaos is limited (Vieta et al., 2015).

As a combination and further development of SIA and SCBA the SROI method provides a platform of communicating social impacts to different stakeholder groups. Using qualitative and quantitative data makes the report more credible for a wider range of audience and is more likely to have a greater effect and recognition.

3.3. Comparison of methods and selection

In the previous chapters a preselection of methods has been presented. The SIN is a pure qualitative analysis mainly used for internal purposes and can be rather unclear for further communication purposes. The SCBA bases on a rather radical quantification of all data with the overall goal is to provide the least expensive way to provide benefits. The costs and benefits are seen as a trade-off and several important impacts in secondary markets are not included. The SIA is a mainly qualitative analysis aiming to keep project approval from local communities and management. For management purposes the report can be rather obscure without clear indicators to look at. Both analyses still deliver several advantages combined in the SROI. It gives a clear understanding of impacts through the project in form of a ratio. On the way towards this result all relevant stakeholders are involved giving them an understanding and a deciding voice over the effects for them. The SROI is considering the perspective of what the project can do or how it can affect the stakeholders in positive and negative ways. Going the path from the perspective of which social issues need to be addressed through the project is the SIN approach. For the further analysis the SROI has been chosen. It brings a feasible site of what is possible to achieve through the project, also focussing on the external communication for shareholders or investors. The analysis will make it possible to achieve a realistic investment towards the most urgent social challenges.

To fill the analysis with feasible information, data for the basis is mainly collected via desk research from academic journals. This is necessary to gain a knowledge base about social issues in the world and especially in Morocco. In addition, contacts to Moroccan governmental institutions, NGO’s and companies involved in the energy topic in Morocco support and deepen the information gained from desk research. Finally, a research trip to Morocco helped to talk to representatives of the named and receive an own impression of the social situation. Especially talking to locals, looking at their farms and seeing the circumstances supported the already gained knowledge. Statistics were mainly from official international sources such as the World Bank or from the Moroccan governmental social statistics department. Qualitative data was collected from conversations with locals, workers on big exporting farms and their owners, small poor farmers and non-governmental Organizations (NGO.The gained information serves as a living example for the statistical data and also brought new insights on the real situation behind the numbers. The theoretical information through desk research and statistics in addition to the qualitative data gained through observations and conversations build the base for the analysis.

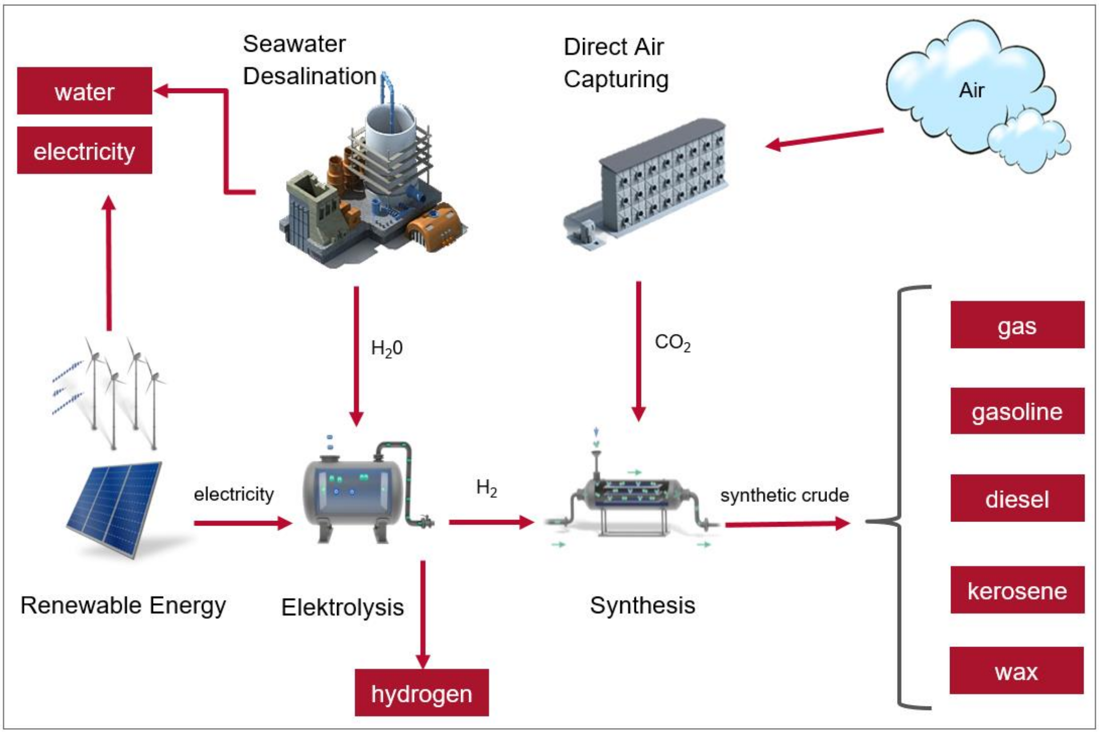
4. Power-to-X Concepts

To reach the climate goals of the Paris agreement, an expansion of renewable energies is necessary. The decreasing prices of renewable electricity encourage to research in other uses despite the direct. Several application areas especially in the transport sector are not able to fully rely on electrical powertrains. One solution therefore researched is the transformation of electricity in different energy carriers. This process is called Power-to-X (PtX). The X can stand for heat, hydrogen, gas, liquid or chemical elements (Eichhammer et al., 2019). Synthetic fuels out of PtX processes, due to their high energy density can fill the gap for these application areas where direct use of renewable energy is not possible (Urbansky, 2020). In order to meet the rising demand of energy and the European climate targets on the other hand a high amount of energy has to be imported from abroad. Several countries deliver fitting conditions of high renewable energy potential, including the Middle East and North Africa region (Frontier Economics, 2018).

Synthetic fuels production and outputs

Synthetic fuels, also called e-fuels, need three main elements for the production: Water, electricity and carbon dioxide (CO_2). Starting point is the electrolysis of water resulting in oxygen and hydrogen. Methanation is a next step, in it, hydrogen and CO_2 are processed to form methane. Synthetic methane and hydrogen are categorized as Power-to-Gas products. If a liquid fuel is needed as the end product, carbon monoxide converted from CO_2 is transformed into a longer-chain hydrocarbon, generally using a Fischer-Tropsch synthesis. This is known as Power-to-Liquid (PtL). These liquid fuels can be refined to diesel, gasoline or kerosene (Urbansky, 2020).

Figure 11: *Power-to-X Processes (Adapted from Deutsche Energie-Agentur [dena], 2018, p. 1)*

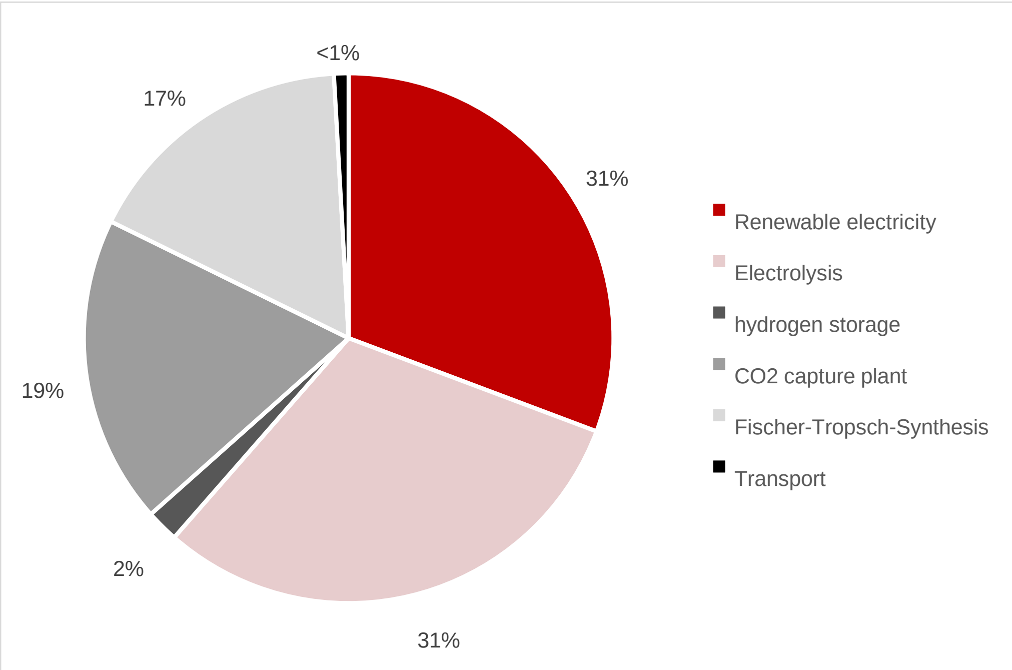


As seen in Figure 11 several outputs are produced in a PtX plant. One of the main advantages is the carbon neutrality through the closed cycle of CO_2, which is captured from the air and in the end released through the combustion. Important for this is the use of renewable energies to gain the needed electricity (Rosenfeld et al., 2019). Possible fields of application can be several reaching from kerosene for air traffic, diesel or gasoline for road traffic to drinking water and electricity for the local population (dena, 2018).

An advantage of these energy resources is the high energy density, which is necessary for many industry sectors as well as some parts of the transport sector, like ln distance aviation. Renewable energies are very fluctuating. Especially solar can only provide energy during day hours. This causes an indispensable storage of energy. However today there is no affordable solution for seasonal electricity storage. Due to their high energy density, e-fuels can store high amounts of energy (Frontier Economics, 2018).

Accessory costs for e-fuels rise from the investments in new plants, while costs can be saved through using the existing infrastructure for the distribution of fossil fuels. Expenses are considered as one of the main disadvantages of synthetic fuels compared to fossil fuels. Also, looking at the transport sector compared to battery electric vehicles the energy efficiency is 4-6 times lower. This can be compensated by generating this energy carrier in places with low costs in producing renewable energy, through for example high solar power (Frontier Economics, 2018). The costs of producing synthetic fuels depend on the different components of a PtX plant. For demonstration purposes a PtL plant is used as an example. Necessary components are a hybrid solar and wind energy plant, the seawater desalination, electrolysis, CO_2 capture plant and the Fischer-Tropsch-Synthesis. The costs distribution is demonstrated in Figure 12. Electricity generation expenses and electrolysis make up about one third of the total costs each. Due to these prioritizations the end user price is very determined by the electricity price of the production country. A comparison of different regions is shown in Appendix 2.

Figure 12: *Cost shares of PtL Production (Frontier Economics, 2018, p. 71)*



To sum up, outputs of PtX plants can range from water, electricity, heat, hydrogen, e-gas to liquid or chemical elements. How these outputs are used to generate a social impact is analysed in the following chapters.

5. Social Return on Investment Analysis

5.1. Project: Power-to-X plant in Morocco

The SROI-analysis is being carried out on a 100 Mega-Watt PtX-plant in Morocco. This size will most likely be used as the basis module for bigger plants, which is why it was chosen for the following analysis. At this state it is a merely hypothetical project and the plant has not been built yet. The plant is supposed to produce synthetic fuels or energies to be mainly exported to the European and more specific the German market. Besides the production of synthetic fuels it has a smaller reactor for the production of synthetic gas. The demand of a drastic CO_2 reduction in order to limit climate change implies a wide openness to all energy carriers. Synthetic fuels are one solution to contribute to this goal. To satisfy the consumption of energy in the world a PtX plant has to be sited at a location with optimal conditions. In a previous thesis, countries were evaluated on their suitability as a host country for a plant. Morocco has been chosen as one example for an optimal country in consequence of its perfect weather conditions and socioeconomic situation. Strong factors were the weather conditions for the production of renewable energy and the availability of a coastline with access to water. The climate of Morocco is ideal for running a renewable energy plant, as sun irradiations provide a high production efficiency everywhere in the country. Regions facing the Atlantic Ocean benefit from exceptional wind conditions, which enable to produce onshore wind based electricity at low costs. Moreover, production and transport costs needed to be low to be able to compete on the German market. The long coastline with large sparsely populated areas offers optimal locations for a plant without extremely impairing the population and environment. Socioeconomic factors included the political stability and the development and openness for renewable energies of a country. Morocco is already a trading partner of European countries with a quite stable political situation, with harbours along the coast ex- and importing globally and an existing gas pipeline. These can be used to export the synthetic fuels (Prié, 2019). According to Samir Rachidi (Appendix 3.5.), the national institute for energy research, studies have already been performed on the PtX potential of Morocco. This shows the openness of the country for new technologies.

5.2. Identified scope and stakeholders

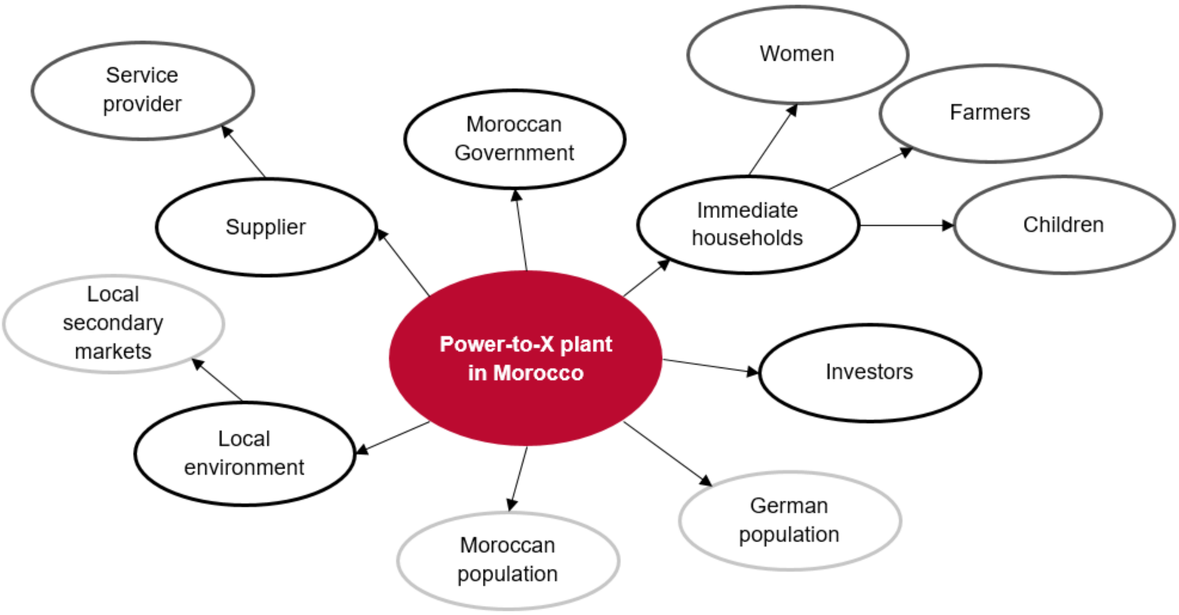
The first step in the SROI is the establishment of the scope and the stakeholders. The sustainable product development department at AUDI AG is analysing the location possibilities of PtX plants worldwide. These plants would be built by energy investors with a main economic objective. In the course of these analyses AUDI AG was interested in calculating the social sustainable impact of a PtX plant. To stress the importance a scenario with a 4%-investment was constructed. Meaning 4% of the revenue every year goes into social projects in Morocco. The result of several considerations led to this percentage as a result. First of all, conversation with national institutes in Morocco and private investors made clear that the investment has to be within a reasonable range to not scare investors off. On the other hand, it should not fall below a certain amount to achieve a considerable impact. The objectives hereby were to address the most severe social issues possible through the PtX plant. Audience for the SROI are governments from developed and developing countries, NGO's and especially potential energy investors. Its purpose is to increase the awareness of possible benefits of a PtX plant for developing countries. The activity includes the construction of the plant containing all relevant parts (see Chapter 4.). A time period of 5 years was taken to measure the social impact. This time period is the outcome of different calculations. A 10 year horizon resulted in a proportional impact to 5 years. Also, the uncertainty of the socio-economic circumstances rises with every year. A lower time horizon is unsuitable as well since the short term effects are much higher and deliver a wrong long-term picture of the real impact.

