The Green Economy of Morocco

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To my beloved teachers, family, friends, and Syria.

Abstract

This thesis studies the green economy model of Morocco. This model was principally built on a transition to a renewable energy to respond to the country's development challenges and to meet its Nationally Determined Contributions (NDC). Its challenges are linked to the consequences of climate change and to scarcity of fossil fuel energy sources. The central research question of this thesis is: to what extent may Morocco be able to achieve what it has promised to deliver by adopting its own green economy approach. The research question is addressed by analyzing the country's time-series data, scrutinizing its model, and assessing its progress through a customised measurement framework. A mixed methods approach combining quantitative and qualitative analysis is used to answer the research question. This includes analysis of nine interviews with key informants in the energy sector and available data from Morocco's national and international sources.

The results of the time-series analysis show that Morocco has only been able to slow carbon emission growth and delink emissions from its economic growth. Studying the energy transition to renewable energy, Morocco's model largely ignores important elements to decarbonize its key economic sectors which are responsible for a large share of carbon emissions – in particular the transport, heating, industry and residential sectors. The measurement framework shows that Morocco is far from achieving its NDC commitments in any mitigation scenario, though the country has achieved some socioeconomic benefits. These findings demonstrate that Morocco's green economy model is insufficient to help the country overcome its development challenges and meet its global commitments.

This thesis offers a new insight into Morocco's green economy in theory and practice. It adds new depth to the discussion on the steady-state economy and the degrowth argument in terms of the possibility of reducing emissions, while keeping the economy growing. It supports the conclusion that middle-income economies follow a path of weak sustainability. This thesis also extends the application of the Porter Hypothesis to country level beyond the narrow view of traditional environmental policies. Moreover, this thesis provides a strong evidence for the existence of the Environmental Kuznets Curve theory in Morocco. This thesis proposes a customised green economy measurement framework for Morocco.

Key recommendations for Morocco to increase the possibility of greening its economy are an expansion of the economy's electrification, an acceleration of the energy sector's shift from fossil fuel to various renewable energy sources, and a decentralisation of its electricity system. This requires radical transformation in how to power its economy.

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Rami,

Declaration

“I declare that, except where explicit reference is made to the contribution of others, that this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.”

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24 June 2022

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Abbreviations

$	United States dollar
ADEREE	National Agency for Renewable Energies and Energy Efficiency
AFOLU	Agriculture, Forestry, and Other Land Use
AIC	Akaike Information Criterion
AMEE	Moroccan Agency for Energy Efficiency
ANRE	National Electricity Regulatory Authority
ARDL	Autoregressive Distributed Lag
b	billion
BAU	business-as-usual
CCUS	Carbon Capture, Utilisation and Storage
CDER	Centre for the Development of Renewable Energies
CH_4	Methane
CKC	Carbon Kuznets Curve
CO_2	Carbon dioxide
COP	UN Climate Change Conference of the Parties
CSP	Concentrated Solar Power
CUSUM	Cumulative sum of recursive residuals
CUSUMSQ	Cumulative sum of squares of recursive residuals
DOLS	Dynamic Ordinary Least Squares Estimator
ECM	Error Correction Model
ECT	Error correction term
EIB	European Investment Bank
EKC	Environmental Kuznets Curve
ENSA	Ecole Nationale des Sciences Appliquées
EU	European Union
EVs	Electric vehicles
FDI	Foreign Direct Investment
FMOLS	Fully Modified Ordinary Least Squares
FTE	Full time equivalent
GDP	Gross Domestic Product
GGEI	Global Green Economy Index
GGGI	Global Green Growth Institute

GGKP	Green Growth Knowledge Platform
GHG	Greenhouse gas
GNI	Gross National Income
HAC	Autocorrelation consistent
HFCs	Hydrofluorocarbons
HQ	Hannan-Quinn information criterion
ICC	International Chamber of Commerce
IEA	International Energy Agency
ILO	International Labour Organization
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent power plant
IUCN	International Union for Conservation of Nature
IWE	Integrated Wind Energy
J	Joule
kgoe	Kilogram of oil equivalent
ktoe	Kilotonnes of oil equivalent
kWh	Kilowatt hour
LPG	Liquid petroleum gas
MASEN	Moroccan Agency for Solar Energy
MEME	The Ministry of Energy, Mines and Environment
MENA	Middle East and North Africa
Mtoe	Million tonnes of oil equivalent
N_2O	Nitrous oxide
NBS	Nature-based Solutions
NDC	Nationally Determined Contributions
NF_3	Nitrogen trifluoride
O&M	Operations and Maintenance
OECD	the Organisation for Economic Cooperation and Development
OMNEEA	The Moroccan Organization of the Energy, Water and Agriculture Nexus
ONE	Office National de l’Electricité (English translation: the National Office of Electricity)

ONEE	Office National de l'Electricité et de l'Eau potable (English translation: the National Office of Electricity and Drinking Water)
PFCs	Perfluorocarbons
PNAP	Plan National d'Actions Prioritaires (English translation: National Plan of Priority Actions)
PPAs	Power Purchase Agreements
PSR	Pressure state response
PV	Photovoltaic
R&D	Research and development
SDG	Sustainable Development Goal
SEEA	System of Environmental-Economic Accounting
SF_6	Sulfur hexafluoride
SIC	Schwarz Information Criterion
SIE	Société d'Investissement Energétique (English translation: Energy Investment Company)
SIP	Solar Integrated Programme
STEP	Pumping Energy Transfer Station
TFEC	Total final energy consumption
TJ	Terajoules
toe	Tonne of oil equivalent
TPES	Total primary energy supply
TWh	Terawatt-hour
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USA	The United States of America
USD	United States dollar
VAR	Vector Autoregressions
WTO	World Trade Organization

Chapter One

Introduction

1.1. Introduction

This thesis studies the green economy model of Morocco which has been built on a transition to renewable energy. Morocco launched its Energy Strategy in 2009 to accelerate this transition. This was followed by announcements of several large-scale solar and wind energy projects. The country has made a commitment to a green economy since its participation in the Earth Summit held in Rio de Janeiro, Brazil, in 1992. [1] This was followed by hosting two major United Nations climate change summits in Marrakech COP7 in 2001, and COP22 in 2016 (UNFCC 2016).[2] Furthermore, Morocco was one of the first countries to sign the Paris Agreement in 2016 and committed itself to reduce carbon emissions according to an ambitious plan to limit global warming to 1.5°C.[3]

Morocco has sought to diversify its energy mix from renewable energy sources and increased generation of solar and wind energy. Despite its efforts, however, the country has achieved limited progress towards a green economy. The country's model has largely ignored important elements to decarbonize key economic sectors responsible for a large share of carbon emissions; in particular, the transport, heating, industry and residential sectors. Electrification, a decentralized electricity system and the use of different types of renewable energy sources such as offshore wind and hydrogen, are key approaches to reduce carbon emissions, are missing in its green economy model.

To this end, this thesis argues that Morocco's progress on green economy transition is very limited, and its existing model is insufficient to deliver its green ambitions. I validate my argument by analyzing the country's time-series data, scrutinizing its model, and assessing its progress through a customised green economy measurement framework.

To do so, I undertake four main steps. Firstly, I investigate Morocco's main motivations and ambitions for pursuing a green agenda linked to responding to its development challenges and to meet its global commitments. Secondly, by means of an econometric estimation, I provide a deep understanding of the progress Morocco has made towards a green economy in terms of decoupling its economic growth from environmental

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[1] Earth Summit is the United Nations Conference on Environment and Development (UNCED), also known as the Rio Conference, held in Rio de Janeiro in Brazil from 3–14 June 1992. One of major results of the UNCED Conference was Agenda 21 a program of actions calling for investment in future strategies to achieve overall sustainable development in the 21st century (UN, 1992).

[2] Total international participants of the seventh Conference of the Parties (COP7) included 4,460 concerned parties representing 170 global economies and international organizations (UNFCC, 2001).

[3] The Paris Agreement, drafted in 2015 within the UNFCCC, deals with GHG emission mitigation, adaptation and finance. The agreement's long-term temperature goal is to keep the increase in global average temperature to well below 2°C above pre-industrial levels, and to pursue efforts to limit the increase to 1.5°C, recognizing that this would substantially reduce the risks and impacts of climate change.

impacts. Thirdly, I examine the evolution of renewable energy in Morocco and its desired benefits from an energy transition. Then, I address number of key challenges which the country face during its transition and identify the policy gap in its green economy model. Lastly, I develop a customised measurement tool to help monitor Morocco's green economy progress based on its particular circumstances and green ambitions, taking into account global practices.

This analysis is supported by the qualitative analysis of nine interviews with key informants in the energy sector and available data from Morocco's national and international sources. The diversity of interviews is important to understand the energy policy from various perspectives in the country and also to cross-check the results of my study.[4]

1.2. National context

By hosting COP7 in 2001 and COP22 in 2016, Marrakech brought together thousands of negotiators, government representatives, business leaders and citizens, from almost every country in the world, to discuss climate change issues. The latter conference helped Morocco build its new green economy image and functioned to accelerate the country's transition to renewable energy. Morocco was recognized as a leader in green economy transition with regards to carbon emissions, renewable energy, resource efficiency and climate policy (Burck et al., 2019; Prisco, 2016). However, I argue that its approach is far from helping the country achieve its green ambitions and suffers from major drawbacks. This thesis assesses Morocco's green economy model and reveals important shortcomings in its approach related to the decarbonization of its economy. In particular, its current approach ignores reducing carbon emissions from energy-intensive sectors: transport, heating, industry and residential.

Morocco's global involvement in climate change issues visibly started in 1992 when the country participated in the Earth Summit and signed and ratified its three agreements on biodiversity, desertification and climate change (Hilale, 2011). Since then, the country has made considerable efforts to tackle climate change and transition towards renewable energy (MEME, 2012). Morocco reacted actively to the Earth Summit by creating its Ministry of the Environment which paved the way towards creating Morocco's National Strategy for the Environment and Sustainable Development (Tarradell, 2004). In addition, the National Committee for Climate Change was established in 2001. Morocco also ratified the Kyoto Protocol in 2002 under which the Kingdom pledged to reduce its greenhouse gas emissions

[4] Appendix A provides details about the interviews and profile of informants.

substantially[5] (Nachmany et al., 2015).[6] These steps demonstrate Morocco's continuous commitment to green growth and sustainable development.[7]

In his speech at the international meeting on 'Climate change: challenges and prospects for Morocco', in Rabat, in 2009, King Mohammed VI declared that Morocco suffers from the effects of climate change and emphasised the importance of fighting against climate change and achieving sustainable development by exploring the right balance between the country's development needs and reducing GHG emissions. The king stressed the need to pursue green growth and making considerable investment in renewable energy as an alternative and more sustainable source of energy. This speech contextualised the green economy model of Morocco, based on a transition to renewable energy to tackle climate change and reach desired development goals. The most important impacts of climate change on Morocco include increased frequency of droughts and worsening desertification affecting the agriculture sector, reducing cereal crops, and threatening biodiversity (MEME, 2009).

King Mohammed VI launched the Energy Strategy in 2009, the backbone of country's transition to a green economy as strongly recognized by the World Bank (2014). This strategy specified ambitious targets to increase energy efficiency by 12% and share of renewable electricity to 42% of the installed electrical power in its energy mix by 2020. Later, during COP21, held in Paris in 2015, King Mohammed VI announced new 2030 targets to reach a renewable energy level of 52% of the installed electrical power and a 15% energy efficiency gain. These bold targets paved the way for further acceleration of the country's energy transition. However, this Energy Strategy ignored the transformation of the energy system regarding an increased electrification of fossil fuel energy-intensive sectors.[8]

The other striking steps which the Kingdom took to ease its green transition include amending its constitution in 2011 to incorporate sustainable development as a right for every citizen which must be respected, the reduction of fossil fuel subsidies to make renewable energy more competitive, and welcoming investments in clean energy sector.

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[5] Seven main GHGs contribute to climate change, as covered by the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). Different activities emit different gases. Carbon emissions account the majority of GHG emissions (UK Government, 2021a).

[6] Following the ratification of the Kyoto Protocol in 2002, Morocco developed the Clean Development Mechanism (CDM) (2003–2005). Accordingly, a portfolio of 40 projects and programmes has been developed, of which eight projects are registered with the CDM Executive Board with a potential reduction of GHG emissions estimated at 5.4 m tons of CO_2 equivalent per year (MEME, 2012).

[7] Section 2.2.3 in Chapter Two distinguishes between green economy and green growth. Whereas Section 2.2.4 explains the relationship between green economy and sustainable development.

[8] Section 5.5 in Chapter Five examines the policy gap in energy transition to achieve green growth.

Morocco's commitment to energy transition has been globally recognized. The World Bank emphasised that renewable energy is key to Morocco's transition to a green economy. It could provide considerable socioeconomic and environmental benefits to the country, such as job creation and reductions in carbon emissions. Moreover, energy security, environment protection, economic growth and social responsibility are the key elements of sustainable development goals (SDGs). The UN (2020) asserts the need to foster renewable energy to achieve SDG 7 which is 'Ensure access to affordable, reliable, sustainable and modern energy for all' as well as SDG 13 which is 'Take urgent action to combat climate change and its impacts'. Therefore, renewable energy has a significant role to play towards reducing carbon emissions and achieving sustainable development goals in Morocco.

The country was granted the Energy Efficiency Visionary Award during the Energy Efficiency Global Forum held in Washington, D.C. in May 2017.[9] During the event, King Mohammed VI sent a message to the forum stating:

> This award confirms the Kingdom of Morocco's positioning as one of the countries that have managed to make the most of their renewable energy potential by developing solar power plants, wind farms and hydroelectric plants, and by introducing energy efficiency measures in all key sectors of the Moroccan economy […] the security of energy supply, energy availability, energy efficiency and environmental protection are the bedrock of my country's energy strategy (Maroc.ma, 2017).

This message stresses the king's commitment to supporting Morocco's Energy Strategy and reaching its objectives. The message outlines elements of the strategy on energy security, renewable energy, energy efficiency, leadership, regional positioning, and environmental protection. There is a particular focus on hydro, solar and wind energy sources without any mention of other renewable energy sources, such as biofuel, waste and green hydrogen, which Morocco has potential to develop.

Furthermore, a Best State Strategy Award for renewable energy was given to Morocco at the Africa Investments Forum & Awards (November 2017, Paris), acknowledging its steady efforts and leadership in promoting solar and wind energy. This demonstrates that Morocco is ahead of other African countries in renewable energy. However, the country is falling short of recent global practices, and the efforts made by advanced economies in energy transition which consider the electrification of heating and transport, the use of hydrogen and a decentralization of the electricity system.

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[9] The Energy Efficiency Global Forum is an annual event which brings businesses, governments and advocates together for two days to discuss energy efficiency issues and build global partnerships (Alliance to Save Energy, 2017).

Morocco was one of the first countries to sign the Paris Agreement in 2016. The country has developed its Nationally Determined Contribution (NDC) with bold targets to significantly reduce its carbon emissions. This is despite the fact that the country is responsible for only a small share of the global problem of climate change (UNFCCC, 2016). Strikingly, Morocco is one of only two global economies (along with Gambia) whose target is within the 1.5°C threshold.[10] Scientifically, this means that the Kingdom is committed to and must reach a net-zero emission economy by around 2050.[11] Its strategy to fight against climate change is guided by addressing the causes of the problem. The country aims to separate its economic growth from carbon emissions and substantially reduce its emissions as outlined in its National Plan Against Global Warming (MEME, 2009). This requires great efforts to substantially reduce its carbon emissions, especially from sectors responsible for majority of the emissions including transport, residential, and industry.

It is worth mentioning that Morocco was ranked sixth globally in the 2020 Climate Change Performance Index which means that the Moroccan government's efforts on climate change are very stringent (Burck et al., 2019).[12] Moreover, the World Bank is supporting Morocco's shift towards green growth through a range of operations in sectors such as water, energy, transport and agriculture (World Bank, 2014). The EU is collaborating with Morocco to fight against climate change and to work together on advancing their energy transition, protecting the environment and boosting the green economy. For example, a Green Partnership, which is EU's first initiatives with a partner country, has been proposed to strengthen their cooperation to share best practice and develop joint projects in circular economy, green finance, and clean energy. The partnership was proposed to contribute to achieving Morocco's objectives, both in decarbonizing its economy and strengthening the resilience of sectors most vulnerable to the effects of climate change (Directorate-General for Climate Action, 2021). This provides an example of the support given to Morocco from the international community to ease its green transition by engaging in global efforts to tackle climate change.

Morocco's purpose of its green economy approach is to contribute to its economic growth and help achieve sustainable development as well as to meet its NDC commitments.

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[10] The 2014 IPCC AR5 serves the scientific basis for the 2015 Paris Agreement. It sets the 1850–1900 period as a proxy for the pre-industrial period. To date, the planet has warmed 1.2°C above pre-industrial levels (Schleussner, 2021).

[11] To minimise the worst climate impacts, and avoid irreversible damage to our societies, economies and the environment, we must hold temperature rise to 1.5°C above pre-industrial levels. This requires halving greenhouse gas emissions by 2030 and reaching net-zero emissions by 2050 (Science Based Targets, 2021).

[12] None of the countries has occupied positions one to three as no country is considered to be doing enough to prevent dangerous climate change (Burck et al., 2019).

Its bold and ambitious plans for green economy transition are often recognized by various organizations in the international context as a model for the development of renewable energy in developing countries. The Kingdom envisages that its aspiring programme will stand as a green economy model in the Middle East and North Africa region (Günay et. al., 2018). However, this thesis claims that Morocco's focus on decarbonizing electricity has largely ignored the role of transport, heating, and industry in generating increased carbon emissions which is global issue. The next section highlights some global efforts to tackle climate change, and recent practices for the decarbonization of economies.

1.3. Global context

In the global context, Pope Francis declared a climate emergency in June 2019. He also called for a radical energy transition away from fossil fuels towards renewable energy sources (Harvey, 2019). Since then, an increasing number of countries have declared a climate emergency including the UK, Canada, France, Spain, Japan, New Zealand, the EU (on behalf of member states) and many others. By 2020, 126 countries responsible for 51% of global GHG emissions had adopted net-zero emission targets for 2050 (Olhoff and Christensen, 2020).[13] The phrase 'net-zero' has been the centre of climate change discourse in the last few years (Black et al., 2021).[14] While the predominant view to tackle climate change has been to reduce global GHG emissions by around 80%, the shift towards the need to reach net-zero emissions by around 2050 appeared in the IPCC Fifth Assessment Report in 2014[15] and was also adopted by the Paris Agreement in 2015 (Paterson, 2021).[16]

The recent technological breakthrough in renewable energy, such as offshore wind development, supported by increasing funds allocated by governments on renewable energy and energy efficiency, has made net-zero emission targets increasingly possible.[17] For

[13] On 8 February 2021, UN Secretary-General, António Guterres, stated that countries representing 70% of the world economy and 65% of global carbon dioxide emissions have now committed to net-zero targets (Guterres, 2021). Also, the Energy and Climate Intelligence Unit and Oxford Net Zero report that two-thirds of the global economy set net-zero targets by 2021 (Black et al., 2021).

[14] Pledges of net-zero emissions are rapidly growing, these net-zero targets are increasingly appearing in governments' economic development plans, corporate strategies, investors' portfolio targets and the manifestos of regional governments and city councils (Black et al., 2021).

[15] The IPCC Fifth Assessment Report provides an overview of the state of knowledge concerning the science of climate change (Change, 2014).

[16] Current projections of global population size and GDP per capita imply that the world must reduce its rate of CO_2 emissions per unit of real GDP by around 9% per year on average to reach net-zero emission targets by 2050. Between 1990 and 2016, global emissions per unit of real GDP decreased only by 1.8% per year (Lenaerts et al., 2021).

[17] While carbon neutral refers to a policy of not increasing carbon emissions and of achieving carbon reduction through offsets, net-zero carbon means making changes to reduce carbon emissions to the lowest amount – and offsetting as a last resort (Bigg, 2021).

example, in March 2019, the UK government and the Offshore Wind Industry Council signed a Sector Deal aimed at increasing offshore wind contributions by up to 30 GW of generating capacity by 2030 (UK Government, 2020a). This means that offshore wind will become the backbone of the energy system in the UK.

The COVID-19 pandemic has renewed the climate change agenda's global momentum and applications of the green economy.[18] Many governments have developed strategies and plans to accelerate green economy transition and prioritized green recovery as a response to the worst economic recession since the Great Depression of 1929. For instance, in November 2020, the UK Prime Minister, Boris Johnson, announced his Ten Point Plan for a Green Industrial Revolution in order to assist the recovery of the UK economy from the consequences of COVID-19 Crisis (Box 1). The plan has allocated £12 billion of government investment, and potentially three times as much from the private sector, to create and support up to 250,000 green jobs in clean energy, transport, nature and innovative energy technologies. In his announcement, Johnson introduced his plan by stating:

> Imagine how our Green Industrial Revolution could transform life across our United Kingdom. You cook your breakfast using hydrogen power before getting in your electric car, having charged it overnight from batteries made in the Midlands. Around you the air is cleaner, and the trucks and trains, ships and planes are running on hydrogen or a synthetic fuel. British towns and regions — Teesside, Port Talbot, Merseyside and Mansfield — have become synonymous with green technology and the jobs they bring. This is where Britain's ability to make hydrogen and capture carbon pioneered the decarbonisation of transport, industry and power (UK Government, 2020c, p.3).

This quote asserts the growing momentum given to the green economy in practice. Johnson outlines the green opportunities to decarbonize the UK's economic sectors, mainly through energy transition. He suggests replacing gas with hydrogen for cooking. He further envisages using electric vehicles, battery storage, and hydrogen-powered cars and buses instead of fossil fuel vehicles. This vision sets out the route map of the UK to decarbonize transport, industry and energy, and also aims to create a significant number of jobs in green sectors across the British supply chain.

[18] The emission reduction rate observed as a result of restrictions in the first half of 2020 is broadly comparable to the reduction rate of annual emissions needed to achieve the 1.5°C threshold (Le Quéré et al., 2020).

Box 1: UK Prime Minister's Ten Point Plan for a Green Industrial Revolution

In his ten-point plan, launched on 18 November 2020, UK Prime Minister sets out the approach of the government to recover its economy, support green jobs, and accelerate its path to net-zero economy. The plan focuses on the following areas:

1. Advancing offshore wind.
2. Driving the growth of low-carbon hydrogen.
3. Delivering new and advanced nuclear power.
4. Accelerating the shift to zero emission vehicles.
5. Green public transport, cycling and walking.
6. Jet zero and green ships.
7. Greener buildings.
8. Investing in carbon capture, usage and storage.
9. Protecting the natural environment.
10. Green finance and innovation.

Source: UK Government (2020c)

The Ten Point Plan was designed in the run up to the COP26 climate summit held in Glasgow in 2021. This international conference brought global parties together to accelerate actions towards the Paris Agreement's temperature goal of limiting the carbon emissions, and to share global practices on the decarbonization of economies (Box 2).

Box 2: COP26 in Glasgow

COP 26, a global conference took place from 31 October to 12 November 2021, brought global parties together to accelerate actions towards the goals of the Paris Agreement and the United Nations Framework Convention on Climate Change (UNFCCC). Updated Paris Agreement commitments have been reviewed. Many countries have presented their 2030 ambitious targets for emission reductions that align with reaching net-zero by the middle of the century. This conference has further highlighted the importance of green economy transition to tackle climate change. The UNEP argued that this conference was the most important intergovernmental meeting on the climate crisis since the Paris Agreement in 2015.

Source: UK Government (2021c).

Moreover, climate change was one of the first executive orders that the President of the United States, Joe Biden, signed in the first days of his presidency period and election in November 2020, and, therefore, the USA has requested rejoining the Paris Agreement

(White House, 2021). This emphasises that climate change is at the top of Biden's political agenda and will guide the USA's future of development.[19]

The green economy agenda was initially articulated by international institutions to advise developed and developing economies on alternative development approaches to overcome financial and economic crises and avoid global risks. These institutions include the OECD, the IMF, the World Bank, the WTO, and the UNEP (Ferguson, 2015). Global practices show that there is no single green economy model. This varies across countries based on their particular context, resources and priorities. Several countries have already developed their own green economy strategies, policies and programmes. For example, in Asia, South Korea is one of the forerunners. In 2009, the country announced a five-year plan to annually invest approximately 2% of its GDP in green economy sectors. The plan includes increasing renewable energy to 11% of its energy supplies by 2030, and reducing its greenhouse gas emissions 30% by 2020 (World Bank, 2012b). China has also implemented a five-year plan (2011–2015) that includes a large portion of investment into green sectors, such as renewable energy and green technologies (Loiseau et al., 2016). The EU has developed Europe 2020 and the Resource Efficiency Roadmap for a smart, inclusive and sustainable economy (Mazza and ten Brink, 2012). The EU has prioritized renewable energy in order to become the first climate-neutral continent by 2050, as outlined in the European Green Deal (EU strategy on offshore renewable energy, 2020).

In Africa, some examples can be drawn from developing countries which attempt to practice green economy. Burkina Faso, a landlocked country with severe and unpredictable climatic seasons which contributes to food insecurity, has been implementing a Strategy for Accelerated Growth and Sustainable Development since 2011. This strategy aims to improve productivity and growth of the agriculture sector which represents a large share of its GDP. Ethiopia, one of the fastest-growing economies in the world according to the IMF (2012), has the largest water reserves in Africa. Hydroelectric plants represented more than 88% of Ethiopia's total installed electrical power in 2012. Therefore, the country has developed its Climate Resilient and Green Economy Strategy with emphasis on hydropower development, rural cooking technologies, livestock value chain and forestry development. These four pillars are seen to have immediate economic growth effects and resulted in a large reduction of carbon emissions. Tunisia suffers from increasing spatial disparities and social exclusion in addition to high pressure on its natural resources and ecosystem, accompanied by growing

[19] The former US Secretary of State, John Kerry, was appointed as a US special envoy for climate change on 23 November 2020 (Milman, 2020).

energy needs. Therefore, its National Strategy for Sustainable Development has prioritized renewable energy and energy efficiency to achieve an inclusive green growth (Avis, 2018).

The experience of the above mentioned African developing countries emphasizes the importance of adopting a green agenda based on national concerns and priorities. Therefore, it is clear that a green economy has been initiated as an alternative development route and as an attempt to overcome the development challenges facing developed and developing economies alike while tackling climate change. The green economy model needs to be tailored to suit the particular needs and conditions of each economy to mitigate the impact of their development problems while tackling climate change issues.

1.4. Green economy in Morocco

Morocco's national context demonstrates persistent commitment of the Kingdom to join global efforts to tackle climate change issues. The country built its own green economy model largely based on energy transition towards renewable energy. The question that one could raise is: why has Morocco been widely involved in global efforts to fight against climate change and put notable efforts into renewable energy transition?

Morocco stands out as a particularly interesting case. It is the only Northern African country with almost no proven oil and gas reserves, therefore most of its energy needs are imported. Thus, it is a very energy dependent economy.[20] In addition, Morocco suffers from the effects of climate change. The Kingdom has been experiencing extreme weather. More frequent and severe drought events have been happening especially after 1990. This has severely impacted Morocco's agriculture sector, which had traditionally been a key engine for its economic growth and employed the largest share of workers. Accordingly, the consequences of climate change and energy challenges are Morocco's main development issues and have brought serious challenges to its socioeconomic development, more severely after 1990 which I examine in Chapter Three.

The Kingdom has been seeking an alternative development route to overcome these challenges through an overarching approach. Its involvement in the global discussion on climate change discourse, since its participation in the Earth Summit in 1992, has opened its way towards green agenda. Morocco has realized that a green economy model could contribute towards helping the country overcome its energy challenges and the consequences of climate change. In particular, the 2009 National Plan Against Global Warming clearly

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[20] Energy dependency refers to the extent to which an economy relies on energy imports to meet its energy needs (Eurostat, 2021).

stated that Morocco's strategy in addressing the causes of climate change comes through separation of its economic growth from GHG emissions by reducing emissions through the introduction of clean energy (MEME, 2009).

Consequently, Morocco has developed its Energy Strategy in 2009 and pledged to significantly reduce its carbon emissions according to the Paris Agreement's goal to hold the global average temperature rise at 1.5°C in 2016. Although its efforts into green economy transition have been widely acknowledged, I argue in this thesis that due to serious drawbacks in its approach to decarbonize its economy, Morocco's model is far from helping the country deliver its global promises and overcoming its development challenges. The main problematic issue in its approach is focussing on decarbonisation of only electricity system while excluding other key sectors which are responsible for large share of emissions.

Accordingly, the aim of this thesis is to identify the Kingdom's motivations for pursuing a green agenda in Chapter Three and to assess its model and progress in subsequent chapters. I monitor its efforts through analyzing the time-series data of carbon emissions, economic growth and energy consumption in Chapter Four, scrutinize its green economy model in Chapter Five, and assess its progress through a customised green economy measurement framework in Chapter Six. This will help me understand the extent to which Morocco, an African fossil fuel scarce developing country impacted by the climate change, has achieved transition into a green economy.

This answers the question on whether the current green economy approach in Morocco is achievable. Such a question provokes debates on green economy literature about whether green growth in practice is possible or not (e.g. Hickel and Kallis, 2020), about the level of transformation of the economy this model needs (e.g. Ehresman and Okereke, 2015; Mundaca, 2016; Paterson, 2021), and whether green economy transition brings short-term or long-term benefits to national economies (e.g. Porter and van der Linde, 1995; Jacobs, 2012). Recent global practices and discussions on the green agenda in the last few years on decarbonization of economies inspired by technological advances in energy transition to renewable energy such as offshore wind and decarbonization of transport and heating urge to reopen the debates on delivering green economy.

1.5. Research gap

The introduction clearly shows that the discourse on green economy transition and particularly its applications have developed significantly in the last few years. The discussion is now focussing not only on reaching net-zero carbon emissions, which is an important element of the green economy, but also how to reach these targets and make a green economy transition achievable as quickly as possible. National economies are now in the race to be net-zero by 2050 in line with Paris Agreement goals. This growing momentum urges to revisit the literature on possibility of the green economy. This will enrich the debate about the extent to which a green economy is achievable, the level of transformation that green economy needs, and also the benefits of a green economy. The research literature on green economy does not take into account recent practical developments inspired by the technological advances, particularly around energy transition to renewable energy. Examining the green economy model in Morocco will provide a new insight into delivering a green economy and will add to the aforementioned literature.

In a recent study, Cooper et al. (2020) conclude that research on green growth in African countries is limited, and it is even scarcer in relation to Morocco. This means that knowledge about a green economy approach on the whole continent, in general, and Morocco in particular, remains poorly understood. Tiba and Omri (2017) survey empirical country-specific studies conducted between 1978 and 2014 on the relationship between economic growth and environment. No particular study analyses this dynamic relationship in Morocco. Few later studies such as ul Haq et al. (2016), Anas (2017), and El Moummy et al. (2020) tried to test this relationship in the country, however, these studies could be criticized on missing to consider important elements of the green economy model of Morocco.[21] This implies that investment in research on green economy in Morocco is needed.

Addressing this missing quantitative analysis for Morocco is essential to provide deep understanding of the progress the country has made in decoupling its economic growth from environmental damages, which is a core objective of the green economy. The measurement framework of green economy for its implementation and monitoring is lacking (Barr, 2013). A number of tools have been developed to measure the progress of countries on a green economy transition. But these tools do not reflect recent practice on the green economy in consideration of decarbonization of economies. Furthermore, as there is no one model of a green economy which varies across countries, none of them suits Morocco to assess its green transition. Therefore, it is essential to develop a customised measurement framework that suits the conditions of Morocco to measure its green economy progress.

To this end, this thesis studies the green economy of Morocco which contributes towards bridging the research gap between green economy literature and recent practice.

[21] Detailed discussion on previous studies on Morocco are provided in Section 4.2 in Chapter Three.

This thesis addresses the policy gap in a country that has committed itself to greening its economy relatively early in comparison to other economies. To do so, I will examine the development challenges that influenced Morocco to pursue a green agenda since its participation in the Rio Conference in 1992, when the Kingdom has demonstrated its global commitment to tackle climate change. In doing so, this thesis will try to investigate what green economy means to Morocco. I will quantitively assess whether the economic growth of Morocco has become greener. Furthermore, this thesis will investigate the evolution of the green agenda in Morocco and its main path, which was largely built on renewable energy, and identify the policy gap in its model. Lastly, this thesis will develop a customised measurement framework to monitor the progress of green economy transition in Morocco. This proposed tool is useful to understand the development of its energy transition to renewable energy and to identify the strengths and weaknesses of its green transition in policy.

1.6. Research question and argument

The central research question of this thesis is: to what extent may Morocco be able to achieve what it has promised to deliver by adopting its own green economy approach? In other words, this thesis will try to assess to what extent could the existing green economy model in Morocco help the country overcome its development challenges and meet its global commitments and national ambitions.

The research is guided by three sub-questions that have been derived after examining the literature:

a) To what extent is the current green economy model in Morocco achievable in the view of keeping the economy growing while reducing its carbon emissions according to its NDC?

b) What level of transformation of economy is needed to deliver the required green economy transition in Morocco?

c) To what extent does this green economy transition in Morocco bring the desired short-term benefits?

Although it appears that Morocco has achieved some degree of progress towards its green economy, in the view of energy transition, I argue in this thesis that Morocco is unlikely to achieve its global commitments and overcome its development challenges. The problematic concentration on the existing electricity system over the other key sectors hinders its progress on green economy. The country is unlikely to deliver its green ambitions without considering recent global practice on the electrification of economies and reduction of emissions from the most polluting sectors, mainly transport, heating, residential and industry.

1.7. Research methodology

The research question was addressed by using a mixed methods approach combining quantitative and qualitative analysis. The time-series analysis of the relationship between economic growth and environment, considering energy use, quantitively assessed the progress Morocco has made on its green transition. An empirical approach using econometric estimation was used to test this relationship. Chapter Four provides details on the methodology used to undertake this econometric estimation. Also, Appendix B includes the data used to perform the econometric model.

Qualitative analysis evaluated the efforts Morocco has made on green economy transition and identified a number of key challenges of meeting its green ambitions. Nine semi-structured academic online interviews were conducted with key informants in the energy sector who represent public bodies, private businesses, academia, and the banking sector. This provided deep insight into number of aspects of the green economy model of Morocco and uncovered some generic challenges of applying its green agenda.

Moreover, in order to support the analysis of Morocco's green economy model, this research incorporated available data from national and international sources, including the World Bank, the UN, and the IEA. These agencies publish internationally recognized statistical databases which are widely available and accessible.

The mixed methods approach used in this study allows me to reveal the great complexity within this research project, and to undertake a structural analysis of the research question (Olsen 2004; Hesse-Biber and Johnson, 2013). Generally, quantitative methods allow a researcher to analyse empirical facts regarding a certain phenomenon in the real world. In the explanatory phase of an investigation, quantitative methods can identify patterns and associations that may otherwise be masked (McEvoy and Richards, 2006). However, quantitative methods on their own may not be capable of explaining the essence and roots of a certain phenomenon. In this case, qualitative methods allow the researcher to observe what is hidden and to investigate the complex structure related to the main research problem. Qualitative methods help explain complex concepts and relationships that are unlikely to be captured by predetermined response categories or standardised quantitative measures (McEvoy and Richards, 2006).

Creswell et al. (2011) show that mixed methods help the researcher overcome deficiencies in either a quantitative or a qualitative research approach. For instance, while quantitative approaches are useful in providing reliable patterns, associations and comparisons regarding certain social phenomena, they are less likely to explain why the phenomena take place. Mixed methods can bridge this limitation by providing a deeper explanation and understanding of the social reality. In this thesis, the purpose of employing mixed methods is not only to validate the quantitative findings using qualitative methods, or vice versa, but also to advance the understanding of a number of challenges Morocco is facing during its green transition.

The rationale for adapting online interviews was due to the fact that I was unable to obtain a visit visa from the Moroccan authorities. The intent of the research was to conduct face-to-face interviews in their natural settings which could offer a suitable interview environment for me and the participants. The difficulties in travelling to Morocco made me decide to carry out in-depth online interviews by employing a computer-mediated communication mechanism.[22] Salmons (2014) notes that an online interview technique is a viable alternative which allows the researcher to choose from varied communication options and talk directly and remotely to participants at any time. This can bypass potential geographical and political obstacles. Online interviewing is, therefore, considered to be inherently cost and time effective for research. Various software were available to conduct the interviews including voice and video call applications. Skype and WhatsApp mobile applications were used which were available to me and the participants alike.