Table 1: *Scope of Power-to-X plant in Morocco (Own Illustration)*

<table>
<tr><td colspan="2">Organization:
AUDI AG</td><td>Carried out by:
Anna Maria Preissler</td></tr>
<tr><td colspan="2">Objectives:
Improve the social situation of the local population by addressing severe social issues through a Power-to-X plant in Morocco, which generates renewable energy carriers</td><td>Time period:
5 years</td></tr>
<tr><td>Audience:
• Producers/manufacturers that are potentially interested in building a Power-to-X plant
• Governments of developed and developing countries
• NGO`s
• German population</td><td>Activity:
• Build a Power-to-X plant in Morocco
• The plant includes a seawater desalination plant, solar and wind energy plant, Carbon dioxide capture plant, electrolyser and Fischer-Tropsch- and/or Methanation synthesis</td><td>Range:
Only focusing on the impacts for the population of Morocco</td></tr>
<tr><td colspan="2">Purpose:
• Increase the awareness of the possible benefits of a PtX plant for developing countries
• Attract potential investors</td><td>Forecast or Evaluation:
Forecast – the plant hasn't been built yet</td></tr>
</table>

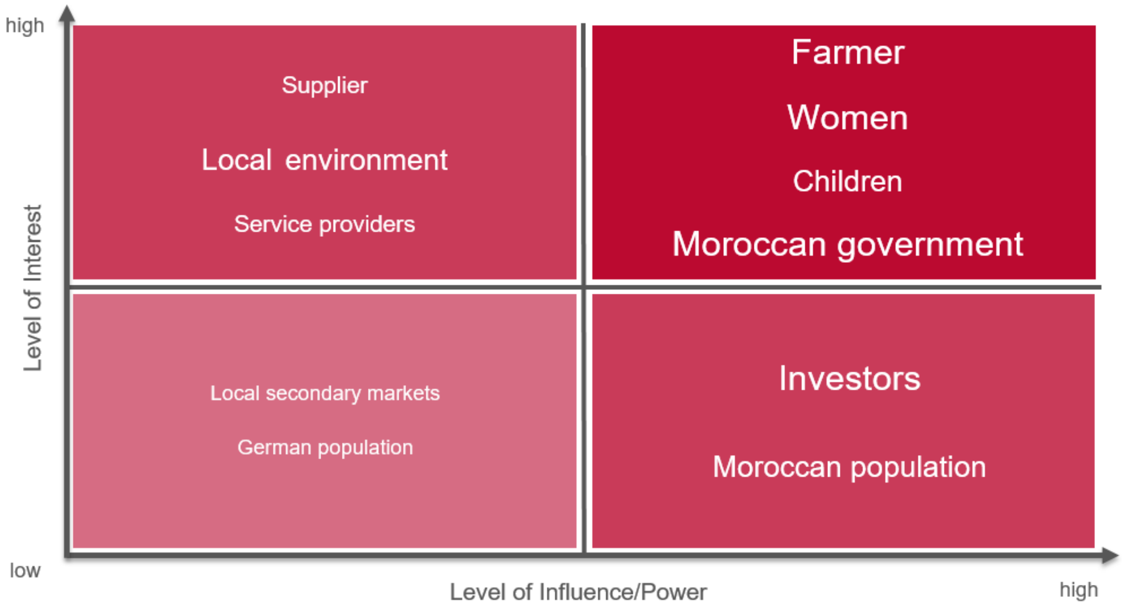
In a next step the relevant stakeholders were identified to find out how much value is being created or destroyed and for whom. At first all stakeholders directly or indirectly affected by the project were listed. A mind map was used as a tool to gather all thoughts. Mind Maps were invented by Tony Buzan as a cognitive note-taking technique to maximize the outcome of thoughts (Buzan & Buzan, 2006). Figure 13 shows the Mind Map created. The immediate households were further separated in their members. According to Ministry of Agriculture, Fisheries, Rural Development, Water and Forests (2014) 80% of the rural inhabitants are employed in the agricultural sector. On the basis of this data the assumption was made that every immediate household is farming. Stakeholder groups coloured in light grey are only indirectly affected by the plant. Black circles indicate a direct impact.

Figure 13: *Stakeholder Mind Map (Own Illustration)*



The identified stakeholders were then put in a stakeholder matrix based on two parameters. These are the extent of their power of influence – positive or negative – and their interest in the project dependent on the impact on them (Milani, 2019). Stakeholders with a high level of both parameters were used for the SROI. The size of the script in the Figure 14 indicates the size of the stakeholder group. Suppliers and service providers have a high level of interest in the project, because they benefit directly of the success of the plant. Local environment is a big stakeholder and has a high interest as well, as it is directly affected by the sustainability of the plant. All of them do not have a high influence on the implementation of the plant. Local secondary markets and the German population have very low influence and interest, because they are only indirectly affected. Investors are a big stakeholder with a high influence and power over the plant, they can decide whether or not it will be built. Their interest in the plant is rather low at this state of the project since there are no investors yet and the SROI serves inter alia as a tool to communicate to potential investors. The Moroccan population, which is not immediately locally affected has a high influence to stop or support through for example rallies and demonstrations against it. The support of the population is as important as the support of the local government, since the government will eventually follow the opinion of the population. People not directly living next to the plant do not have that much interest in the plant, therefore the level of interest was set at a low scale. The identified key players are farmers, women, children and the Moroccan government. To simplify the following calculations of the SROI it is assumed that every woman is responsible for household activities and is not a farmer. Because of this gendered view of responsibilities all household outcomes are calculated for women and all outcomes affecting the farm are calculated for farmers. This does not exclude that many outcomes have an impact on all members. They all have a high influence on the success or fail of the project and also have the highest interest as they are impacted the most.

Figure 14: *Stakeholder Matrix (Own Illustration)*



The Stakeholders were mainly involved through statistical information found through official data sources. During the research trip to Morocco several farmers and their families were interviewed on their farms to gain a deeper understanding over the potential impact on them. Further conversations with the chairman of a Moroccan NGO for rural development ‘Amis des ècoles’ were held. IRESEN ‘the National Research Institute for Solar Energy and New Energies’ and directors of local companies involved in governmental actions, were observed to represent the governmental opinion.

5.3. Mapping outcomes

This phase is usually the start of filling the first columns of the impact map with general information and the scope of the analysis. This part has already been shown in Table 1. The next step is the identification of inputs. Two major inputs need to be considered. First one is the investment taken each year for social engagement. The second part is invested by the farmers selling their land. The part of the plant including the seawater desalination, the electrolysis and the synthesis is not built on fertile land to minimize the negative effect on the local population. The energy park is built on fertile land to have a double land use effect. Some parts can be leased, but a proportion of area is permanently sealed for the construction of the windmills. This area is bought by investors from the farmers and cannot be used for agriculture anymore. The revenue, which would be created through this plant, is the input of farmers. To simplify the calculation wheat has been chosen as the crop cultivated on the farms. Cereals make up most of the agricultural production in Morocco, with wheat taking a large share (Food and Agriculture Organization of the United Nations, 2018). The following table shows the calculation of inputs from investors and farmers. The 4% investment are taken from the expected revenue of e-diesel sold in Germany. The input for farmers is calculated through the average yield, gained on an area with this size. To sum up, the total input over the time period of five years is ~7,500,000 €.

Table 2: *Input Calculation (Own Illustration)*

Data	Value
Annual e-diesel production [GWh/a]	300
Annual e-diesel production [l/a]	30,108,390
E-diesel purchase price in Germany [€/l]	1.25
Expected revenue of e-diesel [€/a]	37,635,488
Investment scenario [%]	4
Input from Investors [€/a]	**1,505,420**
Permanent sealed area per windmill [ha]	0.3
Average performance per windmill [MW]	7.5
Windmills needed for PtX plant	13
Permanent sealed area for Windpark [ha]	4
Reference price for wheat [MAD/t]	2,800
Cereal yield [kg/ha/a]	1,758
Yield for windmill area [kg/a]	7,031
Revenue for windmill area [MAD/a]	19,686
Input from Farmer [€/a]	**1,870**
Total input over 5 years [€]	**7,536,449**

The decision where the investment is going was set after the main social issues in Morocco were identified. The action fields where then aligned with the possibilities of the PtX plant. The literature analysis stated, that the problems of developing countries often repeat themselves (see Chapter 2.). Poverty in Morocco especially in rural areas stems from low income agriculture and the lack of access to basic services like safe water. According to Haut Commissariat au Plan (2014a) 62,2% of the rural population does not have access to running water and only 16% of the cultivated land is irrigated. This has several reasons. Morocco is ranked as one of the 25 most water-stressed countries in the world. Water supply is low to begin with, but rising demands through a fast growing population and economic development and climate change have pushed Morocco further into extreme stress (Hofste et al., 2019). A second reason is the missing infrastructure in the rural regions. Irrigation plays a fundamental economic and social role. The 16% irrigated land generate half of the agricultural Gross Domestic Product and 75% of agricultural exports, generating a far higher income for farmers (The World Bank, 2018d). Safe and readily available water for households on the other hand is one of the most effective instruments in promoting health and reducing poverty (World Health Organization, 2019). Combining these two aspects shows the great importance of water for the local population. The PtX plant includes a desalination plant, which produces safe water. Due to the big importance of water for the reduction of poverty half of the input is put into the supply of water.

One quarter is invested into the supply of synthetic gas. Morocco's households mainly use gas for cooking and heating, because the government subsidizes the supply. Poor households, which cannot afford it, collect firewood and animal waste. Those produce toxic gases when burnt and are the major source of indoor pollution. The supply of e-gas addresses the energy poverty in households. Inter alia due to the high usage of firewood for cooking and heating Morocco is losing about 30,000 hectares per year to deforestation (Global Forest Watch, 2015). Planted forest are expanding at an average annual rate of 8%, well below the optimal rate of 15 to 20% needed to maintain the ecological balance. Forests play a critical role in stabilizing the climate, providing food, preserving the scarce water resources and especially protecting the soil from eroding (Food and Agriculture Organization of the United Nations, 2016b). Argan trees make up 18% of Morocco's forests and have a major economic matter. The oil made from the fruits is exported worldwide today for cosmetic products and culinary virtues. Many rural households are dependent on the oil production (Lybbert et al., 2010). Due to the economic and ecologic importance of Argan trees the last quarter is invested into reforestation and sustainable education. The training is especially important for children to not only give them future economic security, but also make them aware about the importance of sustainability. Amal Zniber (see Appendix 3.2.) highlighted the necessity of education for the change of the local population as well. According to her education delivers the basis for further action. Conversations with farmers (see Appendix 3.1., 3.3. and 3.4.) showed even clearer the lack of understanding of the complex contexts of resource use and sustainability. Knowledge of water scarcity was not present since these farms did not have a problem with water delivery. For this scenario the decision fell to only educate children through schools. This was due to the rising complications to get time and access to people out of school. In addition, it is easier for children to adapt their behaviour and the success rates are much greater. A real support is therefore given through a combination of economic opportunities today mainly for adults and development and education for self-support for the future.

Table 3: *Output Calculation Part 1 (Own Illustration)*

Data	Value
Input from Investors over 5 years [€]	7,527,098
Input in water production [%]	2
Input in water production over 5 years [€]	3,763,549
Water production costs [€/m³]	0.212
Water output over 5 years [m³]	**17,752,589**
Input in e-gas production [%]	1
Input in e-gas production over 5 years [€]	1,881,774
E-gas production costs [€/kg]	1.46
E-gas output over 5 years [kg]	**1,288,887**
Input in reforestation [%]	$\frac{2}{3}$
Input in reforestation over 5 years [€]	1,254,516
Reforestation costs [€/ha]	1,165
Reforestation output over 5 years [ha]	**1,077**
Input in sustainable education [%]	$\frac{1}{3}$
Input in sustainable education over 5 years [€]	627,258
Sustainable education costs [€/student]	135.22
Sustainable education output over 5 years [students]	**4,639**

The table above shows the calculation of part of the output resulting from the specific fields of investments. Depending on the costs of the production in the case of water and e-gas and the input share, the output of water sums up to 17,774,643 m^3 and the output of e-gas sums up to 1,290,488 kg over the time period of five years. The output of reforestation and sustainable education depends in the input share and the costs per hectare or per student. All together an area of 1,078 hectare are reforested and 4,644 students are educated.

Table 4: *Output Calculation Part 2 (Own Illustration)*

Data	Value
Annual production of renewable energy [GWh/a]	576
Overlap [%]	3.5
Annual electricity output [GWh/a]	20.16
Electricity output over 5 years [GWh]	**100.8**
Jobs for photovoltaic plant	200
Jobs for wind park	18
Jobs for rest of plant	158
Long term employment output	**376**
Required area for renewable energy plant [ha]	670
Permanent sealed area [ha]	4
Land lease output [ha]	**666**
Sale of land output [ha]	**4**

Four other outputs occur only through the plant itself. As mentioned before one input paid by the farmers is the loss in agricultural land for the permanent sealed area. This loss is happening through the sale of four hectares of land, which can also be seen as an output. The other area still has to be leased by the investors to be able to use it. This land can still be used for cultivation by the farmers and additionally they have the land lease of 666 hectare as an output. The second output stems from employment. A PtX plant consists of several components, which have to be operated and maintained by workers. The long term employment has an output of 376 people. The renewable energy part of the plant has to deliver enough electricity to power the plant full-time. This is only possible when a certain overlap during peak times is accepted. This overlap results in an electricity output of 100.8 Giga-Watt-hours over the time period of five years.

Impact Value Chains

The outcomes are described in an impact value chain for every stakeholder group. The impact value chains (see Appendix 4.1., 4.2., 4.3. and 4.4.) do not include the activity of building the PtX plant, since it repeats itself for every group and they do not include the impact, because at this state it has not been calculated yet. The outputs clarified before do not affect all stakeholders the same way. For women relevant outputs are water, e-gas, reforestation, long term employment and electricity – shown in the impact value chain in Appendix 4.2. The starting outcome of electricity is the access to it. Due to the free supply women save costs leading to the final outcome of higher household, for which women are responsible. The electricity supply for households has to be seen critical. It is generated from wind and solar plants, which are very fluctuating due to their dependence on the climate conditions of wind and sun every day. The use of the renewable energy plants is maximized producing only a slight overlap every year. This overlap cannot be considered as a regular amount of electricity on a daily basis, but rather as an excess over a few weeks or days. Therefore, households cannot be supplied with free climate-neutral electricity every day. Still it can have a significant impact over the whole year.

Water as an output has a much bigger influence on women. The water from the desalination plant can be used as drinking water for the whole household and serves as the starting outcome. Women spend less time on collecting water, have a lower risk of water-related diseases – this counts for all household members - and cost savings for potable water. Without access to a tap, water has to be collected from wells, rivers and other sources. The time necessary to collect the amount of water for the whole household is restricted by the physical possibilities and the distance to the source. This time can be used for wage-earning activities delivering an own or higher income for women. Additionally, water from sources outside the house are often contaminated and lead to water-borne diseases, most commonly are diarrhoeal infections. A lower risk leads to less sick-days and therefore again more time for wage-earning activities giving an own income. Higher financial assets are also achieved for the minority of women living in houses with access to running water saving the monthly supply costs.

The e-gas can be used for heating and cooking. This affects women, because it means less time spent on collecting firewood and access to clean cooking and therefore a lower risk of illnesses due to indoor pollution. Many households still use solid fuels, such as firewood, animal waste or coal in open fires as cooking fuel, which leads to major indoor pollution. 3.8 million people a year die worldwide prematurely from illness attributable to the household air pollution (World Health Organization, 2018). Again, eradicating this health deficit leads to less sick days. Women also benefit from the cost savings they have for firewood and coal right now. Households already cooking with gas save these costs. They further gain the opportunity through reforestation of Argan trees to get access to jobs in the Argan oil production to have an additional employment opportunity. Another possibility of working arises through the long term employment on the plant. In summary all outcomes lead to the final outcomes of either an own or additional income for women or higher household assets.

The next stakeholder group of farmers is affected by the output of water, land lease, sale of land and long term employment. From water they get access to irrigation water to increase the agricultural production and the land lease for the renewable energy plants gives them an additional income through the rent they receive. One big benefit out of it is the continued use of the land for cultivation. In the course of the analysis the consideration of including the possible effect of agrivoltaics came up. This means using a field for agriculture and solar modules to gain a bigger land use effect. The Fraunhofer Institute for Solar Energy Systems is currently analysing the impacts together with a farm in Baden-Wuerttemberg. First results show a benefit for both sides. Agricultural crop yields increase due to a soggier soil through the partial shadowing of the solar panels. These need lesser cooling due to the moister soil underneath them (Fraunhofer-Institut für Solare Energiesysteme ISE, 2019). The technology is not researched far enough to consider the possible impact on the farmers in the following calculations. The rest of the land, which they cannot use anymore, is being sold to the investors, who are paying a financial compensation for it. The long term employment output is relevant to both stakeholder groups' women and farmers. Like for women it results in access to jobs on the plant. For farmers all outcomes lead to either a higher income or higher farm assets.

Children are the last member of households impacted by the plant. They gain from the outputs water, e-gas and sustainable education. The outcomes following water and e-gas are the same as for women. The time available through both outcomes can be used for education, followed by more employment opportunities in the future and with it a higher future income as the final outcome. Reasons for the low schooling rates especially of girls are obligations to help with household duties. Boys leave school when they are old enough to help on the farm. Other limited factors include the long distances to schools and the bad conditions with missing sanitary facilities or heating. These precarious terms make it hard for schools to find teachers in remote areas (see Appendix 3.2., 3.4.). Outcomes of sustainable education of other projects, such as the litter less campaign in eco schools show significant changes in children regarding knowledge gain across multiple disciplines focusing on environmental issues, emotional and social skills and civic interest and engagement with a rising feeling of civic engagement. To sum up, the perception, the behaviour and the opinion leadership levels change (Foundation for Environmental Education, 2017). These outcomes are quite important for the future of these children and their surrounding even though they are not fully measurable in quantitative terms. To stress the significance, they are still mentioned in the impact value chain leading to a higher future wellbeing.