Charmaz (2014) explains that the number of interviews depends on the analytical level to which the researcher aspires as well as the purpose of the research. Charmaz also points out that small samples can produce an in-depth interview study of lasting significance. Interviews were conducted at the time when the COVID-19 pandemic broke. This added to the challenges of finding available participants. This required approaching an additional number of potential interviewees. Online interviews contributed to mitigating the impact of the pandemic. As a result, I conducted nine in-depth semi-structured online interviews during January 2020 and February 2020. My initial aim was to conduct enough interviews with representatives from Morocco’s national entities and international organisations

[22] Computer-mediated communication is defined as any human communication that occurs through the use of two or more electronic devices.

dealing with energy transition and climate change in Morocco, categorised by three groups, as detailed in Appendix A. This is in order to explore wide aspects of green economy transition in Morocco and to confidently reach data saturation. The diversity of interviews I conducted from academic, public, private and banking sectors is central to this research to obtain different and perhaps conflicting perspectives on energy transition in the country. Interviewees are varied from the Ministry of Energy, and various institutions which are responsible for the delivery of energy strategy. However, the impact of the COVID-19 pandemic stopped me conducting more interviews. I acknowledge this limitation which needs to be addressed in future research.

I approached potential interviewees using their contact details which were available online. I also contacted some others through direct messages on LinkedIn. In some cases, some of them introduced me to certain potential interviewees. For those who agreed to participate, an introductory message, outlining the purpose of the research, was sent to them. Interview duration varied from 30 to 75 minutes. The interviews were recorded by two methods: computer-based recording software and a digital recorder to secure two separate copies of each interview to avoid any technical challenges, so the data could be obtained and transcribed. At the end of each interview, the respondents were asked to sign and return the consent form which had been approved by the College of Social Sciences Research Ethics Committee at the University of Glasgow.

The participants were identified in this thesis by their official positions at their institutions. Interviews were conducted mostly in Arabic language and some in the English language. Given the fact that Arabic is my first language, I manually transcribed and translated the Arabic interviews to English. Appendix A presents details on the data collection including the interview questions, informants' profiles, the consent form and the ethical approval.

1.8. The significance of the study

This thesis explores a special case: the experience of a fossil fuel resource-scarce developing country in the MENA region, i.e. Morocco. To the best of my knowledge, this thesis is a pioneer in examining the green economy in Morocco, taking into account the recent debate on this sphere and the latest initiatives to decarbonize the global economy.

By addressing the research questions, I am confident that this thesis and its implications make original theoretical and practical contributions to the green economy discourse detailed in Section 7.3 in Chapter Seven. Five theoretical implications arise. First, the thesis may contribute to the literature on steady-state economy and degrowth theory on the impossibility to reduce emissions, to tackle climate change, while growing the economy. This is achieved through examining green growth in Morocco. Second, by studying Morocco's green economy model, this thesis validates the argument that middle-income economies follow a weak sustainability path to achieve economic growth. Also, this point contributes to the discussion that decarbonization of economies requires dramatic change of the economy and countries need to follow a path of strong sustainability in order to deal with climate change issues. Third, this thesis extends the application of the Porter Hypothesis to the country level for Morocco. This hypothesis claims no trade-off occurs between economic growth and environmental protection in the short run. Forth, by examining the relationship between carbon emissions, economic growth and energy consumption, the thesis validates the EKC theory for Morocco which argues that emissions per capita initially increase with rising income per capita, then peak and decline after a threshold level of GDP per capita is reached. Finally, this thesis responds to the methodological issue in the literature on the need to develop a measurement framework to track Morocco's green transition. The developed tool in this thesis is essential to understand energy transition and successes and failures in policy in Morocco. This tool is cross-checked with the results of empirical analysis and also the interviews I conducted to ensure the validity of the proposed indicators.

Given the problematic concentration of its current approach on only electricity system and ignoring other important sectors, the practical contributions of this thesis cover key recommendations for Morocco to increase the possibility of greening its economy. This contribution points towards expanding Morocco's energy transition and introducing new ways to power its economy, including increased electrification of its key sectors such as its transport, heating, industry, and residential sectors; the use of hydrogen and offshore wind energy; and a decentralized electricity system. This requires radical transformation across many sectors, particularly in how to power its economy.

1.9. Research scope

The scope of this thesis is the Kingdom of Morocco. I am particularly interested in studying this Middle Eastern country because I was born and raised in Syria. Both countries share many common aspects, including language, history, culture, religion, demography and development. Morocco provides a very interesting green economy case. The country is classified as a lower-middle income country according to the World Bank (2022). Nevertheless, it has been pursuing a green agenda and made a global commitment to tackle climate change relatively early in comparison to other economies in MENA region. The country has put significant efforts into greening its economy. It is pointed to as being a regional leader in green economy. Therefore, as a developing country in the MENA region, Morocco might offer useful lessons on green growth to other countries in the MENA region, in particular Syria, to rebuild their economy.

The main analysis of my research on Morocco runs from 1992 until February 2020. This is because Morocco started its green journey in 1992 when it participated in the Earth Summit held in Rio de Janeiro in Brazil. Importantly, I obtained satisfactory access to the materials on the green economy of Morocco. In addition, a number of key informants were also approachable to me to undertake the research. Thus, I completed the nine interviews with key informants from Morocco in February 2020. This determines the main analysis scope of this research.

For the purpose of the empirical study which requires historical time-series data, the available annual data were collected for the period of 1971–2014 from the database of the World Bank's World Development Indicators which is freely accessible and provides annual and consistent data. This time span was sufficient to build the econometric model and generate robust results.

1.10. The organization of the thesis

After this introduction, that addresses the main issue and sets out my analysis agenda, Chapter Two introduces the green economy concept and its emergence. The chapter also reviews the green economy literature on whether a green economy is achievable, on the level of transformation of economy that green economy needs, and also considers the short-term versus long-term benefits of green economy.

Chapter Three examines the development challenges of Morocco since 1992 and its unique features categorized by political, socioeconomic and environmental aspects. This is achieved by exploring secondary sources, mainly from governmental and international institutions. Chapter Three concludes with key actions that the country has taken to overcome its development challenges since 1992.

Chapter Four quantitively assesses the progress that Morocco has made on the green economy and the extent to which the country has realized its green agenda ambitions. By developing an empirical approach using econometric estimation, this chapter provides a deep understanding of the dynamic relationship between Morocco's economic growth and environment, which is a core element of the green economy. This quantitative analysis explores whether the country has been able to either relatively or absolutely decouple its economic growth from its environmental impact. This analysis takes into account Morocco's energy consumption as a key driver for its economic growth and responsible for a high proportion of its emissions. The analysis relies on the World Bank's World Development Indicators which provide a sufficient time-series database needed for the purpose of the quantitative analysis.

Chapter Five examines the energy transition in Morocco as a key route of its green economy model. In particular, this chapter reviews the evolution of renewable energy in Morocco and its related intended benefits to overcome the development challenges outlined in Chapter Three. Also, this chapter identifies a number of key challenges that the country faces in its green transition. Furthermore, this chapter critically assesses the energy transition model that has been developed to achieve its green objectives. The research of this chapter is supported by analysis of nine interviews I conducted with key informants in Morocco's energy sector.

Chapter Six further evaluates the progress of Morocco's green agenda by developing a customised analysis framework that suits Morocco in consideration of its unique features. This chapter addresses the methodological issue on measuring green economy transition in Morocco. Data is primarily collected from reputable sources such as the World Bank and the International Energy Agency. Other sources are also considered where needed to bridge data gap as much as possible.

Chapter Seven concludes the thesis by synthesising and highlighting the findings in relation to the research questions. The chapter discusses the implications of the findings for theory and policy. After that, the limitations of the research are outlined and potential scope for further research is suggested.

Five appendices are included at the end of this thesis. Appendix A contains details about the qualitative data collection including interview questions, interviewee details, a consent form, and ethical approval. Appendix B presents the econometrics model data. Appendix C includes the results of the econometrics model. Appendix D presents the proposed Morocco's green economy measurement framework. Appendix E reviews the studied existing measurement frameworks.

Chapter Two

Literature review

2.1. Introduction

This thesis examines the green economy model of Morocco. In order to study Morocco's model, it is essential to understand the foundation of the green economy concept and to review the related debates and recent discussion.

This literature chapter consists of two parts. Part one examines the concept of a green economy highlighting its emergence, its central concepts and its relationship with sustainable development. This provides the foundation for the recent debate on green economy in practice, that I discuss in part two. On whether green economy is possible or not, whether it is delivered as business as usual in existing economic systems or requires radical transformation of the economy, and whether it brings short-term or long-term benefits to a country's economy and society. Following the recent momentum in green economy in practice, efforts are being made by many countries to be net-zero economies by the middle of the 21st century. This debate on green economy needs to be revisited by studying Morocco's experience, which follows in the next chapters.

2.2. Green economy concept

In this section I discuss the emergence of green economy and its definition. Then I review green economy related concepts and its relationship with sustainable development.

2.2.1. Emergence of green economy

Green economy has been initiated to address concerns about climate change and ecological breakdown, such as an increase in global temperature, extreme weather events and a rise of GHG emissions (Box 3). The literature on climate change discourse is copious.[23] Within the global political economy, Clapp and Davergne (2011) categorise world views on the causes and solutions of global environmental change into four groups. First, market liberals believe that weak economic growth and market failures to respect the environment are the main causes of climate change. Hence, accelerating economic growth and correcting market and policy failures could reduce climate change. Second, institutionalists emphasise the need for global cooperation and stronger global institutions concerning the adoption of sustainable development principles to deal with environmental scarcity and population growth, since lack of cooperation and weak institutions are responsible for environmental degradation. Third, bioenvironmentalists stress the biological limit of the planet to support continuous

[23] This thesis does not aim to discuss the consequences of climate change, but to study an alternative development approach that deals with its causes, which is widely linked to increased CO_2 emissions.

growth. Therefore, limiting economic and population growth is needed to prevent environmental damage. Lastly, social greens blame global capitalism and inequality for causing environmental problems. According to them, promotion of ecological justice and a rejection of industrialism are effective solutions to our environmental problems.

As can be seen from the above categories, different views provide different solutions to tackle climate change and prevent environmental damage. Thus, as these are the ultimate objectives of these views, then growth would be accepted to a certain extent by these groups if this growth could be delivered without causing climate change and harming the environment, e.g. through reducing carbon emissions. To this end, green growth has been introduced as an alternative development model to demonstrate that economic growth needs to be delivered without damaging the natural environment and the ecosystem, and, vice versa, that environmental protection should not limit economic growth (Hickel and Kallis, 2020). Hence, it appears that this concept could limit the conflict between these different views.

The concept of green economy emerged from the development of two foundational concepts: natural capital and ecosystem services (Boehnert, 2016).[24] Therefore, the notion can be linked to environmental economics theory and ecological economics theory (Loiseau et al., 2016). Environmental economics, which is understood as a particular consideration of neoclassical economics, studies environmental externalities and the effective management of natural resources to find a solution for the deterioration of the natural environment. This theory assumes perfect substitutability between human-made capital and natural capital. In other words, a loss in one element can be offset by gains in the other. This is so-called weak sustainability which suggests no need for a complete change of the economic system to protect the environment (Munda, 1997). On the other hand, ecological economics addresses the relationship between the ecosystem and the economic system. This theory embraces the concept of strong sustainability which assumes that certain sorts of natural capital are critical, and not readily substitutable by human-made capital. In other words, natural capital and human-made capital are complementary but not limitlessly substitutable. This means that the loss of natural capital cannot be offset by gains in human-made capital (Munda, 1997).

[24] Natural capital was first used by E. F. Schumacher (1973). The concept was coined to address the challenge of achieving global sustainability. Whereas the concept of an ecosystem was first used in 1935 by Arthur Tansley. Applications of this concept include a communication tool for policy guidance and priority setting and the designing of economic instruments for conservation. Four types of ecosystem services are identified: provisioning, regulation, cultural, and supporting services (Boehnert, 2016).

Loiseau et al. (2016) assert that environmental economics is closely related to cleaner production and resource efficiency, whereas ecological economics relies on advanced concepts such as industrial ecology or circular economy.[25] Importantly, Loiseau et al. (2016) insist that weak sustainability does not require radical change in the economy. In contrast, strong sustainability implies more structural change in the economy and society to meet the challenges of sustainability and climate change. Loiseau et al. (2016) find that green economy has been more often associated with environmental economics, and, hence, is more related to weak sustainability. However, they suggest that in order to make an effective transition to a green economy, which is needed to deal with climate change issues, decision makers should focus on the delivery of ecological approaches, and, therefore, strong sustainability. This is required to achieve permanent and quick absolute-decoupling of economic growth from environmental impacts in addition to reducing carbon emissions. To this end, Lenaerts et al. (2021) conclude that the global decoupling rate from 1995 to 2018 was only -1.8% annually, this needs to be accelerated to -8.7% to achieve net zero by 2050. Similarly, Hickel and Kallis, (2020) stress that decoupling rate must rapidly occur at 10.5% per year for 1.5°C, or 7.3% per year for 2°C target scenarios. This is essential to deliver economic growth without damaging the natural environment.

Likewise, Barua and Khataniar (2016) conclude that economies need to shift from weak sustainability to strong sustainability to achieve strong and sustainable economic growth. They find that middle-income economies follow the path of weak sustainability. In contrast, high-income economies gradually move from a path of weak to strong sustainability through various policy interventions to reduce their carbon emissions.[26] This means that economies, during their development stages, follow the argument of 'grow now, clean up later'. That is, in the early stage of development, countries exploit possible and available resources to achieve economic growth. However, after a certain level of development, economies gradually become more respectful towards the environment.

This result agrees with the Environmental Kuznets Curve (EKC) in the environmental economics literature. The theory holds that GHG emissions per person initially increase with rising income per capita due to industrialization, then peak and decline after a GDP threshold as countries become more energy efficient, more technologically sophisticated and more inclined and able to reduce their GHG emissions (Mir and Storm, 2016). The theory assumes an inverted U-shaped relationship between pollution and growth (Özcan and Öztürk, 2019).

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[25] Industrial ecology is a field of study focused on the production processes of goods and services from the perspective of nature, trying to mimic a natural system by conserving and reusing resources (Chertow, 2008).
[26] Their conclusion is based on a study on selected emerging Asian countries.

This theory does not specify the income level of economies to reach a turning point which depends on various considerations. Grossman and Kruger (1995) estimate that it could occur at an income per capita of less than $8,000 (see Section 4.2, Chapter Four). If the EKC hypothesis is true, it could be argued that economic growth is not a threat to the environment but rather a solution for environmental problems. This agrees with the view of market liberals. But uncertainty surrounds this argument. For example, Ginevicius et al. (2017) support the idea that sustainable development is an oxymoron. This is due to the existing environmental problems and climate change caused by rising emissions as a result of continuous economic growth.

Carbon emissions are generated primarily from burning fossil fuels, the main and traditional energy sources to power the global economy, and are major causes of environmental damage and climate change (Ukaogo et al., 2020). Three avenues to address the environmental problems arising from this energy source perspective could be explored.

Firstly, reducing reliance on fossil fuel sources by limiting the growth, or so-called ‘degrowth’ offers a possible solution. This approach argues that it is impossible to reduce emissions while keeping the economy growing (Sullivan, 2017). Victor (2010) adopts a bold position by stating that zero economic growth may be insufficient, and degrowth of national economies may be unavoidable to reduce burning fossil fuel energy. By developing three macroeconomic scenarios on growth and GHG emissions for the Canadian economy, Victor (2012) finds that emissions continue to rise in the business-as-usual scenario, exceeding the 2005 level by 77% in 2035. In the low/no growth scenario emissions are 56% less than the business-as-usual scenario in 2035, and 22% less than in 2005. In the degrowth scenario, emissions are 88% less than in the business-as-usual level in 2035, and 78% below the 2005 level. Therefore, degrowth is claimed to be essential to considerably reduce emissions. However, these scenarios were developed without considering the possibility of replacing fossil fuels with clean energy. Nevertheless, the degrowth model lacks political support (Hickel and Kallis, 2020) and seems to be unrealistic due to the related concerns of reduced working hours, consumption and population (Lenaerts et al., 2021). Similarly, Dietz and O’Neill (2013) in their book *Enough is Enough* supports the philosophy of a steady-state economy away from a growth-based system to overcome social and environmental problems. Again, it is hard to gain political support for reduced working hours and consumption or decreasing the population, provided as examples of ‘strategies of enough’ to support the delivery of a steady-state economy. Also limiting population growth does not seem to provide an immediate or short-term solution to the problem of climate change.

Secondly, one could argue that we can keep burning fossil fuels if the associated emissions can be offset by the removal or the purchasing of carbon credit through an emissions trading scheme in the carbon market. However, the carbon market has been criticized for its inability to solve environmental problems and the damage might be sustained through offsetting rather than reduction or elimination practices (Sullivan, 2017). Also offsetting involves dealing with the consequences of the problem rather than emission causes.

Thirdly, we could follow an alternative approach by breaking the tradition of relying on fossil fuels. Using cleaner energy sources to power the economy and keep it growing while reducing carbon emissions and protecting the environment would be an alternative solution. This implies an absolute-decoupling of economic growth from emissions. This decoupling needs to be significantly accelerated in order to reject the proposition of steady-state economy and degrowth argument. To this end, green economy, which suggests switching to renewable energy sources, could offer a possible countermeasure to limit the risk of climate change.

Given that international climate change discourse has shifted from 80% reductions in GHG emissions to net-zero emission targets by 2050, Paterson (2021) argues that this difference is more dramatic than it might appear. Energy transition implies the deployment of renewable energy at large-scale and quick pace. This suggests moving entirely away from powering the global economy from fossil fuel sources towards more sustainable and cleaner sources of energy. Therefore, contemporary discussion on the green economy appears to be moving from supporting the concept of weak sustainability, claimed by Loiseau et al. (2016), to support strong sustainability in terms of dramatically reducing carbon emissions and respecting natural resources to a greater extent. This suggests more systematic change in the economy and society to support green transition away from a business-as-usual scenario.

Although textbooks have already discussed protecting the environment and achieving economic growth since the 1950s, the green economy was first mentioned in *Blueprint for a Green Economy*, a report prepared by a group of leading environmental economists for the UK government in 1989. The report discussed approaches for delivering economic growth while achieving sustainable development (Borel-Saladin and Turok, 2013). However, green economy was only mentioned in the title with no further reference in the text (Kasztelan, 2017). It seems that the notion was used only in the title of the report to attract public attention.

Box 3: Facts on climate change

- The global average temperature in 2019 was 1.1°C above the pre-industrial period. This may have caused an increased frequency and magnitude of extreme weather events from heatwaves, droughts, flooding, winter storms, hurricanes and wildfires.
- The year 2019 concluded a decade of exceptional global heat, retreating ice and record sea levels driven by greenhouse gases produced by human activities.
- About 30% of the world's population is exposed to deadly heat waves for more than 20 days a year.
- Average temperatures for the five-year (2015–2019) and ten-year (2010–2019) periods are the highest on record.
- The year 2019 was the second hottest year on record.
- In 2019, total greenhouse gas emissions, including land-use change, reached a new high of 59.1 gigatonnes of carbon dioxide equivalent (GtCO2e).
- Based on today's insufficient global commitments to reduce climate polluting emissions, a rebound in greenhouse gases from a return to high-carbon societies after the pandemic may push 2030 emissions even higher – up to 60 GtCO2e.
- Over 75% of methane emissions could be mitigated with technology that exists today.
- Limiting warming to 1.5°C implies reaching net-zero carbon emissions globally around 2050 and concurrent deep reductions in emissions of non-carbon forcers, particularly methane.
- Many changes due to past and future greenhouse gas emissions are irreversible for centuries to millennia, especially changes in the ocean, ice sheets and global sea level.
- Changes in several climatic impact-drivers would be more widespread at 2°C compared to 1.5°C global warming, and even more widespread and/or pronounced for higher warming levels.
- Limiting human-induced global warming to a specific level requires limiting cumulative carbon emissions, reaching at least net-zero carbon emissions, along with strong reductions in other greenhouse gas emissions.

Sources: Rogelj, J. *et al.*, 2018; IPCC ; 2021; UNDP, 2022

Jacobs (1993) also labelled his book *The Green Economy: Environment, Sustainable Development and the Politics of the Future*. Jacobs outlined how public policy could achieve sustainable development through, for example, public spending, financial incentives, taxes, and reforms. This appears as an attempt to move from green economy theory into practice, and promote the government's role to support the green transition. However, the book does not suggest economic and social structural change to deliver green growth. This supports the path of weak sustainability to deal with climate change and achieve sustainable development.

Since then, the concept of green economy has become increasingly common (Loiseau et al., 2016). Green economy's momentum has become more evident after multiple crises hit the global economy. Mainly the 2008 global financial crash and the food crisis in many developing countries (Ferguson, 2015). Accordingly, the UNEP launched a Green Economy Initiative in 2008 which provided the UN's response to the global economic crisis, and was aimed at supporting a global transition to the green economy. The Green Economy Initiative explored the potential of investing in assets such as energy efficiency, renewable energy, technology, chemical and waste management and low-carbon buildings (Newton, 2011).[27] These areas are constantly viewed as elements of the green economy in order to protect the environment and stimulate global economic recovery (Borel-Saladin and Turok, 2013). This appears to be the first serious discussion on the role of energy transition in achieving green growth, whereas the previous emphasis had been on investing in natural resources and biodiversity. The latter may generally provide long-term benefits and does not contribute substantially to immediate carbon emission reductions, and hence it is not very appealing to decision makers who normally seek short-term benefits to their economies and societies.[28]

The popularity of green economy also increased when the concept was the Rio+20 UN Conference theme, Brazil, June 2012 (Ehresman and Okereke, 2015). The Conference adopted green economy guidelines in the context of sustainable development and poverty eradication. The importance of respecting national circumstances and priorities and taking into account the needs of developing countries to achieve sustainable development were stressed in the conference. The necessity of closing the technological gap between developed and developing countries was agreed upon in order to deliver green economy across the globe (UN, 2021). However, it is claimed that the conference did not address the required systematic changes of economy and society (Newell and Roberts, 2016) and failed to draw a vision and concrete roadmap for green transition (Georgeson et al., 2017). Georgeson et al. (2017) also claim that green economy practices after the conference were relatively unsuccessful. Likewise, Loiseau et al. (2016) argue that the operationality of green economy was limited and lacked a framework for its implementation and monitoring. One could argue that, at the time of the conference, the knowledge on green economy in practice was limited and not many believed that this transition was practical or even possible. This might be due to the fact that the available technologies were insufficient to deliver the green transition.

Academically, strong interest in green economy has also grown significantly since the Rio+20 Conference. Scholars have been focusing on the relevance of green economy to national policy in many global economies (Ehresman and Okereke, 2015; Hickel and Kallis,

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[27] In 2009, low-carbon FDI amounted to roughly $90 billion (UNCTAD, 2010).
[28] In 2008, global solar and wind electricity generators supplied 11 TWh and 221 TWh, whereas these figures jumped significantly to 554 TWh and 1,273 TWh in 10 years (IEA, 2020).

2020). The COVID-19 crisis has renewed the global momentum for green economy in the political discourse and its role in mitigating the impact of climate change. Many governments have prioritized green recovery to overcome the consequences of the pandemic. In particular, many countries have committed to become net-zero emission economies by around 2050 according to the Paris Agreement, such as the UK, the United States, and the EU. This path is mainly based on the energy transition, which could limit the increase in global average temperature while boosting economic growth and creating jobs in green sectors, such as renewable energy and energy efficiency.

The above narrative shows that the green economy notion receives particular attention after each global crisis. Aberbach and Christensen (2001) note that a crisis event may provide a window of opportunity for radical reforms or new strategies. Given recent global practices, especially after 2019 when many countries declared a climate emergency and later adopted green recovery plans from the consequences of the COVID-19 pandemic, it appears that this pandemic presents an opportunity to renew the global economic system which has been characterised as 'grey' and the shift towards a green economy in many countries is now likely to be dramatic.

2.2.2. Definition of the green economy

Green economy has been defined by several institutions. These include the UNEP, OECD, UNCTAD, World Bank, Green Economy Coalition,[29] International Chamber of Commerce, Danish 92 Group,[30] and the Global Green Growth Institute (GGGI).[31] Allen and Clouth (2012) survey eight definitions of the green economy and 13 definitions of green growth. Table 1 reviews these various definitions developed principally by international institutions.

Although there is no agreed definition of the green economy, differences between definitions are insignificant (Scott et al., 2013). The three leading proponents of green growth at the international level (UNEP, OECD, World Bank), agree on the method for achieving green growth. This is principally through technological change and substitution to improve the ecological efficiency of the economy, and the role of the governments in accelerating this transition through regulations and incentives. However, definitions differ

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[29] Green Economy Coalition, established in 2009, is an alliance between trade unions, businesses, NGOs, UN agencies and civil society. The purpose of this coalition is to promote green economy practices around the world (Green Economy Coalition, 2021).
[30] The Danish 92 Group, established in 1991, is a coalition between 25 Danish NGO's working on issues related to the environment and development (The Danish 92 Group, 2015).
[31] Global Green Growth Institute is a treaty-based international, inter-governmental organization dedicated to supporting and promoting strong, inclusive and sustainable economic growth in developing countries and emerging economies (Global Green Growth Institute, 2021).

in the clarity of their claims (Hickel and Kallis, 2020). EEA (2014) reports that the scope of green economy definitions by various institutions are broadly characterised by three objectives: improving resource efficiency, ensuring ecosystem resilience, and enhancing social equity. The working definition developed by the UNEP (2011) has been widely quoted in numerous publications and claimed to be the most comprehensive definition (Kasztelan, 2017):

> The green economy is one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low-carbon, resource efficient and socially inclusive. In a green economy, growth in income and employment should be driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services (UNEP, 2011, p.2).

This definition perceives the green economy as a development approach aimed at achieving economic growth, social equality and environmental sustainability. This model includes a reduction of carbon emissions, an increase in energy and resource efficiency, a rebuilding of natural capital and a creation of green jobs.[32] Also, the private and public sectors have roles to play to deliver this green transition. Accordingly, the UNEP emphasises the complete separation of growth from environmental impact. This definition is aligned with ecological economics and strong sustainability. Nevertheless, it is unclear from their 2011 definition whether the green economy provides short-term or long-term benefits, nor the level of transformation of economy which green economy transition requires. These aspects are debatable, although their 2009 definition and UNCTAD definition suggest long-term benefits of green economy. Whereas, Global Green Growth Institute and Rwanda stress on the short-term benefits of green growth. It is worth mentioning that Global Sustainability Panel revealed the important role of renewable energy in protecting the natural environment in its definition.

In the same vein, Jacobs (2012) stresses that the essence of the green economy is about decoupling economic growth from environmental impacts and resource use. Specifically, Hickel and Kallis (2020) clarify that the assumption of green growth theory is to absolutely decouple GDP growth from resource use and carbon emissions at a rate sufficient to prevent climate change and ecological breakdown. This description outlines two roles of the green economy. The first is to broadly limit the negative impact of economic growth on the

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[32] According to the ILO, green jobs are any decent jobs that contribute to preserving or restoring the quality of the environment whether it is in agriculture, industry, services or administration. Green jobs are central to sustainable development and respond to the global challenges of environmental protection, economic development and social inclusion (ILO, 2021).

environment through emission reduction at a quick pace, on a large-scale. The second is about resource efficiency when delivering economic growth, such as improving efficiency of energy, water, land, material use and other natural resources, as well as promoting circular practices. However, this separation of economic growth from carbon emissions and resource use needs to be sufficient to overcome climate change and ecological challenges. In other words, this absolute-decoupling must be met at high rate as quickly as possible.

Recent global discussion and practice on the delivery of the green economy show that attention has been primarily given to carbon emission reduction through energy transition (See Section 1.3, Chapter One). Renewable energy is promised to deliver most of these carbon emission reductions. Besides, energy efficiency contributes to this reduction to a significant extent.

Table 1: Definitions of green economy and green growth

Green economy definitions
1. One that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. It is low-carbon, resource efficient, and socially inclusive. In a green economy, growth in income and employment should be driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services (UNEP, 2011).
2. A system of economic activities related to the production, distribution and consumption of goods and services that result in improved human well-being over the long-term, while not exposing future generations to significant environmental risks or ecological scarcities (UNEP, 2009). (previous definition of UNEP).
3. An economy that results in improved human well-being and reduced inequalities, while not exposing future generations to significant environmental risks and ecological scarcities. It seeks to bring long-term societal benefits to short-term activities aimed at mitigating environmental risks. A green economy is an enabling component of the overarching goal of sustainable development (UNCTAD, 2011).
4. Green economy is a resilient economy that provides a better quality of life for all within the ecological limits of the planet (Green Economy Coalition, 2011).
5. Green economy is described as an economy in which economic growth and environmental responsibility work together in a mutually reinforcing fashion while supporting progress on social development (International Chamber of Commerce, 2011)
6. The green economy is not a state but a process of transformation and a constant dynamic progression. The green economy does away with the systemic distortions and dysfunctionalities of the current mainstream economy and results in human well-being and equitable access to opportunity for all people, while safeguarding environmental and economic integrity in order to remain within the planet's finite carrying capacity. The economy cannot be green without being equitable (Danish 92 Group, 2012).
7. The green economy involves largely new economic activities and must provide an important entry-point for broad-based black economic empowerment, addressing the needs of women and youth entrepreneurs and offering opportunities for enterprises in the social economy (Government of South Africa, 2011).
8. Green economy can be seen as a lens for focusing on and seizing opportunities to advance economic and environmental goals simultaneously (Rio+20 Objectives and Themes of the Conference – UNCSD, 2011).
Green growth definitions
1. Green growth aims to foster economic growth and development while ensuring that natural assets and environmental services are protected and maintained. The approach places a premium on technology and innovation from smart grid systems and high efficiency lighting systems to renewable energies including solar and geothermal power as well as on improving incentives for technology development and innovation (Global Sustainability Panel, 2011).
2. Fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies (OECD, 2011).

3. Green growth is a policy focus for the Asia Pacific region that emphasises environmentally sustainable economic progress to foster low-carbon, socially inclusive development (UNESCAP website).
4. Green growth is, in general terms, economic progress that fosters environmentally sustainable, low-carbon and socially inclusive development. Pursuing green growth involves outlining a path to achieving economic growth and well-being while using fewer resources and generating fewer emissions in meeting demands for food production, transport, construction and housing, and energy (UNESCAP, 2012). (Another definition)
5. Green growth is about making growth processes resource-efficient, cleaner and more resilient without necessarily slowing them. Development that is green, [which here means resources-efficient], clean and resilient (World Bank, 2011).
6. Green growth is the new revolutionary development paradigm that sustains economic growth while at the same time ensuring climatic and environmental sustainability. It focuses on addressing the root causes of these challenges while ensuring the creation of the necessary channels for resource distribution and access to basic commodities for the impoverished (GGGI website).
7. Green growth is growth that emphasises environmentally sustainable economic progress to foster low-carbon, socially inclusive development (UN DESA – Rio+20 Objectives and Themes of the Conference).
8. Green growth is growth that is efficient in its use of natural resources, clean in that it minimises pollution and environmental impacts and resilient in that it accounts for natural hazards (World Bank, 2012a).
9. Inclusive green growth aims to operationalise sustainable development by reconciling developing countries' urgent need for rapid growth and poverty alleviation with the need to avoid irreversible and costly environmental damage (World Bank, 2012a).
10. Green growth is a growth achieved by saving and using energy and resources efficiently to reduce climate change and damage to the environment, securing new growth engines through research and development of green technology, creating new job opportunities, and achieving harmony between the economy and environment (RoK Framework Act on Low Carbon, Green Growth, 2010).
11. Green growth is defined as environmentally sustainable progress that fosters low-carbon, socially inclusive development (Government of Cambodia, 2009).
12. Green growth is an emerging concept that recognises that environmental protection is a driver of global and national economic development. It refocuses society on achieving qualitative growth rather than simply increasing GDP (Government of Rwanda, 2011).
13. Green growth means job creation or GDP growth compatible with or driven by actions to reduce greenhouse gases (Green Growth Leaders, 2011).

Source: ALLEN, C. and CLOUTH, S., 2012. *A guidebook to the Green Economy*. New York: UNDESA.

2.2.3. Green economy and related concepts

Allen and Clouth (2012) highlight that green economy, green growth, and low-carbon development are used interchangeably. Also, Jacobs (2012) recognizes other sister concepts which are in frequent use, including low emission and climate-compatible growth. Nevertheless, there is a significant overlap between these concepts. These notions have economic growth and environmental protection in common. The mixed use of these concepts can be linked to the fact that the institutions which support and discuss these concepts are largely the same institutions (Jacobs, 2012). Nevertheless, the most commonly used notions are green economy and green growth.

ICC (2012) differentiates between green economy and green growth. Green growth is seen as a bottom-up approach of greening products, processes, services, technologies and supply chain that promote sustainable practices. Contrastingly, green economy is a top-down approach that addresses changes and reforms at the strategic and macroeconomic policy level, including new approaches to incorporate externalities of the cost of environmental damage in the economic system. To understand this distinction, I differentiate between the terms ‘green economy’ and ‘green growth’ by distinguishing between ‘economy’ and ‘growth’. Economy often describes the complex system and relationships between institutions, regulations, businesses, customers, products, services, and many others. Whereas growth is narrower in scope. It is a progress that either increases or decreases, and is often described quantitively, such as GDP growth. So green growth could be seen as the economic growth of the green economy model. Hence, it can be understood that ICC suggests that the green economy approach entails potential structural changes while the green growth model requires greening processes or outputs (goods, services).

Briefly considering, low-carbon development. It can be considered a subset of green growth and green economy. Low-carbon development emphasises a critical role for green economy and green growth: a reduction of carbon emissions, among other aspects.

In this thesis, I will mainly utilise the terms green economy and green growth. The former to insist on the importance of considering the whole economic system, and the latter to stress economic output.

2.2.4. Relationship between green economy and sustainable development

Green economy and sustainable development are often linked. The most quoted definition of sustainable development was developed by the Brundtland Commission in 1987.[33] According to their report, sustainable development is a 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987, p.6). Since sustainable development and green growth imply meeting environmental objectives, Jacobs (2012) claims that green growth was invented to revive the discourse on climate change and environmental threats, through turning these threats into economic opportunities, because the concept of sustainable development has been receiving decreasing attention from policymakers.

Nevertheless, the relationship between green economy and sustainable development are debatable (Ehresman and Okereke, 2015). Firstly, sustainable development is claimed to be a very wide concept and incorporates ill-defined objectives which are difficult to operationalize. In contrast, green growth is self-explanatory in terms of achieving economic growth and protecting the natural environment (Jacobs, 2012). Similarly, Borel-Saladin and Turok (2013) argue that green growth is narrower in scope than sustainable development. It provides a clear and practical agenda and measurable progress on economic growth and environmental protection. Moreover, a green economy allows policymakers to pay particular attention to the economic pillar of sustainability and foster greater understanding for environmental and social problems.

Secondly, green economy is believed by international institutions to be a practical approach for achieving sustainable development (Volodymyrivna, 2015). Borel-Saladin and Turok (2013) claim that the various definitions of the green economy are consistent with sustainable development as an ultimate objective. Particularly, green economy is a means to reconcile the economic and environmental pillars of sustainable development, without ignoring its social aspects. So, the green economy has not been promoted as a substitute for sustainable development but as a tool to achieve it. Thirdly, green economy is seen as a synonym of sustainable development, it is arguably a relabelling of sustainable development and adds nothing new to its concept (Ehresman and Okereke, 2015).

[33] Brundtland Commission report was published by the UN's World Commission for Environment and Development, chaired by former Norwegian Prime Minister Gro Harlem Brundtland, and thus referred to as the Brundtland Commission (Brundtland, 1987).

From the above it can be noted that the debate on the relationship between green economy and sustainable development is not about the differing objectives of the two notions, rather it is about the process of achieving simultaneous objectives. So it appears that there is no contradiction between the objectives of the green economy and sustainable development.

By comparing the UNEP's and Brundtland Commission's definitions of green economy and sustainable development, the most quoted definitions of the two concepts, the definition of sustainable development broadens debate on the appropriate route, either through green economy or not. This realistic approach depends on knowledge and available technologies at any given time. The definition of green economy is more specific about its growth approach, mostly through carbon emission reductions and energy and resource efficiency, than sustainable development. If this proposed green approach will meet the needs of current and future generations, then the green economy will lead to sustainable development. A few years ago it was hard to believe carbon emission reductions, and energy and resource efficiency were possible on a large-scale, at a quick pace. The recent evolution of energy transition provides more confidence for decision makers to replace fossil fuel energy with renewable energy, and cut carbon emissions significantly in the next few decades, to reach net-zero emissions by 2050. Therefore, it is increasingly accepted to claim that green growth leads to sustainable development, and may prove that development can be sustainable. This is particularly important due to the broad consensus that considerable reductions of emissions help tackle climate change and achieve broad socioeconomic benefits to national economies. Consequently, it appears that green economy is narrower in scope than sustainable development yet could attain its objectives. Also, green economy objectives do not challenge sustainable development objectives.

This discussion provokes debate on the possibility of delivering green economy to achieve its objectives, the extent of transformation of economy this green transition requires, and whether this transition benefits future generations alongside the needs of the present. These aspects will be discussed in the next section.

2.3. The debates on green economy

The above narrative provides the foundation for the recent debate on green economy practice. This debate focuses on the possibility of the green economy, the degree of adjustment required, whether it is deliverable through business as usual or needs structural change and radical transformation of the economy, and whether it brings short-term or long-terms benefits to the economy and society. The debate about these fundamental matters of the green economy is reviewed below.

2.3.1. Possibility of green growth

The World Bank (2012b) argues that green growth may be possible by pursuing green policies through four channels linked to input, efficiency, stimulus and innovation effects. Firstly, the input channel suggests an increase in the quantity of natural, human and physical capital. This goal can be achieved by the effective management of natural resources and risks and increases in human development. Secondly, the efficiency channel proposes productivity increase through correcting market failures and enhancing resource use, such as an improvement of energy efficiency. Thirdly, the stimulus channel can occur during an economic recession, when economic activities shrink and employment is low. Large investments in green infrastructure increase demand which might increase the employment rate over the short-term. Lastly, the innovation channel aims to push production frontiers through investment in R&D for green technologies such as renewable energy.

Importantly, Hickel and Kallis (2020) assert that green growth theory assumes that absolute-decoupling of GDP growth from resource use and carbon emissions is feasible at a rate sufficient to overcome climate change and ecological challenges. In accordance with the Paris Agreement, countries need to achieve an absolute-decoupling of economic growth from carbon emissions, and ensure that carbon reductions are permanent and fast enough to prevent further global warming. This is because tackling climate change as per the Paris Agreement targets is not simply to reduce emissions which is a matter of flows, but to keep total emissions from exceeding specific levels which is a matter of stocks.

Hickel and Kallis (2020) discuss the possibility of green growth through examining the empirical literature since the Rio+ 20 conference on sustainable development in 2012. They find no empirical evidence that absolute-decoupling of economic growth from resource use can be achieved on a global scale. In addition, they conclude that absolute-decoupling of economic growth from carbon emissions is highly unlikely to be achieved rapidly enough to limit global warming aligned with the Paris Agreement's temperature goal of 1.5°C or 2°C. A major reason for this conclusion is that technology is unable to support this transition, drawing on an example on Carbon Capture and Storage technology which has not been proven to be economically viable or scalable. Another reason is given by the World Bank (2012b) who finds that many firms and households fail to make cost-effective energy efficiency investments, probably because of market failures and behavioural biases.

However, Hickel and Kallis (2020) discuss that green growth can be theoretically accomplished quick enough to meet the objectives of the Paris Agreement by a rapid shift to entirely renewable energy to eliminate emissions from fossil fuel sources. This needs to be accompanied by alternative industrial processes to eliminate emissions from the production of polluting industries, such as cement, steel and plastic. The question arises is whether this could happen quick enough according to the Paris Agreement. This suggests radical transformation of the way we power our global economy away from business as usual.

Given the fact that in the last few years many countries have declared a climate emergency and accordingly adopted green growth strategies, and in addition many countries have already started their energy transition journey and developed ambitious targets to cut their carbon emissions inspired by technological advances in renewable energy, the conclusion of Hickel and Kallis needs to be revisited. Examining the energy transition of Morocco compared to the latest global practice will provide further insight on the possibility of green growth. This is studied in the subsequent chapters.

2.3.2. Business as usual vs transformation of economy

Some definitions describe green economy or green growth as business as usual, others suggest that transformation of the economy is required. To this end, by examining the academic literature and policy discourse, Ehresman and Okereke (2015) recognize three categories of transformative potential in delivering a green economy: radical, minimal and zero transformation.

The first category suggests that the green economy concept has a radical transformative potential. This model implies an economic paradigm shift and the need for deep, structural and systematic changes. This requires a new industrial revolution via new inventions, social changes and economic developments (Bowen and Fankhauser, 2011). Likewise, Richardson (2013), Mundaca (2016) and Paterson (2021) insist that the green economy will not be delivered by traditional institutional mechanisms, nor by marginal changes to the economic structure that has made the ‘grey’ economy. The green economy will need grassroots initiatives and technological innovation to address the interactions between human and environmental systems.

Whereas the second category considers that green economy could have little transformative potential (Bowen and Fankhauser, 2011). Cato (2012) reports that this is because radical transformation could create a threat for existing political powers. Thus, the mainstream political discourse on green economy focuses on minimal transformation of the economy. Therefore, the green economy has thus far been built on the market model and incorporation of environmental sustainability with the existing growth model (Ehresman and Okereke, 2015). This political discourse on no or minimal transformation of the economy in the green economy model connects to two factors. First, policymakers are unconfident that green economy is achievable. Second, if green economy is possible, they are unsure if this model brings short-term benefits to the economy and society, since politicians seek immediate wins from any given model. Failing to bring short-term benefits could threaten their power.

The third category argues that the green economy is nothing more than a cover for business as usual. Here, the emphasis on green growth is considered as a false hope, it is principally seen as the free-market model, and functions primarily to delay the inevitable social and environmental damage if we fail to alter our economic model (Ehresman and Okereke, 2015).

It can be seen from the above discussion and Hickel and Kallis's (2020) conclusion, that the green economy is unlikely to be delivered through an existing economic model. To meet the Paris Agreement, a reduction of carbon emissions must be permanent and significant. It is hard to imagine that this reduction across all sectors and to stop burning fossil fuels could be achievable through a business-as-usual scenario. Therefore, only systematic change is expected to deliver a green economy. This could include institutional and regulatory reforms, and transformation of power generation. Indeed, the depth and width of economical and social transformation will depend on various factors including the circumstances of the economy, stage of its development and government willingness and commitment to deliver.

Recent global practices on energy transition, supported by technological advances in renewable energy, has motivated governments to develop a new model to power their economies and a phasing out of coal-fired electricity generation. This includes, for example, the deployment of large-scale offshore wind farms, a decentralized electricity system and the introduction of electric vehicles. Therefore, a green economy does not appear to be business as usual, and hence a radical transformation of the economy seems to be necessary.

Studying the experience of Morocco (Chapter Five) with reference to recent global practices in delivering a green economy will add to this debate on level of transformation of the economy that the green economy requires.

2.3.3. Long-term vs short-term benefits

One of the important matters of the green economy discourse is whether this alternative development approach brings short-term or long-term benefits to the economy and society. The traditional perspective is that environmental protection measures needed to tackle climate change, such as environmental standards or carbon taxes, impose an additional cost to businesses. This extra cost may hinder the competitiveness of firms (Ambec et al., 2013). This perspective has been challenged by a number of economists and scholars. For example, Porter and van der Linde (1995) argue that well-designed environmental policies foster innovation and enhance competitiveness. This is called the Porter Hypothesis which suggests that there is no trade-off between economic growth and environmental protection but instead a win–win situation is created. Hence, environmental investment is valuable.

For example, pollution is often seen as a waste of resources, therefore a reduction in pollution may lead to an improvement in resource efficiency and productivity. Thus, market-based environmental measures such as taxes could stimulate innovation which may offset the associated cost of complying with environmental restrictions. The Porter Hypothesis has been criticized for ignoring the profitable opportunities for businesses (Ambec et al., 2013). However, the empirical evidence drawn from the literature on the validity of Porter Hypothesis shows mixed results and does not lead to a consensus on the trade-off between economic growth and environmental protection (van Leeuwen and Mohnen, 2017).

Since the Porter Hypothesis was primarily developed at the firm level, Petroni et al. (2019) question the validity of the theory at a regional, country or global level. This thesis extends the application of this theory to the country level by exploring environmental policies through transition to renewable energy which could foster technological innovation and economic growth while protecting the environment. This could offer a more effective solution to radically reduce emissions beyond the narrow utilization of traditional environmental policies, such as carbon taxes or cap-and-trade emission allowances.[34] Although these market-based instruments provide some corrections of the market failure to tackle climate change, a solution is lacking to reduce reliance on fossil fuel energy sources which are responsible for most emissions.

Jacobs (2012) distinguishes between a standard and a strong version of green growth. A standard version of green growth asserts the long-running economic benefits of

[34] A cap is set on the greenhouse gases that businesses can emit (via the total number of allowances in circulation), which will decrease over time. Businesses then buy and sell emissions allowances through government auctions or secondary markets.

environmental protection through a variety of policies, such as renewable resources use, industrial and consumer productivity improvements, and recycling. Namely, that there is a trade-off between lower growth in the short-run and higher growth in the long-run. This claim argues that although the cost of tackling climate change is significant, it is manageable and also the economic cost of failing to reduce emissions at present may be much larger in the future.

In contrast, a strong version of green growth claims that environmental policy is not only far from having a slowing affect on economic growth, it can also be a driver for economic growth in the short run. This claim has been supported by three types of evidence. Firstly, following the 2008 financial crisis, environmentally friendly policies to recover economies, such as investments in energy efficiency and renewable energy, have helped create jobs and stimulate economic growth. Secondly, although renewable energy in general has been considerably more expensive than fossil fuels, and required substantial public subsidy, the associated costs to the economy have fallen as the scale of generation has increased and technological advances have occurred. In addition, the investment and operational cost of renewable energy is decreasing. Thirdly, environmental technologies including renewable energy seem to be on the edge of creating a new industrial revolution as shown in Section 1.3 in Chapter One.

Similarly, the World Bank (2012b) believes that green policies can contribute to the economic growth over the short-term, if they are designed in an appropriate framework. In a green growth context, any new policy should be examined for how to maximize its potential for short-term socioeconomic benefits, while minimizing the costs associated with green transition. This transition needs to be measured to be effectively delivered. Given the need to develop a green economy measurement framework (Barr, 2013), especially after recent global practices, Chapter Six addresses this methodological issue.

Examining Morocco in comparison to global practice will provide some theoretical contributions in terms of extending the application of the Porter Hypothesis to the national level. In particular, this thesis will try to answer whether environmental policies through renewable energy transition could deliver economic growth in the short run. This thesis will also reveal whether the path Morocco has taken is a standard or strong version of green growth.

2.4. Conclusion

The above literature has shown that the green economy discourse has emerged to tackle climate change and ecological risks while delivering economic growth. World views on global environmental change in the global political economy, identified by Clapp and Davergne (2011), suggest different solutions to tackle climate change and prevent environmental damage. Therefore, I argue that if tackling global environmental change can be largely achieved by decreasing carbon emissions, then this justifies green growth as an alternative development model to demonstrate that economic growth can be delivered without damaging the natural environment and ecosystem. This is through reduction of emissions at a quick pace and on a large-scale and being more resource efficient (Hickel and Kallis (2020). Therefore, the green economy model can limit the conflict between different views and be seen as a path towards economic growth.

While the green economy has been more related to weak sustainability, Loiseau et al. (2016) and Barua and Khataniar (2016) conclude that economies need to shift from weak sustainability to strong sustainability in order to deal with climate change concerns. Moreover, Barua and Khataniar (2016) find that middle-income economies follow a path of weak sustainability, while high-income economies gradually move from a path of weak to strong sustainability. This result agrees with the Environmental Kuznets Curve (EKC) theory in the environmental economics literature. Therefore, if this theory is true, it could be argued that economic growth is not a threat to the environment, but rather a solution for environmental problems.

I identified three avenues to address climate change and environmental damage through tackling their major cause: carbon emissions. The first route involves reducing reliance on fossil fuel energy sources by limiting growth, degrowth or via a steady-state economy (Sullivan, 2017; Victor, 2010, 2012; Dietz and O'Neill, 2013). This solution lacks political support and is unrealistic. The second route involves offsetting carbon emissions by removing emissions or purchasing carbon credit. This solution has been criticized as ineffective as it deals with the consequences of the problem but not the main causes. The third approach, as a green economy approach suggests, is to replace fossil fuels with cleaner renewable energy sources to power the global economy. Therefore, growth could be sustainable from an energy standpoint, and no contradiction arises between the objectives of the green economy and sustainable development. Also, it can be seen that the green economy is narrower in scope than sustainable development by focusing on limiting emissions and improving resource efficiency.

Global crises, and more recently the COVID-19 pandemic, have increased attention on climate change issues. The latest discussion has shifted from 80% reductions in GHG emissions to net-zero emission targets by 2050. Therefore, the role of the green economy in reducing carbon emissions has been given particular attention. This has been widely built on energy transition to renewable energy. Recent technological advances in renewable energy could make green economy more achievable. This might require radical transformation of the economy and is expected to deliver short-term benefits to the economy. The latter supports the strong version of green growth and the Porter Hypothesis argument which I extend to country level. Therefore, recent green economy discussion considers that environmental policy, far from slowing economic growth, is a driver for economic growth in the short run. Thus, the global green economy discourse appears to be moving from supporting the concept of weak to strong sustainability. This green economy transition needs to be monitored to be effectively delivered.

These developments urge us to reopen debates on how to best deliver a green economy. To this end, this thesis tries to bridge the gap between the green economy literature and recent practice by examining the green economy model in Morocco in the following chapters. This provides a new insight on green economy and adds to the aforementioned literature.

Chapter Three

The development challenges of Morocco and its green agenda since 1992

3.1. Introduction

The previous chapter provided the essential theoretical literature on the green economy and the basis for recent debate and discussion around this notion. It has shown that the green economy emerged to address concerns about climate change and ecological risks whilst delivering economic growth. Given growing global concerns surrounding climate change issues, many countries have joined the Paris Agreement, and therefore have taken action to meet such global commitments. The recent international discussion on the green economy emphasises the importance of delivery on this new development approach, the level of transformation of the economy needed, and the socioeconomic and environmental benefits of this transition.

Global practices show that no single green economy model exists, rather it varies across nations based on their particular context, resources and priorities as discussed in Section 1.3 in Chapter One. Therefore, this chapter now shifts our focus to Morocco to examine the basis of the country's green economy model and asks: why has Morocco joined global efforts to tackle climate change and pursue a green agenda? This chapter specifically explores development challenges facing Morocco that urged the country to build its green economy model on energy transition to renewable energy, as shown in Chapter One. It will outline Morocco's development problems directly linked to the consequences of climate change and the energy sector. Also, this chapter examines how the country has dealt with these issues since its participation in the Earth Summit, Rio de Janeiro, 1992, when the Kingdom expressed its interest in the global climate change discourse.

For the sake of clarity, the chapter begins with some background on Morocco in terms of its political status and stage of development. This is important to understand how the country exercises its power which in turn influences its development. Then, this chapter examines the consequences of climate change and the energy challenges in Morocco since 1992. Lastly, the chapter outlines its responses to these issues. This will establish the foundation of its green economy model and its main motivations to build this model on energy transition to renewable energy, which will be discussed in detail in the following chapters. The outcome of these actions is also assessed in the following chapters.

The analysis of this chapter is mainly based on secondary sources which include published reports and available data from reputable national and international sources principally the World Bank, UNDP and IEA.

3.2. Background

Morocco is a Northern African country that spans the Mediterranean Sea to the Atlantic Ocean, covering an area of 446,550 square kilometres. The Kingdom of Morocco is a semi-constitutional monarchy with an elected parliament. In July 1999, Mohammed VI came into power after the death of his father, King Hassan II. The Kingdom has been politically stable for decades which has been the cornerstone of its development since the 1990s.

Morocco managed to avoid the disorder of the Arab Spring in 2011 without damaging its economy. The king immediately responded to civil demonstrations and introduced political reforms by reducing his power and strengthening the authority of the prime minister and parliament. Critically, the king proposed constitutional amendments in 2011. The new constitution incorporates sustainable development as a right to every citizen. Accordingly, the economic, social, and environmental pillars of sustainable development have become increasingly the main objectives of the Kingdom; the public authorities have proposed to mobilize all their means to respect this right (MEME, 2012). Also, the government launched an economic plan aimed at improving the socioeconomic status of Moroccans, especially in terms of creating jobs and achieving inclusive growth. This plan was supported by prominent international institutions such as the IMF (Khan and Mezran, 2015). It appears that these actions have helped the country avoid civil disturbance. Also, the government's efforts were supported by the international community who wanted to ensure political stability in the country and prevent disorder as commented on by one interviewee. The interviewee also added that 'the stability of Morocco is important to the stability of Europe in order to prevent refugees and migrants making their way to Europe and limit the rise in refugee flows' (Interview 3, Renewable Energy and Energy Efficiency Specialist at MEME).

Morocco has recorded robust economic growth over the past three decades. The size of the economy in terms of real GDP has more than tripled from 1992 to 2019 reaching $126.3 billion in constant 2010 prices. While the level of economic development in terms of real GDP per capita almost doubled, hitting $3,407 in constant 2010 prices over the same period (World Bank, 2021). Therefore, by income level the country is classified as a lower-middle income country according to World Bank classifications (World Bank, 2022).[35]

[35] For the 2022 fiscal year, low-income economies are defined as those with a GNI per capita, calculated using the World Bank Atlas method, of $1,045 or less in 2020; lower middle-income economies are those with a GNI per capita between $1,046 and $4,095; upper middle-income economies are those with a GNI per capita between $4,096 and $12,695; high-income economies are those with a GNI per capita of $12,696 or more (World Bank, 2022).

Morocco's population has grown by 42% since 1992, reaching 36.5 million in 2019; whereas population growth decreased slightly from 1.77% in 1992 to 1.22% in 2019 (World Bank, 2021). It is expected that the population will increase to 40 million in 2040 (Garcia and Leidreiter, 2016). This rapid and substantial population increase raises concerns about the country's development across multiple aspects, including jobs, energy, carbon emissions, and the environment. This requires particular attention from the government to achieve sustainable development as outlined in the 2011 constitution. Table 2 compares these key indicators in 1992 and 2019.

Table 2: Selected indicators for Morocco in 1992 and 2019

	1992	2019
Area (km square)	446,550	446,550
GDP (constant 2010 US$, billion)	45.3	126.3
GDP per capita (constant 2010 US$)	1,747.3	3,407
Population (millions)	25.7	36.5

Source: WORLD BANK, 2021. *World development indicators 2021*. The World Bank. [viewed 24 August 2021]. Available from: https://data.worldbank.org/country/morocco

Furthermore, Morocco has made significant improvements over the past three decades in human development according to the Human Development Index (HDI). However, its rank remains low which was 121st, out of 189 countries in 2020 edition. This shows that significant margins for improvement exist. Between 1992 and 2018, HDI rose from 0.47 to 0.68, which put the country in the medium human development category. Looking into the details of this scoring, Morocco's life expectancy at birth increased by 11 years, and expected years of schooling increased by 6.5 years. Its GNI per capita also increased by about 94% during the same period (UNDP, 2020). In addition, the World Bank (2017) reports that there had been a significant poverty reduction in Morocco between 2001 and 2014.

However, this development was not inclusive across the country. Significant social and spatial inequalities continue, especially in rural areas which are lagging in the provision of services. This is more evident in health services (Sarr et al., 2019). Figure 1 illustrates the development of HDI of Morocco and its three components between 1992 and 2018.

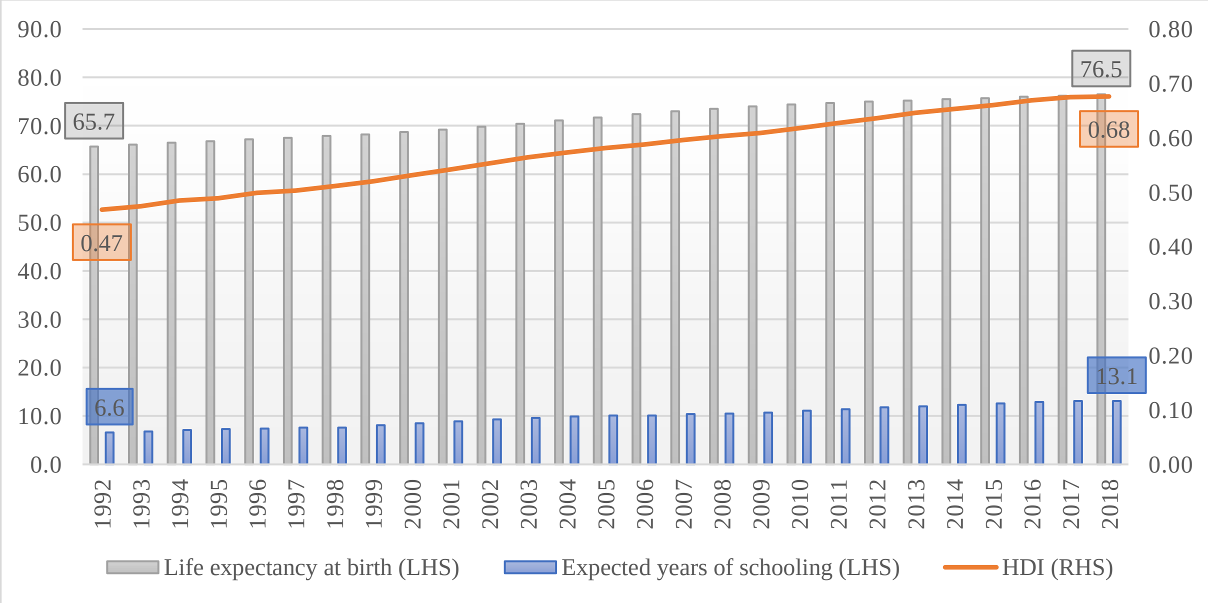

Figure 1: Human Development Index (HDI), life expectancy at birth and Expected years of schooling (years) in Morocco between 1992–2018

UNITED NATIONS DEVELOPMENT PROGRAMME, 2020. *Human Development Index 2020* [online]. United Nations Development Programme (UNDP). [viewed 22 June 2020]. Available from: http://hdr.undp.org/en/content/human-development-index-hdi

In summary, Morocco has achieved notable development since 1992 supported by its political stability as reflected in its economic growth and human development as shown above. However, this progress has been mostly quantitative and could have been more significant than achieved. This is because the country has been facing major difficulties, mainly associated with two interlinked reasons: the consequences of climate change in terms of frequent drought events, and energy challenges due to scarcity of fossil fuel resources. Sections 3.3 and 3.4 will examine these two challenges in Morocco, and their impact on various aspects of its development. Whereas Section 3.5 will outline the main actions the Kingdom has taken to attempt to overcome these challenges.

3.3. Consequences of climate change

Morocco is highly vulnerable to the long-term negative effects of climate change, such as rises in average temperature, changing rainfall patterns, droughts, desertification, flooding, heat waves, and a rise in sea level. On average, the temperature has already risen by 1°C in two thirds of the country's territory. In particular, the frequency of droughts has significantly increased and is expected to continue. The country has had larger arid or semi-arid zones, since 1991, in comparison with 1961. Furthermore, climate projections provide a deteriorating condition throughout the 21st century compared to the period before 1990 (MEME, 2009). During the 21st century, agricultural production may decline by 15% to 40%. This involves the risk of rising food prices, increasing social inequality and deterioration of the socioeconomic equilibrium of the country (RES4MED, 2018). Of Morocco's total territory, 93% already has an arid or semi-arid climate (Terrapon-Pfaff and Amroune, 2018). Climate change effects have had direct consequences on the country's development: impacting not only the agriculture sector, but the entire economy.

Despite significant economic growth since 1992, as shown in Section 3.2, the country's GDP growth has been fluctuating, and more severely during the 1990s (World Bank, 2021). This was mainly due to severe and more frequent drought that led to negative and slow growth in many terms during the 1990s. Drought has impacted its agriculture sector and forced the country to import grain which has adversely affected the whole economy. Reduced incomes due to drought caused GDP to fall by 7.6% in 1995, by 2.3% in 1997, and by 1.5% in 1999. While during the years between droughts, sufficient rains brought a good agricultural season which led to strong economic growth (Verner et al., 2018).

The economy has become more diverse during the 2000s supported by the emergence of export industries, such as automotive, electronic and aerospace sectors. Also, the economy has benefited from the strong growth of public investments and the launch of major infrastructure projects, such as highways, ports, airports and railway (Attijariwafa Bank, 2018). These factors have helped Morocco become less volatile and vulnerable to climate change in the 2000s, compared to the previous decade, and, therefore, to achieve positive economic growth (Sarr et al., 2019). This is evident by the fact that contributions of agriculture sector in GDP fell from 18% to 12% between 1990 and 2007. Also, the growth of non-agricultural GDP accelerated to 5% between 2004 and 2011 compared to only 3% in the 1990s (Attijariwafa Bank, 2018). However, severe drought in 2005 cut Morocco's cereal production by half and slowed its GDP growth to 3.29% (Huppé et al., 2013; World Bank, 2020).

Overall, GDP growth averaged 5.19% between 2001 and 2008; then it decreased to 3.6% between 2009 and 2018 (World Bank, 2020). This drop was mainly due to the global financial crisis and the impact of the Arab Spring in neighbouring countries (Attijariwafa Bank, 2018) in addition to drought (World Bank, 2017). However, the effect of the global financial crisis on the Moroccan economy has been relatively limited for several reasons. These reasons include strong domestic demand, limited exposure of its financial sector to international markets, sound financial position, and a stable exchange rate pegged to a basket of currencies composed of the euro and the dollar. Furthermore, considerable progress has been achieved in trade liberalization, with the reduction of nominal tariffs and the signing of several trade agreements: with the EU in 1997 and the United States in 2004, for instance (Sarr et al., 2019).

In 2014, economic growth dropped to 2.7%, versus 4.5% in 2013. This drop was due to a decline in the primary sector's contribution to overall growth, following an exceptionally good harvest in 2013. Secondary and tertiary sectors' contribution to growth increased due to an increased contribution of the mining and construction industries, strong growth in the manufacturing industries (in particular the automotive and aerospace industries and agribusiness), an improved services sector, growth in the tourism industry, increased telecommunications activities and the strengthening of business services. The added value created by the secondary sectors increased by 3.0% in 2014, against 0.3% in 2013, and the added value of the tertiary sectors increased by 3.7% in 2014, versus 2.7% in 2013 (UNECA, 2015). Again, due to severe drought in 2015, growth slowed in 2016 (World Bank, 2016). Figure 2 demonstrates this fluctuation in annual GDP growth between 1992 and 2018. It shows that this fluctuation was more significant during the 1990s due to severe drought and less sharp after 2000 when the economy became more diverse, as discussed above.

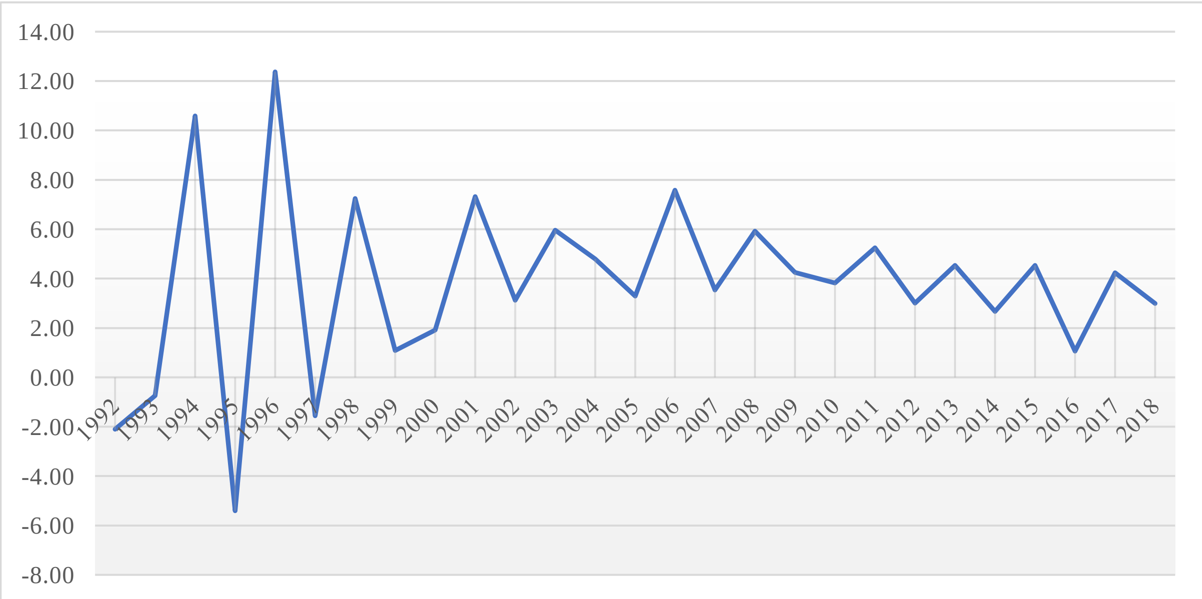

Figure 2: GDP growth (annual %) in Morocco between 1992–2018

WORLD BANK, 2020. *World development indicators 2020* [online]. The World Bank. [viewed 21 June 2020]. Available from: https://data.worldbank.org/country/morocco

Frequent drought and its negative impact on the agriculture sector, in particular, has contributed to the shift of Morocco's economy towards a more service-oriented economy. While the agriculture sector grew by 13.8 times between 1992 and 2019, the services sector increased by 63.9 times and the industry sector grew by 29.2 times (World Bank, 2020). This also helped reduce the informal sector which averaged 34% of GDP between 1991 and 2015, but dropped to 27.1% in 2015 (Medina and Schneider, 2018). Figure 3 shows the increase in the added value of the industry and services sectors in comparison with the agriculture, forestry and fishing sector between 1992 and 2019.

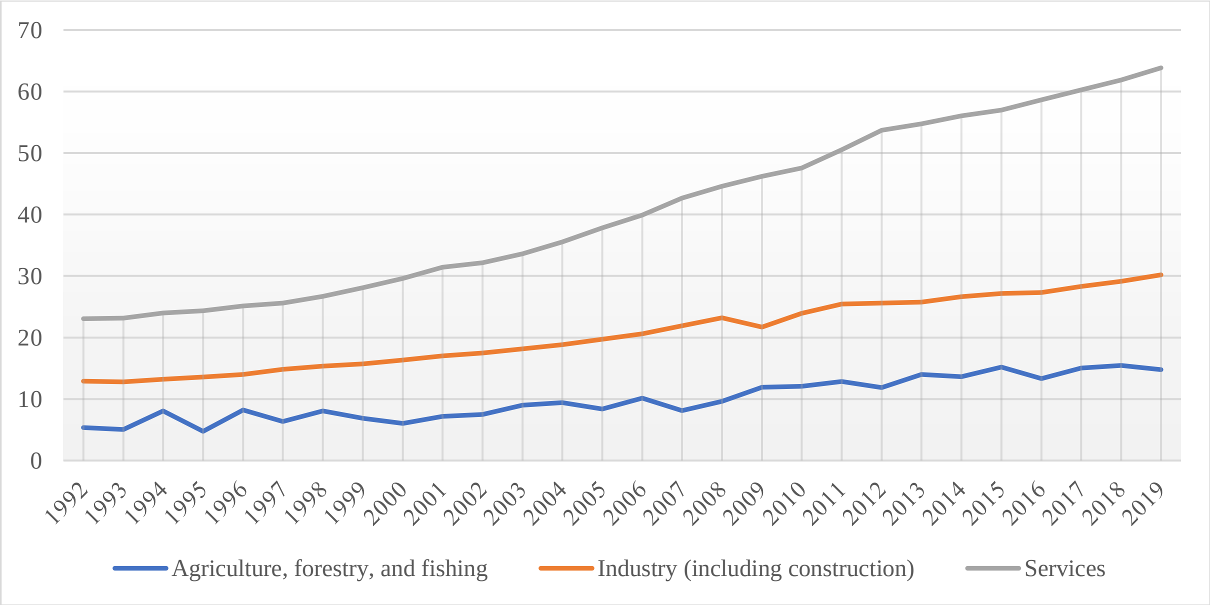

Figure 3: Value added of agriculture, forestry, and fishing; industry (including construction); and services, (constant 2010 US$) in Morocco between 1992–2019

WORLD BANK, 2020. *World development indicators 2020* [online]. The World Bank. [viewed 01 December 2020]. Available from: https://data.worldbank.org/country/morocco

The consequences of climate change and drought, accompanied by the emergence of new industries and an increase in the services sector are the main reason for rapid urbanization and demographic changes in Morocco. Between 1960 (the first general census) and 2004, the size of the urban population multiplied five times while the size of rural population increased by only 1.5. This exerted considerable pressure on Morocco's resources and led to a water scarcity in some areas (The Ministry of Habitat, 2014). According to the World Bank (2021), the urban population increased from 12.8 million (50% of total population) in 1992 to 23.5 million (63.5% of total population) in 2020.

Another supporting evidence for Morocco’s changing economy concerns employment trends, which shifted from agriculture to services. Share of employment in agriculture has declined from 47.2% in 1991 to 38.1% in 2018, whereas share of employment in services has risen from 32.6% to 40.3% in the same period, as seen in Figure 4 (World Bank, 2020). Figure 4 shows that share of employment in the services sector started to surpass that of agriculture sector in 2012.

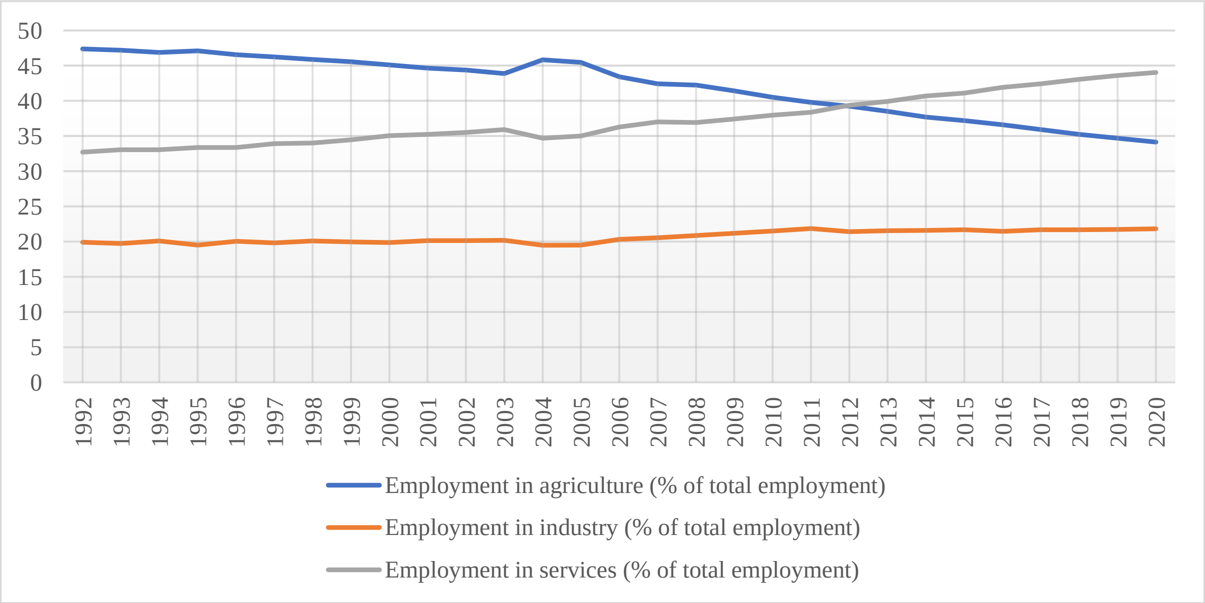

Figure 4: Employment in the agriculture and services sectors (% of total employment) in Morocco between 1992–2020

Source: WORLD BANK, 2020. *World development indicators 2020*. The World Bank. [viewed 01 December 2020]. Available from: https://data.worldbank.org/country/morocco

This continuous changing structure of the economy has not enabled the country to reduce its unemployment rate which has hovered over 13% between 1992 and 2000, and then declined to around 9% in 2006 and remined broadly constant since then (World Bank, 2020). A more detailed analysis according to 2018 figures shows that unemployment has been more evident among the youth (22%), and is even higher among graduates (22.5%), and the urban population which grew substantially (Garcia and Leidreiter, 2016; World Bank, 2020). This reflects the fact that job creation in the industry and services sectors, especially through the private sector which absorbs about 88% of total employment in Morocco, has been insufficient to employ the growing workforce, despite significant growth in these two sectors. This is because productivity in the industry and services sectors are generally higher than in the agriculture sector, and the two sectors are less labour-intensive than agriculture sector. This has led to a decline in the labour force participation rate between 2000 and 2018 from 53.1% to 46.2% (Sarr et al., 2019).