The sustainable education impacts not only the children. The project in eco schools showed the change in behaviour especially in solid waste dumping in the open. The collection of solid waste usually takes time and money, which can be saved through more sustainable actions. The government also benefits indirectly from the water and e-gas supply of the population, because less subsidies are necessary for support. The electricity grid feed has a positive impact on the share of renewable energies in the country and therefore the avoided CO_2 costs. In other cases, electricity for the plant would be used from fossil energy sources. Furthermore less own electricity production is necessary, which is quite important since Morocco is importing 91% of its total energy use, making it highly dependent on other countries (The World Bank, 2014a). The Argan trees reforested absorb CO_2, which helps the government to avoid social costs. Additional income tax occurs from the newly created jobs on the plant. All of these outcomes benefit the government in form of a higher state budget.

This chapter fully describes the different parts of the impact value chain for all stakeholder groups. The inputs identified and valued, result in several outputs leading to a chain of events of outcomes. These different outcomes all direct to one or more final outcome for every stakeholder, valued in the following chapters and finally used to calculate the SROI.

5.4. Evidencing and valuing outcomes

One major aspect of a SROI is the monetarization of outcomes. Indicators are used to measure the evidence on the outcome that is occurring. Based on the impact value chains for the stakeholders most of the tracers are quite straightforward. Most outcomes can directly be used as indicators, including more time for own use, cost savings, less subsidies, additional income tax, one-time payment as financial compensation and the rent received for leased land. For the shrinking necessity of electricity production, the costs of producing electricity are being used. New and additional employment opportunities for different stakeholder groups are listed through the wage earned in this job category. For farmers the increase in agricultural production is measured with the higher revenue received from it.

Collection of Data and Quantification of Outcomes

In a next step data about the outcomes was collected to support the calculations. All data is mainly based on official governmental or non-governmental platforms and is supported by observations from the research field trip to Morocco and statements of representatives of the stakeholder groups. Afterwards the quantified outcome for every output was measured. The following tables demonstrate the calculations for every output. In general, the reach of the outcomes is determined by the amount of output and the demand by the households and farms.

Table 5: *Quantified Outcome of Water (Own Illustration)*

Data	Value
Water output over 5 years [m^3]	17,752,589
Annual water output [m^3/a]	3,550,518
Potable water demand per household [m^3/a]	96.73
Need of irrigation of wheat per farm [m^3/a]	8,925
Total water demand of farm and household [m^3/a]	9,022
Reach of outcome: Households with farm supplied with water	**394**

The table above shows the calculation of outcome of water. Due to the already explained circumstances of the rural population in Morocco (see Chapter 5.2.) households and farms are considered as one social complex. Thus, water demands for both were considered. The water demand for households is set according to the suggestions by the World Health Organization (2020). For farming a medium amount of irrigation water requirement was taken to measure. Together the need of water is 9,022 m^3 per year. The water output per year divided by the demand gives the outcome of 394 households with farms permanently supplied with water. In the full version of calculations (see Appendix 5) the outcome of water is demonstrated in three options. Option one is shown in Table 5. The second option describes the situation if only households are supplied with potable water. Therefore, much more people could be reached, because the amount for daily needs is much smaller than the agricultural water needs. Option three is the case in which only farms are supplied with irrigation water. The last two possibilities are not used in the final calculation of the SROI.

Table 6: *Quantified Outcome of e-gas (Own Illustration)*

Data	Value
E-gas output over 5 years [kg]	1,288,887
Annual e-gas output [kg/a]	257,777
Consumption of Butane per person [kg/a]	60.21
Equivalent consumption of e-gas per person [kg/a]	53.95
Household demand of e-gas [kg/a]	285.94
Reach of outcome: Households supplied with e-gas	**901**

Second outcome is calculated in Table 6. Gas only affects households, since farming is mainly a manual work in Morocco without machinery. The population, which has access to gas is consuming butane, due to the different heating values of gases the equivalent value of e-gas is a little bit smaller. With the output of 257,777 kg e-gas per year 901 households could completely be supplied. Again, the outcome is based on the number of households supplied and not individuals, to stress the main importance of the social complex.

Table 7: *Quantified Outcome of Reforestation, Sustainable Education and Electricity (Own Illustration)*

Data	Value
Workers for Argan oil production [capita/ha]	3
Reforestation output over 5 years [ha]	1,077
Reforestation output [ha/a]	215.42
Reach of outcome: Households with additional employment	**646**
Sustainable Education output [students]	4,639
Average number of children per household	3.3
Reach of outcome: Households supplied with sustainable education	**1,406**
Electricity output over 5 years [GWh]	100.8
Annual electricity output [GWh/a]	20.16
Electricity consumption [MWh/a]	0.9
Electricity consumption per household [MWh/a]	4.77
Reach of outcome: Households supplied with electricity	**4,226**

The next two outputs affect in the first place specific stakeholder groups. Employment in the Argan oil production are especially for women. For every hectare of trees, a certain number of workers are needed. Every household has on average one women, one man and 3.3 children. The reforestation output per year divided by the number of workers per hectare provide 646 households with a new employment opportunity. Sustainable education is a specific action for children. All together 1,406 households are affected by the new learning possibilities of their youngest members. Electricity affects everyone living together. The consumption in Morocco per person is very low today, which is why a high number of 4,226 households can be supplied with renewable electricity from the PtX plant.

Table 8: *Quantified Outcome of Employment and Land Lease (Own Illustration)*

Data	Value
Long term employment output	376
Average number of people of working age per household	2
Reach of outcome: Households with new employment	**188**
Land lease output [ha]	666
Average farm size [ha]	3
Reach of outcome: Farms leasing agricultural land	**222**
Sale of land output [ha]	4
Average farm size [ha]	3
Reach of outcome: Farms selling agricultural land	**1.33**

Long term Employment on the PtX plant, Land lease and Sale of Land are the last two outputs. Employment on the plant can affect farmers and women – forming the working age group in every household. Following this assumption 188 household will have new employment opportunities for two people. 222 farms also lease their agricultural land for the renewable energy plant, starting from an average farm size of three hectares.

Duration of Outcomes

Most of the final outcomes relevant to the stakeholders last only as long as the activity of operating the plant does. If the investors stop financing the facility or just stop to invest in these social inclusion projects, the outcomes disappear, too. In general, they can be divided into two groups. One group consists of outcomes depending on the duration of the plant operation and the other group with outcomes independent of the duration and having a much longer effect. The first one includes the following. For women, an own or higher income through more time for wage earning activities and jobs on the plant and higher household assets through cost savings, only exists during the plant. For farmers all outcomes leading to the final outcome of a higher income and cost savings leading to higher farm assets are dependent. The increase of the state budget is also bound to this condition, except the avoided social costs through the new Argan forest areas, which exist also after the plant is shut down. In addition to it the second group with outcomes independent of the duration, only comprises the hereafter. For women the higher income through the employment opportunity in the Argan oil production – this is the same reason as for the government - and for children the higher future wellbeing from access to sustainable education and the higher future income are independent of the plant. The benefit for children only increases with the years of education, but also only a short-time of education already has an effect lasting longer than the duration of the plant. In conclusion all of the outcomes are calculated for the whole time period of five years except for the financial compensation for sale of land, which is only a big one-time payment.

In a next step the final outcomes were valued using the data collected before. In the full version of calculations every output has its own excel spreadsheet. In it all data concerning this output can be found including the outcome and its value for the stakeholder groups. In the following section the value of outcomes is explained separately for every stakeholder.

Value of Outcomes

Women get an overall value of 2,462,968 € per year. It is split up in the outcomes described before. To calculate the value of additional income through the time gained from collecting water, the average time spend per round and the demand of water per household are taken to calculate the total time needed for water per day. This is then put on a level with the wage, which would be earned during this time according to the minimum wage in agriculture in Morocco. The final value is calculated for the share of household without access to potable water of the ones the plant is able to supply. An additional income of 249,389 € per year is the result. For the health effect the DALY’s caused due to water-borne diarrhoea for the whole country are down scaled to the 245 households. DALYs is an acronym for disability-adjusted life years describing the years lost due to death and sickness (Institute for Health Metrics and Evaluation, 2016). The time gained for wage-earning activities add up to an income of 27,591 €. Women living in houses with water access safe 10.14 MAD per cubic meter they use according to the water tariffs. All together an additional household asset of

13,861 € (see Appendix 5.1.). Access to e-gas ends in three final outcomes. Additional income merges from the time gained through less sick-days and less time spent gathering firewood. As proxies the share of rural population using firewood for cooking and heating, the average time spend on collecting firewood and the minimum wage in agriculture is used. This time is worth 126,232 € per year. The DALYs lost due to indoor air pollution are again down scaled to the number of households using unclean fuels. This includes the use of animal waste, firewood and charcoal. The gain is 2,425 € for all. Cost savings occur for households with access to gas and the ones paying for the supply of firewood and charcoal. For both the demand, the price for each and the share of the population using either gas or firewood and charcoal. Savings amount to 30,559 € for unclean fuels and 98,521 € for gas (see Appendix 5.2.). The additional income from the employment opportunity in oil production merges from the Argan tree reforestation. The income of 76,109 € in the first year, increases every year proportionally with the area reforested every year. For the calculation the average yield per hectare and the amount of fruit necessary to produce one litre of Argan oil are used. Together with the time necessary and the minimum wage in agriculture the additional income is calculated (see Appendix 5.3.7). The value of 1,725,595 € additional household assets through cost savings for electricity are taken from the average demand and the price per kilowatt-hour in Morocco (see Appendix 5.5.). The higher income through a new employment opportunity on the plant is only counted in half, because it is an outcome for farmer and women. For women and farmer this is equally 1,112,878 €.

Table 9: *Proxies for Valuing Outcomes for Women (Own Illustration)*

Starting Outcome	Outcomes	Indicator	Proxy
Access to potable water	Less time spent on collecting water → more time for wage-earning activities	Own / More income	Average time spent on collecting water per round
	Lower risk of water-related diseases → less sick-days → more time for wage-earning activities		DALYs lost due to water-borne diarrhoea
	Cost savings for potable water	Higher household assets	Water tariffs of Morocco
Access to e-gas	Less time spent on collecting firewood → more time for wage-earning activities	Own / More income	Average time spent on collecting firewood
	Access to clean cooking → lower risk of illness due to indoor pollution → less sick-days → more time for wage-earning activities		DALYs lost due to indoor pollution
	Cost savings for gas supply	Higher household assets	Gas price in Morocco
	Cost savings for firewood and charcoal supply	Higher household assets	Average expenditure for firewood and charcoal per household
Access to jobs in Argan oil production	Additional employment opportunity	Own / More income	Average time spent on producing Argan oil from one hectare
Access to electricity	Cost savings for electricity	Higher household assets	Electricity tariffs of Morocco
Access to jobs on plant	New employment opportunity	Higher income	Average salary in private sector

The total value for farmers is 976,153 €. Most of it is coming from the outcome of access to irrigation water. The higher income stems from the increase in agricultural production. For the calculation the selling price for wheat and the average yield per hectare sum in the average revenue for a farm. This is multiplied with the average increase in agricultural production through irrigation to give the total additional revenue. This number is then up scaled to the share of farms supplied with water, which did not have irrigation before. The value of a higher income adds up to 714,085 € per year. The other 16% of farms, which already have irrigation, benefit from the 15,483 € cost savings for supply. These are dependent on the demand per farm and the irrigation water tariffs in Morocco. Farmers directly impacted by the plant also have an additional income of 113,707 € for the lease, measured by the purchase price of agricultural land and the average buy/rent ratio, which give the average lease for land and the required area for the renewable energy plant. Additionally, the value of the one-time payment of 20,000 € for the financial compensation for sales of land requires the purchase price and the area of the permanent sealed ground.

Table 10: *Proxies for Valuing Outcomes for Farmers (Own Illustration)*

Starting Outcome	Outcome	Indicator	Proxy
Access to irrigation water	Increase in agricultural production	Higher income	Average increase in agricultural production through irrigation
	Cost savings for irrigation water	Higher farm assets	Irrigation water tariffs of Morocco
Land lease for renewable energy plant	Rent received for leased land	Higher income	Average rental price of agricultural land
Financial compensation for sale of land	Receipt of one-time payment	Higher farm assets	Average purchase price of agricultural land
Access to jobs on plant	New employment opportunity	Higher income	Average salary in private sector

Children get a value of 86,152 € per year. Because of the only qualitative outcomes of sustainable education for children, they are not included in Table 11. The additional time from access to potable water and e-gas for education is calculated similar to the time for wage-earning activities for women. For children the future income depends further on the average future wage increase through additional school years. The value adds up to 57,199 € for water and 28,952 € for e-gas.

Table 11: *Proxies for Valuing Outcomes for Children (Own Illustration)*

Starting Outcome	Outcome	Indicator	Proxy
Access to potable water	Less time spent on collecting water → more time for education → more future employment opportunities	Higher future income	Average future wage increase through additional school time
Access to e-gas	Less time spent on collecting firewood → more time for education → more future employment opportunities	Higher future income	Average future wage increase through additional school time

The value of 14,938,890 € is the total benefit for the government. The proxies chosen to calculate the value of outcomes are shown in Table 12. First part is the higher state budget through lesser subsidies paid. For the calculation the real water price in both cases and the end user price are significant to get the subsidies paid for it. This multiplied with the farms already under irrigation and the households with tap water gives the total value of 5,161 € saved for irrigation water and 3,636 € subsidies saved for potable water. The subsidies saved for e-gas supply of population are even greater with 163,994 € per year. Benefits from electricity grid-feed are split into the avoided CO_2 costs and the decreasing electricity production. The average price for electricity is multiplied with the total grid-feed. The result value of 2,020,919 € is the amount saved for the power production. The avoided CO_2 costs saved, are measured with the average CO_2 avoidance costs of renewable energy plants up scaled to the planned size for the PtX plant. These cost savings add up to 12,297,936 €. Fourth part is the additional income tax from employees on the plant, making up to 445,151 € per year for all workers. Through reforestation the government saves social costs of 66,263 €, like for women this amount rises every year proportionally with the area of new Argan trees and therefore the absorption of CO_2. The last part is the changing behaviour of children on the basis of sustainable education. They dump less solid waste in public, which has to be collected. The average costs of solid waste collection multiplied with the decreased dumped waste adds up to 2,093 €.

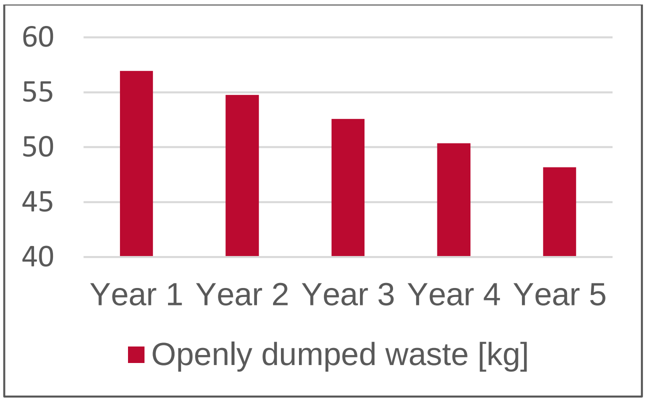
Table 12: *Proxies for Valuing Outcomes for the Government (Own Illustration)*

Starting Outcome	Outcome	Indicator	Proxy
Water supply of poulation	Drinking water supply → less subsidies necessary	Higher state budget	Subsidies paid for potable water
	Irrigation water supply → less subsidies necessary		Subsidies paid for irrigation water
E-gas supply of population	E-gas supply for cooking and heating → less subsidies necessary	Higher state budget	Subsidies paid for gas
Electricity grid-feed	Less electricity production necessary	Higher state budget	Average price for electricity
	Higher share of renewable energies in electricity mix → avoided CO_2 costs	Higher state budget	Average CO_2 avoidance costs for wind and solar plants
Access to jobs on plant for population	Income tax	Higher state budget	Income tax rate
Argan forest areas	CO_2 absorption by trees → avoided social costs	Higher state budget	Average social costs of CO_2
Access to sustainable education for children	Change in behaviour of children → cost savings for solid waste collection	Higher state budget	Average costs of solid waste collection

5.5. Establishing impact

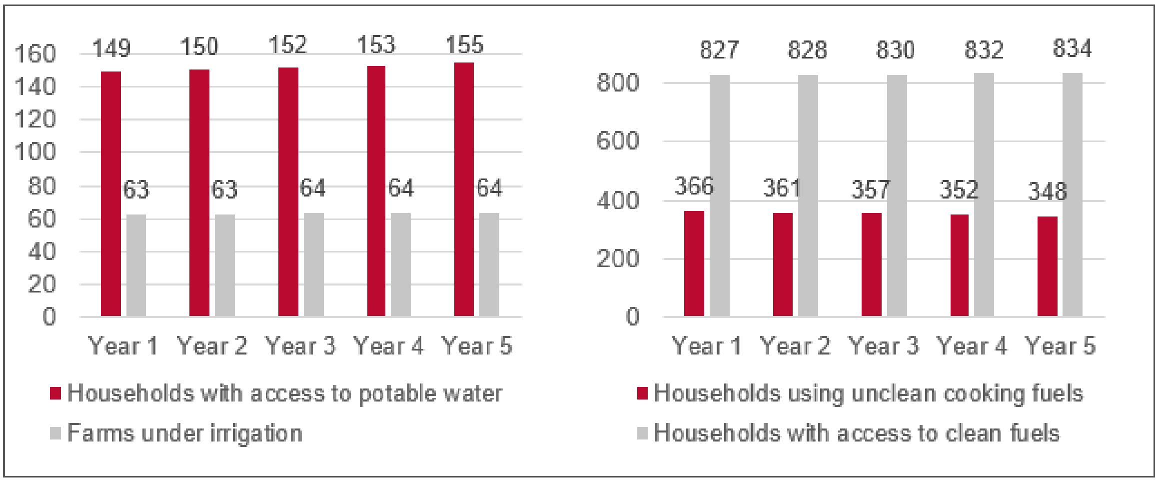
For some values of outcomes calculated in the chapter before there is a certain deadweight and miss-attribution. The change towards a more sustainable behaviour is estimated to rise anyway every year due to the growing awareness of the importance of sustainability. For the difference in behaviour an estimation was taken based on the statements of Amal Zniber (see Appendix 3.2.). Figure 15 shows the change in behaviour of openly dumping waste. The amount shrinks over the time period.

Figure 15: *Deadweight of Openly Dumped Waste (Own Illustration)*



Some attribution has to be given to the government for the improvement in living standards, like rising access to potable water and gas in rural areas. This assumption is based on the change in access to basic services in the last ten years. The percentage difference is assumed to continue. The percentages where then projected on the time period of five years taken for the SROI. The number of households and farms is already adapted to the number of households supplied with water and gas. The change in farms under irrigation is much smaller due to the high water scarcity especially in the south of the country. The decreased use of unclean fuels cannot be fully attributed to the government, it is more a mixture with deadweight. 93% of households already have access to clean cooking fuels, still 41% of the rural population uses unclean fuels, because they are cheaper. The decreasing number of households using unclean fuels is more due to the fact that more people become aware of the negative environmental and health effects of unclean fuels. Normally the deadweight and attribution are subtracted as a percentage from the outcome. In this case the outcomes decrease through improvements in public services or knowledge over time, which directly affects the households with farms. This is the reason why the percentage change is directly subtracted from the range of outcomes.

Figure 16: *Change in Attribution (Own Illustration)*

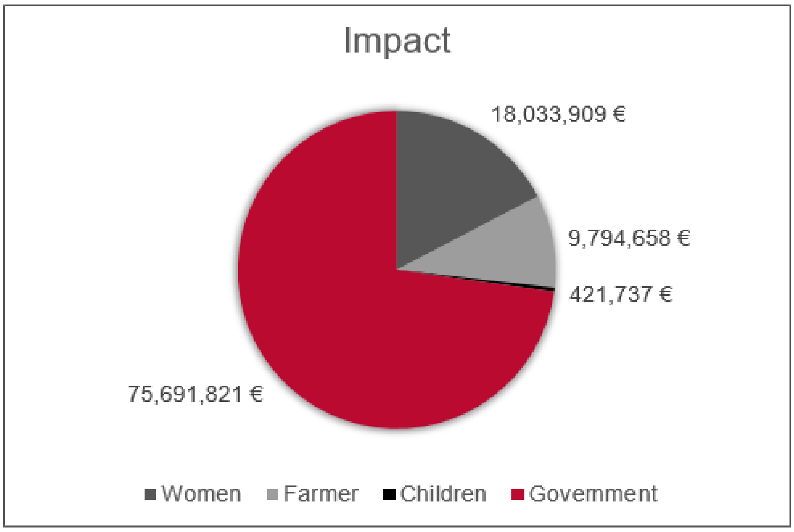


Usually a certain drop-off is calculated for the outcomes, due to the reason that most outcomes normally wear off after some time. This is not the case for the scenario used in this SROI. The amount of output is dependent on the production of the PtX plant. The economic character of it guarantees the consistent efficiency of all parts. Thus, the outcomes mostly dependent on the operation of the plant will stay the same. In any case the outcome would even rise with the years due to rising wages and with-it end-user prices for electricity, gas and so on, but this is not included, because it could only be based on very vague estimations. The establishments are documented in the Appendix 5.11.

Impact Calculations

From every value calculated in Chapter 5.4., the deadweight and the attribution are deducted accordingly. Figure 17 summarizes the impacts on each stakeholder group over the total timer period of five years. For the three household members the impact cannot be strictly seen as the impact only on them. Children get the smallest monetary share of the total impact of 421,737 €, this is due to the left-out calculation of the qualitative impact of sustainable education. For children the indirect effects dedicated to the higher income of their parents and higher living standards are estimated to be much higher. Indirect impacts are not included in the SROI. Women benefit most of the private stakeholders, but many impacts calculated for women are relevant to all, like health effects. The higher income of women and farmer advantages not only their households and farms, but also the whole region. A higher well-being and income make it possible for communities to help and support disadvantaged people more and benefits small businesses around through the higher consumption. Another example is rising wages in local firms, through the participation of them in the supply chain. The highest share goes to the government with 75,691,821 €. This impact consisting of cost and subsidies savings and higher taxes has an even greater effect on the whole population of Morocco, as this money can be taken to further invest in the country.

Figure 17: *Impact on Stakeholder Groups (Own Illustration)*



5.6. SROI Calculation

For the final SROI the impact calculated is discounted, recognising the time value of money. Discounting can be seen controversial as it encourages short-termism by reducing the value in the future, especially for environmental considerations, where effects are often even greater after some time. For this project social factors play the greatest role and the focus is on small low-earning rural households. In these areas the time till money is received, counts. The basic 3.5% discount rate recommended is used to give the total present value of 93,819,585 €. The calculations were made according to the formulas explained in Chapter 3.2.4. For the Power-to-X project in Morocco there is 12.45 € of value for every 1 € of input. This ratio shows the high impact of, in comparison a small investment on Morocco. The social value created exceeds the investment by far.

Table 13: *SROI ratio (Own Illustration)*

Data	Value
Total impact [€]	103,941,182
Total present value [€]	93,819,585
Total input [€]	7,536,449
Net present value [€]	86,283,136
SROI [€]	93,819,585 ÷ 7,536,449 **= 12.45 : 1**

Estimating the importance and sensitivity of all elements of the SROI model helps to prioritize the outcomes based on their social meaning. Changes in deadweight and attribution are not very sensitive. This demonstrates the independence of the impact of the PtX plant of general improvements of basic services for the population. On the contrary changing the capacity of the plant from 100MW to 1MW doubles the social value of the SROI ratio. This is mainly due to the fact that employment in higher paid jobs is very important and plays a large role in the life of the rural population. The number of jobs would be smaller, but still have an immense impact. The overlap production of electricity would still benefit the government a lot, but the reach of outcomes, which mainly benefit the local population would decrease to an insignificant level. This would mislead the sense of a social inclusion project to benefit the local rural population. The greatest change on the SROI ratio would be leaving out the consideration of the impacts of electricity supply. The effects would end in a ratio of 2.84 € : 1 €. Even then the ratio is not set equal. The wide diversity of potential outputs of the Power-to-X plant makes it impossible to set the ratio into a negative or neutral outcome only by changing or taking out one output.

6. Implications of SROI results

The usual last step of reporting of the SROI is included in this chapter. The performance of the SROI analysis aimed at evaluating if renewable energy carrier generation projects, like a Power-to-X plant can generate social benefit or rather harm the local population of developing countries, like Morocco. The SROI ratio of 1 € for 12.45 € of social value measured for the key stakeholder groups women, farmer, children and the Moroccan government, clearly shows the large social benefit such a plant can have. Throughout the analysis several key factors were found to help solve the social problems of Morocco. Water, produced in a desalination plant as part of the PtX facility, can additionally be used to supply the local population. Together with the supply of gas, it can immensely improve the health conditions. For all physical outputs supplied the outcome of additional time for work for women or education for children has one of the greatest values. Another key factor for households is the possibility of new or additional employment in higher paid jobs. It has one of the greatest impacts on the families. Overall the biggest monetary impact relates to the government, which is representing the national population. The result of the high SROI ratio shows the big benefit of investing in the social inclusion through a PtX plant.

The SROI ratio is built on many different outputs showing the diversity of benefits a PtX plant delivers to the local population. Since the specifications for the target of the investments were left quite open from the commissioning organization all options were checked. At first sight a PtX plant producing synthetic liquid fuel would deliver the optimal conditions for supplying the locals with fuel for their agricultural machinery and cars. During the research about the living conditions of Morocco it got clear that almost no farmer and household owns fuel powered vehicles, which was confirmed by Amal Zniber (see Appendix 3.2.). So, the decision fell against investment in the supply of liquid fuels. These calculations are demonstrated in Appendix 5.9. This result builds on the existing theory that most households travel far distances to school or to gather water by foot (Haut Commissariat au Plan, 2014a). Motorized means of transport would be useful, but until then fuel would not have any social impact. Water as an output has one of the biggest impacts. Supplying only the households with drinking water would have an even bigger effect, because many more people could be reached. The impact would be 30 times as high as on households combined with farms (see Appendix 5.1.). The third option was to only supply the farms with irrigation water, this would have the smallest impact. Still the decision fell to supply a household with the farm, because it is important to see the combination of both as one social complex. Supplying only households with water would mean that with growing water scarcity people would fall into poverty again, because the rainfed agriculture will not be able to supply enough food. Therefore, a real social impact can only be created by considering all aspects. The supply of e-gas only slightly exceeds the investment. Still it is quite important, due to additional environmental factors of supply of e-gas. These are not considered in the calculations, but during the research it got clear that Morocco loses large areas of forest every year due to deforestation, because many households still use firewood for cooking and heating (Global Forest Watch, 2015). The literature research did not show the access to clean energy as one of the major problems of developing countries, but in Morocco the share of households using unclean fuels is still quite large, because it is cheaper than buying gas (The World Bank, 2019d). Since the plant can produce renewable gas it was an easy path to improve the social life and the environmental situation. This was also the reason for the investment into reforestation. Planting Argan trees does not only give an additional opportunity of employment for women, but also helps to reduce the environmental degradation, reflected in the avoided social costs for the government.

The supply of electricity mainly benefits the government, due to the previously explained conditions of the plant the overlap does not guarantee a continuous supply of electricity for the population. This is not a big problem since these results do not contradict with the existing evidence of almost complete access to electricity from the grid. Only the costs for it would be saved, which still make up a large sum. The theory clearly states that one of the major aspects of poverty is the low income through resource-based and volatile rainfed agriculture (Taqeem Initiative, 2018; The World Bank, 2018c). One part of improvement is irrigation to increase and stabilize the agricultural production and the other part is the opportunity of new employment. In Morocco the minimum wage in agriculture and the wages in the private and public sector vary greatly (The World Bank, 2018c). Creating well-paid jobs helps to reduce poverty for the whole household. Additionally, it increases the tax income of the government. The land rent received does not have the greatest monetary effect but is still useful for the farmers. Building a plant somewhere takes up space, which normally cannot be used for other purposes. With the operation of a renewable energy plant it gets possible to raise the land use efficiency, by letting the farmer keep the land and cultivating it and leasing it to use it for solar and wind power.

The impact on women is the second largest and is emphasized due to the importance of it. The outcomes for women confirm the gathered information in the literature about the social standing of women in Morocco. The gendered distribution of roles and the circumstances of the basic supply often restricts women to household duties and childcare, leaving them no opportunity for own wage-earning activities. Men are responsible for this part giving them a higher decision power than women (Taqeem Initiative, 2018). Earnings can free women from this dependence and empower them to make decisions on their own. The supply of water and gas gives women the time for wage-earning activities, otherwise spent on gathering these goods, being sick or caring for sick children due to indoor pollution or waterborne diseases (see Appendix 3.2.). This time does not only benefit women but also children, which often do not go to school for very long. Especially girls spend their time helping their mothers with household duties (Conceição, 2019). The project of a PtX plant can therefore drastically improve the low schooling rates in Morocco and lower the inequalities between the educational levels of the rural versus the urban population (Haut Commissariat au Plan, 2014a). The impact on the government, representing the whole national population, has the highest monetary value. Increasing the state budget is not necessarily a direct upgrade for the local population around the plant but helps to improve the social conditions of everyone in the country.

The theory states clearly that many problems can be traced back to monetary poverty and subjective poverty particularly in rural areas. Monetary poverty is an iterative process starting with no access to basic services like water, energy and education, leading to a low income without opportunities for leaving the circle also for future generations (Andrade Rosas & Jiménez-Bandala, 2018; Guiga & Rejeb, 2012). The PtX plant is able to deliver many opportunities for access to basic services, a higher educational level for children and higher income through new employment or improving the income from existing work. Raising the living conditions of the rural population and therefore lowering the inequalities and the subjective poverty leaves them without reason to urbanize. The high overall social value of the PtX plant can help to eradicate poverty in the region around it.

Due to the lack of comparable studies in the field of social impact of PtX plants, the generality of the results is limited. Still it is a forecast of the wide range of possibilities of producing a social value. The geographical distance to Morocco and the language barriers also delivered difficulties in finding reliable data, this emphasizes even more the importance of the information gained during the research trip. The generalization for every PtX plant cannot be fully given, since a specific investment scenario was used for the SROI. It was chosen to show the large possibilities for an inclusive project around a PtX plant. A manipulation of the result of the SROI is possible, shown in Chapter 5.6. Lowering the investment would give an even higher ratio since large factors like employment would still exist, but this would miss the target of a real all-round long-term impact. Therefore, it is important to not only look at the end result of the SROI ratio, but at the specific outcomes and who they affect. The calculations are based on the assumptions that the outputs are used for the determined purposes. Of course, it is not possible to influence the stakeholder groups on how and what they use these outputs for. Thus, the outcomes also depend on the willingness and acceptance of the stakeholders. The methodological choice of taking the SROI as an impact measurement technique, also restrained the possibility of including indirect or secondary effects in the calculation. Examples for this are wages in local business through rising consumption, improvement of infrastructure, knowledge spill over effects, but also impacts on culture. Even though this would go beyond the scope of the thesis, these impacts are assumed to be even larger than the direct effects. In the end of course the physical possibilities of the Power-to-X plant itself are limitations to the opportunities of fighting the social problems in Morocco.

7. Conclusion and research prospects

By performing a Social Return on Investment analysis on a Power-to-X plant in Morocco, this thesis has demonstrated that renewable energy carrier generation projects have a positive social impact on developing countries. From today's view a major conflict is the growing global demand of energy and the necessity to drastically reduce emissions to fulfil the climate goals by 2050, agreed to at the United Nations framework convention on climate in Paris in 2015. One solution is the generation of renewable energy carriers in locations with ideal climate conditions, mostly sited in developing countries. These economies still struggle with severe social problems, which should have a priority to be solved. Building a renewable energy carrier generation plant in a lower-income country brings the responsibility with it to contribute to the improvement of the social situation. A Power-to-X plant was expected to be able to fulfil these requirements.

In order to address the right issues to have a significant social impact, it was necessary to identify the most severe social problems of developing countries, with a specific focus on Morocco. The result was to find a solution for poverty, inequalities with resulting rural-urban migration and access to clean water. The main problem is not in the identification of the issues, but more in the complexity of solving it as they are all coherent and one cannot be solved without the other. Inequalities and access to basic services are part of the iterative process of poverty, affecting future generations as well. The multidimensional character of poverty gives many options on where to start, but also many difficulties as not every problem can be worked out at once. The focus is on interrupting the iteration of poverty, to not only change the current living conditions but also provide a different future for following generations. Potential energy investors are interested in a clear statement of the social impact, in the best case in form of a number. To be able to fulfil these requirements the SROI analysis was chosen. This method gives a single monetary result of the real effect of investment as a ratio of input compared to the social value created. The physical possibilities of the PtX plant itself represent the restrictions for the outputs. As described in the last chapter, during the performance of the SROI the diverse opportunities for social outcomes got obvious. The investment scenario chosen only displays a part of the options of outcomes. Taking these results and putting them in a bigger picture it shows that they only serve as an example of the social impact for other developing countries besides Morocco. Looking back at the general social problems in developing countries compared to the issues in Morocco underlines the overall similarity independent of the location of the country on earth. The findings demonstrate the opportunity for these countries to use the natural geographic potential of their region to improve the socioeconomic situation of the population. In comparison with other methods this SROI analysis clearly showed its advantage in using it as a platform of communication to attract energy investors and demonstrate the clear benefits of such an investment to all types of audience. The overall result clearly illustrates the great, potential social impact of renewable energy carriers in developing countries. This thesis is an example to other developing nations on how to use their potential to lift their country out of poverty.