In summary, it can be clearly seen that the consequences of climate change in terms of frequent drought events have been significant on Morocco’s development since 1992. Nevertheless, the increasing diversification of sources of growth especially after 2000 has helped reduce the negative consequences of climate change. The IMF (2018) emphasises that macroeconomic vulnerabilities have declined in Morocco since 2012, but growth remains sensitive to volatile agricultural output. Thus, to sustain economic growth and respond to its population growth, the country needs to further diversify its economy and create more sustainable jobs in growing sectors other than agriculture. Additionally, the growing economy, industrialization, urbanization, and population growth have brought other challenges to Morocco in relation to the energy sector. Meeting the rising demand for energy has posed serious problems for Morocco especially in terms of its financial position and environment. These aspects are discussed in the next section.

3.4. Energy challenges

Morocco is almost the only Northern African country without proven oil and gas sources. Therefore, it is the largest energy importer in the region, mostly from neighbouring countries (Nachmany et al., 2015; Taheripour et al., 2020). Hence, Morocco is facing serious challenges of accessing reliable and affordable sources of energy that meet its growing development needs. Energy use per capita increased by 68% between 1992 and 2014 to reach 555 kgoe, as illustrated in Figure 5 (World Bank, 2021).

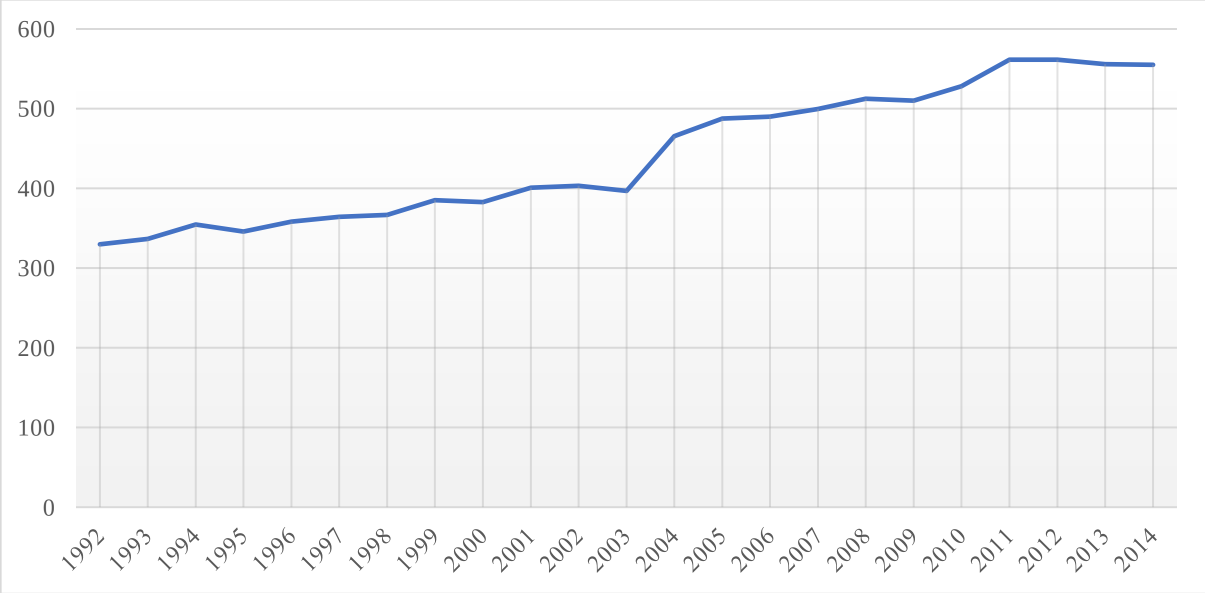

Figure 5: Energy use in kgoe (kg of oil equivalent per capita) in Morocco between 1992–2014

Source: WORLD BANK, 2021. *World development indicators 2021*. The World Bank. [viewed *27 August 2021*]. Available from: https://data.worldbank.org/country/morocco

From the above chart, energy use per capita grew by 16% during the 1990s and by 45% between 2000 and 2014. Total final energy consumption (TFEC) almost tripled between 1992 and 2019 as shown in Figure 6.[36]

[36] International Energy Agency (IEA) source provides more detailed and updated data for energy from 1990 until 2019 in comparison with the World Bank whose last available data ends in 2014. Energy use per capita is not available from IEA database. My analysis of the development of Morocco starts in 1992. Word Bank uses kgoe unit for energy whereas IEA uses TJ for large values (1,000 kgoe = 1 toe = 0.0419 TJ). Whereas electricity consumption is generally measured by TWh.

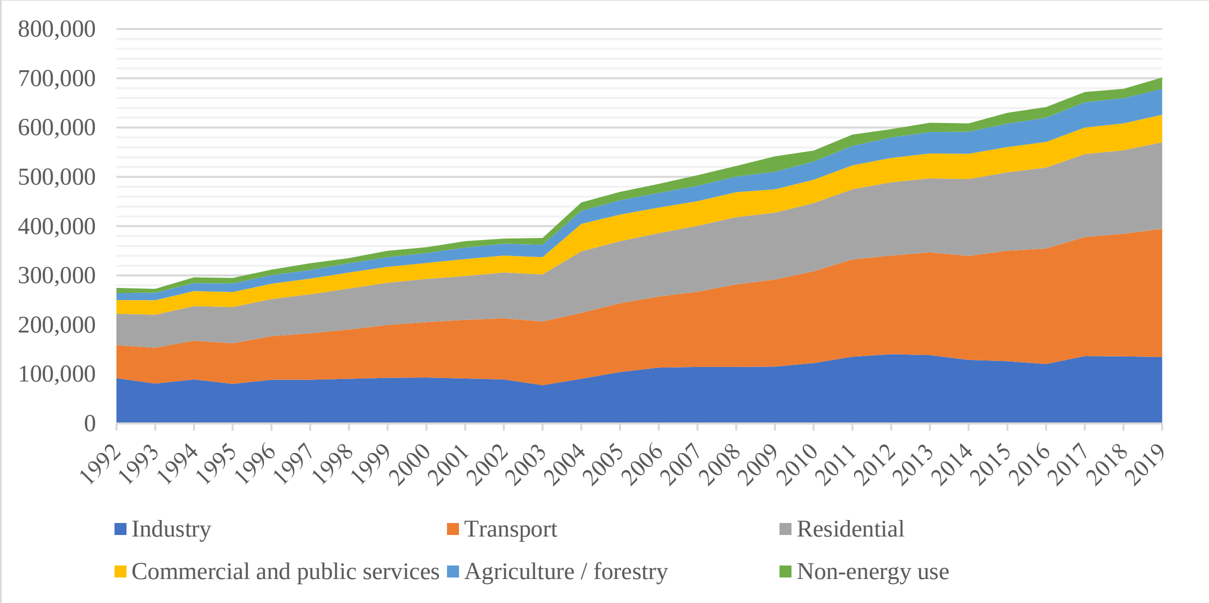

Figure 6: Total final energy consumption (TFEC) in TJ by sector in Morocco between 1992–2019

Source: Author's compilations based on: INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 25 December 2021]. Available from: https://www.iea.org/countries/morocco/

Figure 6 shows that TFEC grew by 27% during the 1990s, whereas it almost doubled between 2000 and 2019. Figure 6 also demonstrates that the energy consumption of the transport and residential sectors marked the highest increase since 1992, even higher after 2000. Energy consumption of these two sectors increased by 3.9 times and 2.8 times respectively between 1992 and 2019. The share of energy use of both sectors in TFEC accounted for 47% in 1992 and increased to 62% in 2019. Also, the energy consumption of the industry sector accounts for a significant proportion of TFEC 19% in 2019, compared to the commercial and public services at 8% (Figure 7). This is discussed in Section 5.5 in Chapter Five.

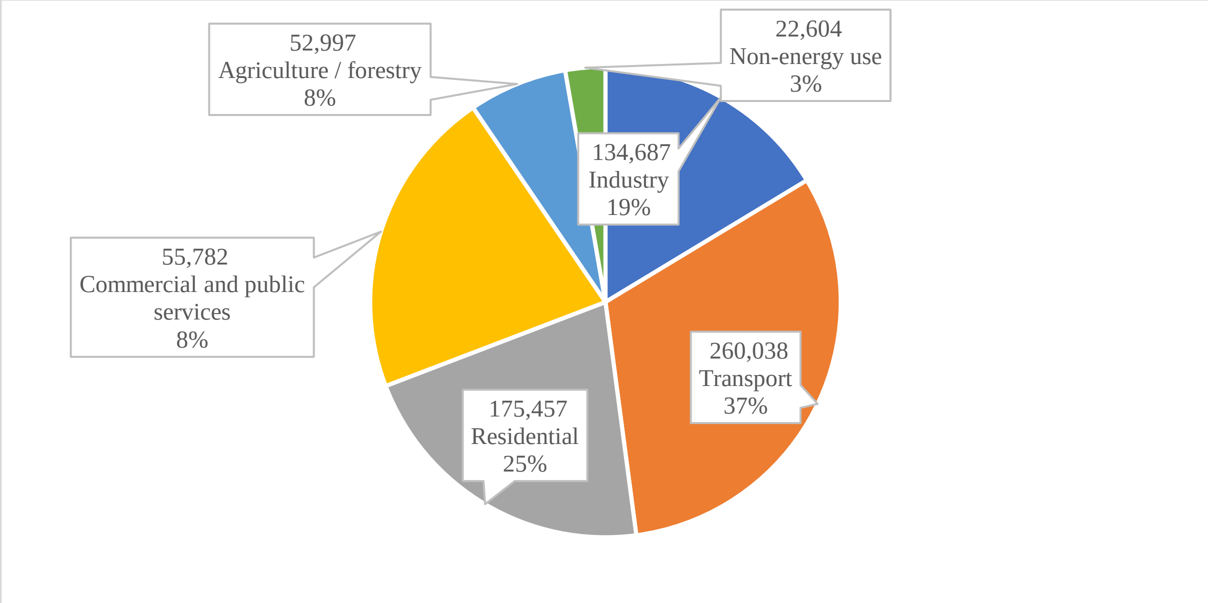

Figure 7: Total final energy consumption (TFEC) in TJ by sector in Morocco in 2019

Source: Author's compilations based on: Source: INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 25 December 2021]. Available from: https://www.iea.org/countries/morocco/

This increase in energy consumption in the transport sector can be explained by the growth of Morocco's vehicles by 59% (61% of which are diesel vehicles) between 2004 and 2011. Whereas the increase in the energy consumption of the residential sector relates to a strong penetration of household appliances which have become available to the vast majority of the population, accompanied by the low-energy efficiency of these appliances (IEA, 2014).

Besides, electricity consumption has grown at a steady rate. It has increased 3.4 fold between 1992 and 2019 to reach 34.6 TWh (IEA, 2021).[37] The Rural Electrification Programme launched in 1995 increased electricity rural access from 18% in 1995 to 99.13% in 2015. This has considerably increased electricity demand (Nygaard and Dafrallah, 2016). It is important to mention that this Rural Electrification Programme introduced the first solar power at a micro-scale in 1995 to connect isolated rural areas with electricity (Choukri et al., 2017). This point is discussed in Section 5.2 in Chapter 5.

In addition, the development of major infrastructure projects also contributed to increased electricity consumption (RES4MED, 2018b). By 2050, it is estimated that annual electricity demand could rise to either 6,880 ktoe (80 TWh) (a historical data extrapolation), 9,900 ktoe (115 TWh) (a national outlook), or 14,620 ktoe (170 TWh) (a model-based

[37] 1 TWh (Terawatt Hour) = 3,600 TJ (Terajoules).

estimate). This will require the deployment of additional electricity generation capacities with volumes four times higher by 2030, and more than ten times higher by 2050 (Schinko et al., 2019).[38] This raises major concerns and requires immediate actions from the Moroccan government to meet the growing and significant energy demand. It is important to mention that these figures do not take into account the electrification of transport, heating, and other sectors which rely on other sources of energy. Therefore, given increased electrification of these sectors will increase electricity demand (discussed in Section 5.5, Chapter Five).

According to 2019 figures, the industry sector is the highest consumer of electricity in Morocco at 37%, followed by the residential sector at 34%, and the commercial and agriculture sector at 17%, while the transport sector accounts for only 1% of the total electricity consumption (IEA, 2021). The minor electricity consumption of transport sector is not surprising given the fact that this sector is not electrified. This is an important point that is raised in Section 5.5 in Chapter 5.

Oil products are the main source of TFEC (74.6%), followed by electricity (17.2%) as shown in Figure 8 (IEA, 2021).

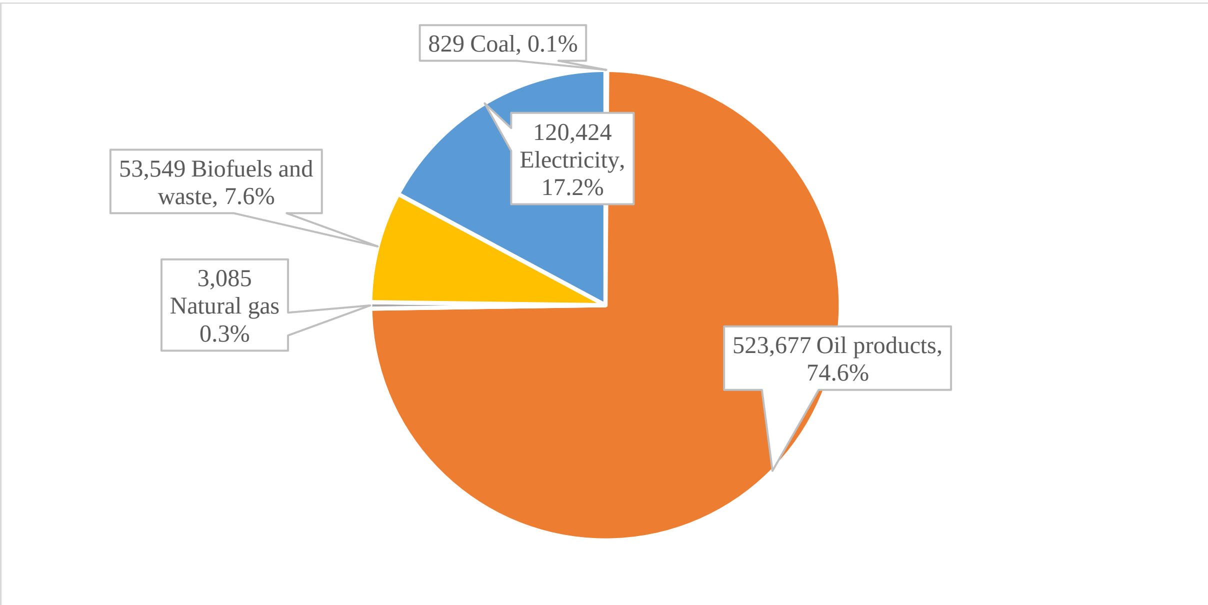

Figure 8: Breakdown of total final energy consumption (TFEC) in TJ by source in Morocco in 2019

Source: Author's compilations based on: INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 28 December 2021]. Available from: https://www.iea.org/countries/morocco/

[38] The World Bank (2020) reports that electric power transmission and distribution losses in Morocco accounted for 14.7% of total generation in 2014. This figure is higher than the global average of 8.25%.

Also, the main sources for electricity generation are dominated by fossil fuels. Principally coal and natural gas sources which accounted for 64.6% and 11.3% respectively in 2019 (IEA, 2021). This shows that the vast proportion of energy sources come from fossil fuels which are responsible for a large proportion of carbon emissions. This causes additional concerns about the environment and climate change.[39]

The sharp rise in energy demand in Morocco since 1992 accompanied by a lack of fossil fuel sources has increased the country's energy imports. Net energy imports rose by 32% during the 1990s and over 100% between 2000 and 2018, from 7.5 Mtoe in 1992 to 20.0 Mtoe in 2018 (Figure 9). Additionally, the energy dependency ratio reached 98% in 2008 (El Hafidi, 2017).[40] Thus, Morocco is highly exposed to the volatility of global energy prices. Its high energy dependency also weakens its political position.

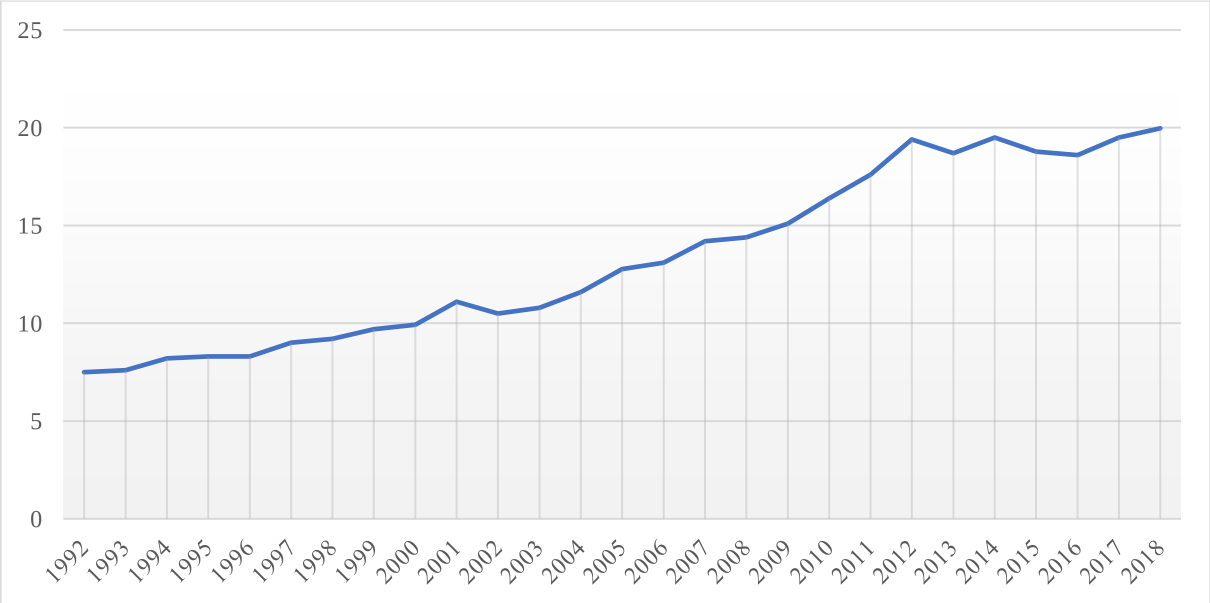

Figure 9: Net energy imports (Mtoe) in Morocco between 1992–2018

Source: Author's compilations based on: INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 27 August 2021]. Available from: https://www.iea.org/countries/morocco/

This excessive dependency on energy imports is a particularly problematic issue for increasing Morocco's energy import bills, and has contributed to its current account deficit. Its current account balance fluctuated as a percentage of GDP between -1.28% in 1992 and

[39] Discussion on carbon emissions by energy source is made in Section 5.5 in Chapter Five.
[40] 1 ktoe = 11,630 MWh, 1 toe = 0.012 GWh, 1 Mtoe = 1,000 ktoe = 11,630 GWh

-5.7% in 2018 (World Bank, 2020). In particular, the deficit has deteriorated after the second half of the 2000s largely due to a sharp increase in international oil prices (Zoubir and White, 2016). In order to reduce high energy prices on public and household income, Morocco introduced energy subsides as a key part of its social protection system for decades. Nevertheless, Morocco has made several attempts to reform its energy subsidy system since the 1990s.

In 1995, petroleum product prices, with the exception of butane gas, were indexed to global prices (Mazraani and Versailles, 2013). This system was suspended in 2000 as it became politically difficult to link domestic energy prices to high international prices. The gap between domestic and international prices grew and peaked at 6.6% of GDP in 2012 (Mazraani and Versailles, 2013). This figure was almost the size of Morocco's overall fiscal deficit, and as much as spending on investment, and more than spending on health and education combined (Fattouh and El-Katiri, 2015). Subsidies were provided on petroleum products including gasoline, diesel, fuel oil and liquid petroleum gas (LPG). The justification for these subsidies was to ensure price stability, consumer purchasing power, and the promotion of selected industries (Merrill et al., 2015). Also, in response to public protests in 2011, the government decided to freeze energy prices (Fattouh and El-Katiri, 2015).[41] Figure 10 presents fuel subsidies in Morocco in relation to global oil prices between 2002 and 2011.

[41] To promote the political stability of the Kingdom, following fears of a potential uprising, the Gulf Cooperation Council (GCC) supported Morocco financially in the form of advantageous loans and unconditioned development aid. This helped the Kingdom to withstand calls from international lending organizations for further fiscal reforms (Fattouh and El-Katiri, 2015).

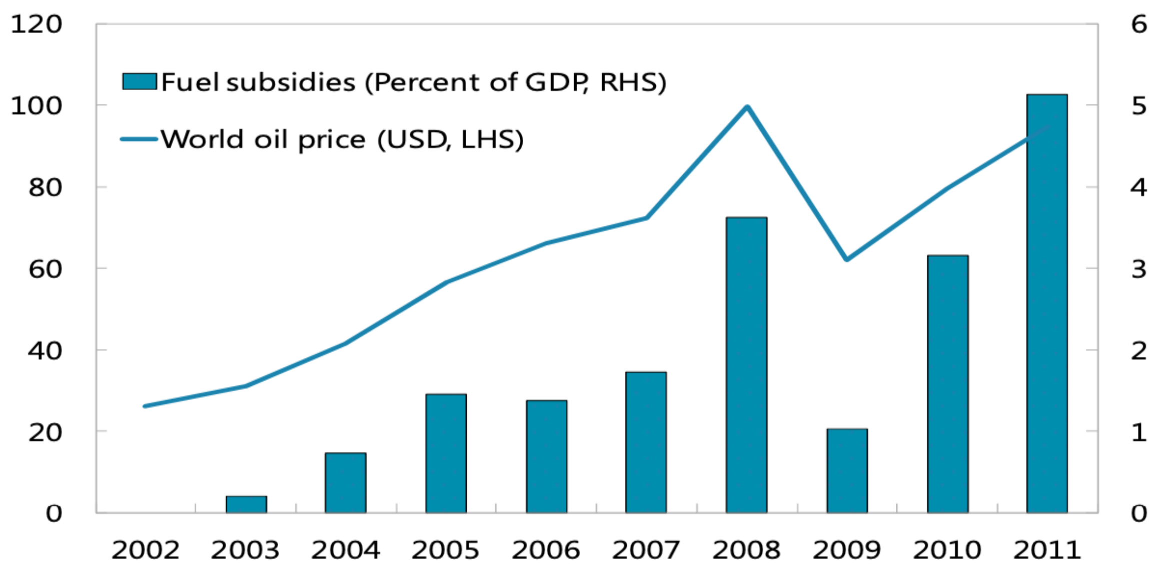

Figure 10: Fuel subsidies in Morocco between 2002–2011

Source: MAZRAANI, S. and VERSAILLES, B., 2013. Fuel Subsidies in Morocco: International Experience and Possible Ways Forward. Chapter II in *Morocco: Selected Issues.* IMF Country Report, (13/110). Washington: International Monetary Fund.

In 2013, a system of partial indexation was reintroduced on petroleum products, excluding butane gas. In 2014, the government removed subsidies to gasoline and industrial fuels and reduced diesel subsidies according to a predefined timeline. A price rise of 5% on retail tariffs was reported in January 2014, and another rise was announced in July 2014. These reforms had a significant impact on the overall subsidy level but left some subsidies in place, including most diesel, butane and petroleum fuel subsidies. Hence, between 2012 and 2014, the government's overall subsidy cost fell by around 25% (Merrill et al., 2015). The butane subsidy is costly, it accounted for nearly 4% of the government budget in 2017. However, butane subsidies remained to avoid a disproportionate burden on the poor who use it mainly for heating, cooking and agricultural irrigation (World Resources Institute, 2021). This means that removing subsidies to butane would increase the energy bills and food prices if no cheaper alternative energy sources are used. Therefore, butane subsidies are necessary to avoid social unrest from low-income people.

Accordingly, it can be seen that energy subsidy has been a major financial and political issue facing Morocco. This connects to growing energy demands and increases in global energy prices particularly after 2000. Especially due to the fact that Morocco is a very energy dependant country, and therefore highly vulnerable to international energy prices.

Significant energy imports accompanied by energy subsidies have contributed to high public debt in Morocco. It rose three fold between 1992 and 2018 reaching nearly $77 billion; however, the public debt's share of GDP dropped sharply from 73% in 1992 to 45% in 2008. This is because of the government's efforts to reduce deficits and debt accumulation, including controlled inflation which led to a surplus in the current account in the early-2000s (Chauffour, 2018). However, the government could not sustain its progress in reducing public debt which increased to 65% in 2018 as illustrated in Figure 11. The country's debt ratio is higher than the average for emerging countries, which stood at approximately 40% of GDP in 2014 (Chauffour, 2018; Countryeconomy.com, 2020). In the same vein, Nor-Eddine and Driss (2019) conclude that the current level of Morocco's public debt constrains its long-term growth.

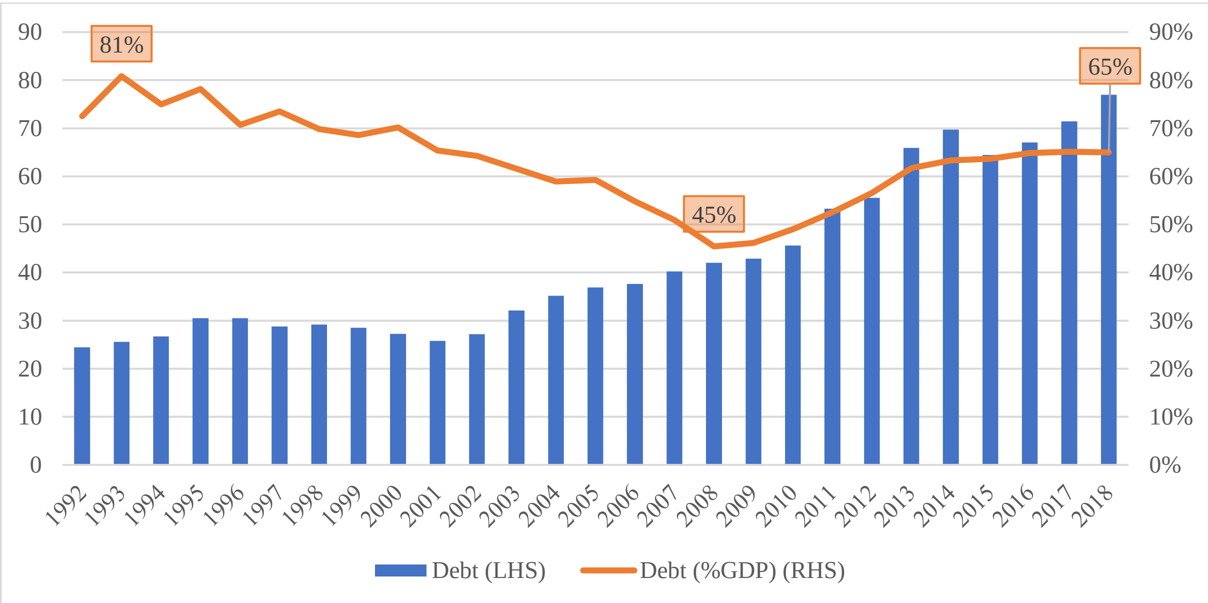

Figure 11: Public debt (billion US$) and debt (% of GDP) in Morocco between 1992–2018

Source: COUNTRYECONOMY.COM, 2020. *Morocco National Debt* [online]. countryeconomy.com. [viewed 13 December 2020]. Available from: https://countryeconomy.com/national-debt/morocco

In addition, given the strong link between energy and water – as all sources of energy generation, including electricity require water to a different extnet (Steinbuks and Hertel, 2013, Ringler et al., 2016) – energy challenges in Morocco have brought additional difficulties in relation to its water security. This has been worsened by frequent drought events (Huppé et al., 2013). Furthermore, desalination, which is important to Morocco, is energy intensive (Gopi et al., 2019). Therefore, Morocco also needs to seek alternative and sustainable source of energy to overcome its water issues.

Energy efficiency is also another challenge facing Morocco. According to the World Bank's World Development Indicators (2021) energy intensity in Morocco was almost stable, just over 3.00 MJ/GDP, between 1992 and 2015 (Figure 12). Energy efficiency indicators are discussed in detail in Chapter Six, Section 6.3.4.[42]

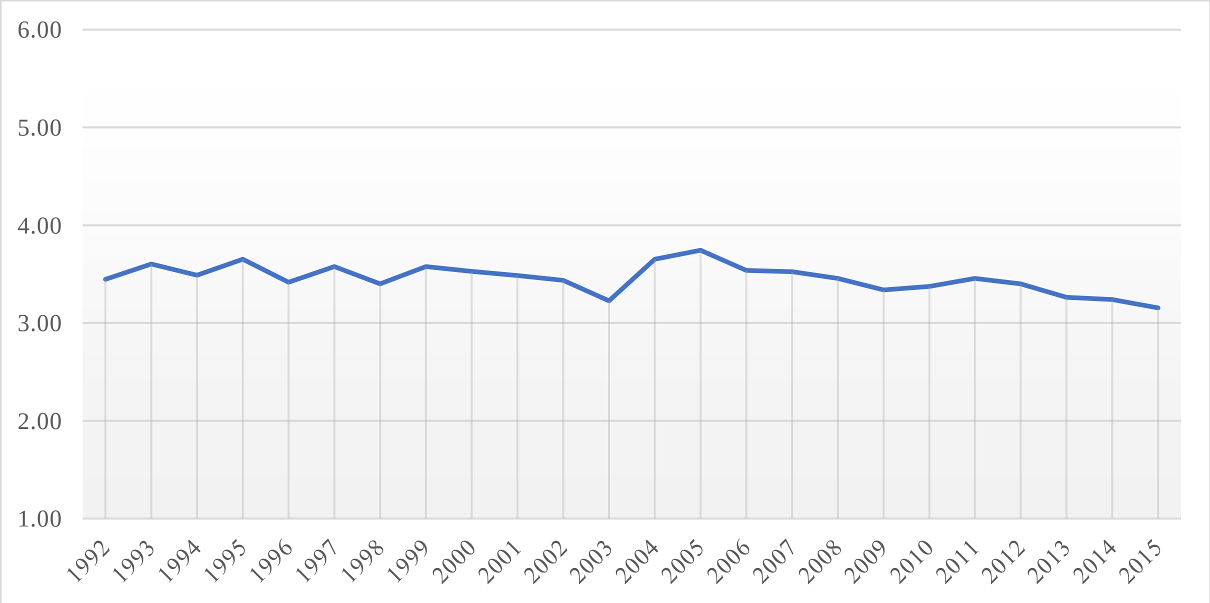

Figure 12: Energy intensity level of primary energy (MJ/$2011 PPP GDP) in Morocco between 1992–2015.

Source: WORLD BANK, 2021. *World development indicators 2021*. The World Bank. [viewed 27 August 2021]. Available from: https://data.worldbank.org/country/morocco

Examining the energy intensity of various sectors in Morocco, the residential sector has been the highest energy-intensive sector. Its energy intensity increased sharply from around 16 MJ/GDP in 2010 to over 18 MJ/GDP in 2013 (Trading Economics, 2018). Although the energy intensity of the transportation sector decreased from over 15 MJ/GDP in 2010 to less than 13 MJ/GDP in 2013, it remains high. Whereas the energy intensity of agriculture was around 2.5 MJ/GDP in 2013 (Trading Economics, 2018), and 2.5 for the manufacturing sector in 2018 (IEA, 2021), While energy intensity was the lowest in the services sector, around 0.4 MJ/GDP in 2018 (IEA, 2021). Generally high energy intensity means low energy

[42] The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (2017) indicates that decline in energy intensity is a proxy for energy efficiency improvements. According to the World Bank (2021), the energy intensity level of primary energy is the ratio between energy supply and gross domestic product measured at purchasing power parity. Energy intensity is an indication of how much energy is used to produce one unit of economic output. A lower ratio indicates that less energy is used to produce one unit of output. This indicator is obtained by dividing the total primary energy supply over GDP measured in constant 2011 US dollars at purchasing power parity (World Bank, 2021).

efficiency, especially in the residential and transport sectors which are growing fast in Morocco. This situation contributes to an increase in energy consumption in the country.[43]

Furthermore, increased energy consumption in Morocco has also caused an increase in GHG emissions. GHG emissions per capita increased from 1.25 metric tons per capita in 1992 to 2.34 metric tons per capita in 2014 (World Resources Institute, 2019). In addition, CO_2 emissions per capita, which accounts for the majority of total emissions, rose by 75% during the same period, reaching 1.74 metric tons in 2014 as presented in Figure 13 (World Bank, 2019).

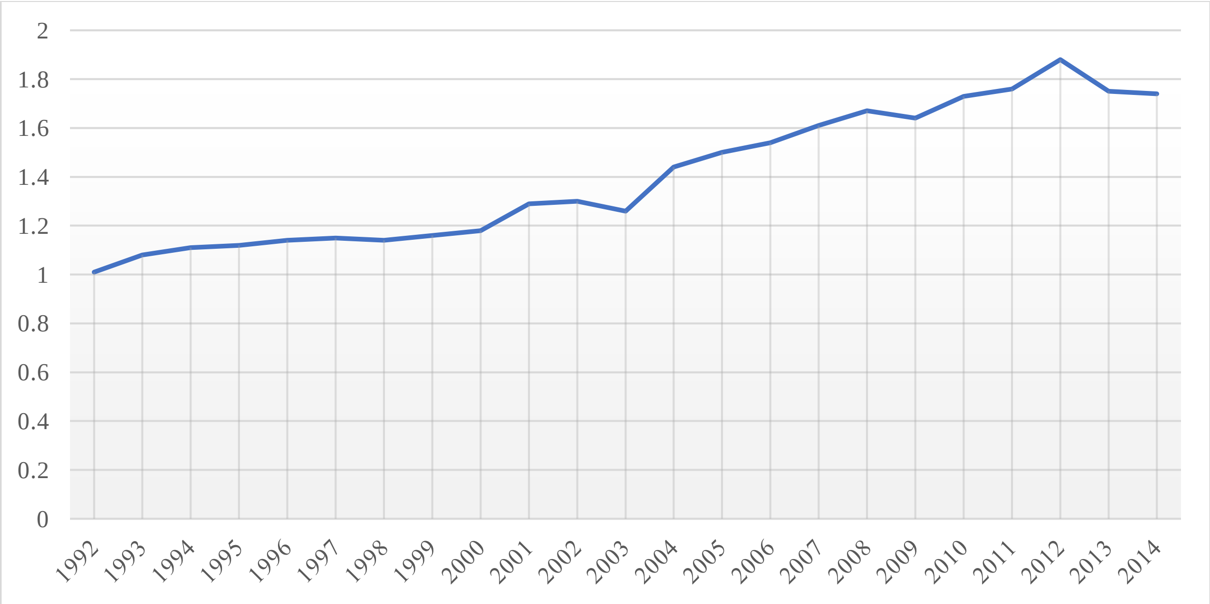

Figure 13: CO_2 emissions (metric tons per capita) in Morocco between 1992–2014

Source: WORLD BANK, 2019. *World development indicators 2019*. The World Bank. [viewed 30 June 2019]. Available from: https://data.worldbank.org/country/morocco

According to the IEA, the electricity and heating sectors are main responsible for CO_2 emissions in Morocco, followed by the transportation, industry and residential sectors (IEA, 2021). This is consistent with the fact that until 2014, the share of electricity generated from renewables has been modest, and also energy intensity in the residential and transport sectors is high in Morocco. This is examined in Section 5.5 in Chapter Five. Additionally, Morocco's biodiversity and ecosystems have been subject to increasing pressure from

[43] Because of lack of available data from reputable sources, there is concern about consistency of these data. I used the most available data from these sources to give an idea about the level of energy intensity.

climate change, deforestation, urbanization, and human practices.[44] Growing carbon emissions pose a serious threat to biodiversity and ecosystems (Taleb, 2016). Therefore, Morocco needs to reduce its emissions which will help protect its biodiversity and ecosystems.

In summary, the growing energy demand and low energy efficiency in Morocco, particularly after 2000, has created many difficulties. Especially in relation to its financial status and environment. Given the lack of fossil fuel energy sources, and therefore reliance on extensive energy imports accompanied by the energy subsidy system, the country is vulnerable to fluctuating international energy prices. This has deteriorated its financial position. Also these energy challenges have threatened Morocco’s water security. In addition, extensive reliance on fossil fuel energy sources accompanied by growing energy consumption has increased its carbon emissions which threaten its biodiversity and ecosystems. In response to the causes and consequences of climate change and energy challenges, Morocco has taken important actions that address its development issues since 1992. These actions are reviewed in the next section.

3.5. Response to the challenges

Since its participation in the Rio Conference in 1992, when the Kingdom became widely involved in global efforts to fight against climate change, the Kingdom has taken various actions to respond to development challenges in relation to the consequences of climate change and the energy sector. The most remarkable action, as widely agreed by the interviewees of this thesis, is the introduction of its Energy Strategy in 2009. Morocco has built its green economy model on energy transition. The introduction of this strategy is considered a developmental milestone due to its spill over effect on various aspects of Morocco’s economy, society, environment and politics. The evolution of the 2009 Energy Strategy and its potential and intended benefits are discussed in Chapter Five.

Morocco’s understanding of its green economy model and responses to its development challenges, until the introduction and delivery of its 2009 Energy Strategy, can be reviewed in three stages. The first stage is between the 1992 Rio Conference until the death of King Hassan II in 1999. The economic growth during this period fluctuated highly, mainly due to extreme drought. Morocco attempted to reform energy subsidies by linking

[44] Morocco’s biodiversity, especially species diversity, is one of the richest in the Mediterranean Basin. Morocco has a species diversity of more than 31,000 species, and 11% of Morocco’s species are endemic, including 20% vascular flora (phanerogams). Morocco also has an exceptional number of wild relatives of domesticated crops (USAID, 2008).

petroleum products to international prices to improve its financial position. This reform was accompanied by the introduction of solar energy to support delivery of the rural electrification programme in 1995. During this period, the country was among the first countries to sign and ratify the Rio Conference's agreements on biodiversity, desertification and climate change (MEME, 2012). Accordingly, the Ministry of Environment was created, and the National Strategy for the Environment and Sustainable Development was developed (Tarradell, 2004). In order to increase the openness of its economy to attract investments and stimulate its economic growth, the country hosted the final session of WTO negotiations and ratified its agreements in 1994 to become a founding member of the World Trade Organization (WTO, 2021). In addition, Morocco signed a free trade agreement with the European Union in 1997 (Catusse, 2009).

The second stage from 1999 to 2009 marked King Mohammed VI's first decade in power. The main characteristic of this period is strong economic growth. The economy became more diverse, and thus less volatile to the effects of climate change compared to the previous decade. New industries emerged, public investments increased, and major infrastructure projects launched. The new economic structure, lessening the domination of the agriculture sector, was characterised by increased urbanization, industrialization and investments, accompanied by population growth and an improved standard of living. Combined these contributed to an increase in Morocco's energy demand which increased its energy imports. During this second stage, the indexation of energy prices with international prices was suspended to avoid social unrest and ensure the country's political stability. These factors have impacted its financial position (see Section 3.4).

Besides, the Kingdom further engaged with global efforts to combat climate change and protect the environment. For instance, Morocco hosted the COP7 in 2001 and ratified Kyoto Protocol in 2002, which is considered the cornerstone of global climate change action. The country also established the National Committee for Climate Change in 2001 to find solutions to its climate change challenges (Nachmany et al., 2015). In addition, King Mohammed VI delivered a speech at the Johannesburg Conference in 2002, the World Summit on Sustainable Development, reiterating the Kingdom's commitment towards sustainable development and climate change (MEME, 2012).

Morocco also extended its economic openness by signing an additional free trade agreement with the United States in 2004 (Catusse, 2009). This demonstrates its political willingness to reform its economy and reduce trade barriers in order to stimulate its economic growth, as evidenced by Morocco's growing exports and imports since 1992 (Figure 14).

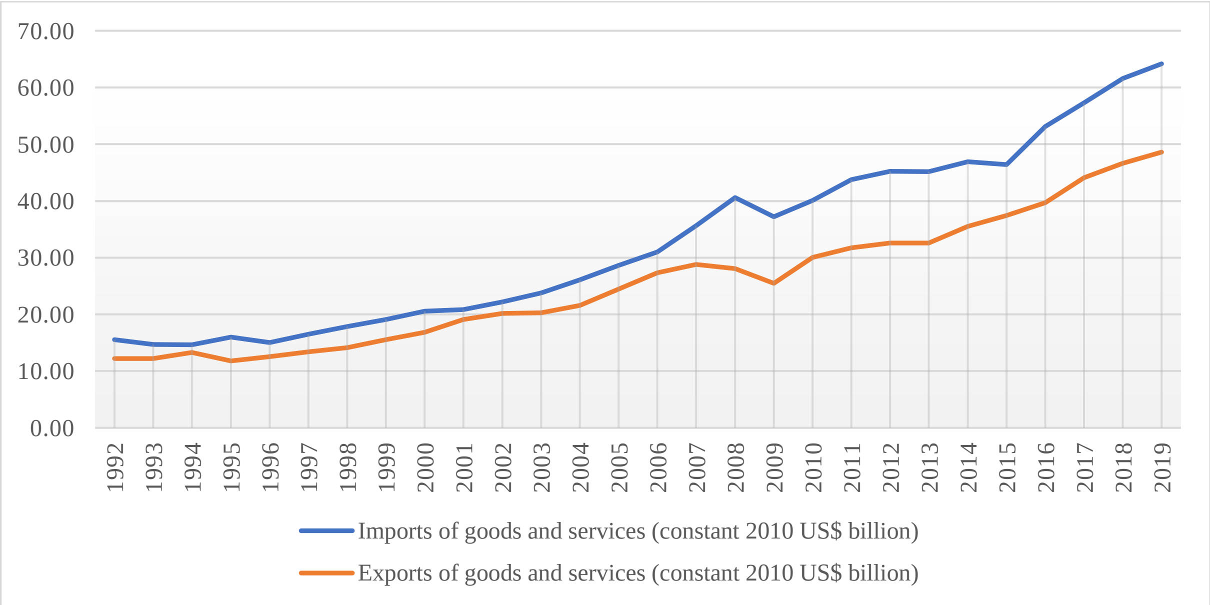

Figure 14: Imports and exports of goods and services (constant 2010 US$ billion) in Morocco between 1992–2019

Source: WORLD BANK, 2020. *World development indicators 2020*. The World Bank. [viewed 01 December 2020]. Available from: https://data.worldbank.org/country/morocco

The second stage ended with a significant rise in international oil prices followed by the global financial crisis which triggered the introduction of the 2009 Energy Strategy.

Third stage begins in 2009 when King Mohammed VI launched the Energy Strategy in order to seek more sustainable solutions to its development problems. This action was motivated by the significant potential of renewable energy in Morocco, and its continuous engagement with global efforts on tackling climate change and achieving sustainable development through a green agenda. This strategy was influenced by the increasing global momentum of the green economy, particularly after the 2008 global financial crisis, and was related to the UNEP Green Economy Initiative on renewable energy and energy efficiency, which is mentioned in Section 2.2.1, Chapter Two.

At the international meeting on 'Climate change: challenges and prospects for Morocco' in 2009, the king emphasised a green growth approach through renewable energy transition. He highlighted the essential need for Morocco to respond to its climate change and energy challenges and reach desired SDGs. The Energy Strategy set out bold targets to increase Morocco's share of renewable energy in its energy mix. This was emphasised in its National Plan Against Global Warming in November 2009. This plan clearly stated that the country's strategy to deal with the causes of climate change comes through a decoupling of its economic growth from emissions, by reducing the GHG emissions via the introduction of clean energy (MEME, 2009). This is a core element of the green economy as discussed in Chapter Two.

The National Plan included adaptation and mitigation projects to deal with the causes and consequences of climate change. The plan stressed that GHG emissions are responsible for 90% of climate change as outlined in the Fourth Report of the Intergovernmental Panel on Climate Change (IPCC). Therefore, the country's mitigation measures for climate change focused on reducing GHG emissions; principally through improving energy efficiency and developing renewable energy as outlined in the 2009 Energy Strategy. This is due to the strong linkages between emissions and fossil fuels. This strategy was thought to provide more than a 90% reduction of energy-related CO_2 emissions by 2030. While energy efficiency measures are expected to contribute to 7% of total CO_2 emission reduction, the remaining and majority of energy-related reduction is planned to be achieved through renewable energy (MEME, 2009).

Following the Arab Spring, an important constitutional amendment was passed in 2011 to incorporate sustainable development. Hence, the economic, social, and environment pillars of sustainable development have been given more emphasis. Accordingly, Morocco adopted the National Charter for Environment and Sustainable Development in 2012 in order to increase its efforts to protect the environment and achieve SDGs (Nachmany et al., 2015). Also, the country could benefit from the outcome of the Rio+20 Conference in 2012 to secure global support to deliver the Energy Strategy that is aligned to its outcome in terms of closing the technological gap between developed and developing countries.

Positive economic growth has occurred during this third stage, and fuel subsidies have been gradually and significantly reduced since 2013. Most critically, energy demand has continued to grow. The country also increased its international commitment to fight against climate change, most notably signing the Paris Agreement and launching its NDC with challenging targets. Strikingly, Morocco is one of only two countries globally (with Gambia) whose Paris Agreement target is within the 1.5°C threshold.[45] Controversially, this means

[45] Controversially, Morocco launched a new 1.4 GW coal-fired power plant in 2018 (Safi Power Plant), and another 1.3 GW coal-fired power plants are expected to be operational in 2023/2024. This raises significant concerns about the country's ability to meet its targets. This could be an indication that growing needs for energy exceeds the country's renewable resources (Climate Action Tracker, 2021).

that the Kingdom has margins in dealing with its emissions, to an extent, whilst still keeping within fair share range, benefitting historically from its low emissions.

Despite Morocco being responsible for only a small share of the global problem of climate change, the Kingdom confirmed its NDC with bold targets in 2016 – to counter the effects of climate change through mitigation and adaptation measures – following its signature of the Paris Agreement. These targets were initially launched at a national conference held in 2015 in Rabat, chaired by the head of government to demonstrate state support and commitment for their implementation. Later they were presented at UNFCCC conference in 2015 to gain global attention and support.[46]

In terms of mitigation, by 2030 Morocco is unconditionally committed to reduce its GHG emissions by 17% with 4% coming from Agriculture, Forestry, and Other Land Use (AFOLU), actions compared to Business-As-Usual (BAU) levels. Also, the country is conditionally committed to reduce its gas emissions by 42% (considering 8% coming from AFOLU), if given substantial support from the international community. This includes, for example, financial, technical and political support. Importantly, meeting these targets rely in large part on vast and rapid transformation of the country's energy sector. This is because the sheer bulk of carbon emissions are energy-related.[47] Table 3 summarises Morocco's NDC mitigation scenarios.

[46] Morocco developed its Intended Nationally Determined Contribution (INDC) in 2015. INDCs pair national policy setting, in which countries determine their contributions in the context of their national priorities, circumstances and capabilities, within a global framework under the Paris Agreement. This drives collective action toward a net zero-carbon and climate-resilient future. The word "intended" was used because countries were communicating proposed climate actions ahead of the Paris Agreement being finalized. However, as countries formally joined the Paris Agreement, the term "intended" was dropped and an INDC is converted into a Nationally Determined Contribution (NDC) (World Resources Institute, 2022).

[47] John Kerry, the U.S. Special Presidential Envoy for Climate, said, during a WEF Conference in January 2021, that 'no single country can fight against climate change which is global risk'. This needs a collaborative approach between developed and developing countries.

Table 3: Summary of Morocco's key data on NDC mitigation scenarios

MTCO2e	2010	2020	2025	2030	Total 2020–2030
Emissions – BAU	93.9	121.6	142.7	170.8	1584.8
Emissions – Unconditional Scenario (with AFOLU)	93.9	107.1	116.7	141.4	1326.9
Emissions – Unconditional Scenario (without AFOLU)	93.9	111.3	122.5	148.7	1390.5
Emissions – Conditional Scenario (with AFOLU)	93.9	97.2	91.6	98.9	1061.3
Emissions – Conditional Scenario (without AFOLU)	93.9	101.9	101.8	113.2	1172.1
Expected Reductions – Unconditional Scenario (with AFOLU)	0.0	14.6	26.0	29.4	257.9
Expected Reductions – Unconditional Scenario (without AFOLU)	0.0	10.3	20.3	22.1	194.3
Expected Reductions – Conditional Scenario (with AFOLU)	0.0	24.4	51.1	71.9	523.5
Expected Reductions – Conditional Scenario (without AFOLU)	0.0	19.7	40.9	57.5	412.7

Source: UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, 2016. *Morocco: Nationally Determined Contribution under the UNFCCC*. New York: United Nations Framework Convention on Climate Change (UNFCCC).

What is striking about the figures in Table 3 is that carbon emission reduction is planned to double if Morocco gains significant support from the international community. Regarding adaptation, Morocco set out bold sectoral goals on agriculture, water, forests, fisheries and aquaculture for 2020 and 2030. Similar to mitigation targets, reaching its proposed adaptation targets will only be possible with significant support from the international community and creditors (IEA, 2019).

In summary, this section outlines the actions that Morocco has taken to respond to development challenges since 1992. The most notable action is the introduction of the 2009 Energy Strategy as stressed in its National Plan Against Global Warming. Energy transition could help the country meet the growing demand for energy from renewable sources, this could help reduce its dependency on imports, and therefore strengthen its financial position. This could also help increase its water security. This is in turn could reduce its carbon emissions and accordingly protect Morocco's environment and biodiversity. Importantly, Morocco's transition to a green economy has been widely supported by the king who aims to achieve wide socioeconomic and environmental benefits. These potential benefits are studied in Chapter Five. Also, the country signed the Paris Agreement and developed its NDC with bold targets to reduce its emissions. Morocco's global engagement in the global events surrounding climate change, such as hosting COP7 in 2001 and COP22 in 2016, demonstrates its endeavours to overcome its development challenges that are related to climate change.

3.6. Conclusion

The aim of this chapter is to understand Morocco's main motivations for pursuing a green agenda by reviewing many aspects of its development challenges, and the country's considerable efforts to tackle climate change following the 1992 Earth Summit, Rio de Janeiro, Brazil.

The chapter has argued that the consequences of climate change and energy sector challenges have been two important interlinked difficulties to Morocco's development since 1992. More frequent and severe drought events, especially after 1990, caused uneven and non-inclusive growth. Also the growing economy, industrialization, urbanization, and population growth have increased its energy needs and emissions. Given the scarcity of fossil fuel resources in Morocco, meeting increasing energy demands through imports is a serious challenge. Also limiting rising emissions, which is seen a priority to deal with the causes of climate change, is another critical challenge to Morocco.

Dealing with these issues has encouraged the country to build its green economy model on energy transition to renewable energy. The most important action the country has taken was the introduction of Energy Strategy in 2009 to support its green economy transition. This model considers the particular circumstances and priorities of Morocco in terms of meeting growing energy demand while reducing emissions. The introduction of the Energy Strategy is considered one of the milestones in Morocco's development.

Morocco has maintained its desire to join global efforts to tackle climate change and to achieve green growth, notably through hosting COP7 in 2001, ratifying the Kyoto Protocol in 2002, signing the Paris Agreement in 2016, and developing its NDC and hosting COP22 in 2016. Importantly its green transition is supported by King Mohammed VI who introduced the 2009 Energy Strategy to increase renewable energy and energy efficiency.

Nevertheless, an important question that one could raise is: what is the outcome of Morocco’s efforts to overcome its development challenges since the Earth Summit and importantly after the introduction of the Energy Strategy? The following chapters approach this question to understand Morocco’s progress and evaluate its green economy model. Chapter Four quantitively assesses Morocco’s progress to decouple its economic growth from carbon emissions based on historical data. Chapter Five evaluates its model and the ability of the country to meet its carbon reduction targets and achieve desired green growth. Chapter Six measures its progress since the introduction of the Energy Strategy based on a customised measurement tool. These chapters advise on the delivery of the green economy model, the level of economy transformation needed, and the socioeconomic and environmental benefits of this transition.

Chapter Four

The relationship between the economic growth, energy, and environment in Morocco

4.1. Introduction

Chapter Three has shown that the green economy model of Morocco is built on an energy transition to renewable energy that may help the country address its climate change and energy concerns. In particular, its model is aimed at supporting the Kingdom to sustain its economic growth whilst reducing its carbon emissions. Based on its Paris Agreement commitment, Morocco has created challenging targets to hold its temperature rise to 1.5°C as shown in Chapter One. This means that the country must achieve absolute-decoupling of economic growth from carbon emissions – a core element of the green economy as discussed in Chapter Two. In addition, Morocco's carbon reduction needs to be significant according to its NDC.

Accordingly, it is necessary to quantitively evaluate the progress Morocco has made on its green transition. In particular, this chapter assesses whether the country has been able to achieve absolute-decoupling of economic growth from carbon emissions, considering energy consumption, through an empirical approach using econometric estimation. This provides deep understanding of the dynamic relationship between economic growth, environment and energy in Morocco.

The purposes of this chapter are to validate whether the relationship between economic growth and environment is cross-coupling, relative-coupling, or absolute-decoupling, and whether such a long-run relationship is stable in Morocco. Therefore, this chapter addresses the research question quantitively to establish the extent to which Morocco has been able to achieve its green ambitions.

The chapter is structured as follows. First, it begins by examining the related literature on the relationship between economic growth, energy and environment. Second, it explains the methodology of the econometric model and the data sets. Third, this chapter reports and discusses the results of analyzing the econometric model. The final section draws some conclusions.

4.2. Related literature

The relationship between economic growth and environment has been extensively explored in recent years, but the results remain controversial (Almeida et al., 2017). The issue of whether economic growth can be delinked from GHG emissions is usually framed via a Carbon Kuznets Curve (CKC). This curve suggests an inverted U-shaped relationship between income per capita and GHG emissions per capita. The CKC hypothesis holds that GHG emissions per person initially increase with rising income per capita due to industrialization, then peak and decline after a threshold level of GDP per capita, as countries become more energy efficient, more technologically sophisticated and more inclined and able to reduce emissions (Mir and Storm, 2016). This theory is based on an original principle developed by Simon Kuznets (1955) regarding the relationship between economic growth and income inequality. Since 1991, the principle has been reinterpreted in the environmental economics literature as the Environmental Kuznets Curve (EKC) (Akbostancı et al., 2009). While CKC focuses only on carbon emissions, EKC may include one or more other types of pollutants, such as methane (CH_4), sulfur hexafluoride (SF_6) and nitrous oxide (N_2O).[48]

Furthermore, since energy is a key driver of economic growth and responsible for a significant share of emissions, the relationship between economic growth, energy and environment has been also studied. The literature on this relationship is classified into three broad categories (Alkhathlan and Javid, 2013). The first category focuses on environmental pollution and the economic growth nexus. This strand of the literature involves testing for the existence of an EKC (Alkhathlan and Javid, 2013). The reviewed literature indicates mixed results for the validity of the EKC hypothesis even within the same country (Ahmad et al., 2017). While numerous researchers have confirmed the inverted U-shaped, several empirical studies have failed to confirm the EKC hypothesis and have suggested different shapes for the relationship between economic growth and environmental quality, such as U-shaped, N-shaped and inverted N-shaped (Marabet and Alsamara, 2017). Different estimations of turning point also arise, Grossman and Kruger (1995) conclude that it could occur at an income per capita of less than $8,000. The main reasons behind conflicting results and different estimations of turning point are linked to choice of variables, the period covered, econometric estimation techniques used, and countries' economic situation (Aslan et al., 2019).

The second category is related to energy consumption and the output nexus. The relationship between energy consumption and economic growth was first studied for the USA (Alshehry and Belloumi, 2015). The related literature presents that economic growth and energy consumption are closely related, as a higher level of economic development requires greater energy consumption. Empirical results from the causality test between energy consumption and economic growth suggest four different results. The first result is unidirectional causality from energy consumption to economic growth, which is also known

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[48] Wagner (2008) uses SKC to refer to sulfur Kuznets curve when analyzing the relationship between GDP per capita and SO2 emissions per capita.

as the growth hypothesis. The second result is unidirectional causality from economic growth to energy consumption, which is also known as the conservation hypothesis. The third result is bidirectional causality between economic growth and energy consumption, which is also known as the feedback hypothesis. The final result suggests that no causal relationship exists between economic growth and energy consumption, this hypothesis is known as the neutrality hypothesis. The conflicting results of these studies may be related to country-specific policies, the use of different energy consumption and income measures, the econometric tool used, omitted variable biases, model specifications and the varying time spans of the studies.

The third category of the literature is a combined approach of the two above categories. It investigates the validity of both nexuses in the same framework (Alkhathlan and Javid, 2013).

The early literature of EKC focused on a cross-country approach or on panel data techniques because of the absence of long time-series of environmental data (Bhattacharya, 2019). Cross-country studies have been criticized for aggregating the performance results of different countries which are not actually similar even if they are in the same region (Bhattacharya, 2019). Also it has been claimed that only single country studies can really provide an answer to the existence of the EKC. It is also argued that the EKC is a long-running phenomenon and that time-series analyses of single countries are preferable over cross-section analyses to consider the dynamics of the causes of the EKC pattern (Akbostancı et al., 2009). Compared to cross country studies, single country studies are fewer in number and their findings have different implications (Akbostancı et al., 2009). Tiba and Omri (2017) attempt to provide an exhaustive list of studies which have examined the EKC hypothesis. They survey 51 country-specific studies covering the period from 1978 to 2014 as presented in Table 4 below.

Table 4: Summary of the existing empirical country-specific studies on EKC

No.	Study	Period	Country	EKC hypothesis
1	Roca et al.	1973−1996	Spain	No evidence
2	Day and Grafton	1974–1997	Canada	No evidence
3	Haisheng et al.	1990–2002	China	Support
4	Paudel et al.	1985−1999	the state of Louisiana (USA)	No evidence
5	Plassmann and Khanna	1990	USA	Support
		1975–1999	Canada	Support
6	Ang	1960–2000	France	No evidence
7	Akbostanci et al.	1968−2003	Turkey	No evidence
		1992−2001	58 Turkish provinces	No evidence
8	Halicioglu	1960–2005	Turkey	Support
9	Fodha and Zaghdoud (2010)	1961–2004	Tunisia	Support
10	Ghosh	1971−2006	India	Support
11	Iwata et al.	1960–2003	France	Support
12	Ozturk and Acaravci	1968–2005	Turkey	No evidence
13	Pao et al.	1990–2007	Russia	No evidence
14	Pao and Tsai	1980–2007	Brazil	No evidence
15	Jalil and Feridun	1953–2006	China	Support
16	Nasir and Rehman	1972–2008	Pakistan	Support
17	Ahmed and Long	1971−2008	Pakistan	Support
18	Akpan and Akpan	1970−2008	Nigeria	No evidence
19	Alam et al.	1972−2006	Bangladesh	Support
20	Du et al.	1995–2009	China	No evidence
21	Esteve and Tamarit	1857–2007	Spain	Support
22	Fosten et al.	1850−2002	United Kingdom	Support
23	Franklin and Ruth	1900−2000	United States	Support
24	Hamit-Haggar	1990–2007	Canada	Support
25	Jayanthakumaran and Liu	1990–2007	China	Support
26	Saboori et al.	1980−2009	Malaysia	Support
27	Shahbaz et al.	1971–2009	Pakistan	Support
28	Pao et al.	1980−2009	China	No evidence
29	Ahmed and Long	1971–2008	Pakistan	No evidence
30	Alkhathlan and Javid (2013)	1980−2011	Saudi Arabia	Support
31	Baek and Kim	1971–2007	Korea	Support
32	Giovanis	1991–2009	United Kingdom	No evidence
33	Kanjilal and Ghosh	1971−2008	India	Support
34	Kohler	1960–2009	South Africa	Support
35	Ozturk and Acaravci	1960–2007	Turkey	Support

No.	Study	Period	Country	EKC hypothesis
36	Saboori and Sulaiman	1980–2009	Malaysia	Support
37	Shahbaz et al.	1971–2011	Malaysia	Support
38	Shahbaz et al.	1970–2010	Turkey	Support
39	Shahbaz et al.	1965–2008	South Africa	Support
40	Shahbaz et al.	1980–2010	Romania	Support
41	Sulaiman et al.	1980–2009	Malaysia	Support
42	Tiwari et al.	1966–2009	India	Support
43	Esmaeili and Nasrnia	1976–2006	Iran	Support
44	Farhani et al. (2014)	1971–2008	Tunisia	Support
45	Katircioğlu	1971–2010	Singapore	Support
46	Lau et al.	1970–2008	Malaysia	Support
47	Sephton and Mann	1857–2007	UK	Support
48	Shahbaz et al. (2014)	1971–2010	Tunisia	Support
49	Robalino-López et al.	1980–2025	Ecuador	No evidence
50	Yang and Zhao	1970–2008	India	Support
51	Yavuz	1960–2007	Turkey	Support

Source: TIBA, S. and OMRI, A., 2017. Literature survey on the relationships between energy, environment and economic growth. *Renewable and Sustainable Energy Reviews*, *69*, pp.1129-1146.

Table 4 shows that the majority of studied countries confirm the EKC hypothesis. However, it also presents some conflicting results for number of countries such as France, Turkey, Spain and Canada, for some of the reasons mentioned above. Table 4 also shows that no study has been undertaken on Morocco.

The overwhelming majority of empirical EKC studies use domestic production-based CO_2 emissions data to test the hypothesis (Mir and Storm, 2016). The main reason for studying CO_2 emissions among other environmental indicators is that carbon emissions are central in the current debate on environment protection and sustainable development. Carbon emissions have been recognized by most scientists as a major source of global warming through their greenhouse effects (Akbostancı et al., 2009). CO_2 emissions also account for 82% of GHGs in 2015 (United States Environmental Protection Agency, 2018). Another reason is that CO_2 emissions are directly related to the use of energy, either in production or consumption. There is a strong correlation between fossil fuel energy use, CO_2 emissions and economic activity. Therefore, the relationship between CO_2 emissions, energy consumption and economic growth has important implications for environmental and economic policies (Azomahou et al., 2005).

Policymakers are struggling to understand the confusing and controversial conclusions of the relationship between economic growth and environmental impact. Almeida et al. (2017) conclude that there is a need to improve our knowledge on the impacts of economic development on the environment and on the wellbeing of people. The shape of this relationship and the existence of an inverted U-shape turning point have implications for policy. Policy recommendations differ depending on whether there is a negative or a positive impact of economic development on environmental quality (Azomahou et al., 2005). Some studies, such as Azomahou et al. (2005), conclude that not only poor countries, but also richer countries, face environmental deterioration. The economic development process normally results in increased CO_2 emissions. Hence, economic development might not be a sufficient condition to reduce CO_2 emissions. Thus, all countries should strive to cut these emissions to protect the environment. Likewise, other studies argue that policymakers in developing countries should not assume that economic growth automatically reduces air and water pollution (Akbostancı et al., 2009). This aligns with the claim of Barua and Khataniar (2016) and Loiseau et al. (2016) that transition to a green economy urges countries to follow a path of strong sustainability to deal with the concerns about climate change issues.

Although there is growing literature on the EKC hypothesis, empirical studies in the MENA region have been given less attention (Arouri et al., 2012, ul Haq et al., 2016). Examining Tiba and Omri's (2017) survey on existing empirical studies on the EKC conducted between 1978 to 2014, none of them has solely examined Morocco.

Later studies on the existence of the EKC in Morocco include ul Haq et al. (2016), Anas (2017), and El Moummy et al. (2020). Ul Haq et al. (2016) explore the relationship between GDP per capita, carbon emissions per capita, electricity consumption per capita, and trade openness in Morocco from 1971 to 2011. This study does not confirm the EKC hypothesis in long run. However, this study considers GDP per capita in current US$, so it does not take into account the effects of inflation or deflation in the country. Furthermore, its model includes electricity consumption which accounts for only 17.2% of total final energy consumption in 2019 as shown in Figure 8. Electricity is responsible for only a small share of total carbon emissions in the country which largely come from heating, residential, transport and industry sectors. Hence, the result of this study on the existence of the EKC in Morocco is questionable.

Anas (2017) studies the relationship between real GDP per capita and CO_2 emissions per capita between 1966 and 2014 in Morocco. The results support the EKC hypothesis, the turning point is estimated when real GDP per capita reaches $7800 in 2040. However, details on the cointegration approach and econometric technique are not provided in the study. This raises concerns about the validity of the analysis and results provided. Also, energy consumption, which is responsible for the majority of carbon emissions in Morocco and also key component of the green economy model of the country as illustrated in Section 3.4 in Chapter Three, is not included in the model. Therefore, the result of this study is also questionable and could be inconclusive.

El Moummy et al. (2020) test the validity of EKC hypothesis in Morocco by examining the relationship between CO_2 emissions, economic growth, renewable electricity and trade openness for the period 1990-2017. The result does not confirm the EKC hypothesis in Morocco. Nevertheless, this study does not take sufficient time-series data to understand the relationship prior to 1990 when the Morocco's economy was dominated by the agriculture sector, before shifting into more service-oriented economy.

These three studies on Morocco do not provide clear understandings of the relationships between carbon emissions, economic growth and energy consumption in the country within the sufficient period of time. They suffer from fundamental shortcomings. Thus, this thesis builds on and extends the work of previous studies and contributes to filling the gap in the existing literature related to the existence of the EKC hypothesis in Morocco, which helps understands the progress the Kingdom has made on its green journey. This thesis takes advantage of a single country approach. It considers a combined approach of two methods: environmental pollution and the economic growth nexus as well as energy consumption and the economic growth nexus, as they are important elements of the green economy model of Morocco. More specifically, considering energy consumption this study aims to quantitatively investigate whether there is adverse effect of environmental degradation by CO_2 emissions on economic growth in Morocco. This is because the energy sector is a key driver of the development of Morocco, and responsible for the large proportion of carbon emissions as shown in Chapter Three. To do so, the study tries to test the cointegration and causal relations between CO_2 emissions, economic growth and energy consumption. This study provides deep understanding on whether or not the current pattern of growth will decrease environmental impact in Morocco. This study contributes to the empirical literature on the impact of economic growth on Morocco's environment. Furthermore, the findings of this study will feed into the next chapters.

4.3. Methodology

An empirical approach using econometric estimation will be used to test the relationship between Morocco's economic growth, environment, and energy consumption. These three areas are main elements of the green economy model in the Kingdom. The main selected variables chosen for the study are CO_2 emissions per capita (in metric tons), real GDP per capita (constant 2010 US$), and energy use per capita (kg of oil equivalent). This is because the traditional empirical specifications of the EKC include an indicator of environmental degradation as the dependent variable, and levels and squares of real GDP per capita as independent variables (Akbostancı et al., 2009). Also the purpose of inclusion only total energy use per capita in the equation is to make the model simple. The inclusion of additional variables may deviate from the primary goal of testing the relationship between economic growth, environment and energy consumption. Furthermore, a short form of the data reduces the risk of loss of analytical freedom (List and Gallet, 1999).

Annual data were collected from the World Bank's World Development Indicators for the period of 1971–2014, considering that the selected variables are only available together for this period. The data shows that real GDP per capita in Morocco almost tripled in this period from 1,054 to 3,125 in constant 2010 US$ as shown in Figure 15.

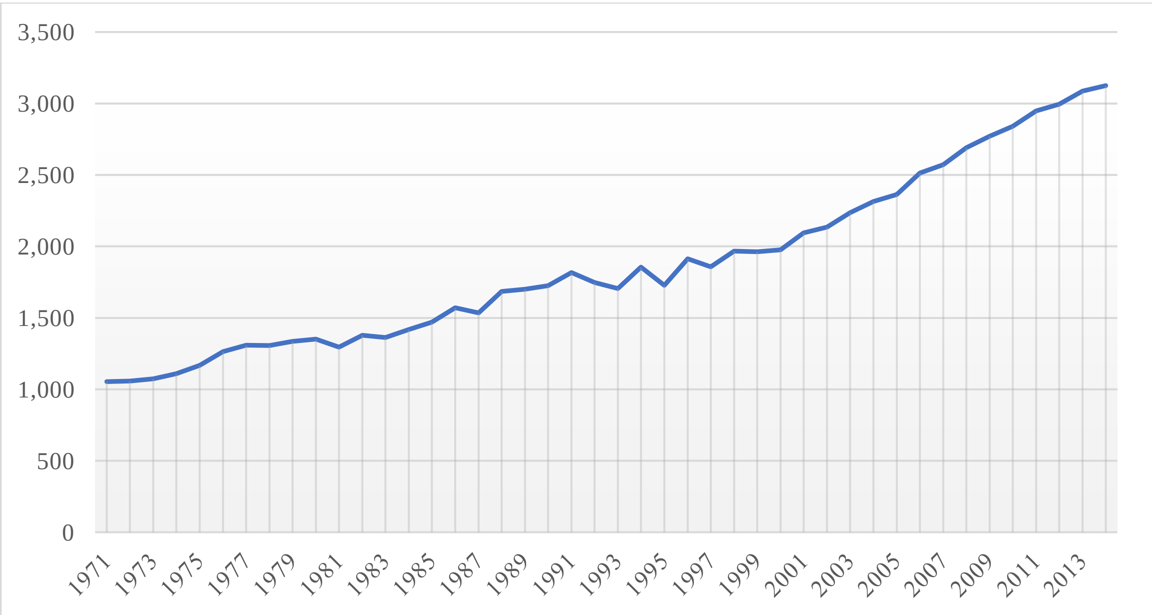

Figure 15: GDP per capita (constant 2010 US$) in Morocco between 1971–2014

Source: WORLD BANK, 2019. *World development indicators 2019*. The World Bank. [viewed 30 June 2019]. Available from: https://data.worldbank.org/country/morocco

Similarly, the energy use per capita jumped from 180.70 kgoe to 555.14 kgoe in the same period in the country as presented in Figure 16.