Based on these conclusions, future investors should consider the comprehensive possibilities of achieving a social change in developing countries. The SROI delivers a great option to measure this impact, but the focus should always be on delivering diverse and significant outcomes. Otherwise only the issues of the present generation will be solved and future generations will remain in the circle of poverty. Already small social investments can make a huge difference if they are addressed correctly and are improving the overall situation. From the economic perspective social engagement can bring a higher acceptance of new technology by the local population, which is important for the future possibility to enlarge the plant. It can also be used as advertising material, whereby the outcomes should always be the priority.

When plans for a PtX plant get more concrete and the location of it has been chosen, a second SROI should be performed to analyse the social impact again for this specific region. Even though the problems repeat themselves everywhere there can be still be small differences in the details. For the problem analysis it is most essential to include the effected stakeholders on site. Only through an in-depth analysis in cooperation with the stakeholders without the geographical distance, it can be guaranteed that the right fields of actions are addressed. The outputs should then be adjusted accordingly. It is also quite important for the acceptance and therefore the success of the plant itself. Further research is needed for a comprehensive analysis of the social impact. It needs to include the indirect effects of a PtX plant with a greater stakeholder group. Qualitative outcomes, which cannot be measured in monetary terms need to be included in a different way. Finally, an evaluative SROI after the plant has been built is recommended to verify the forecasting results.

To sum up, renewable energy carrier generation projects deliver great opportunities to contribute to an overall social change in developing countries. They combine a solution for sustainably covering the global energy demand, while improving the social situation of the population around it. This thesis has demonstrated that a great social impact of renewable energy carrier generation plants can be achieved by addressing the correct most important issues.

V. Appendix

Appendix 1: Evaluation of impact measurement methods

Requirements:

Purpose: Evaluation	Assessment of one plant is necessary
Time frame: Prospective	Plant has not been built yet
Orientation: Input	Difference in Inputs is essential
Length of time: /	Not relevant
Perspective: Macro (Society)	Impact on population is measured
Approach: Impact methods + Monetisation	Monetisation for clear result important
No specific focus on a topic	no predetermined path of impact

Legend:
X= yes
O=partially

OASIS = Ongoing Assessment of Social Impacts
PSIA = Poverty Social Impact Assessment
SCBA = Social Cost Benefit Analysis

SCEA = Social Cost-Effectiveness Analysis
SIA = Social Impact Assessment
SROI = Social Return on Investment

Characteristics	**Types**	**Balanced scorecard**	**BoP assessment framework**	**Measuring impact framework**	**OASIS**	**PSIA**	**SCBA**	**SCEA**	**social e-valuator**	**SIA**	**Social Impact Navigator**	**SROI**
Purposes	Screening	X	X	X	–	X	X	–	–	X	X	–
	Monitoring	X	X	X	X	–	–	–	X	X	X	X
	Reporting	X	X	X	X	X	X	X	X	X	X	X
	Evaluation	X	X	X	X	X	X	X	X	X	X	X
Time frame	Prospective	X	X	X	–	–	X	–	–	X	–	X
	Ongoing	X	X	X	X	–	X	–	X	X	X	X
	Retrospective	X	X	X	X	X	X	X	X	X	–	X
Orientation	Input	–	X	X	X	X	X	X	X	X	X	X
	Output	X	–	–	X	–	–	–	–	–	–	–
Length of time frame	Short term	X	X	X	X	X	X	X	X	X	X	X
	Long term	–	–	X	–	X	X	X	–	–	–	–
Perspective	Micro (individual)	–	X	–	X	X	–	–	X	–	–	X
	Meso (corporation)	X	X	X	–	–	–	–	–	–	X	–
	Macro (society)	X	X	X	X	X	X	X	O	X	X	X
Approach	Process methods	X	X	X	X	X	X	X	X	X	X	X
	Impact methods	O	X	X	X	X	X	–	O	X	X	X
	Monetisation	–	–	–	–	–	X	X	X	–	–	X
Specific Focus on a Topic		–	X	–	X	X	–	–	X	–	–	–

Appendix 2: International comparison of PtX (synthetic methane and liquid fuels) production cost (Frontier Economics, 2018, p. 28)

Note: Prices of natural gas and premium petrol are based on average values from scenarios by the World Bank and the IEA. Other cost reductions for PtG / PtL may result from advancements in PV, from battery storage that increases full load hours, and from especially large electrolysis facilities. Cost increases may result from higher cost of capital due to higher country risks.

* Offshore wind power
** PV and PV / wind systems
*** Geothermal / hydropower (total potential limited to 50 terawatt hours)

Note: 10 cents per kilowatt hour is equivalent to around 90 cents per liter of liquid fuel.

Appendix 3: Observation protocols

Appendix 3.1.: Observation of Mr. Ahmed’s farm

Participants: Jarrais Ahmed, Translator

Observation day: 17th February 2020

Start: 1 p.m.

End: 3 p.m.

Observation location: Ahmed’s Farm close to Mohamedia, Morocco

Jarris Ahmed only speaks Arabic. For the visit of the farm a translator came to translate from Arabic to English. The farm is located at 20km distance to Mohamedia in Morocco. Its distance to the next paved road is approximately three to five kilometres. I can see different buildings and halls on the farm, all of them seem to have a connection to the electricity grid. Plastic waste is lying around everywhere. On one field there are big piles of waste mainly plastic, one of them is burning. Some houses and old cars are also there. I ask Jarrais Ahmed: “How many hectares belong to your farm? Did you buy your farmland, or did you inherit it and how much do you think is it worth now?” The translator translates my question in Arabic and tells me his answer in English. He says: “His farm has 20 hectares of land and he inherited it from his father. Right now, they sell the land around here for 20,000€ per hectare. It is really worth a lot because it is still in the region of Casablanca. In the South of Morocco, they sell it for 1,000€ per hectare.” Some workers are walking around and greeting us. I ask him how many workers he engages and how much they earn. The translator tells me, this depends on the season: “When there is a lot to do, he has up to 70 workers. Permanently he engages eight workers, who also live on the farm. They all earn between 80 and 120 Dirham per day.”

I ask him: “I can see some voltage lines on your farm. Do you also have a connection to the potable water pipeline and wastewater canals?” The translator tells me his answer: “He has a connection to electricity and potable water, which was financed by the government. A waste collection does not exist outside the city. No one around here has a connection to wastewater canals, which is why they also do not have sanitary facilities, for these things they dig a hole behind the house." We walk around the farm and he shows me his water well. In a small building next to it, I can see his motor to pump the water up. It is filled up with gas. The translator tells me, that this was a motor from an old car. Before it was filled up with diesel, but this was too expensive. Gas is more efficient and costs about half of diesel. Now it only costs around 150€ per month. I ask him about problems with water scarcity. He tells me he has no problems. It rains less every year, but he can just dig his well deeper to get water. He explains me that there are small plastic pipelines laying on the fields to water the plants. He mostly grows alfalfa as food for the animals.

We walk into one of the halls and see some chickens in the anteroom and in the big part, there is straw and animal waste on the floor piled up. He explains us that these are for champignons. He grows them three month a year over the winter. They like it cold. He would do it all year, because it gives much more profit than filling the halls with chickens, but over the summer, it gets too hot. 1,000 Dirham capital gives 1,100 Dirham back. He would need a cooling system, but electricity would be too expensive for it. The rest of the year he has chickens in the halls, they like it warm. He has four buildings with 10,000 chickens each. Half of them are for egg production and the other half is for meat production. He shows us his gas heating construction, which he uses on the colder days for the chickens. The translator explains to me: "Gas heating with an open flame is very dangerous and inefficient. The Straw could burn very fast. Heating lamps would be more efficient, but electricity is much more expensive than gas. Another problem with the electricity is the grid overload. A few years ago, he was the only farmer using the grid now there are 100 people using the same grid. There are blackouts all the time. The grid just did not grow with the population here. If he would use too much electricity for heating or cooling, there would be even more blackouts."

He shows us another hall where he has big cages with birds in them. The farmer explains to us, that he breeds them and sells them on the local market. He leads us to his house to sit down. I ask him about his major difficulties on the farm. The translator tells me his answer: "All energy is very expensive. He does not need to pay for the water he pumps up, but he must pay for the gas. The government subsidizes the gas bottles, so they have a fixed price 40 Dirham per 12kg bottle." The farmer shows me his potable water and electricity bill. I ask him about his workers: "Did your workers go to school? If they have children, do they go to school and if they do, how long?" He talks to one of his workers before he answers me. He tells me that most of them did not go to school, but their children got to school around six years. Afterwards they learn how to work on the farm from their fathers. Girls also go to school some time and when they are old enough, they help their mothers with household duties. We say goodbye and leave the farm.

Appendix 3.2.: Observation of Mrs. Zniber's non-governmental organisation

Participants: Amal Zniber

Observation day: 18th February 2020

Start: 9 a.m.

End: 11 p.m.

Location: Maroc Bureau, Casablanca, Morocco

Amal Zniber gives me her two business cards. One says director at Maroc Bureau and the other president of "amis des ècoles". She introduces herself: "Hello, I'm Amal Zniber. I am working full time as a director at Maroc Bureau, but my passion is "amis des écoles". My husband and I founded this NGO for rural development in Morocco a few years ago. Our goal is to support rural areas through different projects. We go where no one else is going because you cannot reach it by car or because there are no sanitary facilities and hotels, you can stay in. This is where we start it. It is easy to help in the slums in Casablanca, but it is much harder to work outside in the nowhere." I also introduce myself: "Hello Amal, thank you for agreeing to meet me today. As I already explained via email, I am a German student at the Katholische Universität Eichstätt-Ingolstadt in my Master studies with a major in Entrepreneurship and Social Innovation. I am working on my master thesis in cooperation with Audi AG. The topic is "Renewable Energy Carrier Generation in Developing Countries - Analyzing the Social Impact of Power-to-x Gigaplants in Morocco". I am currently in Morocco to get to know the country and to further analyse the social issues of the people. Could you tell me more about the selection of your projects?" During the whole time people come into the room to serve tea or ask for a signature from her. She tells me in a longer monologue about her projects: They have a certain region, where they are mostly active in. In this region, they look for major problems and talk to people what they need most and then look at what is possible through donations. In the beginning of her work she made the mistake of going there and trying to tell them what their problems are and what they need. This did not work out. Moroccan people are proud and feel offended when someone from outside tells them what to do. They did not accept the help. Integrating them in the project evaluation process eradicates these problems.

My next question aims at the major problems she sees in the rural areas. I wanted to hear her opinion on this. Her answer was: “A big problem is waste. The waste is coming with the economic development, especially plastic. There is no waste collection on the countryside only in the cities. They just leave it everywhere and the major waste is brought in big holes where they burn it. This of course emits many bad gases and is very unsustainable. People do not understand that this waste is a real problem for the environment, which leads back to their insufficient education. During my work I realized it all starts with education. Education is the basis, if this is missing the other things will not work, too. We tried to build sustainable schools, where the children learn more about sustainability and we plant trees with them. Many projects plant trees and then leave them there; the result is the trees die within weeks because they do not have enough water. In our project we teach the children that they have to water them as well and how to care about them. Another project of ours was the isolation of the schools. Through the climate change the weather conditions are becoming more and more extreme. It is getting hotter in the summer and in the winter, it is becoming even colder. The schools do not have isolations, which makes them really unattractive to teachers and children. It is very difficult to get teachers for the rural areas, so schools are there but without teachers, the school is meaningless. We insulated one classroom, which is very sustainable too, because now they do not need heating it and it is still warm enough.” She shows me pictures of her with children in a school. One picture shows her in a bathroom. She explains to me: “For girls a big problem are the missing sanitary facilities in some schools. Girls do not go to school because of that. Moroccans find education really important; the schooling rate is rising every year. Also, school is compulsory for nine years. If children do not go to school, it has other reasons. Missing insulation or heating, missing sanitary facilities, other important duties in the household where they have to help their parents or too long distances to the next school. And again, often the school building is there, but no teacher wants to work there. You need someone who is willing to work there, which is quite difficult to find with these working conditions.”

Our next topic is the living conditions in the areas she works at. Amal explains to me the basic principle of a Moroccan community: “Well there are three things, which are important for Moroccan communities: A bakery, a mosque and a Hammam. Arabs go there once a week to be scrubbed because they do not have hot water in their houses. If there is no hammam this is a real problem for hygiene. Sanitary in general is a huge problem. Almost no house outside the city has sanitary facilities.”

She shows me more pictures of houses with families in front of them. On the photo I can see a solar panel on the roof of the house. I ask her about it and about potable water pipelines in these areas. Amal tells me that almost every household has electricity. Most of them are connected to the grid and if they are too far away the have small solar power panels. The households get “Power cards” they can recharge for electricity. In the rural areas most of them are seasonal workers. They only have money for electricity when they have work. In the regions she works at no one has potable water. The water for the household is taken from rivers and wells. Often the water is not cooked before using it, leading to illnesses. She tells me that she saw women washing their clothes with Ariel in the river and further down other women take the water to drink. That was the reason for the implementation of rural washers, which work with natural soap from olive oil, which is not harmful for the environment. I ask her about the health conditions in these areas and if there are any health issues documented through contaminated water. Amal tells me that in her organisation, they only assume that most illnesses are due to contaminated water, but they have not started any studies yet, since it is difficult to measure. Most of these people do not go to the doctor, because it is too far away and the medical car is very bad. People can go to the hospital for free, but they often cannot afford the medication they need. Like teachers there are not a lot of doctors in these areas. Amal has the strong opinion that everything is traced back to education. People do not know that their illnesses stem from contaminated water.

I introduce our next topic: The division of labour between men and women in rural Morocco. Amal shows me pictures of women carrying water cans with children and explains the picture to me. The women on the photo is living in the region she works at. Often the division of labour is quite clear women are responsible for childcare, cooking and the household. Men are the wage earners. If they do not earn enough for the family, the wife works as well. If they do, they do not earn less than men for the same work. She gives the example of agricultural workers. I ask her how the farmers deal with the dry weather conditions in Morocco. Again, she shows me pictures of some farmers with their sheep and tells me: “Well concern about sustainability is rising in Morocco as well. The climate change is hitting Morocco really hard, the weather is becoming more extreme and it is getting hotter and dryer. Water scarcity is a major problem here. But the main share of the population has other problems. They use wood or coal for heating. Gas is mainly used for cooking and heating. They do not realize their water is running out. For farming they do not have agricultural machinery and for transport they are using donkeys and horses. Their problems are in the range of their households. They do not have the capacity to think about climate change.” I thank her for her time, and we say goodbye to each other.

Appendix 3.3.: Observation of farm 1 near Casablanca

Participants: Farmer, Translator

Observation day: 20th February 2020

Start: 3 p.m.

End: 4 p.m.

Location: Farm near Casablanca

We park the car on the road. The translator and I walk up to the farm. There are some small houses around a field. Three people are working in the field. One woman is standing next to four grazing sheep. The farmer comes to us. The translator asks him if it would be ok for us to look at his farm and ask him some questions. The farmer is fine with it. I let the translator ask him about some key facts of his farm. He tells us that he cultivates 0,5 hectare of land with mint for tea together with his extended family. They all live on the farm. I see some children next to the house watching us and ask him about them. He introduces them as his children and the women with the sheep is his wife. He shows me with his fingers that he has four children. I ask some questions about their living conditions: If they have electricity and running water, a shower and a toilet. He tells me that they have electricity and potable water, but since they have to pay for it, they are using the water from the well most of the time. Electricity is very expensive, so they try to use candles and wood if possible. He laughs when the translator asks him about the toilet and shower. He finds it quite funny, because he thinks this is something unnecessary. I ask him again about his children if they came from school at this moment. He affirms my assumption and tells me how important this is for him, because he never went to school.

I try to ask him some more about his farming and talk about the well he mentioned. The farmer leads me into his field and shows me the mint he is growing and the irrigation system he has. I ask him about how much water he needs, but he cannot answer the question. He argues that he waters for two days after he plants the mint and then waits if it grows, but he does not know how much water it is he uses. We thank him for his time and say goodbye.

Appendix 3.4.: Observation of farm 2 near Casablanca

Participants: Farmer 2, Translator

Observation Day: 20th February 2020

Start: 4 p.m.

End: 5 p.m.