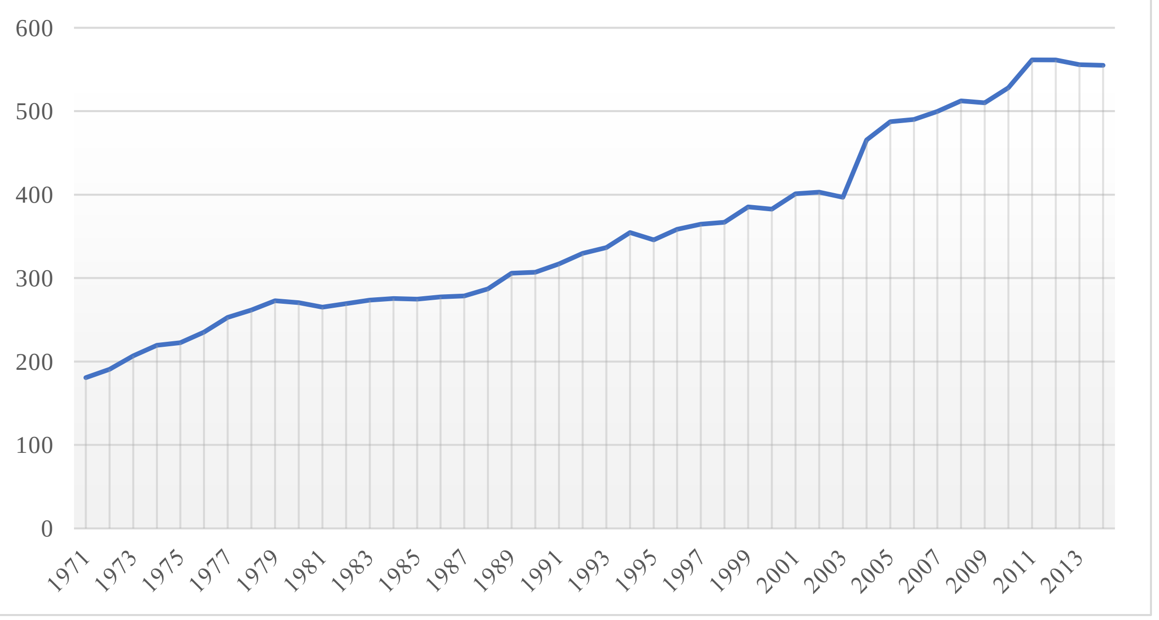

Figure 16: Energy use (kg of oil equivalent per capita) in Morocco between 1971–2014

Source: WORLD BANK, 2019. *World development indicators 2019*. The World Bank. [viewed 30 June 2019]. Available from: https://data.worldbank.org/country/morocco

Whereas CO_2 emissions per capita rose from 0.50 to 1.74 metric tons per capita in same duration in the Kingdom as illustrated in Figure 17.

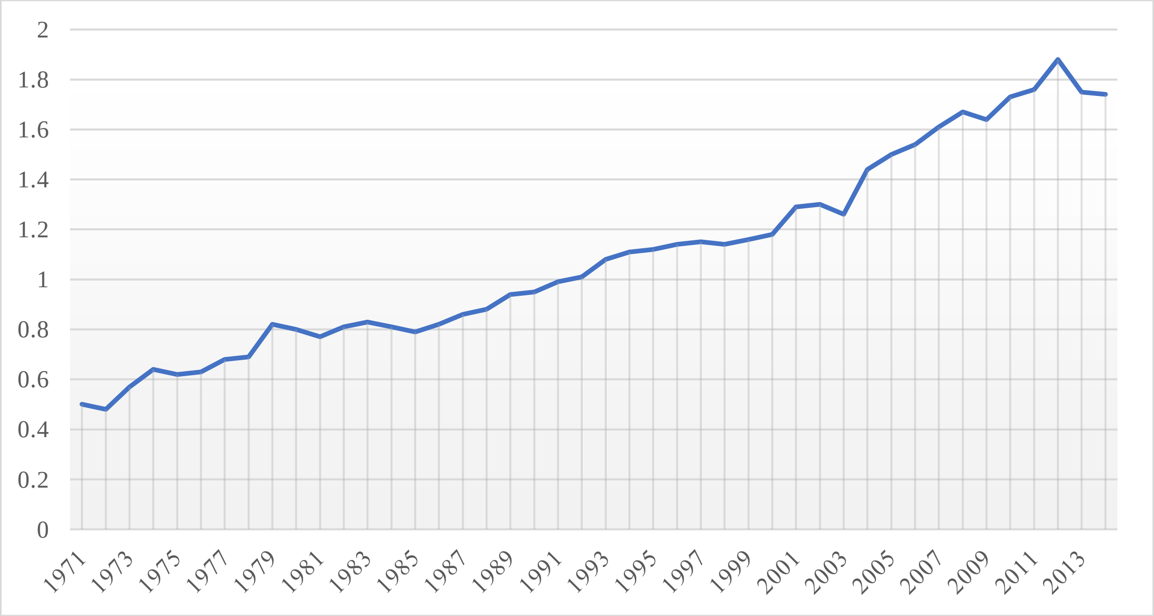

Figure 17: CO_2 emissions (metric tons per capita) in Morocco between 1971–2014

Source: WORLD BANK, 2019. *World development indicators 2019*. The World Bank. [viewed 30 June 2019]. Available from: https://data.worldbank.org/country/morocco

On closer inspection, GDP per capita has grown faster in Morocco than CO_2 emissions per capita in any given year since 1992 until 2014 as illustrated in Figure 18. Therefore, it appears that 1992 could be a turning point. Recall that Morocco became more service-oriented economy as discussed in Section 3.3 in Chapter Three. The results of the econometric model will confirm this conclusion. Appendix B presents the annual data of the Model.

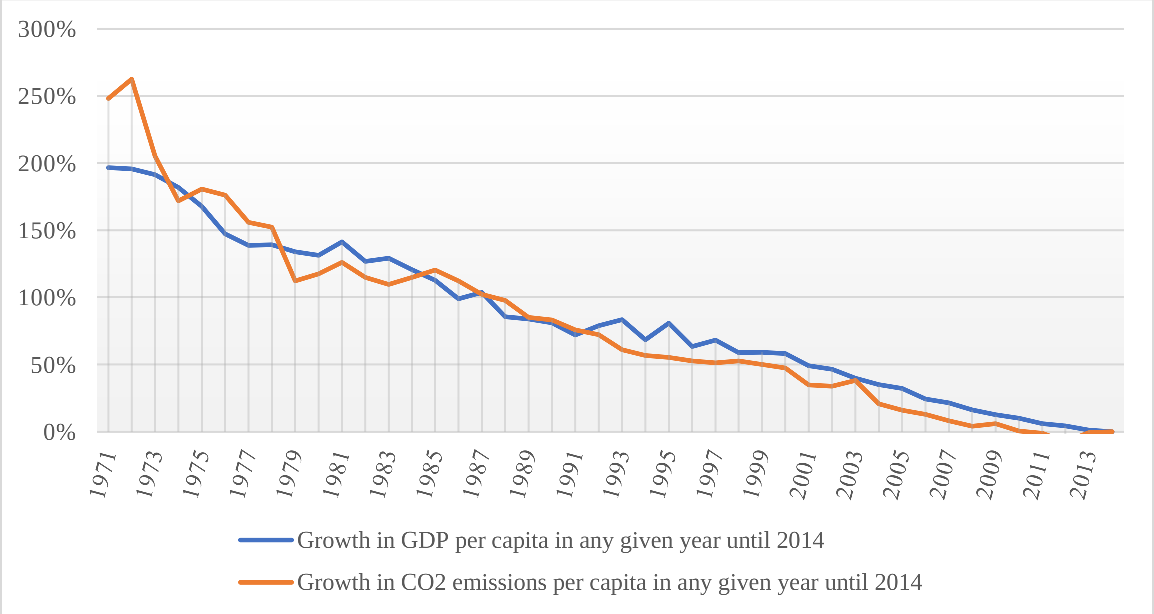

Figure 18: Growth in real GDP per capita and CO_2 emissions per capita in any given year until 2014

Source: Author's calculations based on: WORLD BANK, 2019. *World development indicators 2019*. The World Bank. [viewed 30 June 2019]. Available from: https://data.worldbank.org/country/morocco

The general form of the model testing EKC can be written as:

$$Y = F\,(X.\ X^2.\ M) \qquad (1)$$

Considering the variables of this study, the Model will be:

$$CO_{2t} = \beta_0 + \beta_1\ GDP_t + \beta_2\ GDPSQ_t + \beta_3\ EU_t + \varepsilon_t \qquad (2)$$

Where CO_2 is carbon dioxide emissions per capita, *GDP* is real gross domestic product per capita, *GDPSQ* is real GDP per capita square, *EU* is energy use per capita. β_0 is a constant, β_1 is the coefficient of real GDP per capita, β_2 is the coefficient of real GDP per capita square, β_3 is a coefficient of energy use per capita. ε_t is the error term. Variables are usually transformed to their natural logarithmic forms to achieve consistent empirical evidence. It is well known that log-linear equation moderates sharpness in the time-series data and allows for better results that control variance, compared to simple specification (Marabet and Alsamara, 2017). This thesis stresses that all variables used in the study hereafter will be in natural logarithmic forms. So, all results are based on this consideration. Therefore, the Model will be:

$$lnCO_{2t} = \beta_0 + \beta_1\ lnGDP_t + \beta_2\ (lnGDP_t)^2 + \beta_3\ lnEU_t + \varepsilon_t \qquad (3)$$

Here if $\beta_1 = \beta_2 = 0$, it will show a level relation, i.e. no relation between CO_2 emissions per capita and real GDP per capita. If $\beta_1 > 0$ *and* $\beta_2 = 0$ or $\beta_1 < 0$ *and* $\beta_2 = 0$, there will be a monotonically increasing or decreasing linear relationship respectively. If $\beta_1<0$ *and* $\beta_2>0$, there will be a U-shaped relationship. Whereas if $\beta_1>0$ *and* $\beta_2<0$, there will be an inverted-U-shaped relationship between CO_2 emissions per capita and real GDP per capita which supports the EKC theory.

Assuming that energy consumption is constant, the turning point will be log real GDP per capita = $-\beta_1/2\beta_2$. As the value of real GDP per capita is in logarithmic form, so, exp(log real GDP per capita) will provide the monetary value representing the EKC's peak. However, there may be different shapes for this relationship such as N-shape and inverted N-shape which can be examined by adding cubic and quadratic income variables (Marabet and Alsamara, 2017).

Assuming that the turning point exists, β_1 and β_2 explain the relationship between CO_2 emissions per capita and real GDP per capita in the two terms before and after the turning point respectively, either cross-coupling, relative-decoupling or absolute-decoupling with each other. If $\beta_1>1$ *or* $\beta_2>1$, then the two variables are considered to be cross-coupling in the given term. Whereas if $0<\beta_1<1$ or $0<\beta_2<1$, which reflects that the growth of real GDP per capita is greater than that of CO_2 emissions per capita in the given period, two variables are considered to be relative-decoupling. While if $\beta_1<0$ or $\beta_2<0$, which indicates that the CO_2 emissions per capita decreases with GDP growth per capita in the given term, then the two variables are considered to be absolute-decoupling (Wang, 2013).

This study will test the presence of cointegration between the variables to explore the long-run relationship between the variables of the study. To this end, various cointegration approaches can test this relationship. Engle and Granger, Johansen and Juselius and Phillips and Hansen require that all the series should be integrated in a unique order of integration (Shahbaz et al., 2013). Also, Ordinary Least Square (OLS) is only suitable if all variables are stationary at level (Wooldridge, 2009). Whereas the Autoregressive Distributed Lag (ARDL) bounds cointegration approach by Pesaran et al. (2001) has distinguishing features in comparison with other traditional cointegration approaches. First, this test of cointegration can be used regardless of the stationarity level of the underlying variables, either I(0), I(1) or a combination of both. Second, the ARDL test captures the data generating process by taking a sufficient number of lags. Third, short-run adjustments can be integrated with the long-run equilibrium in the ARDL by deriving an Error Correction Model (ECM) via a simple linear transformation without losing long-run information. Fourth, the ARDL approach is valid for a small and finite data size. Fifth, ARDL is free from residual correlation so, there is no endogeneity problem due to the selection of appropriate lag selection. Endogeneity broadly refers to situations in which an explanatory variable is correlated with the error term (Wooldridge, 2009). Sixth, dependent and independent variables can be distinguished by the ARDL approach. However, the ARDL cannot be applied for the order of integration 2, i.e. I(2) variables (Nkoro and Uko, 2016).

In case the data series are not centered about zero, the Model will typically require a constant term; whereas the Model in which the series exhibit a trend, will generally have better fit when a trend term is incorporated. The results on coefficients and their probabilities of constant and trend will appropriately determine the need of their inclusion in the Model.

The study will conduct unit root tests to check the order of integration. If no variable surpasses the order of integration I(1), then applying ARDL is appropriate rather than standard cointegration approaches. In the sense that many time-series variables are stationary only after differencing, using differenced variables for regressions implies a loss of relevant long-run properties or information of the equilibrium relationship between the variables under consideration. Cointegration by the ARDL makes it possible to retrieve the relevant long-run information of the relationship between the considered variables that had been lost on differencing. It integrates short-run dynamics with long-run equilibrium (Nkoro and Uko, 2016). The existence of unit roots will be tested for the variables of CO_2 emissions per capita, real GDP per capita, real GDP per capita square and energy use per capita.

The study will select the optimum lag length by estimation of Vector Autoregressions (VAR). Here, the lag length is how many terms back down to be tested. VAR Lag Order Selection Criteria will determine the best criterion to select the model with the best fit, either Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), Hannan-Quinn information criterion (HQ) or any other criterion. The model with the lowest value is preferred. However, Romero (2007) affirms that the SIC deals with the problem of inconsistency noticed in the AIC. Also, Akaike (1977) shows that the SIC can be more successful in estimating the order of an autoregressive model. Nevertheless, in annual data, which is the case of this study, small lags should be enough and the smallest value of different information criteria derived from VAR will confirm the appropriate lag length technique.

In unit root tests, both the trend and intercept will be included initially, if the results show that the coefficient of trend is not significant, then only the intercept will be included. In this case, to ensure the tests run properly, the coefficient of the intercept should be significant, otherwise, both the trend and intercept will be excluded. In case of non-stationary at level, unit root tests at first difference are performed and also checking the coefficients of the trend and intercept again for their possible inclusion. Accordingly, the ARDL Model will be:

$$\Delta\, lnCO_{2t} = \beta_0 + \beta_1\, lnCO_{2t-1} + \beta_2\, lnGDP_{t-1} + \beta_3\, (lnGDP_{t-1})^2 + \beta_4\, lnEU_{t-1} + \sum_{i=1}^{p} \beta_5\, \Delta\, lnCO_{2t-i} + \sum_{i=0}^{q} \beta_6\, \Delta\, lnGDP_{t-i} + \sum_{i=0}^{r} \beta_7\, \Delta\, (lnGDP_{t-i})^2 + \sum_{i=0}^{s} \beta_8\, \Delta\, lnEU_{t-i} + \varepsilon_t \qquad (4)$$

In case where the intercept and trend will be included, the Model will be:

$$\Delta\, lnCO_{2t} = \beta_0 + \alpha_{0t} + \beta_1\, lnCO_{2t-1} + \beta_2\, lnGDP_{t-1} + \beta_3\, (lnGDP_{t-1})^2 + \beta_4\, lnEU_{t-1} + \sum_{i=1}^{p} \beta_5\, \Delta\, lnCO_{2t-i} + \sum_{i=0}^{q} \beta_6\, \Delta\, lnGDP_{t-i} + \sum_{i=0}^{r} \beta_7\, \Delta\, (lnGDP_{t-i})^2 + \sum_{i=0}^{s} \beta_8\, \Delta\, lnEU_{t-i} + \varepsilon_t \qquad (5)$$

β_0 is the coefficient of intercept, α_0 is the coefficient of trend, β_1, β_2, β_3, β_4 are coefficients that give information on the long-run information for CO_2 emissions per capita, real GDP per capita, real GDP per capita square, and energy use per capita respectively. Whereas, β_5, β_6, β_7, β_8 are coefficients that give information on the short run for the same variables respectively. Also, *p*, *q*, *r* and *s* are lag length for CO_2 emissions per capita, real GDP per capita, real GDP per capita square, and energy use per capita respectively.

The procedures begin with estimating the ARDL to enable a F-Bounds Test to determine the joint significance of the coefficients of the lagged variables. The essence of this procedure is to examine the likelihood of any possible long-run relationship among the respective variables. Critical values for this F-statistics are given by Pesaran et al. (2001). They introduce two types of bounds. One is lower bound that consider all variables as I(0) and other is upper bound that considers all variables as I(1). If calculated F-Statistics is higher than the upper bound, it means the null hypothesis of no cointegration is rejected concluding the existence of cointegration. If F-statistics is below the lower bound, it means that there is no long-run relationship among the variables. If F-statistics is between lower and upper bound, then results are inconclusive (Pesaran et al., 2001). In this situation, the negative and significant error correction term ECT, which will be explained below, will confirm the long-run relationship among variables (Begum et al., 2015).

When this procedure is completed, the next step is the estimation of the long-run coefficients of the ARDL model. In order to estimate long-run coefficients for constant, trend, real GDP per capita, real GDP per capita square and energy use per capita, β_0, α_0, β_2, β_3, and β_4 will be divided by a coefficient of $lnCO_{2t-1}$ respectively, which is the negative error correction term (β_1). That is, the long-run coefficients for constant is $-\beta 0/\beta 1$, the long-run coefficients for trend is $-\alpha 0/\beta 1$, the long-run coefficients for real GDP per capita is $-\beta 2/\beta 1$, the long-run coefficients for real GDP per capita square is $-\beta 3/\beta 1$, and the long-run coefficients for energy use per capita is $-\beta 4/\beta 1$.

This study also estimates the ECM to investigate the short-run dynamics of the respective variables along with the short-run adjustment rate towards the long-run rate. That is, the ECT as the speed of adjustment parameter shows how much of the disequilibrium is being corrected; that is, the extent to which any disequilibrium in the previous period is being adjusted. A positive coefficient indicates a divergence, while a negative coefficient indicates convergence. ECT = 0 shows that there is no adjustment, and to claim that there is a long-run relationship does not make sense (Nkoro and Uko, 2016). In addition, the probability of the ECT should be significant.

The ARDL cointegration approach confirms the existence or absence of a long-term relationship between the variables included in the model, the existence of cointegration does not indicate the direction of causality. Hence, the Granger causality test is exercised to test the causal relationship among the variables for both the short run and long run. The long-run relationship between variables implies that there must be a causal relationship between the variables, either bidirectional or at least unidirectional (Granger, 1969).[49] Leamer (1985) argues that there is deficiency in the words ‘Granger causality’, whereas the word ‘precedence’ is more accurate to reflect the right meaning of the test as one variable precedes another. Causality is closely related to the idea of cause-and-effect, but Granger causality does not test this relationship, it tests whether a particular variable comes before another in the time-series. Therefore, precedence would give more accurate meaning. However, I will utilise ‘Granger causality’ in this thesis to be understood by econometricians, although the meaning is precedence.

Residual diagnostic tests including serial correlation, non-normality of disturbances and heteroscedasticity tests will be conducted to check the goodness of fit of the Model. Serial correlation means that the error term contains autocorrelation, i.e. residuals in one period are correlated with residuals in previous periods (Pickup, 2015). Serial correlation causes the estimated variances of the regression coefficients to be biased, leading to unreliable hypothesis testing. In this case, the t-statistics will actually appear to be more significant than they really are (Salvatore and Reagle, 2011). Regarding normality, it is important to investigate the extent to which regression errors exhibit departures from normality, i.e. whether the errors of the Model are normally distributed or not. Normality is

[49] Causality is closely related to the idea of cause-and-effect, although it is not exactly the same. A variable X is causal to variable Y if X is the cause of Y or Y is the cause of X. However, Granger causality is not testing a true cause-and-effect relationship; What we want to know is if a particular variable comes before another in the time-series. In other words, if we find Granger causality in the data there is not a causal link in the true sense of the word. When econometricians say “cause,” what they mean is “Granger-cause,” although a more appropriate word might be “precedence” (Leamer, 1985).

required for the validity of the test (Mamingi, 2005). The Jarque-Bera's test is used to test departures from normality. It is a test for the normality of residuals based on skewness and kurtosis (Pesaran, 2015).[50] The null hypothesis is a normal distribution, a small probability value leads to the rejection of the null hypothesis of a normal distribution. Whereas heteroscedasticity means the variance of the error term is not constant for the observations. This leads to inefficient estimates of the coefficients, as well as biased estimates of the standard errors (Salvatore and Reagle, 2011). To address the serial correlation, a standard approach may be to increase the number of lags for both the dependent variable and the regressors. To address the presence of heteroscedasticity, a heteroscedasticity and autocorrelation consistent (HAC) covariance matrix adjustment is used (Zeileis, 2004).

This study will also examine the stability tests of the coefficients by employing the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ), according to the method by Pesaran et al. (2001). The CUSUM test is based on a plot of the sum of the recursive residuals. If this sum goes outside a critical bound, it is concluded that there is a structural break at the point at which the sum begins its movement towards the bound. CUSUMSQ is similar to the CUSUM test, but plots the cumulative sum of squared recursive residuals, expressed as a fraction of these squared residuals summed over all observation (Kennedy, 2008). It is argued that if the CUSUM and CUSUMSQ statistics are within the critical bound of the 5% level of significance then the null hypothesis is rejected suggesting that the regression will be considered as stable.

Finally, the study will evaluate the robustness of the long-run coefficients obtained from the ARDL estimator by applying the dynamic OLS (DOLS) procedure. The prime benefit of the DOLS approach is that it considers the presence of a mixed order of integration of the respective variables in the cointegrated framework. The estimation of DOLS involves regressing one of the I(1) variables against other variables, some of which are I(1) with leads (p) and lags (-p) of the first difference, and others are I(0) variables that include a constant term. Thus, this estimator solves two important limitations: a possible endogeneity problem and small sample bias (Begum et al., 2015). Fully Modified Ordinary Least Squares (FMOLS) will be also estimated. FMOLS regression is designed to provide optimal estimates of cointegrating regressions. The method modifies least squares to account for

[50] Skewness is a measure of asymmetry of the distribution of the series around its mean. The skewness of a symmetric distribution, such as the normal distribution, is zero. Positive skewness means that the distribution has a long right tail and negative skewness implies that the distribution has a long left tail.
Kurtosis measures the peakedness or flatness of the distribution of the series. The kurtosis of the normal distribution is 3. If the kurtosis exceeds 3, the distribution is peaked (leptokurtic) relative to the normal; if the kurtosis is less than 3, the distribution is flat (platykurtic) relative to the normal (E-views, 2020).

serial correlation effects and for endogeneity in the regressors that results from the existence of a cointegrating relationship (Phillips, 1995). So both the DOLS and FMOLS are free from serial correlation, small sample bias, and the endogeneity issue (Ahmad et al., 2017).

4.4. Empirical results

Using the methodology mentioned above, the tests that will be applied on Morocco's data are the unit root to check stationarity and the order of integration of the variables. In that case that all variables are stationary either at level I(0) or at first difference I(1), then the ARDL will be run to determine the joint significance of the coefficient of the lagged variables through examining F-Bound tests. Once the cointegration relationship exists, long-run coefficients of the ARDL will be tested to obtain the long-run coefficients, and the ECM will be estimated to investigate the speed of adjustment. Then the Granger causality test will be applied to check the direction of relationships (precedence) among variables. Residual diagnostic tests will be used including serial correlation, non-normality of disturbances and heteroscedasticity, to check the goodness of fit of the model. Two stability tests will be also used: CUSUM and CUSUMSQ. Dynamic OLS and FMOLS will be also performed to check the robustness of the long-run coefficients. All these tests will be conducted using EViews 10 which is a statistical software package, used mainly for time-series oriented econometric analysis. The summary of the results are shown below, and Appendix C includes all tables and figures generated by EViews 10. Table 5 presents the descriptive statistics of variables.

Table 5: Descriptive statistics of the variables

	Ln CO_2 emissions per capita	Ln GDP per capita	Ln GDP per capita square	Ln Energy use per capita
Mean	0.025196	7.485417	56.12986	5.822093
Median	0.044286	7.460074	55.65273	5.808551
Maximum	0.635051	8.047215	64.75767	6.330568
Minimum	-0.729667	6.960018	48.44185	5.196845
Std. Dev.	0.368576	0.317302	4.764921	0.315567
Skewness	-0.114065	0.136726	0.199163	0.054265
Kurtosis	2.116465	2.017086	2.030245	2.066246
Observations	44	44	44	44

Source: Author's calculations.

The table above shows that the number of observations is 44. This is sufficient to perform the Model.

VAR tests considering 6 maximum lags show that the lag length for CO_2 emissions per capita and energy use per capita is 1, whereas the lag length for real GDP per capita and real GDP per capita square is 2. In addition, VAR tests confirm that SIC is the best technique to determine lag lengths as it has the lowest value among other criteria. Table 6 illustrates these results of the VAR tests.

Table 6: VAR Lag Order Selection Criteria

Lag	LR	FPE	AIC	SIC	HQ
Ln CO_2 emissions per capita					
0	NA	0.093798	0.471254	0.514349	0.486587
1	137.1997*	0.002187*	-3.287217*	-3.201028*	-3.256552*
Ln Real GDP per capita					
0	NA	0.077539	0.280892	0.323986	0.296224
1	143.2622	0.001528	-3.645983	-3.559794	-3.615318
2	14.69775	0.001059	-4.013287	-3.884004*	-3.967289
3	0.049177	0.001115	-3.962102	-3.789724	-3.900771
4	3.711765	0.001051	-4.021948	-3.806476	-3.945285
5	0.723524	0.001084	-3.991927	-3.733360	-3.899931
6	6.663913*	0.000923*	-4.154260*	-3.852599	-4.046931*
Ln Real GDP per capita square					
0	NA	17.89029	5.722123	5.765217	5.737455
1	144.5394	0.340272	1.759771	1.845959	1.790436
2	14.95258	0.234017	1.385186	1.514469*	1.431184
3	0.039533	0.246489	1.436654	1.609032	1.497985
4	3.901795	0.231010	1.371050	1.586522	1.447713
5	0.681892	0.238630	1.402372	1.660938	1.494368
6	6.258177*	0.205873*	1.253127*	1.554788	1.360456*
Ln Energy use per capita					
0	NA	0.072453	0.213053	0.256147	0.228385
1	149.3979*	0.001204*	-3.884256*	-3.798067*	-3.853591*

** indicates lag order selected by the criterion*

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SIC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Source: Author's calculations.

The unit root tests via an Augmented Dickey-Fuller test show that the order of integration of variables are I(0) for CO_2 emissions per capita and I(1) for other variables. Trend and intercept are included in unit root tests in the case of CO_2 emissions per capita; whereas only intercept is included in the tests for the other variables following the results of the tests as shown in Table 7. The mix results of level of integration along with no variable is greater than I(1) justify using the ARDL cointegration approach.

Table 7: Augmented Dickey-Fuller Unit Root Tests

		Probability of	Ln CO_2 emissions per capita	Ln GDP per capita	Ln GDP per capita square	Ln Energy use per capita
Model with a trend and a constant	At level	Variable	0.0053	0.6444	0.8124	0.1882
		Constant	0.0007*	0.0627	0.1226	0.0060
		Trend	0.0002*	0.0674	0.1299	0.0109
	At first difference	Variable	-	0.0013	0.0012	0.0000
		Constant	-	0.0094	0.0129	0.0115
		Trend	-	0.9009	0.6583	0.4235
Model with a constant	At level	Variable	-	0.9424	0.9721	0.6554
		Constant	-	0.7090	0.7552	0.1532
	At first difference	Variable	-	0.0002*	0.0002*	0.0000*
		Constant	-	0.0002*	0.0002*	0.0008*

** indicates that the coefficient is significant at level 1%.*

Source: Author's calculations.

Considering 4 maximum automatic selection lags and following the SIC selection method, the ARDL test shows that the ideal model is ARDL (1, 0, 0, 0). This means that the model will use 1 lag for CO_2 emissions per capita and 0 lag for other variables. The trend is not included in the model, justified by the fact that its coefficient probability is not significant. White’s robust standard errors and t-statistic is used to address the heteroscedasticity of the residuals as shown in Table 13.

The ARDL Long-Run Form and Bounds Test shows that the null hypothesis of a no level relationship is rejected as the F-statistic value is higher than the upper bound of 5% significance and also of 1% significance, concluding the existence of cointegration. The t-statistic also confirms this result as illustrated in Table 9. The results of the ARDL Long-Run Form show that the real GDP per capita has a positive coefficient and it is statistically significant. While the real GDP per capita square coefficient is negative and statistically significant. These results are presented in Table 8. Therefore, the data available for Morocco supports the theory of EKC, i.e. an inverted U-shaped relationship between CO_2 emissions and economic growth.

The results suggest that, in Morocco, initially economic growth increased CO_2 emissions but, after a sustained period of growth, this relation has reversed, i.e. further increases in economic growth reduce CO_2 emissions. Also the results show that an increase of 1% in real GDP per capita from 2014 levels will be associated with a long-run decrease of 0.22% in CO_2 emissions per capita. The coefficient of energy use per capita is positive and significant concluding the positive relationship between energy use per capita and CO_2 emissions per capita as shown in Table 8. An increase of 1% in the energy use per capita from 2014 levels will be associated with a long-run increase of 1.17% in CO_2 emissions per capita. The long-run equation can be estimated and presented as following:

CO_2 = - 18.9061 + 3.2428*GDP - 0.2164*GDPS + 1.1696*EU

Table 8: ARDL Long-Run Form and Bounds Test

Variable	Coefficient	t-Statistic	Probability
Ln GDP per capita	3.242837	2.729145	0.0096*
Ln GDP per capita square	-0.216365	-2.726344	0.0096*
Ln Energy use per capita	1.169617	9.566644	0.0000*

** indicates that the coefficient is significant at level 1%.*

Source: Author's calculations.

As explained in the methodology section, assuming that energy consumption is constant, the turning point will be log real GDP per capita which is 7.5. As this value is in logarithmic form the monetary value representing the peak is calculated through exp(log real GDP per capita) which is $1794.72. Real GDP per capita in Morocco reached this value several times between 1990 and 1996 as shown in Figure 15. This result could be further explained by the fact that GDP per capita has started to grow faster than growth in CO_2 emissions per capita since 1992 as presented in Figure 18. Thus, the turning point appears to be when real GDP per capita reached $1794.72 in 1992. In other words, economic growth has become greener since 1992 when Morocco began to separate its economic growth from carbon emissions.

Morocco’s decoupling at $1794.72 is comparatively low according to the estimation of Grossman and Kruger ($8,000). Morocco’s result is relatively similar to Tunisia’s result, a lower-middle income country in the MENA region, at $1,200 as estimated by Fodha and Zaghdoud (2010). Other studies on MENA region on Tunisia (Farhani et al., 2014, Shahbaz et al. 2014) and Saudi Arabia (Alkhathlan and Javid, 2013) did not calculate the turning point.

Since the coefficient of real GDP per capita is greater than 1, then the growth of CO_2 emissions per capita is greater than that of real GDP per capita before the turning point. This indicates that the two variables are cross-coupling in the first term between 1971 and 1992. Also, given that the coefficient of real GDP per capita square is negative, then CO_2 emissions per capita and real GDP per capita are absolute-decoupling in the second period after the turning point in 1992.

This result can be explained by the fact that the Moroccan economy has become more service-oriented since 1992, as shown in Chapter Three. The services sector was much less energy intensive, and therefore generating less emissions than the agriculture and industry sectors in Morocco. According to the World Bank’s World Development Indicators (2020), between 1992 and 2014, the services sector added $32 billion to the economy, whereas the agriculture and industry sectors together added $22 billion in the same period as presented in Figure 3 in Section 3.3 in Chapter Three.

Table 9: F-Bounds Test and t-Bounds Test for the ARDL Model

		10%		5%		1%	
	Value	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F-statistic	18.20197	2.72	3.77	3.23	4.35	4.29	5.61
t-statistic	-7.936875	-2.57	-3.46	-2.86	-3.78	-3.43	-4.37

Null Hypothesis: No levels relationship

Source: Author's calculations.

The ARDL Error Correction Regression shows that the speed of adjustment (ECT) has a negative sign and it is highly significant, as illustrated in Table 10. The ECT coefficient (-0.76) confirms that if there is disturbance in the short-run equilibrium the Model will converge to a long-run equilibrium path with a 76% adjustment speed on yearly basis, i.e. in almost 9 months.

Table 10: ARDL Error Correction Regression

Variable	Coefficient	t-Statistic	Probability
CointEq(-1)	-0.761706	-8.863175	0.0000*

** indicates that the coefficient is significant at level 1%.*

Source: Author's calculations.

Although Morocco has achieved absolute-decoupling of its economic growth from carbon emissions, its carbon emissions have been rising. It appears that the decoupling rate has been insufficient to reduce the emissions in Morocco. As discussed in Section 2.2.1 in Chapter Two, Lenaerts et al. (2021) stress that decoupling rate needs to be significant to achieve net zero by 2050.

The results of the Granger causality test are shown in Table 11 and Figure 19. In the long run, a unidirectional Granger causality is running from real GDP per capita towards energy use per capita at a 5% significant level, from energy use per capita to CO_2 emissions per capita at a 1% significant level, and from real GDP per capita towards CO_2 emissions per capita at a 1% significant level. Based on these strong Granger causality results, the evidence shows that economic growth precedes energy usage and emissions in the long run. Also, energy consumption precedes carbon emissions. Accordingly, two avenues could be explored to further accelerate the decoupling rate to help Morocco reduce its emissions: reduce CO_2 emissions per unit of energy through renewable energy and/or reduce energy intensity per GDP by improving energy efficiency. This quantitively suggests that economic growth in Morocco could be delivered by more environmentally friendly and energy efficient means. In short, the economic growth in Morocco could be even greener.

Table 11: Pairwise Granger Causality Tests

Null Hypothesis	F-Statistic	Probability
Ln GDP per capita does not Granger Cause Ln CO_2 emissions per capita	7.33195	0.0099*
Ln CO_2 emissions per capita does not Granger Cause Ln GDP per capita	2.99901	0.0910
Ln Energy use per capita does not Granger Cause Ln CO_2 emissions per capita	13.3454	0.0007*
Ln CO_2 emissions per capita does not Granger Cause Ln Energy use per capita	0.78883	0.3798
Ln Energy use per capita does not Granger Cause Ln GDP per capita	2.59058	0.1154
Ln GDP per capita does not Granger Cause Ln Energy use per capita	5.92165	0.0195**

** indicates that the coefficient is significant at level 1%.*

*** indicates that the coefficient is significant at level 5%.*

Source: Author's calculations.

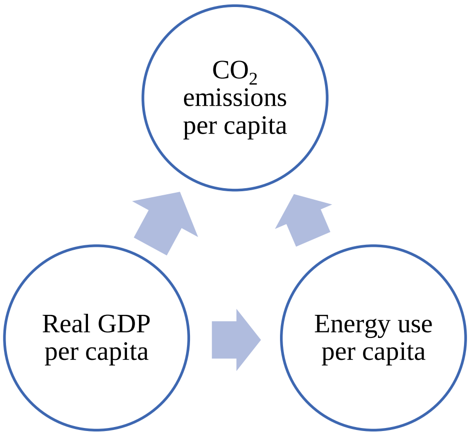

Figure 19: Pairwise Granger Causality Tests

Source: Author's calculations.

The results from the residual diagnostic tests presented in Table 12, reveal that no first-order serial correlation is present and the null hypothesis is not rejected, i.e. there is no serial correlation among the variables of the study. Regarding the normality test, the null hypothesis of a normal distribution is not rejected as shown in Figure 20. This means that the model passes the Jarque-Bera’s normality test, suggesting that the errors are normally distributed. The heteroskedasticity test (ARCH test) shows that there is no autocorrelation of error terms as illustrated in Table 13.

Table 12: Breusch-Godfrey Serial Correlation LM Test

Null Hypothesis	Probability
No serial correlation at up to 2 lags	0.7205

Source: Author's calculations.

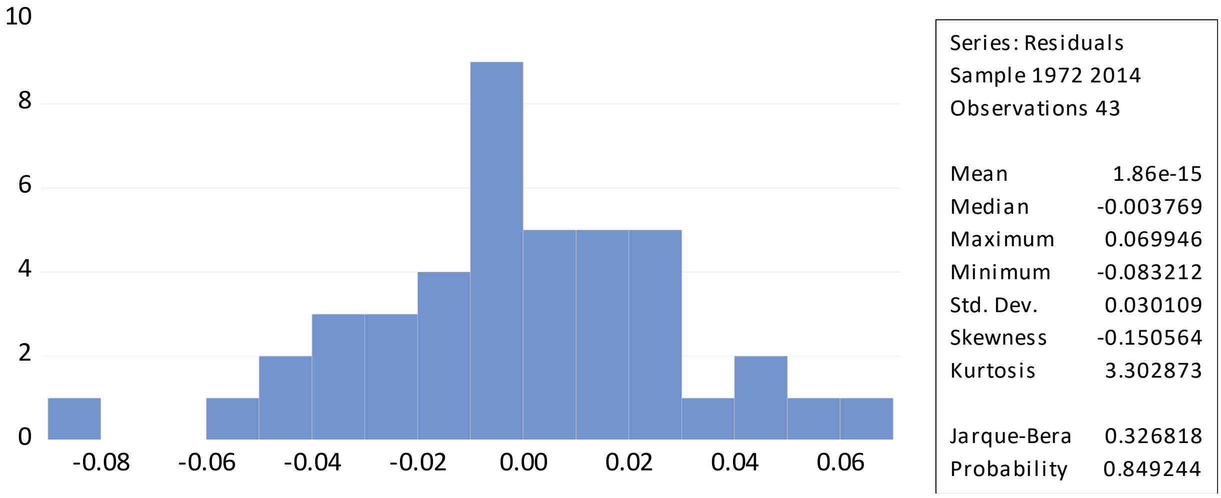

Figure 20: Normality test

Source: Author's calculations.

Table 13: Heteroskedasticity Test: ARCH

F-statistic	Probability
1.845138	0.1719

Source: Author's calculations.

Regarding stability tests, the CUSUM and CUSUM square tests presented in Figures 21 and 22 show that the variables in the model are stable over a long period of time as their statistics are within the critical bound of the 5% level of significance. These two tests also confirm that there is no structural break during the studied period. Thus, the overall Model is reliable for policy purposes.

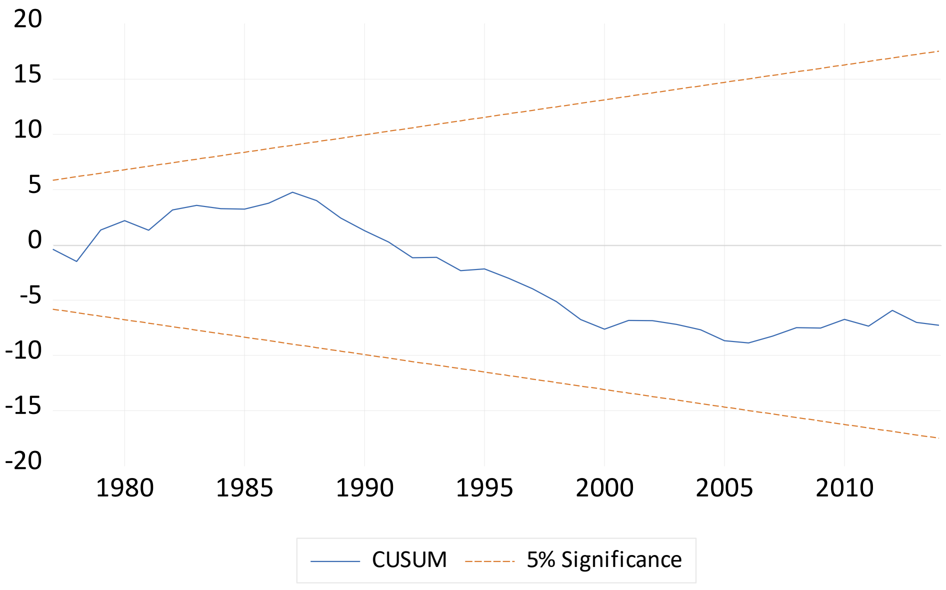

Figure 21: CUSUM test

Source: Author's calculations.

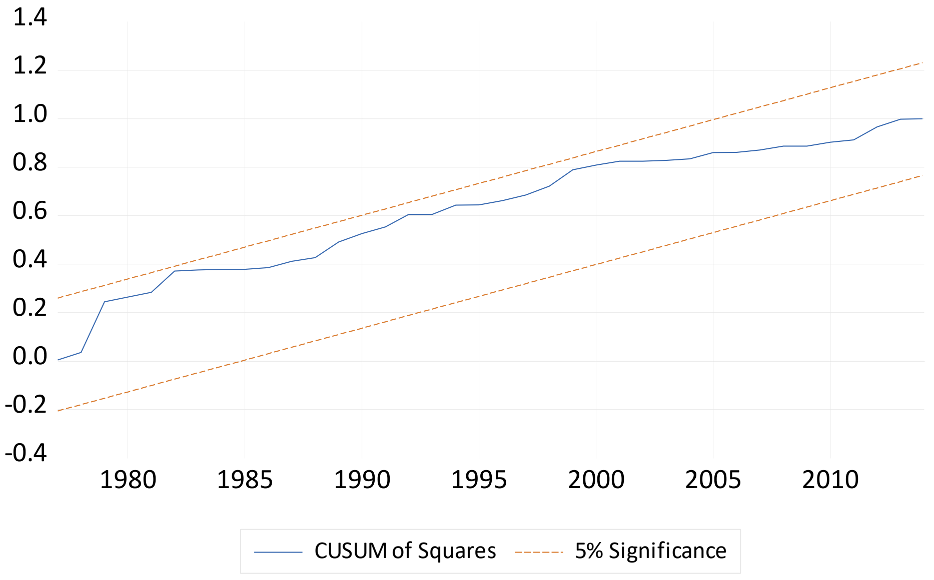

Figure 22: CUSUM of Squares test

Source: Author's calculations.

Finally, with regard to robustness tests, the result from the DOLS is consistent with the ARDL according to the sign and significance of the coefficients as illustrated in Table 14. The FMOLS is also consistent with the ARDL in the long run and confirms the validity of EKC as shown in Table 15. Hence the results are robust.

Table 14: Dynamic Least Squares (DOLS) test

Variable	Coefficient	t-Statistic	Probability
Ln CO_2 emissions per capita (-1)	0.238294	2.427728	0.0200**
Ln GDP per capita	2.470089	2.734078	0.0094*
Ln GDP per capita square	-0.164807	-2.722482	0.0097*
Ln Energy use per capita	0.890905	5.948369	0.0000*
Constant	-14.40088	-3.987818	0.0003*

** indicates that the coefficient is significant at level 1%.*

*** indicates that the coefficient is significant at level 5%.*

Source: Author's calculations.

Table 15: Fully Modified Least Squares (FMOLS) test

Variable	Coefficient	t-Statistic	Probability
Ln CO_2 emissions per capita (-1)	0.261012	2.765436	0.0088*
Ln GDP per capita	2.189482	2.431441	0.0200**
Ln GDP per capita square	-0.138835	-2.357082	0.0238**
Ln Energy use per capita	0.744305	5.637463	0.0000*
Constant	-12.90240	-3.519890	0.0012*

** indicates that the coefficient is significant at level 1%.*

*** indicates that the coefficient is significant at level 5%.*

Source: Author's calculations.

4.5. Conclusion

This chapter has offered an empirical analysis of the relationship between economic growth, energy consumption and environment in Morocco during the period from 1971 to 2014. It is important to understand this relationship to assess the progress Morocco has made on its green economy in terms of its absolute-decoupling of economic growth from environmental impacts which *is* essential but *not* sufficient to tackle climate change if not coupled with reducing emissions. The analysis of this chapter has built an econometric model following EKC theory which is used to test the relationship between economic growth and carbon emissions.

This chapter has revealed important findings. First, there is a long-run cointegrating relationship between CO_2 emissions, GDP growth, and energy consumption in Morocco.

Second, Morocco's available data validates the EKC theory, i.e. an inverted U-shaped relationship between CO_2 emissions and economic growth. The results suggest that, in Morocco, initially economic growth increased CO_2 emissions but, after a sustained period of growth, this relation has reversed, i.e. further increases in economic growth reduce CO_2 emissions. The turning point appears to be when real GDP per capita reached $1794.72 in 1992. In other words, economic growth has become greener since 1992 when Morocco began to separate its economic growth from emissions.

Before 1992, Morocco cross-coupled economic growth to CO_2 emissions. Whereas after 1992, the country achieved absolute-decoupling between the two variables. This result can be explained by the fact that the Moroccan economy has become more service-oriented since 1992 which is more energy efficient and generates emissions less than the agriculture and industry sectors as shown in Section 4.3.

Based on Granger causality results in the long run, evidence shows that economic growth precedes energy usage and emissions. Also, energy consumption precedes carbon emission. This quantitively suggests that economic growth in Morocco could be delivered by more environmentally friendly and energy efficient means. This means that the numbers support the claim that the economic growth in Morocco could be even greener, apparently if the model is designed to rely on renewable and cleaner energy sources.

Diagnostic results confirm that there is no serial correlation, the Model is correctly specified, the errors are normally distributed, and there is no autocorrelation of error terms. In addition, the stability tests show that the overall model is stable over a long period of time and confirm the validity of EKC. These tests suggest that the results are robust and reliable for policy purposes.

Accordingly, Morocco has achieved absolute-decoupling of its economic growth from carbon emissions. This conclusion is consistent with the results of other studies on MENA countries such as Tunisia (Fodha and Zaghdoud, 2010; Farhani et al., 2014; Shahbaz et al., 2014) and Saudi Arabia (Alkhathlan and Javid, 2013). However Morocco's carbon emissions have been rising. This does not align with its NDC targets and is insufficient to tackle the causes of climate change in the country, in terms of reducing emissions as stressed in its National Plan Against Global Warming. Therefore, the existence of EKC in Morocco does not mean the country has been able to reduce its carbon emissions, but only slowed the growth of its emissions and delinked them from its economic growth. It appears that the rate of decoupling has been insufficient to reduce the emissions. Thus, two avenues could be explored to further accelerate decoupling rate to help Morocco meet its targets: reduce CO_2

emissions per unit of energy through renewable energy and/or reduce energy intensity per GDP by improving energy efficiency. This indicates that the Moroccan government should make further progress to decarbonize its economy in order to meet its commitments. This result supports the claim of Hickel and Kallis (2020) and Lenaerts et al. (2021) in terms of that absolute-decoupling of economic growth from the carbon emissions needs to be sufficient to reduce emissions.

This chapter answers the research question empirically on the extent to which Morocco has been able to achieve its green growth. The results provide a primary motivation to further evaluate its green economy model in Chapter Five, in terms of Morocco's ability to reduce its emissions and meet its commitments.

Chapter Five

Morocco's green economy model on energy transition: evolution, opportunities, challenges, and policy gap

5.1. Introduction

Chapter Three concluded that Morocco has built its green economy model on energy transition in order to help the country overcome its development challenges and to meet its global commitments. Challenges which are linked to the consequences of climate change and energy sector. In particular, this model was planned to help Morocco meet growing energy demands while limiting carbon emissions which are thought to be the causes of climate change in the country. Additionally, the Kingdom has made firm global commitments according to the Paris Agreement which suggests absolute separation of economic growth from carbon emissions and also encourages the country to be carbon neutral by 2050. Accordingly, Morocco has developed its NDC with bold targets to significantly reduce its emissions by 2030. The country aims to realize its ambitions by the delivery of its 2009 Energy Strategy which principally focuses on renewable energy and energy efficiency. The Minister of Energy, Mines and Environment (MEME) claims that delivery of this strategy could provide more than a 90% reduction of energy-related CO_2 emissions by 2030. Energy efficiency measures are expected to contribute to 7% of the total reduction of CO_2 emissions. Whereas the majority of energy-related reduction will be achieved through renewable energy as mentioned in Section 3.5 in Chapter Three. The Energy Strategy is considered critical to Morocco. It is one of Morocco's most important developmental milestones, and the backbone of its sustainable development. However, the appropriateness of this Energy Strategy to achieve Morocco's targets is questionable.

It is worth mentioning that the remaining carbon reductions could be achieved through Nature-Based Solutions (NBS).[51] These solutions generally fall into four categories: forestry, wetland-related, restorative agriculture, and ocean-based practices (American University, 2020). Although these are important practices, they contribute towards Morocco's emission reduction targets by only a smaller share than that of energy transition. That is why the latter is given particular attention by the country, as commented on by one of my interviewees who added that NBS could contribute towards only 10% of carbon emission reductions in the country (Interview 7, Senior Researcher at IRESEN).

In the same vein, the latest discussion on green economy focuses predominantly on energy transition's role in the decarbonization of the global economy. This is inspired by the

[51] The European Commission defines NBS as 'Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.' (European Commission, 2021). The International Union for Conservation of Nature (IUCN) reports that NBS could contribute to meeting Paris climate goals by 37%. However, the share of contribution varies across countries (IUCN, 2021).

technological advances of the renewable energy sector. Therefore, as shown in Chapter Two, the recent debate on green economy focuses on the green economy's possibility in terms of reaching net-zero emission targets, the level of economic transformation this transition requires, and its potential benefits to the economy. Hence, examining Morocco's energy transition in this chapter could add to the aforementioned literature. Thus, this chapter attempts to answer the main research question of this thesis, which concerns the ability of Morocco to deliver its green agenda in terms of limiting its emissions by adopting its own green economy approach to energy transition.

Chapter Four empirically demonstrated that Morocco appears to have been able to absolutely-decouple its economic growth from carbon emissions. However, its carbon emissions have been rising. Therefore, its efforts are insufficient to deliver its green ambitions to tackle the causes of climate change. This chapter further assesses the green economy model of Morocco and identifies the policy gaps in its green transition. Thus, this chapter tries to answer the central research question concerning whether the green economy model of Morocco is sufficient to realize its green ambitions and support its green economy transition. In particular, this chapter critically assesses the appropriateness of Morocco's green economy model, the level of transformation of economy this transition requires, and the potential benefits of its green model. To do so, this thesis relies on secondary sources which include Morocco's national and international data and studies in relation to energy sector as well as qualitative analysis of nine interviews with key informants in energy sector. As renewable energy is planned to deliver more significant emission cuts than energy efficiency, it will be given particular attention in this chapter.

This chapter is not meant to examine any delay in delivering Energy Strategy projects in Morocco, but to examine the overall approach of its energy transition in decarbonizing its energy intensive sectors. Also identifying the appropriate technical and financial resources and the technological mix needed to transition towards a green economy requires developing economic modelling. This, however, is not the purpose of this study. Also, this thesis will not draw a policy or roadmap for the green economy of Morocco. Rather it will identify the policy gap in the country's energy transition in line with recent global practices and the context of the green economy agenda. This needs to be addressed to advise the country how best to transition into a green economy and realize its benefits.

This chapter begins by reviewing the evolution of the Energy Strategy since Morocco's participation in the global discussion on climate change in 1992. This provides deep understanding of the development of its green agenda, and related reforms and milestones.

Second, it explores the intended benefits of its energy transition which is aimed at dealing with the country's development concerns. After that, the chapter presents a number of important challenges related to the delivery of its Energy Strategy. Lastly, it examines the energy policy gap of its green economy model in comparison with recent global practices. Addressing this gap is essential to advise the country how to realize its green ambitions.

5.2. Evolution of renewable energy

Various studies have shown that Morocco has a huge potential and favourable conditions for renewable energy, particularly for solar and wind energy. Due to its long coastline with considerable wind speeds, the total onshore wind power potential is estimated to be about 7,936 TWh/year (Schinke et al., 2016). The country's offshore wind potential is estimated to be ten times its onshore potential (El Hafidi, 2017). In addition, its annual sunshine duration varies between 2,700 hours in the north and up to 3,500 hours in the south with intensive average solar radiation of more than 5 kWh/m^2 per day. Given these favorable conditions, even with conservative assumptions, the potential of Concentrating Solar Power (CSP) generation alone reaches 20,000 TWh/year. Also, Morocco has hydropower potential which is estimated to be about 5 TWh/year (Schinke et al., 2016).

In 2019, electricity consumption in Morocco was 33 TWh (120,424 TJ), while the TFEC was 195 TWh (703,584 TJ) (IEA, 2021). Whereas its estimated electricity needs are between 80 and 170 TWh/year by 2050 (Schinko et al., 2019). These estimations do not consider increased electrification of the economy, in particular the transport and heating sectors, which currently rely on other forms of energy sources, mainly fossil fuels including oil products and natural gas (Section 5.5).

From the above, it can be seen that the Kingdom has a strong renewable energy potential to meet not only its current needs of electricity, but also to power the whole economy from renewable energy with significant export potential. In particular, the country is well situated for building large-scale solar energy power and wind farms.

The next section reviews the evolution of renewable energy in Morocco. The section chronologically incorporates a review of Morocco's legal and institutional reforms into the energy transition progress to provide a holistic picture about the evolution of renewable energy. This is examined through three distinct phases: a) prior to the introduction of the 2009 Energy Strategy, b) between 2009 and 2015 after launching the Energy Strategy with initial targets, and c) after 2015 when the government set new targets to accelerate renewable energy transition. The consequences of climate change and energy challenges have influenced the development of renewable energy in the country. Table 16 summarises the key events in the development of renewable energy sector and related reforms discussed below.

5.2.1. Phase one (pre-2009): Hydroelectricity domination and limited envisaging of other renewable energy sources

The development of renewable energy in Morocco before 2009 is characterised by the domination of hydropower as the country's main renewable energy source for decades, accompanied with attempts to use solar and wind energy on a limited scale. This is unsurprising, given the fact that hydroelectricity was the main form of renewable energy not only in the Middle East but also globally in developed and developing countries alike. Traditionally, the energy sector in Morocco was monopolised by the national power ONE[52] under supervision of the MEME in generation and transmission. ONE only provided distribution to other municipal entities. Some efforts to reform the energy sector have been made since the 1990s in terms of generation and distribution in order to overcome a number of difficulties. This paved the way to wider liberalization of the energy sector and further development of renewable energy by the end of the 2000s.

From 1990, the energy sector experienced serious power supply shortages due to the country's difficult economic and financial legacy from the 1980s, and its excessive dependency on energy imports (Usman and Amegroud, 2019).[53] Despite strong resistance to the private ownership of strategic sectors, mainly the energy sector, partial liberalization of energy generation through Law 2-94-503 was first introduced in 1994, but only for small projects up to 10 MW (Law 2-94-503, 1994). This law allowed ONE to enter into Power Purchase Agreements (PPAs) with Independent Power Producers (IPPs). This partial liberalization strengthened ONE's financial position in addition to improving the performance of generation facilities and offering electricity to consumers at competitive prices (Usman and Amegroud, 2019). This was followed by the removal of energy subsidies in 1995 to further strengthen ONE's financial status. This allowed it to fund the Rural Electrification Programme launched in the same year. This has significantly increased electricity demand, as shown in Section 3.4 in Chapter Three. It is important to mention that this rural electrification programme was only meant to connect isolated rural areas with

[52] Office National de l'Electricité (English translation: the National Office of Electricity).
[53] By March 1983, the country was bankrupt and could no longer service its debt (Usman and Amegroud, 2019).

electricity, but not to electrify other sectors of the economy powered by other forms of energy. For example, the transport sector powered by oil products.

In December 1996, Morocco participated in the Maghreb-Europe Gas Pipeline for regional integration, which introduced natural gas into the supply mix. Although natural gas energy supply had been limited before 2005, this was important step to help the country meet some energy needs and increase energy security. Then in 1997, Decree 3-127-97 was passed which allowed private electricity distribution utilities to enter the energy market, for the first time, through transferred management. In 2000, energy subsidies were reintroduced as it became politically difficult to keep linking domestic energy prices to growing international prices, as discussed in Section 3.4 in Chapter Three. Law 28-01 was issued in 2002 authorizing ONE's participation in private generation projects to help meet increasing energy demand. Also, Law 54-05 was proposed in 2005 allowing private sector investment in electricity distribution. In 2008, the government introduced Law 16-08 which enabled large power consumers to produce their own electricity from renewable energy, limited to 50 MW. Although this was an important step, it did not provide a major role for renewable energy in the energy mix.

Hydroelectricity generation is considered a traditional component of Morocco's power plants. It began in the 1960s when large dams were launched in order to increase hydropower capacity (RES4MED, 2018a). The electricity generated from hydropower increased from 964 GWh (3,470 TJ) in 1992 to its peak at 3,631 GWh (13,071 TJ) in 2010, accounting for only 2% of Morocco's total primary energy supply (TPES) (IEA, 2021). The installed capacity in 2018 stood at 1,771 MW. Its potential has been well exploited. Therefore, RES4MED (2018a) claims that only the construction of small or micro hydropower plants can be realized in the short-term to add to the existing network. However, hydroelectricity generation was unstable during the 1990s due to the fact that hydropower is very sensitive to climate change (IEA, 2020). Extreme weather in terms of drought events have impacted the reliability and stability of hydropower generation in Morocco. A severe drought reduced the contribution of hydropower to total electricity generation by more than 60% for five consecutive years (Usman and Amegroud, 2019). IEA (2020) reports that Morocco is likely to experience a significant drop in its hydropower capacity factor during the rest of the century. Considering these future climate forecasts, Morocco has decided to increase shares of other renewable sources over hydropower to meet its energy needs (IEA, 2020b).[54] Hence,

[54] Hydropower dams also threaten ecology and biodiversity, release substantial greenhouse gases, displace thousands of people, and affect food security, water quality and agriculture. Starting in the late 1960s, big dams stopped being built in developed nations, because the best sites for dams were already developed, the costs

it can be seen that hydropower is not a sustainable source of energy for Morocco, and, therefore, other renewable energy sources have been attempted in the country.

Solar energy was first introduced in Morocco through the Rural Electrification Programme on a small scale in 1995. This is because it is more economical to bring electricity to some isolated rural areas than connecting them to the national grid. Morocco installed solar kits with a capacity of 70 kW or 200 kW, totalling around 10 MW of photovoltaic (PV) energy over 16 years (Choukri et al., 2017). Whereas the first wind farms were commissioned in the 2000s on behalf of ONEE through PPA with a private developer. The Abdelkhalek Torrés wind farm with 91 wind turbines was launched in 2000 with a total capacity of 54 MW in Tetouan. During the 2000s, various small-scale wind farms were developed (Choukri et al., 2017). By 2010, the total installed capacity of wind power reached 287 MW (RES4MED, 2018b).[55] These small-scale solar and wind energy projects have given Morocco some experience in the renewable energy sector and encouraged the country to develop larger projects to meet its growing electricity needs.

Given the suspension of the indexation of energy prices to international prices in 2000, this has made Morocco vulnerable to increases in international fuel prices. Growing energy demands, especially during the 2000s, increased energy import to $10 billion and energy dependency to 98% in 2008 (MEME, 2015, Interview 3). This has put a heavy fiscal burden on the national budget. Morocco has also realized that its main energy source was unsustainable to meet its energy needs. In addition, its own renewable energy sources were promising but its contribution only accounted for a small portion of its total energy generation. To this end, the National Plan of Priority Actions (PNAP) was launched in April 2008 by King Mohammed VI.[56] This plan was aimed at pursuing low-carbon opportunities to achieve the country’s economic and social objectives. The PNAP focused on four pillars of the energy sector: energy security with a diversification of fuel types and origins, access to energy for all Moroccans at affordable prices, the promotion of renewable energy and energy efficiency, and regional energy integration with the Euro-Mediterranean markets (CTF Trust Fund Committee, 2009). Therefore, the PNAP has sought to increase the energy

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became too high, and most importantly, growing environmental and social concerns made those costs unacceptable. The cost of repairing a small dam can be up to three times the cost of removing it which is an important reason for the growing trend to remove dams (Moran et al., 2018).

[55] Wind energy has been significantly developed in the last few years, and the capacity of wind turbines has tremendously increased especially offshore wind turbines. In Scotland the recent Seagreen Offshore Wind Project is building 114 wind turbines with a total installed capacity of 1,075 MW. Also, the NnG Offshore Wind Farm is constructing 54 wind turbines with a total installed capacity of 448 MW (Invest in Angus, 2021).

[56] PNAP (Plan National d’Actions Prioritaires, English translation: National Plan of Priority Actions). This plan was launched on 15 April 2008, a few months before the global financial crisis was declared in September 2008.

supply from various sources including renewable energy, while lowering carbon emissions. Although, the PNAP did not set strategic targets to increase renewable electricity, it paved the way for the introduction of the 2009 Energy Strategy.

5.2.2. Phase two (2009–2015): introduction of energy strategy with initial targets for 2020

The Energy Strategy was introduced in 2009 by King Mohammed VI. Steinbacher (2015) claims that the significant rise in oil prices in 2007 and 2008 was identified as being a major trigger for the introduction of the Energy Strategy. The strategy was built on the four objectives of the PNAP. The aim of the strategy was to help the country diversify its energy sources, optimize its electricity mix, increase its production from renewable sources, promote its energy efficiency, advance its regional integration, and protect the environment by reducing emissions (MEME, 2020). The development of the strategy was driven by the challenges of meeting growing demands for energy and achieving wide socioeconomic and environmental objectives (Usman and Amegroud, 2019).

The strategy set out bold targets to increase the share of renewable energy to 42% of the country's installed electrical power and reach a 12% energy efficiency gain by 2020. Accordingly, integrated programs for the installation of 6,000 MW of renewable sources were targeted. This included 2,000 MW for wind energy, 2,000 MW for solar energy, and 2,000 MW for hydropower (MEME, 2020). Following the introduction of the strategy, the Solar Integrated Programme (SIP) and Integrated Wind Energy (IWE) programmes were launched in 2009 and 2010 respectively. They included a set of projects on large-scale wind farms as well as solar projects using CSP and PV technologies (Choukri et al., 2017). These projects required an estimated investment of $12.5 billion. The objectives of these projects included the development of a wide range of expertise and to boost R&D in renewable energy (RES4MED, 2018b). This was an important condition to bridge the gap in skills and supply chains in the renewable energy sector in Morocco.

It is worth noting that funding the projects outlined in the Energy Strategy comes from the government own sources including Hassan II Fund for Economic and Social Development, the Energy Efficiency Fund, the Energy Development Fund, SIE's Renewable Energy Fund and the ONEE's own funds. In addition, Morocco has received substantial support from international institutions and countries including Neighbourhood Investment Facility (NIF), KfW Development Bank, the European Commission, the European Investment Bank (EIB), the Agence française de développement, the Clean Technology

Fund, the African Development Bank, Saudi Arabia and the United Arab Emirates (RES4MED, 2018b).[57]

In order to support the delivery of these projects, the Energy Strategy was followed by a number of legislative, regulatory and institutional reforms. One of the main legal texts is Law 13-09, passed in 2010. This law allows private companies to produce electricity from renewable sources and to buy it from the market. The benefits of this law are significant. It is the first step towards the liberalization of the renewable energy market. It allows private electricity developers to access the national grid at high and medium voltage levels and create direct transmission lines for their own use when the capacity of the national electricity grid and interconnections is insufficient (Law 13-09, 2010). Interestingly, the law excludes hydropower with total capacity exceeding 12 MW. This means that Morocco is moving away from hydropower towards solar and wind energy in spite of the strategy's consideration for hydroelectricity. This action may have been driven over concerns about the sustainability of hydroelectricity and the huge potential of solar and wind power. Also, the law at this stage excludes small-scale renewable energy projects to access the national grid.

An important result of these reforms is a hybrid market model where a regulated market, supplied by a single buyer, which is ONE, and distributor companies, coexist within a free retail market supplied by renewables producers and self-producers (RES4MED, 2018a). This means that the production and distribution of electricity has opened to the private sector either through public-private partnerships as in the case of PPAs with IPPs or privately owned-producers. Whereas ONE is still dominating the transportation of energy.

Simultaneously, several institutional reforms were attempted in order to govern the renewable energy sector under supervision of the MEME. The Ministry is responsible for the development and implementation of the Energy Strategy, whereas institutions are developed to facilitate delivery of the energy efficiency and renewable energy projects. The Moroccan Agency for Solar Energy (MASEN) was created under Law 57-09 in 2010. It is a dedicated one-stop shop government institution that provides land and infrastructure for projects, organises auctions, and provides planning permissions. The MASEN has initially supported the development of projects which are outlined in the SIP.[58] In addition, the National Agency for Renewable Energies and Energy Efficiency (ADEREE) was created by

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[57] KfW is a German state-owned development bank, the Neighbourhood Investment Facility (NIF) is an innovative financial instrument used as part of the European Neighbourhood Policy (ENP). Its primary aim is to support key investment infrastructure projects in the transport, energy, social and environment sectors as well as to support private sector development (in particular SMEs) in the neighbourhood region by providing funding that complement loans from European Finance Institutions.
[58] MASEN issued green bonds to finance the 100 MW of NOOR PV 1 projects (IEA, 2020b).

Law 16-09 in 2010. This replaced the Centre for the Development of Renewable Energies which was previously established in 1982, in order to facilitate the implementation of renewable energy and energy efficiency policies. In the same year, Energy Investment Company (SIE) a state's dedicated financial agency, was established by Law 40-08 to contribute to funding renewable energy and energy efficiency projects with an initial capital of over $110 million (SIE, 2021).

In 2011, ONE (electricity) was merged with ONEP (water) by Law 40-09 to form ONEE. This merger was made to support desalination projects and enable a potential reorganization of the power and water distribution sectors (Usman and Amegroud, 2019). This is unsurprising as the water and energy sectors are directly interlinked which require harmonised policy.

The other important legal text to support delivery of the strategy is Law 47-09 on promoting energy efficiency, introduced in 2011. This law sets the criteria for minimum energy performance for appliances and electrical equipment. It also established mandatory energy audits for companies and institutions in the production, transmission and distribution of energy, as well as the performance of an energy impact study for new construction and urban projects (Law 47-09, 2011). In addition, Decree. 2657-11 on wind energy sites was proposed in order to predefine the areas and criteria to host wind farm projects (Decree. 2657-11, 2011). Furthermore, in order to support the R&D in renewable energy, IRESEN, a research institute, was created in 2011 with the participation of several key players in the energy sector in Morocco.

From 2013–2015, the government made significant efforts to phase out fossil fuel subsidies. A price rise of 5% on retail tariffs was reported in January 2014, and other rise was announced in July 2014, as detailed in Section 3.4 in Chapter Three. This was an important step to make the electricity generated from renewable energy competitive, and to secure additional funds for renewable energy projects. Since December 2015, energy subsidies have been removed for most refined products, but have remained heavily on butane. This is still necessary to avoid social unrest from low-income people. It appears that the country does not have alternatives to butane for heating, cooking and agricultural irrigation. Therefore, electrification of these sectors powered by renewable energy could offer an alternative solution to the country, so as to remove remaining fossil fuels subsidies on butane. This solution has been widely ignored in Morocco's Energy Strategy.

Additionally, further regulatory reforms were made to the distribution sector in 2015 through Law 54-14 and Decree 2-15-772. These regulations allow self-producers of electricity from renewable sources to access the national medium voltage grid from production to consumption sites. Consequently, by 2015, the electricity generated from wind power (2,519 GWh, 9,068 TJ) has passed hydroelectricity generation (2,281 GWh, 8,211 TJ) as shown in Figure 24. Hence hydropower is no longer Morocco’s main renewable energy source. Also, the construction of the first large-scale solar plant was completed in Ouarzazate in same year, which was considered the largest solar plant in the world at that time. Morocco’s ability to build this large solar farm and a number of wind energy projects inspired the government to revisit the Energy Strategy and set further ambitious targets.

5.2.3. Phase three (post-2015): Acceleration of renewable energy with new targets for 2030

The evaluation of the implementation of the first phase of the Energy Strategy in 2015 was promising (MEME, 2020). During the 21st session of COP21 held in Paris in 2015, King Mohammed VI set new targets to accelerate Morocco’s energy transition by increasing its share of renewable energy to 52% of installed electrical power, and to reach a 15% energy efficiency gain by 2030 (MEME, 2020). Consequently, the total installed capacity from renewable energy projects is set to reach 11,860 MW, of which 4,560 MW is solar, 4,200 MW is wind, and 3,100 MW is hydropower by 2030 (Azeroual et al., 2018). This is expected to require a $40 billion investment between 2015 and 2030. Also, Morocco is projected to achieve a 32% reduction in GHG emissions by 2030 (RES4MED, 2018b). This demonstrates that the emphasis has been given to solar and wind projects over hydropower. Also it appears that Morocco built its renewable energy objectives based on its current pattern of installed electricity capacity. The Energy Strategy does not take into account increased electricity demand if electrification of the economy is considered. Figure 23 illustrates Morocco’s energy mix targets for 2020 and 2030.

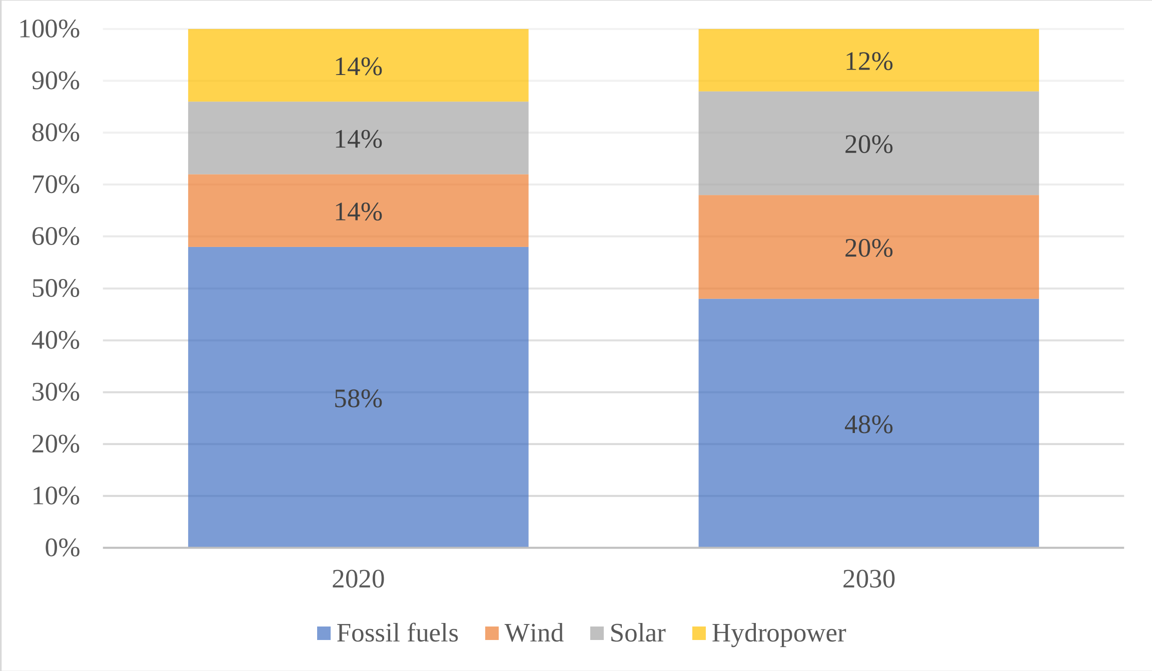

Figure 23: Installed energy mix plans in 2020 and 2030

Source: MINISTRY OF ENERGY, MINES AND ENVIRONMENT, 2012. *Sustainable Development in Morocco: Achievements and perspectives from Rio to Rio +20.* June 2012. Rabat: Ministry of Energy, Mines and Environment.

Accordingly, Morocco became the first African country to set a target for more than 50% of its installed electricity capacity being derived from renewable energy sources (Choukri et al., 2017).[59] The strategy relies mainly on large-scale integrated solar and wind energy programmes through IWE and SIP, more than hydropower. This is because that it is difficult to predict hydroelectricity generation which is heavily reliant on rainfall levels. For this reason, RES4MED (2018b) reports that Morocco has only targeted small hydropower projects in addition to the development of new technologies such as the Pumping Energy Transfer Station (STEP) (RES4MED, 2018b).

To meet these new objectives, additional important regulatory reforms were made. Law 13-09 was amended and supplemented by Law 58-15 in 2016. The new law has expanded private sector access to include a low voltage grid (Law 58-15, 2016). Hence, after this reform, the private sector has been granted the right to access the national grid at all voltage levels. Moreover, hydropower capacity, covered by Law 58-15, increased from 10 MW to 30 MW. This proves that, generally, hydropower projects are expected to be smaller

[59] Morocco’s Energy Strategy won the Best State Strategy Award at the African Investment Forum held in November 2017 in Paris.

than solar and wind energy projects, and hydroelectricity contribution to the final energy consumption is projected to be smaller than that of solar and wind energy.