Location: Farm near Casablanca

The farm is located around 80km outside of Casablanca in Morocco. We park our car next to the unpaved road and walk around ten minutes to the farm. At first, I can see a small field with different kind of vegetables growing on it. One person is working on it. We walk up to the person. The translator asks him if he is the farmer and if it would be ok with him if we would take a look at his farm and ask him some questions about it. He is fine with it. He shows me the different vegetables he grows: Spinach, chard, beans, snow peas and different kind of parsley. I ask him where he sells these vegetables. He tells me that people come and buy an isle of vegetable sometimes they buy two isles. They sell it on local markets, and he gets around half of the price they sell it for. I ask him how big his farm is and how many people work with him on it. He tells us that it has around half a hectare and that he is doing it all alone. Sometimes he has a worker to help him, because he does not have a family. There is no visible irrigation system on the field. I ask him about it, and he tells us that he uses the well of his neighbour, where the water is pumped up by a diesel motor. He takes the water and casts the vegetables with it. I ask him how much water he needs for his plant, but he cannot answer my question. He casts when they need water and does not count how much it is. He also does not know how much he pays for electricity since he never went to school. According to him there was no reason. He learned everything he needed about farming from his father. His neighbour is helping him with paying the bills.

We walk over to a grassland. He shows us his two horses and six cows. Their feet are tied together so they cannot run away. He explains us that one horse is only for a traditional show he participates in, it is not used for farm work. The other one is used for transportation. The cows are sold on the market and used for own food supply. We thank him for his time and say goodbye.

Appendix 3.5.: Observation of Mrs. Nabil's and Mr. Rachidi's presentation

Participants: Nouhaïla Nabil, Samir Rachidi

Observation Day: 19th February 2020

Start: 10 a.m.

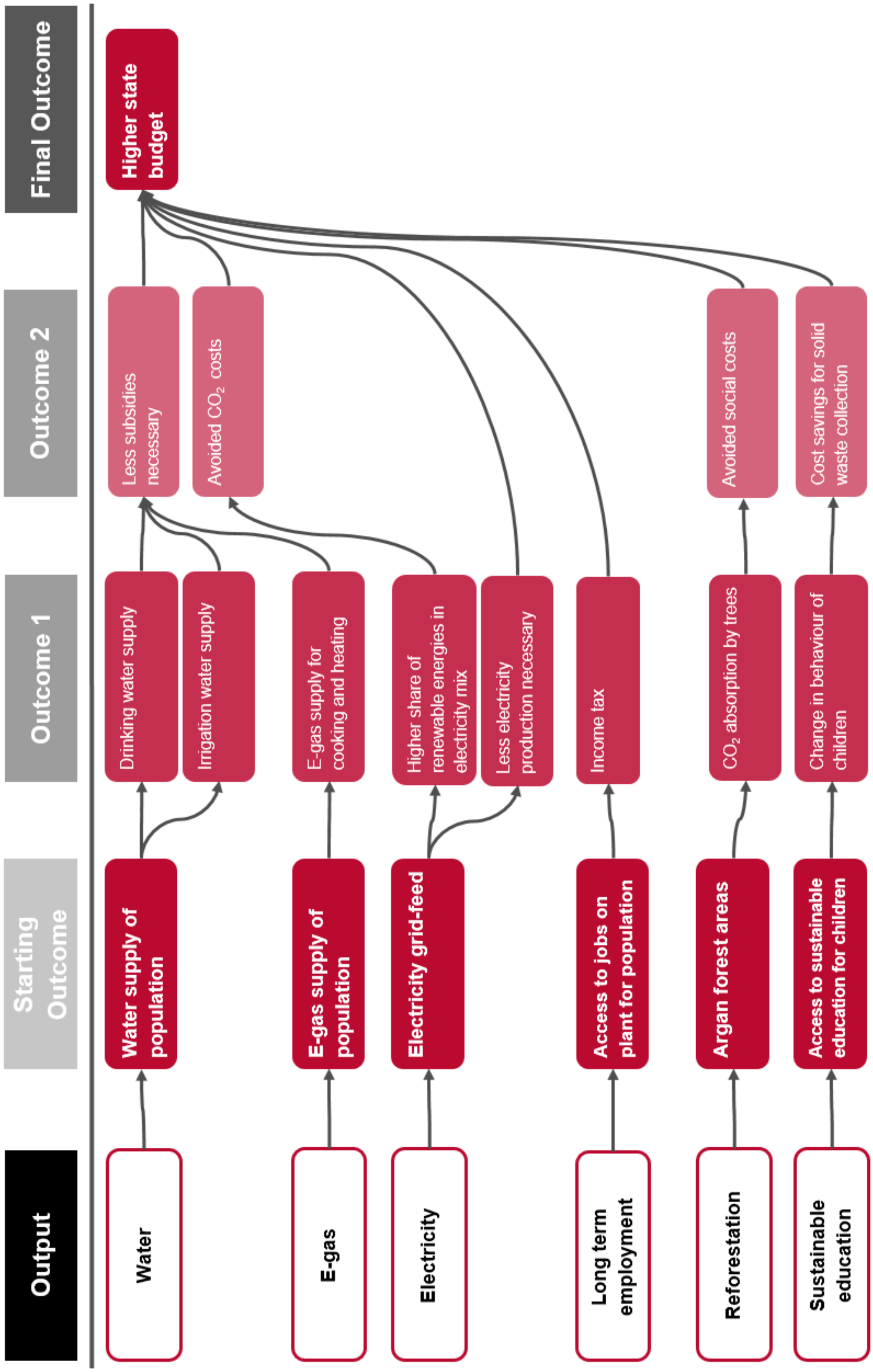
End: 12 a.m.

Location: IRESEN (National Research Institute for Solar Energy and New Energies), Rabat, Morocco

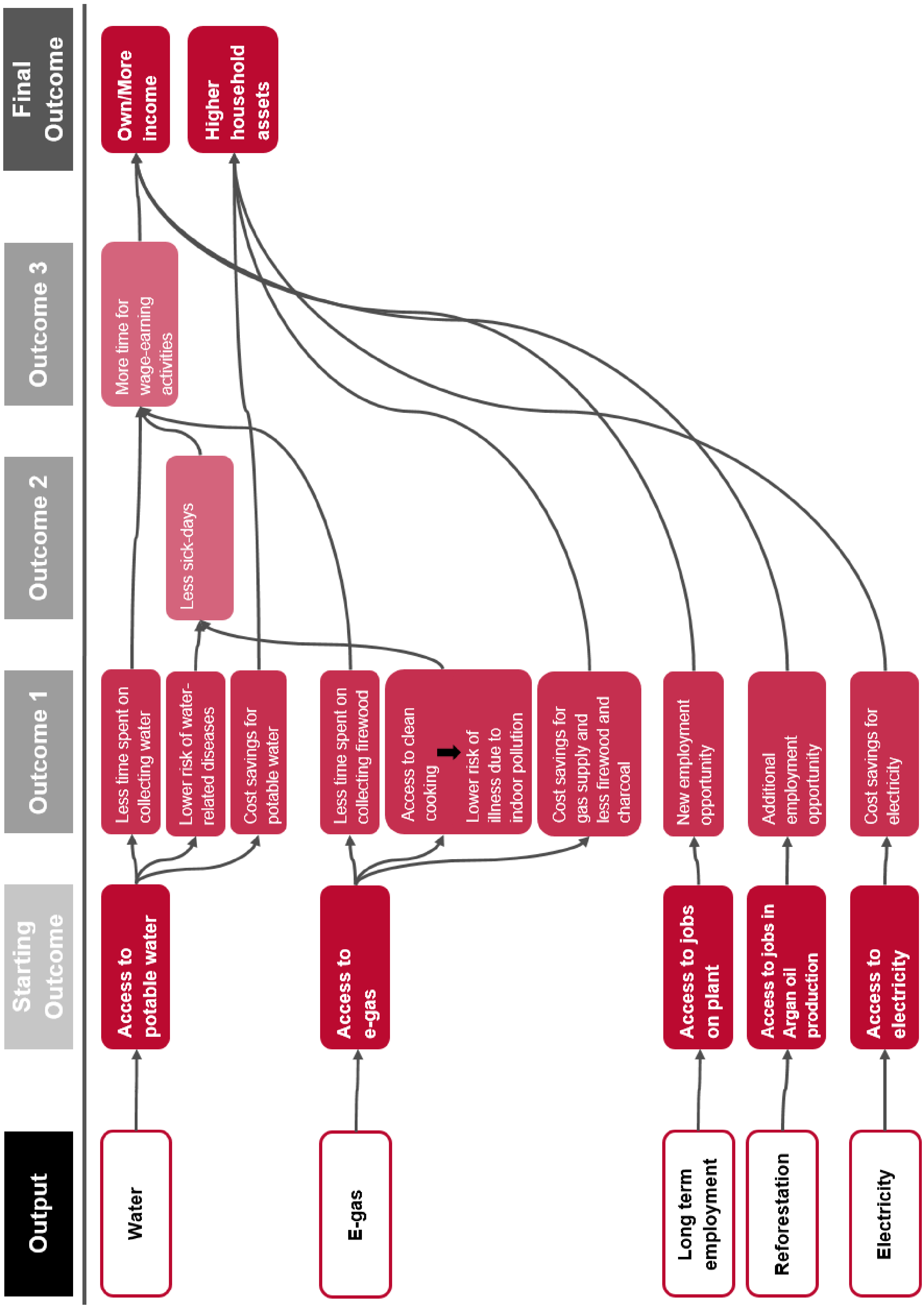
The meeting is located in the building of IRESEN, the National Research Institute for Solar Energy and New Energies in Rabat, Morocco. Samir Rachidi is the Research and Development Director of the Power-to-X department. Nouhaïla Nabil is his employee. The conversation is about the possibilities of a PtX plant in Morocco. IRESEN in cooperation with OCP, the Office Chérifien des Phosphates has already planned a first Pilot PtX plant on the factory of OCP in Jorf Lasfar, Morocco. The Pilot plant is supposed to have a size of one to five Megawatt and produces Ammonia for fertilizer. The site of the plant was chosen because of the existing circumstances. A desalination plant, excess of electricity through a coal power plant and CO_2 from it are already on site. Additionally, the OCP plant already delivers the necessary security measures for Ammonia. In a few years the plant is up scaled to 50 – 100 Megawatt. This project is financed inter alia by PAREMA, which is the German-Moroccan Energy Partnership. PtX is seen by IRESEN as an opportunity to revive the refinery industry and make Morocco more independent of energy imports. The produced fuel can be exported, since the local use of fuel is very small today. In the course of the Pilot plant an environmental impact analysis is performed, which is a governmental requirement. This also includes the impacts of the desalination plant, which are of concern due to high amounts of brine contaminated with chemicals as a by-product and as a second priority it includes indirect effects on population, local business and infrastructure. I thank her for their time, and we say goodbye to each other.

Appendix 4: Impact Value Chains

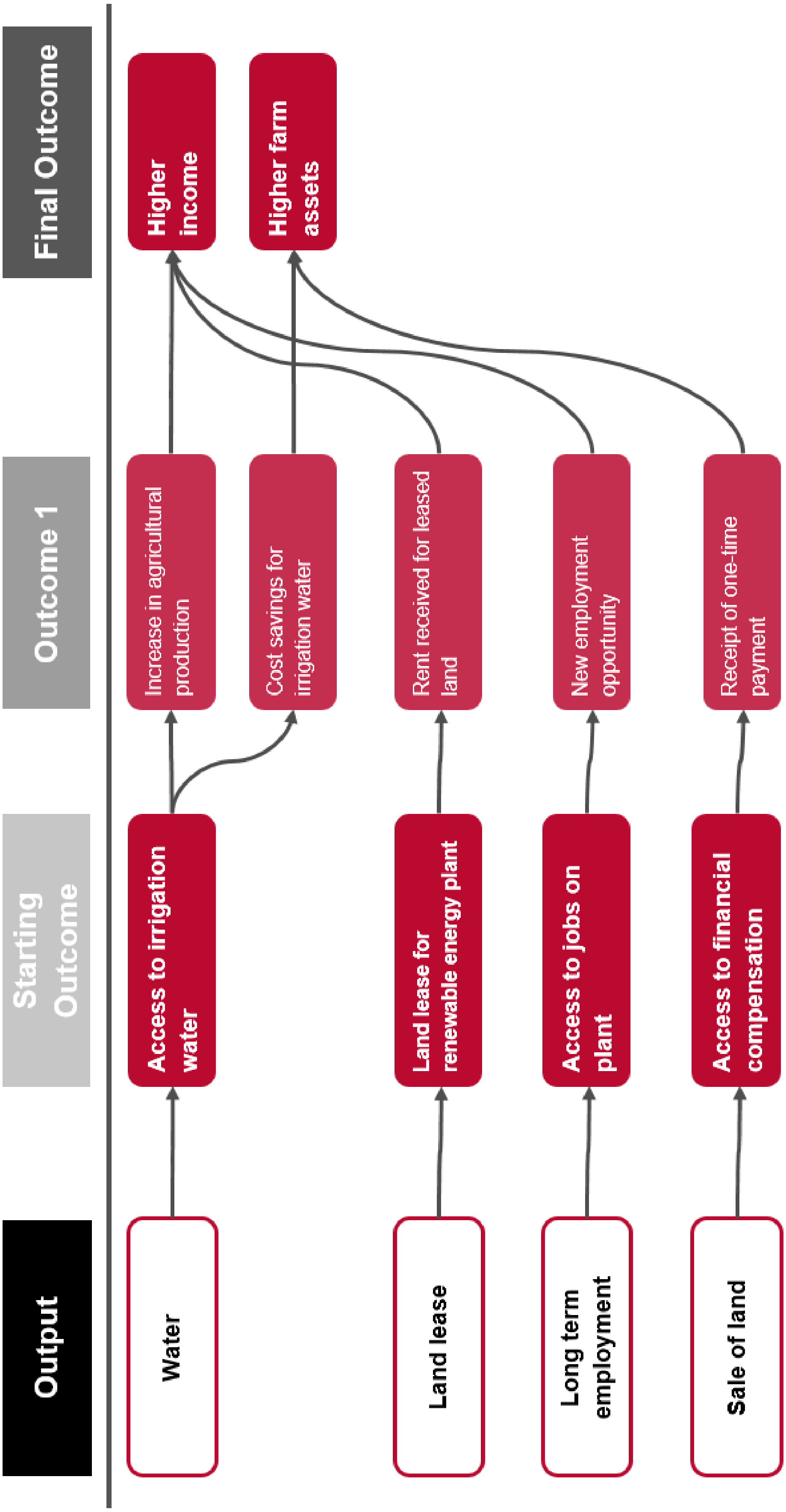
Appendix 4.1.: Impact Value Chain for the Moroccan government



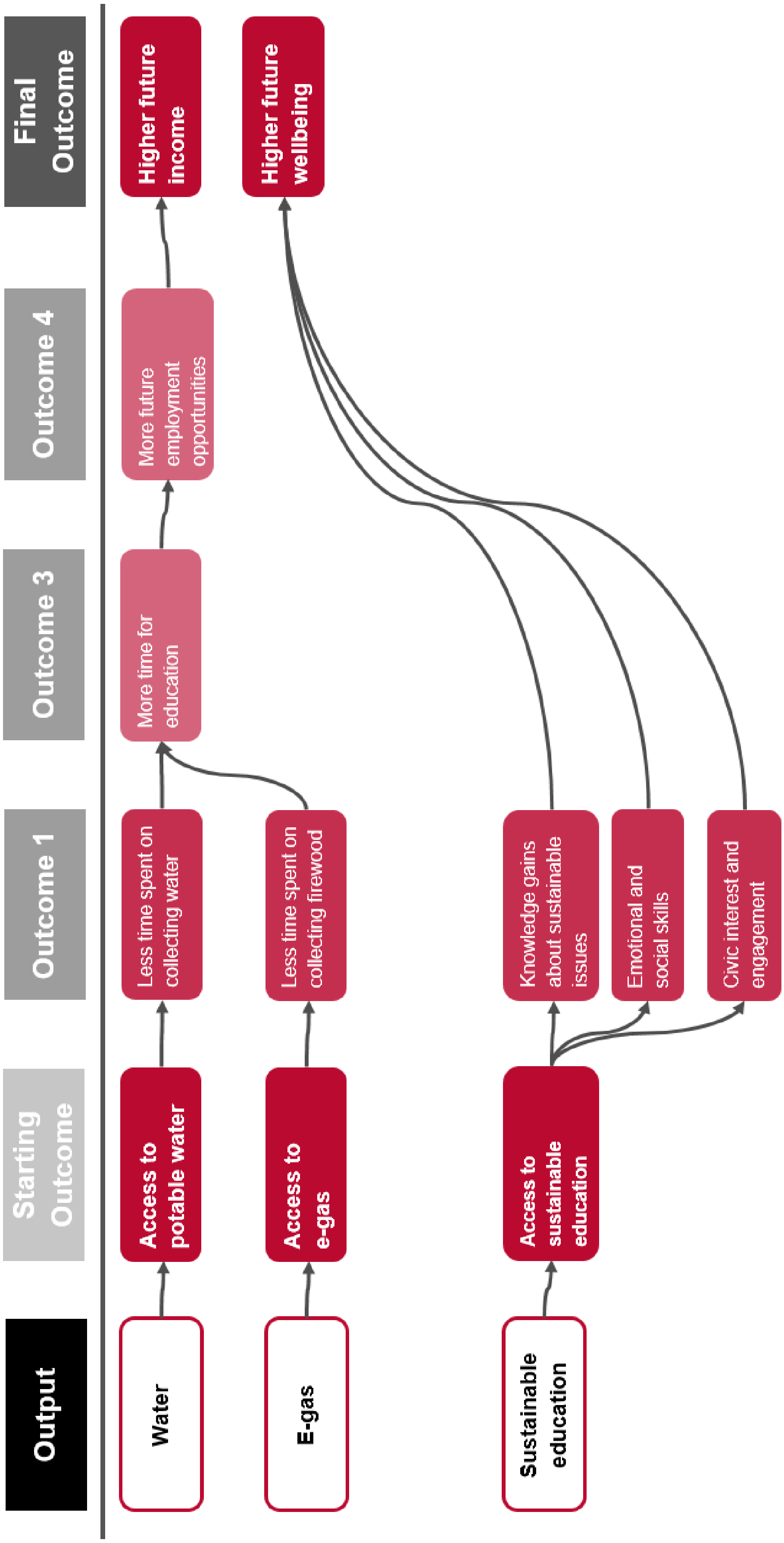
Appendix 4.2.: Impact Value Chain for women



Appendix 4.3.: Impact Value Chain for farmers



Appendix 4.4.: Impact Value Chain for children



Appendix 5: SROI calculation

Appendix 5.1. Water calculations

Water		
Input in water production	€/a	752,710
Input in water production over 5 years	€/5 years	3,763,549
Water production costs	€/m^3	0.212
Water output	m^3/a	3,550,518
Water output over 5 years	**m^3**	**17,752,589**
Potable water demand per household	m^3/a	96.73
Need of irrigation of wheat per farm	m^3/ha	8,925
Total water demand of farm and household	m^3/a	9,022
Reach of outcome: Households with farm supplied with water		**394**
Option 2: Reach of outcome: Households supplied with water		36,707
Option 3: Reach of outcome: Farms supplied with irrigation water		398

Outcomes:		Option 1:
For women: Access to potable water		
Less time spent on collecting water -> More time for wage-earning activities		
Average time spent on collecting water per round	Minutes	25
Average amount of water collected per round by mother and child	Litre	28
Time needed to collect water for household	Minutes	236.61
	Hours	3.94
Share of rural population without access to potable water		62%
Households without access to potable water	1.year	245
	2.year	243
	3.year	242
	4.year	240
	5.year	238
Minimum wage in agriculture	MAD/m	1,813
	MAD/d	69.73
	MAD/h	8.72
Own / More income per household	MAD/d	34.37
	€/d	3.27
	€/m	84.90
	€/a	1,019
Own / More income (for all households)	€/1. year	249,389
	€/2. year	247,785
	€/3. year	246,181
	€/4. year	244,577
	€/5. year	242,974
Value of own / more income	**€/5 years**	**1,230,906**

Less sick-days -> More time for wage-earning activities		
Share of rural population without access to potable water		62%
Households without access to potable water		245
Amount of people without access to potable water	1.year	1,297
	2.year	1,289
	3.year	1,281
	4.year	1,272
	5.year	1,264
DALYs lost due to diarrhoea in Morocco		422,025
Share of diarrhoeal infections due to water contamination		88%
DALYs lost due to water-borne diarrhoea	DALYs/a	371,382
	DALYs/a/capita	0.01
	DALYs/1.year	13.35
	DALYs/2.year	13.26
	DALYs/3.year	13.18
	DALYs/4.year	13.09
	DALYs/5.year	13.01
Minimum wage in agriculture	MAD/a	21,756
Own / More income (for all households)	€/1. year	27,591
	€/2. year	27,414
	€/3. year	27,237
	€/4. year	27,059
	€/5. year	26,882
Value of own / more income	**€/5 years**	**136,183**
Cost savings for potable water		
Households with drinking water access	1.year	149
	2.year	150
	3.year	152
	4.year	153
	5.year	155
Potable water demand per household	m^3/a	96.73
	m^3/m	8.06
Water tariff of Morocco	MAD/m^3	7.98
Water tax	MAD/m^3	2.16
Higher household assets per household	MAD/a	980.79
	€/a	93.18
Higher household assets (for all households)	€/1. year	13,861
	€/2. year	14,008
	€/3. year	14,154
	€/4. year	14,301
	€/5. year	14,448
Value of higher household assets	**€/ 5 years**	**70,772**
Overall value of water on women	€/a	290,841

For farmers: Access to irrigation water		
Increase in agricultural production		
Average increase in agricultural production through irrigation	median	154%
Share of cultivated area under irrigation	1.year	16.0%
	2.year	16.1%
	3.year	16.2%
	4.year	16.2%
	5.year	16.3%
Farms without irrigation	1.year	331
	2.year	330
	3.year	330
	4.year	330
	5.year	329
Price for wheat	MAD/t	2,800
Cereal yield	kg/ha/a	1,758
Average yield per farm	kg/a	5,273
Average revenue per farm	MAD/a	14,765
Cereal yield increase through irrigation	kg/a	8,121
Higher income per farm	MAD/a	22,738
	€/a	2,160
Higher income (for all farms)	€/1. year	714,085
	€/2. year	713,396
	€/3. year	712,707
	€/4. year	712,018
	€/5. year	711,329
Value of higher income	**€/5 years**	**3,563,533**
Cost savings for irrigation water		
Need of irrigation of wheat per farm	m^3/a	8,925
	m^3/m	743.75
Farms under irrigation	1.year	63
	2. year	63
	3.year	64
	4.year	64
	5.year	64
Irrigation water tariff of Morocco	MAD/m^3	0.29
Irrigation water costs per farm	MAD/a	2,588
Higher farm assets per farm	€/a	245.88
Higher farm assets (for all farms)	€/1. year	15,483
	€/2. year	15,561
	€/3. year	15,640
	€/4. year	15,718
	€/5. year	15,797
Value of higher farm assets	**€/5 years**	**78,199**
Overall value of water on farmers	€/a	729,568

For children: Access to potable water		
More time for education -> More future employment opportunities		
Average time spent on collecting water per round	Minutes	25
Average amount of water collected per round by mother and child	Litre	28
Time needed to collect water for household	min/d	236.61
	h/d	3.94
Time not spent in school per child	h/m	78.87
	h/a	946.43
Average school day	h/d	6.25
	h/m	125.00
School days per year		221.00
School hours per year		1,381
School days lost per year	d/a	151.43
	a/child	0.69
Average number of girls per household		1.65
School years lost per household		1.13
Average future wage increase through additional school time	%/a	10%
Average future wage increase through additional school time per household	%/a	11%
Minimum wage in agriculture	MAD/m	1,813
Higher future income per household	MAD/m	204.97
	MAD/a	2,460
	€/a	233.67
Share of rural population without access to potable water		62%
Households without access to potable water	1.year	245
	2.year	243
	3.year	242
	4.year	240
	5.year	238
Higher future income (for all households)	€/1. year	57,199
	€/2. year	56,831
	€/3. year	56,464
	€/4. year	56,096
	€/5. year	55,728
Value of higher future income	**€/5 years**	**282,318**
Overall value of water on children	€/a	57,199

For the government: Water supply of population		
Irrigation water supply -> less subsidies necessary		
Cost recovery of sustainable costs		75%
Irrigation water prices	MAD/m^3	0.29
Real irrigation water price including operation costs	MAD/m^3	0.39
Subsidies paid for irrigation water	MAD/m^3	0.10
Need of irrigation of wheat per farm	m^3 H_2O/a	8,925
Subsidies paid for irrigation water per farm	MAD/a	862.75
	€/a	81.96
Farms under irrigation	1.year	63
	2. year	63
	3.year	64
	4.year	64
	5.year	64
Higher state budget (for all farms)	€/1. year	5,161
	€/2. year	5,187
	€/3. year	5,213
	€/4. year	5,239
	€/5. year	5,266
Value of higher state budget	**€/5 years**	**26,066**
Drinking water supply -> less subsidies necessary		
Cost recovery of operation costs		75%
Water tariff of Morocco	MAD/m^3	7.98
Real water price including operation costs	MAD/m^3	10.64
Subsidies paid for potable water	MAD/m^3	2.66
Households with access to potable water	1.year	149
	2. year	150
	3.year	152
	4.year	153
	5.year	155
Potable water demand per household	m^3/a	96.73
Subsidies paid for potable water per household	MAD/a	257.29
	€/a	24.44
Higher state budget (for all households)	€/1. year	3,636
	€/2. year	3,675
	€/3. year	3,713
	€/4. year	3,752
	€/5. year	3,790
Value of higher state budget	**€/5 years**	**18,565**
Overall value of water on the government	€/1. year	8,797
Total impact	**€**	**5,406,542**

Appendix 5.2. E-gas calculations

E-gas		
Input in e-gas production	€/a	376,355
Input in e-gas production over 5 years	€/5 years	1,881,774
E-gas production costs	€/kg	1.46
E-gas output	kg/a	257,777
E-gas output over 5 years	**kg**	**1,288,887**
Consumption of Butane per person	kg/a	60.21
Consumption of Butane per household	kg/a	319.10
	kWh/capita/a	830.86
Equivalent consumption of e-gas per person	kg/a	53.95
Household demand of e-gas	kg/a	285.94
Reach of outcome: Households supplied with e-gas	-	**901**

Outcomes:		
For women: Access to e-gas		
Less time spent on collecting firewood -> More time for wage-earning activities		
Share of households using firewood	1.year	27.1%
	2.year	26.6%
	3.year	26.1%
	4.year	25.6%
	5.year	25.1%
Households using firewood	1.year	244
	2.year	240
	3.year	235
	4.year	231
	5.year	226
Average time spent on collecting firewood	h/day	2
Minimum wage in agriculture	MAD/m	1,813
	MAD/d	69.73
	MAD/h	8.72
Own / More income per household	MAD/d	17.43
	€/d	1.66
	€/a	516.70
Own / More income (for all households)	€/1. year	126,232
	€/2. year	123,903
	€/3. year	121,574
	€/4. year	119,245
	€/5. year	116,916
Value of own / more income	**€/5years**	**607,871**

Less sick-days -> More time for wage-earning activities		
People using unclean cooking	1.year	1,940
	2.year	1,916
	3.year	1,892
	4.year	1,868
	5.year	1,844
DALYs lost due to indoor pollution	DALYs/a	21,829
DALYs lost due to indoor pollution (for all households)	DALYs/1.year	1.17
	DALYs/2.year	1.16
	DALYs/3.year	1.14
	DALYs/4.year	1.13
	DALYs/5.year	1.12
Minimum wage in agriculture	MAD/a	21,756
	€/a	2,067
Own / More income (for all households)	€/1. year	2,425
	€/2. year	2,395
	€/3. year	2,365
	€/4. year	2,335
	€/5. year	2,305
Value of own / more income	**€/5 years**	**11,825**
Cost savings for gas supply		
Gas price in Morocco	MAD/12kg	42
	€/kg	0.33
Households with access to Butane	1.year	827
	2.year	828
	3.year	830
	4.year	832
	5.year	834
Consumption of Butane per household	kg/a	319.10
Costs for Butane per household	€/a	106.10
Expenditure for Butane per year	MAD/a/capita	236.70
	€/a/capita	22.49
Expenditure for Butane per household	€/a	119.18
Higher household assets (for all households)	€/1. year	98,521
	€/2. year	98,736
	€/3. year	98,951
	€/4. year	99,166
	€/5. year	99,381
Value of higher household assets	**€/5years**	**494,756**

Cost savings for firewood and charcoal supply		
Average expenditure for firewood and charcoal	MAD/a/capita	229
	MAD/a	1,214
Average expenditure for firewood and charcoal per household	€/a	115.30
Share of households using firewood and coal	1.year	29.4%
	2.year	28.9%
	3.year	28.4%
	4.year	27.9%
	5.year	27.4%
Households using firewood and coal	1.year	265
	2.year	261
	3.year	256
	4.year	252
	5.year	247
Higher household assets (for all households)	€/1. year	30,559
	€/2. year	30,040
	€/3. year	29,520
	€/4. year	29,000
	€/5. year	28,481
Value of higher household assets	**€/5 years**	**147,600**
Overall value of e-gas on women	€/a	257,738

For children: Access to e-gas		
More time for education -> more future employment opportunities		
Average time spend on collecting firewood	h/d	2
Average school day	h/d	6.25
Average school days per year	d/a	221
Average school hours per year	h/a	1,381
Time not spent in school per child	h/m	40
	h/a	480
School days lost per year	d/a	76.80
School years lost per child	a/child	0.35
Average number of girls per household		1.65
School years lost per household	a	0.57
Average future wage increase through additional school time	%/a	10%
Average future wage increase through additional school time per household		6%
Minimum wage in agriculture	MAD/m	1,813
Higher future income per household	MAD/m	103.96
	MAD/a	1,247
	€/a	118.51
Share of households using firewood	1.year	27.1%
	2.year	26.6%
	3.year	26.1%
	4.year	25.6%
	5.year	25.1%
Households using firewood	1.year	244
	2.year	240
	3.year	235
	4.year	231
	5.year	226
Higher future income (for all households)	€/1. year	28,952
	€/2. year	28,418
	€/3. year	27,884
	€/4. year	27,350
	€/5. year	26,816
Value of higher future income	**€**	**139,420**
Overall value of e-gas on children	€/a	28,952

For the government: E-gas supply of population		
Less subsidies necessary		
Subsidies paid for gas	MAD/a/capita	394
Subsidies paid for gas per household	MAD/a	2,088
	€/a	198.38
Households with access to Butane	1.year	827
	2.year	828
	3.year	830
	4.year	832
	5.year	834
Subsidies paid for gas (for all households)	€/1. year	163,994
	€/2. year	164,352
	€/3. year	164,710
	€/4. year	165,067
	€/5. year	165,425
Value of higher state budget	**€/5 years**	**823,548**
Overall value of e-gas on the government	€/a	163,994
Total impact	**€**	**2,225,020**

Appendix 5.3. Reforestation calculations

Reforestation		
Input in reforestation	€/a	250,903
Input in reforestation over 5 years	€/5 years	1,254,516
Reforestation costs	MAD/ha	12,260
	€/ha	1,165
Reforestation output	ha	215.42
Reforestation output over 5 years	**ha**	**1,077**
Workers for Argan oil production	capita/ha	3
Women per household		1
Reach of outcome: Households with additional employment		**646**

Outcomes:		
For women: Access to jobs in Argan oil production		
Additional employment opportunity		
Average yield per tree	kg/a	8
Possible density	trees/ha	100
Average yield per ha	kg/ha	800
Amount of fruit necessary to produce Argan oil	kg/L	30
Time needed to produce one litre Argan oil	h/L	16
Argan oil produced from one hectare	L/ha	26.67
Average time spent on producing Argan oil from one hectare	h/ha	426.67
Minimum wage in agriculture	MAD/m	1,813
	MAD/d	69.73
	MAD/h	8.72
	€/h	0.83
	€/ha	353.30
Area reforested carrying fruit	ha/1. year	215.42
	ha/2. year	430.85
	ha/3. year	646.27
	ha/4. year	861.69
	ha/5. year	1,077
Own / More income (for all households)	€/1. year	76,109
	€/2. year	152,217
	€/3. year	228,326
	€/4. year	304,435
	€/5. year	380,543
Value of own / more income	**€/5 years**	**1,141,630**
Overall value of reforestation on women	€/a	76,109

For the government: Argan forest areas		
Avoided CO_2 costs		
Argan tree: CO_2 absorption	t/ha/a	6.70
Average social costs of CO_2	$/t	50
	€/t	45.91
	€/ha	307.60
Area reforested every year	ha/1.year	215.42
	ha/2.year	430.85
	ha/3.year	646.27
	ha/4.year	861.69
	ha/5.year	1,077
Average social costs of CO_2 (for whole reforested area)	€/1. year	66,263
	€/2. year	132,527
	€/3. year	198,790
	€/4. year	265,054
	€/5. year	331,317
Value of higher state budget	**€/5 years**	**993,952**
Overall value of reforestation on the government	€/a	66,263
Total impact	**€**	**2,135,583**

Appendix 5.4. Sustainable education calculations

Sustainable Education		
Input in sustainable education	€/a	125,452
Input in sustainable education over 5 years	€/5 years	627,258
GDP per capita	$/capita	3,121.68
government expenditure per student primary (% of GDP per capita)		19.56%
government expenditure per student primary	$/student/primary ed.	610.63
government expenditure per student primary per year	$/student/year	152.66
Sustainable education costs	€/student/year	135.22
Sustainable education output		928
Sustainable education output over 5 years		**4,639**
Average number of children per household		3.30
Reach of outcome: Households supplied with sustainable education		**1,406**

Outcomes:		
For the government: Access to sustainable education for children		
Cost savings for solid waste collection		
Solid waste generation in rural areas	kg/d	0.30
	kg/a	109.50
Share of solid waste openly dumped		52%
Openly dumped waste	kg/1.year	56.94
	kg/2.year	54.75
	kg/3.year	52.56
	kg/4.year	50.37
	kg/5.year	48.18
Openly dumped waste by all students	kg/1.year	52,825
	kg/2.year	50,793
	kg/3.year	48,761
	kg/4.year	46,730
	kg/5.year	44,698
Average costs of solid waste collection	MAD/t	417.00
Average costs of solid waste collection (for all students)	MAD/1.year	22,028
Average costs of solid waste collection (for all students)	€/1. year	2,093
	€/2. year	2,012
	€/3. year	1,932
	€/4. year	1,851
	€/5. year	1,771
Value of higher state budget	**€/5 years**	**9,658**
Overall value of sustainable education on the government	€/a	2,093
Total impact	**€**	**9,658**

Appendix 5.5. Electricity calculations

Electricity Grid-feed		
Annual production of renewable energy	GWh/a	576
Overlap		3.5%
Annual electricity output	GWh/a	20.16
Electricity output over 5 years	**GWh**	**100.8**
Electricity consumption	MWh/a	0.9
Electricity consumption per household	MWh/a	4.77
Reach of outcome: Households supplied with electricity		**4,226**

Outcomes:		
For women: Access to electricity		
Cost savings for electricity		
Electricity tariff of Morocco	MAD/kWh	0.901
Electricity consumption per household	kWh/a	4,770
Electricity costs per household	MAD/a	4,298
	€/a	408.29
Electricity costs (for all households)	€/a	1,725,595
Value of higher household assets	**€/5 years**	**8,627,976**
Overall value of electricity on women	€/a	1,725,595
For the government: Electricity grid-feed		
Less electricity production necessary		
Average price for electricity	MAD/kWh	1.06
	MAD/a	21,272,832
Average price for electricity (for whole output)	€/a	2,020,919
Value of higher state budget	**€/ 5 years**	**10,104,595**
Avoided CO_2 costs		
Average CO_2 avoidance costs	€/t CO_2	28.56
Avoided CO_2 per MW installed of solar plant	tCO_2/MW	3,052
Avoided CO_2 per MW installed of wind plant	tCO_2/MW	1,254
CO_2 for 100MW wind plant	t CO_2/a	305,200
CO_2 for 100MW solar plant	t CO_2/a	125,400
Average CO_2 avoidance costs for wind plant	€/a	8,716,512
Average CO_2 avoidance costs for solar plant	€/a	3,581,424
Average CO_2 avoidance costs for wind and solar plant	€/a	12,297,936
Value of higher state budget	**€/ 5 years**	**61,489,680**
Overall value of electricity on the government	€/a	14,318,855
Total impact	**€**	**80,222,251**

Appendix 5.6. New employment calculations

New Employment	
Main components of PtX plant:	
Jobs for photovoltaic plant	200
Jobs for wind par	18
Jobs for rest of plant	158
Long term employment output	**376**
Average number of people of working age per household	2
Reach of outcome: Households with new employment	**188**

Outcomes:		
For women and farmers: Access to jobs on plant		
New employment opportunity		
Option 1:		
Minimum wage in private sector	MAD/m	2,571
	MAD/a	30,850
	€/a	2,931
Minimum salary in private sector (for all households)	med/a	1,102,950
Value of higher Income	€5 years	5,514,752
Option 2:		
Average salary in private sector	MAD/m	5,188
	€/a	5,914
Average salary in private sector (for all households)	€/a	2,225,756
Value of higher Income	**€/5 years**	**11,128,779**
Value of new employment for women and farmers	€/a	2,225,756
For the government: Access to jobs on plant for population		
Income tax		
Average yearly income	MAD/a	62,256
Income tax rate		20%
Income tax	MAD/a	12,451
	€/a	1,183
	€/a	445,151
Value of higher state budget	**€/5 years**	**2,225,756**
Value of new employment for the government	€/a	445,151
Total impact	**€**	**13,354,535**

Appendix 5.7. Land lease calculations

Land Lease		
Required area for renewable energy plant	ha	670
Permanent sealed area	ha	4
Land lease output	**ha**	**666**
Average farm size	ha	3
Reach of outcome: Farms leasing agricultural land		**222**

Outcomes:		
For farmers: Land lease for renewable energy plant		
Rent received for leased land		
Average lease price in Africa	€/ha	91.19
Estimated purchase price	med €/ha	5,000
Average buying/rent ratio		29.29
Average rental price of agricultural land	€/ha/a	170.73
Average rental price per farm	€	512.20
Average rental price of agricultural land (for all farms)	€/a	113,707
Value of higher income	**€/ 5 years**	**568,537**
Value of land lease for farmers	€/a	113,707
Total impact	**€**	**568,537**

Appendix 5.8. Sale of land calculations

Sale of Land		
Sale of land output	**ha**	**4**
Average farm size	ha	3
Reach of outcome: Farms selling agricultural land		**1.33**

Outcomes:		
For Farmers: Financial compensation for sale of land		
Receipt of one-time payment		
Average purchase price of agricultural land	med €/ha	5,000
Value of higher farm assets	**€**	**20,000**
Total impact	**€**	**20,000**

Appendix 5.9. Liquid-fuel calculations

Liquid-Fuel		
1/5 investment in liquid-fuel	€/5 years	1,881,774.39
Investment per year		376,354.88
Liquid-Fuel production costs	€/L	1.19
Liquid-Fuel output	L/a	316,797.03
Car ownership per 1000 inhabitants		57
Motorized ownership per 1000 inhabitants		53
Car ownership per household		**0.30**
Motorized two/three-wheeler ownership per household		**0.28**
Tractors per 100 km2		49.02
Tractors per farm		**0.01**

Appendix 5.10. Total impact calculations

Total impact on stakeholder groups					
Output	**Women**	**Farmer**	**Children**	**Govern-ment**	
Water	1,437,861	3,641,732	282,318	44,632	5,406,542
E-gas	1,262,053		139,420	823,548	2,225,020
Reforestation	1,141,630			993,952	2,135,583
Sustainable edu-cation				9,658	9,658
Electricity	8,627,976			71,594,275	80,222,251
Long term em-ployment	5,564,389	5,564,389		2,225,756	13,354,535
Land lease		568,537			568,537
Sale of land		20,000			20,000
TOTAL IMPACT	**18,033,909**	**9,794,658**	**421,737**	**75,691,821**	**103,942,125**

Appendix 5.11. Attribution and deadweight

Attribution				
Water:				
Improvement in access to potable water:				
Year 1	Year 2	Year 3	Year 4	Year 5
0%	0.40%	0.80%	1.20%	1.60%
Increase of area equipped for irrigation:				
Year 1 [ha]	Year 2 [ha]	Year 3 [ha]	Year 4 [ha]	Year 5 [ha]
1520	1527.7	1535.4	1543.1	1550.8
E-gas:				
Improvement in access to clean fuels:				
Year 1	Year 2	Year 3	Year 4	Year 5
0%	0.20%	0.40%	0.60%	0.80%
Decreased use of unclean fuels:				
Year 1	Year 2	Year 3	Year 4	Year 5
0%	0.50%	1.00%	1.50%	2.00%

Deadweight				
Sustainable Education:				
Decreased openly dumped waste:				
Year 1	Year 2	Year 3	Year 4	Year 5
0%	2%	4%	6%	8%

Appendix 5.12. Discounting

Discounting		
	Benefits [€]	**Total present value [€]**
Year 1	20,530,619	19,836,347
Year 2	20,647,522	19,274,683
Year 3	20,784,425	18,746,361
Year 4	20,921,328	18,231,729
Year 5	21,058,231	17,730,466
TOTAL	**103,942,125**	**93,819,585**

Appendix 5.13. Input and SROI calculations

Input		
Expected revenue of e-diesel	€/a	37,635,488
Investment scenario	%	4%
	€/a	**1,505,420**
Input from Investors	€/ 5 years	**7,527,098**
Permanent sealed area per windmill	ha	0.30
Average performance per windmill	MW	7.50
Windmills needed for PtX plant		13.33
Permanent sealed area for windpark	ha	4.00
Reference price for wheat	MAD/t	2,800
Cereal yield	kg/ha/a	1,758
Yield for windmill area	kg/a	7,031
Revenue for windmill area	MAD/a	19,686
	€/a	**1,870**
Input from Farmers	€/5 years	**9,351**

Input during observation period	**€/5 years**	**7,536,449**
Output during observation period	**€/5 years**	**93,819,585**
Net Present Value	€	86,283,136
SROI	**€**	**12.45**

Appendix 5.14. General information for calculations

General information on Morocco		
Inhabitants		36,092,138
Average farm size	ha	3
Average household size		5.30
Average number of people of working age per household		2.00
Average number of children per household		3.30
Average number of girls per household*		1.65
Minimum wage in agriculture	MAD/m	1,812.98
Average school day	h/d	6.25
School days per year	d/a	221
Average future wage increase through additional school time	%/a	10%

*Assumption: equal distribution of girls and boys per household

General information on PtX plant		
Capacity	MW	100
Required Area	ha	670
Annual Fischer-Tropsch-Production	GWh/a	300
Annual Fischer-Tropsch-Production	Litre/a	30,108,390.20
Revenue	€/a	37,635,487.76
% available for local enhancement	%	0.04
Water production costs	€/m^3	0.21
Gas production costs	€/kg PtG	1.46
Annual production of renewable energy	GWh/a	576
Overlap		3.5%
Fuel production costs	€/L	1.19

Information on water		
Drinking Water suggestion by WHO	L/d/capita	50
	L/d/household	265
	L/a	18,250
	m^3 H_2O/a	18.25
Potable Water demand per household	m^3 H_2O/a	96.73
	Litre H_2O/a	96,725
Agricultural water withdrawal	m^3 H_2O/a	9,156,000,000
Area equipped for irrigation	ha	1,520,000
Agricultural water withdrawal	m^3 H_2O/a/ha	6,023.68
Net irrigation water needs for wheat	m^3/ha min	2,550
	m^3/ha med	2,975
Net irrigation water needs for wheat	m^3/ha max	3,400
Net irrigation water needs for wheat per farm	m^3 min.	7,650
Need of irrigation for wheat per farm	m^3 med	8,925
	m^3 max	10,200
Total water demand of farm and household	m^3 H_2O/a	9,021.73
Average time spend on collecting water per round	Minutes	25
Average amount of water collected per round of mother	Litre	20
Average amount of water collected per round of child	Litre	8
Average amount of water collected per round by mother and child	Litre	28
Share of rural population without access to potable water		62%
DALYs lost due to water-borne diarrhoea		422,025
Share of diarrhoeal infections due to water contamination		88%
Average increase in agricultural production through irrigation	min.	142%
	median	154%
	max	166%
Share of cultivated area under irrigation		16%
Price for wheat	MAD/t	2,800
Cereal yield	kg/ha/a	1,757.70
Irrigation water tariff of Morocco	MAD/m^3 H_2O	0.29
Cost recovery of sustainable costs for irrigation water		75%
Cost recovery of operation costs for potable water	min.	75%
	max	90%
	med	83%
Water tariff with over 15m^3 per month	MAD/m^3	7.98
Water tax	MAD/m^3	2.16

Information on e-gas		
Consumption of Butane	t/a	2,173,000
	t/capita/a	0.06
	kg/capita/a	60.21
Heating value Methane	kWh/kg	15.40
Heating value Butane	kWh/kg	13.80
Fuel used for cooking:		
Gas		92%
Electricity		2%
Coal		2%
Firewood		27%
Animal waste		11%
Share unclean/clean cooking:		
Unclean cooking		41%
Clean cooking		93%
Firewood and coal		29%
Average expenditure for firewood	MAD/a/capita	199.10
Average expenditure for coal	MAD/a/capita	29.90
Average time spent collecting firewood	h/d	2
DALYs lost due to indoor air pollution	DALYs/a	21,828.74
Gas price in Morocco	MAD/12kg	42
Expenditure for Butane per year	MAD/a/capita	236.70
Subsidies paid for gas	MAD/a/capita	394

Information on reforestation		
Reforestation costs	MAD/ha	12,260
Argan tree: CO_2 absorption	t/ha/a	6.70
Average social costs of CO_2	$/t	50
	€/t	45.91
Average yield per tree	kg/a	8
Possible density of trees	trees/ha	100
Kilogram of fruit necessary to produce one litre argan oil	kg/L	30
Time needed to produce one litre argan oil	h/L	16
Workers for Argan oil production	capita/ha	3

Information on sustainable education		
GDP per capita	$/capita	3,121.68
Government expenditure per student primary (% of GDP per capita)		19.56%
Solid waste generation in rural areas	kg/d	0.30
Share of solid waste openly dumped		52%
Average costs of solid waste collection	MAD/t	417.00

Information on electricity grid-feed		
Electricity consumption per capita	MWh/a	0.90
Different prices for different hours	MAD/kWh	1.42
	MAD/kWh	1.01
	MAD/kWh	0.74
Average price for electricity	MAD/kWh	1.06
Average CO_2 avoidance costs for wind and solar energy	$/t CO_2	31
	€/t CO_2	28.56
Avoided CO_2 per MW installed of solar plant	tCO_2/MW	3,052
Avoided CO_2 per MW installed of wind plant	tCO_2/MW	1,254
Price per kWh for households	MAD/kWh	0.901

Information on new employment					
Jobs per MW of average capacity	**Manufacturing & Construction Phase**		**Operation & Maintenance Phase**		
Solar Photovoltaic	5.76	6.21	1.2	3	4.8
Wind Power	0.43	2.51	0.27	0.27	
Electrolyses, Syntheses			1	2	3
Seawater desalination plant (for 100MW size)		5,250	25	25	
Minimum wage in private sector	MAD/m	2,570.86			
Average salary in private sector	MAD/m	5,188.00			
Income tax rate		20%			

Information on land lease		
Average lease price in Africa	€/ha	91.19
Estimated purchase price	min €/ha	1,000
	max €/ha	20,000
	med €/ha	5,000
Buy/rent ratio		29.29

Information on LIquid-fuel	
Share of owners of a private car	5.50%
Share of owners of a motorcycle	11.70%
Car ownership per 1000 inhabitants	57
Two/Three-wheeler ownership per 1000 inhabitants	106
Motorized ownership	53
Tractors per 100 km^2	49.02

Information on sale of land		
Permanent surface area per windmill	ha	0.30
Average performance per windmill	MW	7.50

Information on attribution	
Irrigated area in 2020	1,520
	1,485
Irrigated area in 2010	1,443
Difference of cultivated area under irrigation	35
	42
Average difference of cultivated area under irrigation	38.50
Average difference of cultivated area under irrigation per year	7.70

Appendix 6: Personal learning report

The broad direction of the topic was given by the department for renewable fuels at Audi. I chose to work with this department on this topic in addition to the supervision of the professorship of my University, to work on a practical example how to achieve three-dimensional sustainability in companies. In the following paragraphs I summarised my personal learnings I gained throughout the work on this thesis.

During my literature review - mostly of academic journals – I was more and more amazed on how the social problems repeat themselves independent of the location on earth. The issues faced by a part of the population cannot be strictly accounted to one region or country but must be much more seen as a global matter. This goes hand in hand with the realization that the reasons for poverty and other problems are very multidimensional and cannot always be traced back to one reason and therefore issue, which must be solved. The research trip to Morocco showed me even more the huge gap between rich and poor, which somehow feels accepted by everyone. It also got quite clear for me that they are quite open for change and improvement of their living conditions, but the decision has to be made with those people affected. Talking to locals demonstrated me how important it is to dig behind the statistical data. The stories and information given to me by them was much more useful to gain a full picture and gave me additional paths, which the desk research hasn't given me before. They know best which problems have to be solved first. Another major finding was that sustainability can only be achieved when all three dimensions ecologic, economic and social are aimed. Populations living in poverty without access to basic supply like water and education, don't have the capacity to think about the ecological effects of their actions. An improvement in living conditions has to occur first.

The whole work of this thesis made clear to me that there are several ways to work sustainable, benefitting everyone. Most important was the realisation of the multidimensional reasons and branches of social problems. The end result is the least important aspect of this thesis but rather the diverse path towards it. Reasons for these issues are all linked together, which means that just cutting out one does not erase the other ones and will just lead to further problems. To really make a difference all aspects of social problems must be considered and solved.

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