This was followed by further institutional reforms. The National Electricity Regulatory Authority (ANRE) was created by Law 48-15 in 2016 to monitor the free market of renewable electricity and regulate self-producers' access to the national grid (Law 48-15, 2016). Another important reform was extending the scope of the MASEN to include wind and hydropower in addition to solar power by Law 37-16 in 2016. Hence MASEN became the Moroccan Agency for Sustainable Energy instead of the Moroccan Agency for Solar Energy. Furthermore, ADEREE was replaced by the Moroccan Agency for Energy Efficiency (AMEE) by Law 39-16 in 2016. This was an important step to strengthen the governance of projects, either renewable energy or energy efficiency projects. There was an overlap in some responsibilities between ADEREE and MASEN with regards to renewable energy projects. After creating AMEE, MASEN has become the main institution responsible for the delivery of renewable energy projects with clearer responsibilities. Whereas AMEE has been given the role of leading energy efficiency projects as explained by one of interviewees (Interview 3).

In the same year, Morocco hosted the COP22 conference which was considered a further driver for the country's energy transition plan (Günay et. al., 2018). The conference helped build Morocco's new image as a regional leader in energy transition as commented by one of my interviewees (Interview 2, Senior Project Manager and Researcher in Energy & Sustainable Development at Maroc Telecom). Further progress has been made in solar power by launching the construction of a large-scale NOOR Ouarzazate IV solar plant in 2017 by King Mohammed VI.

Furthermore, Draft Law 40-19 was proposed in December 2019 to amend and supplement Law 13-09 in order to further facilitate the delivery of renewable energy projects (Draft Law 40-19, 2019). This law is aimed at improving the legislative and regulatory framework for the implementation of renewable energy projects by the private sector. According to the Law, for greater transparency, carrying capacity needs approval from the ANRE which is the amount of installed capacity from renewable energy sources that can be accommodated in the national electricity transport grid without facing management constraints. The draft Law also introduced 'system services', which allows the national electricity transport grid operator to manage the intermittency of renewable energy sources in order to ensure stability of the grid. Given the uncertainty raised by the current legal framework, the draft law explicitly grants the right for distribution network operators to acquire up to 40% of the total energy supplied from renewable energy sources to supply customers located in their area of operations. The draft law gives the ANRE the right to set the tariff for the sale of excess electricity. The draft Law also removes the geographical requirements of solar energy projects which were previously allowed only to be constructed in the areas predefined by the MEME (Draft Law 40-19, 2019). Therefore, this draft law is expected to accelerate renewable energy projects by expanding the role of private sector and removing some obstacles to the delivery of the projects.

These various reforms have attracted major international players in renewable energy to invest in the Moroccan energy market. Siemens Gamesa Renewable Energy, for example, opened a wind turbine blade factory in Morocco (and the Middle East) in 2017 to manufacture the blades of wind turbines (Siemens, 2017). This is important to support the local economic growth and create domestic jobs in renewable energy sector.

Following these developments, the country's net energy imports declined from 98% in 2008 to 93.3% in 2016 (El Hafidi, 2017). This further reduced to reach 92% in 2019 as stated by one of the interviewees (Interview 3). Also, the share of electricity generated from wind energy significantly increased from 3% in 2010 to 9% in 2017 (IEA, 2020). Additionally, electricity generation of solar thermal and PV power passed hydroelectricity in 2020. This was due to two reasons. First, more solar power projects became operational. Second, hydropower has dropped by more than half since its peak in 2010 (IEA, 2021). However, share of renewable energy remained relatively stable at around 14% between 2013 and 2017 (IEA, 2021). This is because the rise of electricity generated from wind and solar energy has offset the decline in hydroelectricity generation since 2010. Remarkably, IEA (2020) reports that, by 2018, Morocco had the greatest renewable energy capacity in the Arab region. The country has around 74% of the total CSP regional capacity. This demonstrates Morocco's regional leadership in renewable energy.

One of interviewees, a Renewable Energy and Energy Efficiency Engineer at MEME, provided updates on the progress Morocco has made on its energy transition. The interviewee reported that the installed capacity share of renewable energy reached 34% in early 2020. Thus, Morocco did not reach their initial target of 42% of installed capacity (Interview 3). Although the interviewee mentioned the potential impact of COVID-19 pandemic on project delivery, its comprehensive impact was as of yet unclear at the date of the interview, which was at end of January 2020. However, the IEA (2020) reports that the pandemic has caused a delay in the delivery of renewable energy projects in Morocco and disrupted the supply chain.[60] However, the interviewee added, 'despite some delay in the projects, we are satisfied with this progress, given that all projects for 2030 are already planned and scheduled'. He further explained that the difference between installed capacity and power generation was due to the typically intermittent nature of renewable energy which is considered as a global issue. For example, wind speed is not always sufficient to power wind turbines, and solar power only works during the daytime. Frequent maintenance of equipment also interrupts electricity generation. For these reasons, renewable electricity production accounted for 18.5% of Morocco's total electricity generation in 2020 (IEA, 2021). Therefore, even if the country would have reached its targets, the renewable electricity level would still be less far than their Energy Strategy target of 42%. Thus, it is more important to consider the electricity generation amount from renewable energy rather than the installed capacity which the country's Energy Strategy targets set.

Figure 24 presents the progress Morocco has made on its renewable electricity generation from hydroelectricity, solar and wind power between 1992 and 2020. It demonstrates that hydropower was the main source until 2015 when wind power overtook it. Also, Figure 24 shows that electricity generation from solar power has started to clearly appear since 2015 when the construction of the first large-scale solar plant was completed in Ouarzazate. This was followed by the establishment of additional solar power projects. Accordingly, in 2020, the electricity generation of solar thermal and PV power overtook hydroelectricity in 2020 after the continuous falling of hydroelectricity generation.

[60] Due to the COVID-19 pandemic, IEA (2020) reports that Morocco has 11 million outstanding electricity bills. The crisis has led to delays in energy investment and planned projects due to slumps in the supply chain and demand (IEA, 2020b).

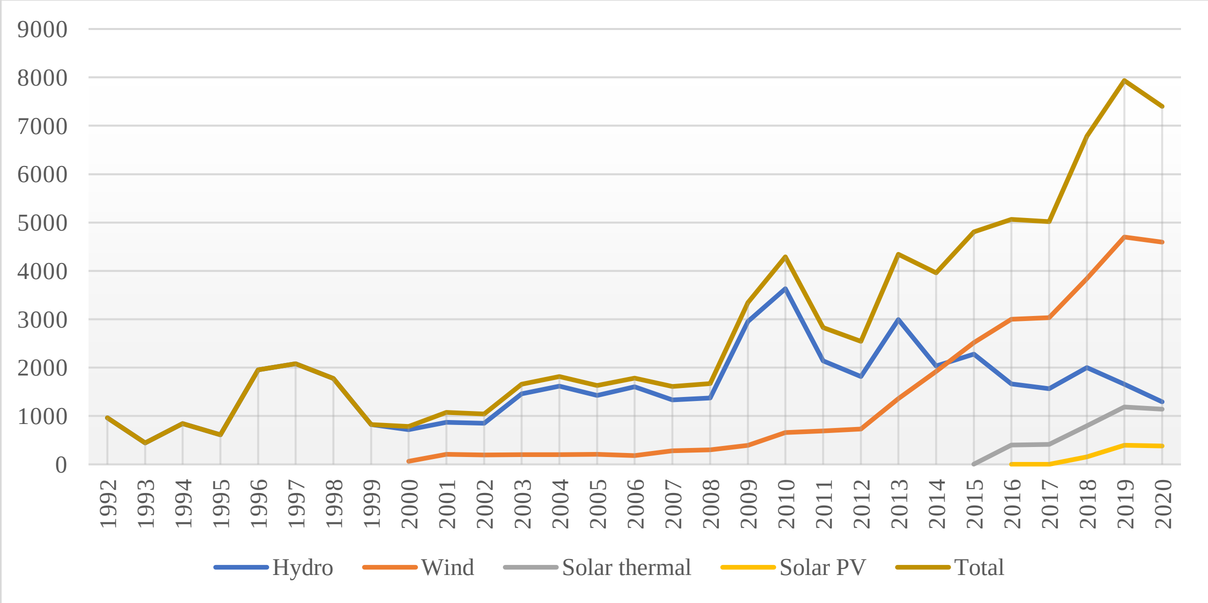

Figure 24: Renewable electricity generation by hydro, solar and wind sources (GWh) in Morocco between 1992–2020

Source: INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 25 December 2021]. Available from: https://www.iea.org/countries/morocco/

Table 16: Renewable energy evolution and related reforms and events

Date	Event	Details
1960s	Hydroelectricity generation began	Hydroelectricity generation has been unstable partly due to climate change which causes frequent droughts.
1994	Law 2-94-503 on partial liberalization of energy generation	The law first introduces partial liberalization. The Law allows ONE to sign PPAs with IPPs (up to 10 MW).
1995	First solar power was launched at a small-scale	Solar power was launched through the Global Rural Electrification Programme to connect rural and isolated towns with electricity.
1995	Removal of energy subsidies	Indexation of petroleum products to international market prices was aimed at strengthening the financial status of ONE.
1996	Regional integration	Regional integration with the Maghreb-Europe Gas Pipeline introduced natural gas into the supply mix to increase the energy security.
1997	Decree 3-127-97 on privatization of electricity distribution utilities	The decree allows for privatization of electricity distribution utilities through transferred management.
2000	Energy subsidies reintroduced	Suspension of indexation of energy prices to international prices.
2000	Introduction of first wind farm	The first wind farm, Abdelkhalek Torrés, was launched in 2000 at small-scale.
2002	Law 28-01 on ONE to participate in private generation projects	The law authorizes ONE's participation in private generation projects.
2005	Law 54-05 on energy distribution	The law opens distribution sector to private investments.
2008	Law 16-08 on self-generation	The law enables industrial units to produce their own electricity from renewable energy. This law raises the ceiling for self-generation from 10 MW to 50 MW.
2009	Introduction of Energy Strategy	Share of renewable energy set to 42% of the installed electrical power by 2020.
2009	Launching of Solar Integrated Programme	The programme is aimed at developing 2,000 MW of solar capacity by 2020.
2010	Law 13-09 on liberalization of renewable energy generation (Draft Law 13-09 was adopted by the Government Council on 12 March 2009)	The purpose of the law is to partially liberalise and develop the renewable energy sector. It allows renewable producers to access high and medium voltage grids to sell their energy directly to end consumers.
2010	Law 16-09 on creation of ADEREE. This institution replaced the Centre for the Development of Renewable Energies which was created in 1982	ADEREE is aimed at facilitating the implementation of renewable energy and energy efficiency policies.
2010	Law 57-09 on creation of MASEN	MASEN is aimed at ensuring the development of integrated projects for producing electricity from only solar energy.

Date	Event	Details
2010	Law 40-08 on creation of Energy Investment Company (SIE)	SIE's main objective is to boost the development of renewable energy and energy efficiency projects.
2010	Integrated Wind Energy programme was launched	The programme intends to increase the wind capacity from 287 MW in 2010 to 2,000 MW by 2020
2011	Law 40-09 on creation of ONEE	The law facilitates the merger of ONE (electricity) and ONEP (water) to create ONEE. This is to support desalination projects and enable a potential reorganization of the power and water distribution sectors.
2011	Law 47-09 on promotion of energy efficiency	The law promotes the energy efficiency and sets the criteria of minimum energy performance for appliances and electrical equipment.
2011	Decree. 2657-11 on wind energy sites	This decree sets the criteria of areas that could host wind farm projects.
2011	Creation of Research Institute for Solar Energy and New Energies (IRESEN)	IRESEN is aimed at consolidating the needs of different stakeholders and ensuring the implementation and enhancement of various research projects.
2013	Partial indexation of energy prices to international prices	System of partial indexation was reintroduced. Butane was excluded from indexation.
2014	Raise in electricity tariffs	Electricity tariffs raised by 5%
2014	Reduction in energy subsidies	Remove subsidies to gasoline and industrial fuels. Subsidies remain for butane, diesel and petroleum products for ONEE.
2015	Law 54-14 which is an amendment of Law 16-08	The new law amending the law 16-08, this law gives the possibility to national self-producers of electricity of over 300 MW to access to the transmission network to carry energy from the production sites to consumption sites.
2015	Decree 2-15-772 on access to distribution grid	The decree grants self-producers to access the distribution grid to supply medium voltage end-users.
2015	Wind power electricity generation passed hydroelectricity generation	Electricity generated from wind power has started to exceed the hydroelectricity generation.
2015	Introduction of first large-scale solar plant in Ouarzazate	This was the largest solar plant in the world in 2015.
2015	Energy Strategy new targets for 2030	Share of renewable energy further set to 52% of the installed electrical power by 2030.
2016	Law 58-15 amending and supplementing Law 13-09 allowing for more liberalization of renewable energy	The new law amends and supplements Law 13-09. This law grants renewable energy producers to access the low voltage grids and sell the energy directly to end users.
2016	Law 48-15 on creation of ANRE	ANRE is aimed at monitoring the free market in electricity generated from renewable sources and

Date	Event	Details
		regulating self-producers' access to the national electricity transmission grid.
2016	Law 37-16 on development of MASEN to be Moroccan Agency for Sustainable Energy	The scope of MASEN was extended to include wind and hydropower.
2016	Law 39-16 on creation of AMEE to replace ADEREE	AMEE replaced ADEREE with main focus on energy efficiency.
2017	Siemens Gamesa Renewable Energy opened new turbine blade factory in Morocco	The factory produced the first blade ‘made in Morocco’. It is the first wind turbine manufacturer in Africa and the Middle East.
2019	Proposed Law 40-19 amending and supplementing Law 13-09	The new law is aimed at accelerating the delivery of renewable energy projects.
2020	Solar power electricity generation reached level of hydroelectricity generation	It appears that the solar power electricity generation started to pass the hydroelectricity generation.

Legend
Institutional reforms
Energy-related legal texts reforms
Subsidies issues
Renewable energy progress
Energy strategy related targets

5.3. Opportunities

As discussed in Chapter Three, Morocco has been facing considerable challenges due to the consequences of climate change and the energy sector. These challenges have been even more severe after 2000. Hence the renewable Energy Strategy was developed to contribute towards overcoming the country’s challenges and achieving various interlinked development benefits. These include economic, social, environmental and political objectives.

By looking at the wider picture of TPES, Morocco seeks to diversify and optimize its energy mix away from relying extensively on fossil fuels sources which accounted for 90% of TPES in 2019. Oil alone accounted for 56.5% of TPES, whereas coal’s share of TPES was 30% in 2019 as illustrated in Figure 25.

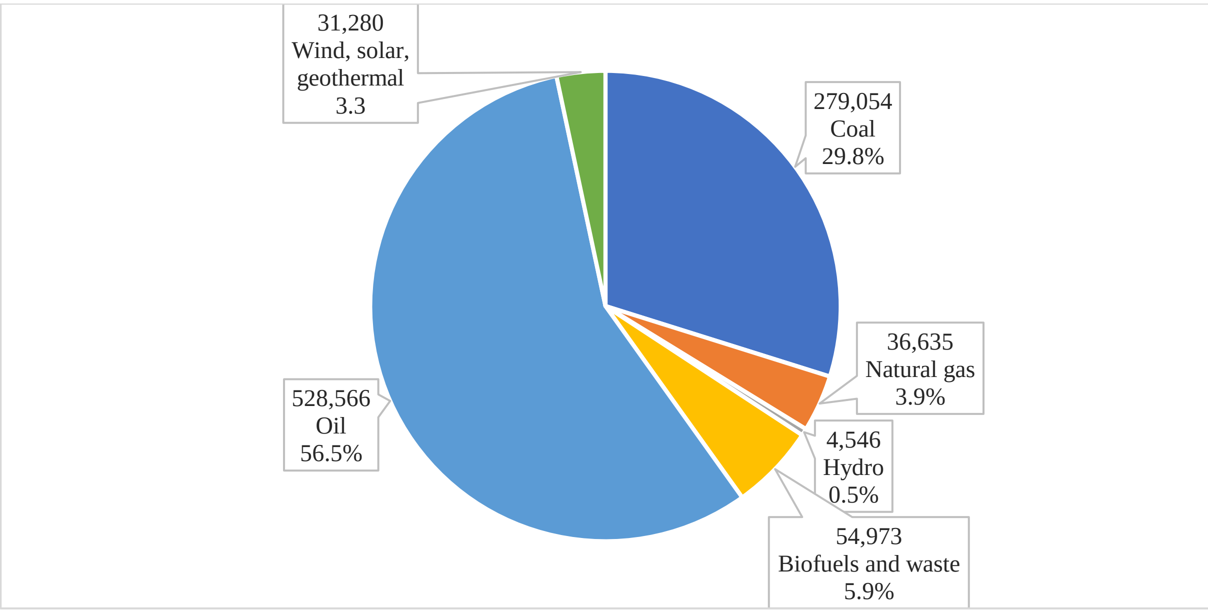

Figure 25: Total primary energy supply (TPES) in TJ by source in Morocco in 2019

Source: Author's compilations based on: INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 25 December 2021]. Available from: https://www.iea.org/countries/morocco/

Figure 26 illustrates how Morocco's reliance on coal and oil has become more evident since the 2000s to respond to growing energy needs, as discussed in Section 3.4 in Chapter Three.

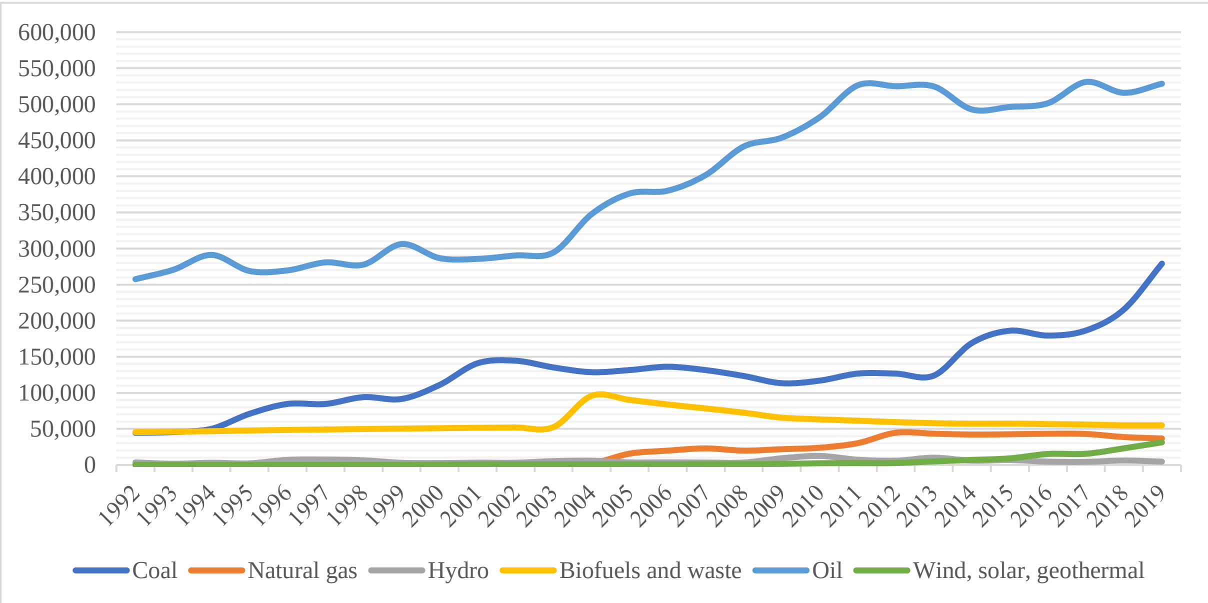

Figure 26: Total primary energy supply (TPES) in TJ by source in Morocco between 1992–2019

Source: Author's compilations based on: INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 25 December 2021]. Available from: https://www.iea.org/countries/morocco/

The objective of diversifying and optimising the country's energy mix is planned to be achieved by increasing its production from renewable sources with a particular focus on wind and solar energy sources. These two sources of energy are more sustainable than hydropower, which was the traditional renewable energy source and vulnerable to climate change due to frequent droughts. Hence, supported by significant potential and natural competitive advantages, wind and solar power could offer a substitute to the decline of hydroelectricity, and also increase the diversification and stability of the country's energy mix.

Solar and wind energy, in turn, could provide electricity at lower prices for households and businesses compared to conventional sources. Electricity cost has reduced notably as the country's renewable projects have developed supported by legal and institutional reforms, and technological advances in renewable energy (Choukri et al., 2017). In terms of solar power, the tariff price was $189 per MWh for NOOR I with 3 hours storage in 2016, it declined to $140 per MWh for NOOR II and $150 per MWh for NOOR III with eight hours storage in 2017. The price was further reduced for NOOR IV (Helioscsp, 2018). The technology used for the first three large-scale solar projects was CSP, whereas the technology used for NOOR IV was PV.[61] In 2019, Morocco auctioned an advanced hybrid (CSP/PV) plant for a record-low peak-hour tariff of $71 per MWh (IRENA, 2018).

With regard to wind power, Morocco contracted 850 MW of onshore wind power at the record-breaking average price of $30 per MWh in 2016. The price was reduced sharply compared with auction price since 2011 which was about $90/MWh. This record was the lowest price across many developed and developing countries such as the UK, Italy, Australia, Canada, Mexico and Brazil (IRENA, 2017). In comparison, the average fuel fossils import price in the first half of 2010s was $90/MWh (RES4MED, 2018b). IRENA (2018) reports that the auction price of offshore wind in Morocco is expected to be less than $15 per MWh in 2020. This will make offshore wind the country's cheapest source of renewable electricity. However, no offshore wind projects are being considered in the country.

[61] Concentrated Solar Thermal systems (CSP) produce electric power by converting the sun's energy into high-temperature heat using various mirror configurations. Whereas PV solar panels make use of the sun's light instead of sun's energy. PV panels have recently demonstrated a large price drop about 30% to 40% in just a couple of years. PV is a lot cheaper than CSP, therefore more energy investors have chosen it in the last few years (SolarFeeds Marketplace, 2021).

The figures above demonstrate that renewable electricity in Morocco is becoming cheaper and more affordable. This will help the country further remove fossil fuels subsidies which remain on butane. This will, in turn, help strengthen its financial position. However, this needs replacing butane with electricity. Namely, this requires the electrification of heating, cooking and agricultural irrigation (as mentioned in Section 5.2.2).

Furthermore, Morocco aims to reduce its dependency on energy imports by increasing renewable energy production. This could reduce its energy import bills which reached $10 billion in 2008 (MEME, 2015). However this also depends on international oil prices. As mentioned in Section 5.2.3, the country has already achieved notable progress by reducing energy dependency from 98% to 92% between 2008 and 2019 as stated by one of my interviewees (Interview 3). In addition, Morocco intends to strengthen its regional integration and export electricity to neighbouring countries. The MEME confirmed that the country started exporting electricity to Spain in 2018 (Morocco World News, 2021). Although its energy export was only marginal, nevertheless, the Kingdom is planning to significantly increase its electricity exports. The country will benefit from its growing production from renewable energy sources.

Deployment of renewable energy projects could foster Morocco's economic growth. These projects require significant investments across the supply chain, from planning and development through construction and fabrication to production and operations. The industry life span of solar and wind farms is about 25 years. The development, construction and operations of these projects generate a significant number of jobs and stimulate the growth of supply chain businesses across various sectors, including construction, engineering, manufacturing, logistics, research, training, and hospitality. This promotes diversification of the economy, and, therefore, increases the stability and resilience of the economy. From a global context, a clear example can be drawn from the Seagreen Offshore Wind Project in Scotland which is expected to create significant jobs during construction and operation phases while providing cleaner energy (Box 4).

Box 4: Seagreen Offshore Wind Project

The Seagreen Offshore Wind Project, which is building 114 wind turbines with a total installed capacity of 1,075 MW, supports 141 jobs associated with the marshalling, storage and logistics, and 30 new jobs created for the construction of its operation and maintenance facility at Montrose Port. This facility is expected to create 120 full-time operational roles and 60 maintenance jobs. In addition, Seagreen is working with local colleges and supporting apprenticeships. The project is investing £400,000 on STEM (Science, Technology, Engineering and Maths) in Angus. Furthermore, Seagreen established Community Benefit Fund with total £1.8 million to help improve local areas in:

- enhancing the environment, conservation and biodiversity.
- improving community spaces, facilities and services.
- promoting health and well-being.
- promoting sustainability.

Source: SEAGREEN (2021).

Rafael de Arce et al. (2012) estimate the economic impact of various investment options of renewable energy production in Morocco. Their overall figures range from 1.21% to 1.99% of the GDP at the end of the forecasting period covered (2040), with a full-time equivalent employment effect of between 269,252 and 499,000 jobs. This means that further renewable energy projects are anticipated to bring significant socioeconomic benefits to the Kingdom.

Under the SIP, bidders are encouraged to promote local businesses and manufacturers. For instance, NOOR I solar plant, awarded to ACWA Power, included a 42% local content share of contracts. To achieve this goal, specialized energy courses were created within major engineering schools and universities (EIB and IRENA, 2015).

One of my interviewees, Professor at Ecole Nationale des Sciences Appliquées (ENSA), and President of the Moroccan Organization of the Energy, Water and Agriculture Nexus (OMNEEA) claimed that the local content in wind farms has passed 60%, whereas it is still small in solar power projects. The opening of the Siemens Gamesa Renewable Energy Factory in 2017 with an investment of more than $100 million helped further increase the local content of wind farms by manufacturing the turbine blades (MEME, 2020). The factory created 600 jobs and produced the first blade made in Morocco. The interviewee commented, ‘we can’t say we practice green economy until we have significant local content which is still marginal in solar projects.' He added, 'the implementation of the Moroccan Solar Plan is not just about electricity production, but a strategic choice for Morocco's development, we need to understand the capability and capacity of our supply chain, and which parts of CSP and PV are suitable for local manufacturers before considering which technologies we will adopt' (Interview 9, Professor at ENSA and President of OMNEEA). This highlights the importance of economic objectives in renewable energy projects in Morocco which include strengthening industry, creating jobs and attracting investments.

In addition, Morocco aims to achieve inclusive development from renewable energy. The government has identified a number of priority development zones for its projects. Any project larger than 2 MW must be located in a predefined development zone (Mahmoud and Habib, 2019). This could reduce the development gap between urban and rural areas and create jobs in the least developed communities. This also could absorb workers moving away from the agriculture sector as a result of severe weather and droughts. However, draft Law 40-19 removes the geographical requirements of solar energy projects, it appears the focus will be to accelerate deployment of solar energy projects by removing some restrictions. Nevertheless, the renewable energy projects should contribute to the local development. According to Decree No. 2657-11, solar and wind farms should have a clear positive impact on the regions and, in particular, the municipalities that will house them. These projects are planned to improve the local infrastructure including roads, drinking water and electricity networks. These projects are also proposed to improve the living conditions of locals, reduce poverty, increase small industry local development, create business opportunities, and contribute to tourist attraction locations (Official Bulletin 5984, 2011).

For example, in the rural community of Haouiza, the installation of a solar energy water pumping system and sanitary infrastructure in a rural school have increased the enrolment of girls up to age 14 from 25% in 2010 to 48% in 2015. Before delivering this project, the school was not connected either to water or to the grid, and there was no sanitary infrastructure. NOOR I employed 1,000 workers during the construction phase. The project also invested in workers' skills (RES4MED, 2018b).

Chentouf and Allouch (2021) estimate the number of Full Time Equivalent (FTE) jobs that could be generated by a typical 5 MW power project from hydropower, wind and solar projects during either the construction phase or the operation and maintenance phase in Morocco. They find that jobs created by these three types of renewable energy projects are relatively similar: between 9.54 for solar and 10.3 for hydropower and wind projects during the construction and installation phase. Whereas expected jobs created during the O&M

phase is higher for solar projects (9 jobs per 5 MW project) than hydropower and wind projects (2.6 and 1.5 jobs per 5 MW project respectively) as shown in Table 17. It is worth mentioning that the construction phase for a large-scale wind farm is estimated at about 3 years whereas this is shorter for solar projects. Also, the O&M phase during the lifetime for both solar and wind projects are estimated to be 25 years. Accordingly, it is estimated that renewable energy jobs in Morocco will create between 431,228 and 448,986 jobs by 2030.

Table 17: Expected FTE jobs of renewable energy projects per 5 MW of capacity

Renewable energy	Construction and installation	Operation and maintenance
Hydropower	10.28	1.50
Wind	10.30	2.64
Solar	9.54	9.07

Source: CHENTOUF, M. and ALLOUCH, M., 2021. Assessment of renewable energy transition in Moroccan electricity sector using a system dynamics approach. *Environmental Progress & Sustainable Energy*, *40*(4), p.e13571.

These results are consistent with RES4MED's (2018b) estimation that solar power projects, through CSP or PV, are anticipated to create the most jobs in Morocco. Also, the results appear to align with Rafael de Arce et al. (2012) results and the Mediterranean Forum of Institute of Economic Sciences estimation that 500,000 jobs will be created from renewable energy projects in Morocco by 2040. This shows significant job opportunities that could be generated in Morocco.[62]

Environmentally, renewable energy projects generate electricity from cleaner sources than fossil fuel energy sources. Hence, this will limit the increase in energy-related emissions in Morocco and contribute to the country's efforts to meet its NDC targets. This will also contribute to its efforts to protect the environment and biodiversity. Protecting the environment is one of the Energy Strategy's objectives. The NOOR Ouarzazate project could potentially reduce emissions by 762,000 tons of CO_2 annually, with 19 million tons over the 25 years of its operation. Also, renewable energy could contribute to improving the water security of the country, since desalination is an energy-intensive industry. Desalinations economic feasibility directly relies on energy factors to generate fresh water (Gopi et al., 2019). The interest in renewable energy-driven desalination systems has been growing

[62] Detailed analysis of the socioeconomic impact of renewable energy projects is not the purpose of this study.

globally (Powell et al., 2017). To this end, the IEA (2020) reports that Morocco is currently building the world's largest Reverse Osmosis (RO) desalination plant powered by wind energy.[63] Also the country has plans to develop number of desalination plants using solar or wind power. Hence, given its water scarcity, Morocco could also benefit from renewable energy to increase its water security.

Moreover, being a regional pioneer in renewable energy gives the country first mover advantage among other Arab and African countries. This could create commercial opportunities for Moroccan businesses. For this reason, the Moroccan Minister of Energy emphasised this fact by stating, 'we are taking African leadership in the field of renewable energy' (MEME, 2021), commenting on Morocco's recognition for the New Partnership for Africa's Development Agency Award in September 2018. Similarly, a Moroccan expert in environment and sustainable development, said, during an interview conducted in October 2020, 'we are now a regional leader in renewable energy among Africa and the Arab World […] we were proactive by taking the first mover advantage' (Interview 2). Another interviewee, a Researcher at IRESEN, confirmed that MASEN has already started working regionally in other African countries and supporting the development of a number of regional renewable energy projects. IRESEN also funded R&D in renewable energy in some African countries (Interview 7).

Importantly, the socioeconomic benefits of renewable energy to Moroccans could support the Kingdom's political stability. This is through job creation in green sectors, economic growth, and improvement of the standard of living of Moroccans. King Mohammed VI was able to overcome social unrest in 2011 by promising to improve the socioeconomic conditions of Moroccans. Important amendments were made to the Kingdom's constitution in the same year ensuring that sustainable development is one of main goals of the country. The objectives of sustainable development are anticipated to be largely achieved through the delivery of the 2009 Energy Strategy.

In summary, the green economy model of Morocco, which was built on energy transition, was aimed at achieving various benefits to the country. These benefits include socioeconomic, environmental and political objectives. Contrary to NBS which generally provide longer-term benefits, energy transition could bring important shorter-term solutions to Morocco that could contribute to overcoming the consequences of climate change and

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[63] A greater shift towards renewable-based desalination could lower the energy and carbon intensity of the water supply, while pairing RO technologies with co-generation plants could help provide the storage and flexibility needed to support a greater uptake of renewables. In RO technology, sea water is forced against semi-permeable membranes under pressure in a continuous flow condition (Applied Membranes, 2021).

energy challenges as discussed above. The above also shows that the broad conception of green economy is not limited to tackling climate change through the separation of economic growth from emissions, but also is linked to achieving wide socioeconomic objectives. However, Morocco faces many barriers and challenges to achieve the objectives of this Energy Strategy and to realize the benefits of its renewable energy projects. A number of key challenges are discussed in the next section.

5.4. Challenges

The previous section explored the opportunities that Morocco aims to achieve from renewable energy to overcome the consequences of climate change and the energy challenges. An energy transition is expected to bring broad benefits that could contribute to the development of country. However, many barriers and challenges are hindering the delivery of renewable energy projects. In order to understand these challenges, qualitative analysis of nine interviews from different key players in energy sector from academic, public, private, and banking sectors has been conducted. These interviews provided invaluable insight to understand the various and perhaps conflicting viewpoints, given the diversity of interviewees.[64] Accordingly, the main challenges are categorized into five areas: policy, technical, economic, environmental and social aspects. It is important to note that the interviewees explained the challenges Morocco faces of delivering its Energy Strategy targets. Therefore, this narrow view does not take into consideration the wide aspects of decarbonization of transport, heat and industry which are missing in its energy transition. Addressing these issues reveals other serious challenges for Morocco. Hence the following points are not exhaustive, but they present some key challenges face the country.

First, with regard to policy challenges, Chentouf and Allouch (2018) report that there is a lack of collaboration between different stakeholders in the delivery of renewable energy projects. Their study does not provide clearer details about this matter, hence it is important to further investigate the issue mainly through interviews with key informants in the energy policy. One of the interviewees, a Professor at Ibnou Zohr University, disagreed that was a lack of collaboration. He stated that collaboration exists between academics, researchers, key energy developers and the industry (Interview 1, Professor at Ibnou Zohr University). Since the introduction of the Energy Strategy in 2009, gradual institutional reforms have created dedicated entities to support the delivery of the strategy, as reviewed in Section 5.2. These reforms have been made while Morocco continue to evolve and progress its strategy.

[64] Appendix A provides details on profile of interviewees.

When the strategy was first introduced, it was unclear who would take the lead of various renewable energy and energy efficiency projects and the responsibilities of different bodies. However, institutional reforms contributed to clearer responsibilities as explained by Interviewee 2 and Interviewee 3.

For example, ADEREE was created in 2010 to facilitate the implementation of renewable energy and energy efficiency policies. Then ADEREE was replaced by AMEE in 2016 to focus solely on energy efficiency. While the renewable energy side has been given to MASEN, which when first created was dealing only with solar projects, later wind and hydropower projects were added to its mandate in 2016 to accelerate the delivery of all kinds of renewable energy projects. These reforms have been made to limit overlapping responsibilities between different agencies. AMEE focuses on energy efficiency, whereas MASEN is responsible for the delivery of all renewable energy projects, and IRESEN was established to undertake the R&D of renewable energy and energy efficiency. The R&D element was the responsibility of many institutions before the establishment of the IRESEN (Interview, 3).

Another interviewee, a Senior Researcher at IRESEN, distinguished between large and small projects clarifying that collaboration is easier for large-scale rather than smaller projects. This is due to the fact that legislative and regulatory texts have favored large-scale projects without proportional support to small and medium-scale producers in terms of financing and incentives (Interview 7). This is more evident in residential and tertiary self-producers and independent production (Bentaibi et al., 2019). Although Law 58-15 gives private small-scale renewable producers the right to access low-voltage grids and sell their energy directly to end consumers, implementation guidelines and procedures are not clearly set. This fact was confirmed by another interviewee, Head of Financing Sustainable Development Directorate in Morocco, who added, ‘we don’t know exactly who is able to sell the spare renewable energy and in which way and what price […] the market is not regulated enough … this is still being discussed at the government level’ (Interview 5, Groupe Crédit Agricole du Maroc). This uncertainty does not encourage the development of small-scale initiatives such as rooftop PVs. Undoubtedly, these smaller projects could contribute significantly to increasing the production of renewable electricity and reducing energy demand from the national grid.

A Senior Researcher at IRESEN linked these circumstances to the fact that electricity generated from small projects is less predictable and uncertain to price and connect to the national grid (Interview 7). The President of OMNEEA suggested that introduction of

Distributed Generation as an integrated green energy network, could help solve the issue (Interview 9). Distributed Generation refers to a variety of technologies that generate electricity at or near where it will be used, such as solar panels and combined heat and power. This could serve a single structure, such as a home or business, or it may be part of a microgrid such as at a major industrial facility. In other words, a decentralized electricity system would contribute to meeting the demand of energy from high energy consumption areas while reducing pressure on the national grid. Accordingly, from the above, it can be seen that Morocco's approach lacks an important element in terms of adopting the concept of decentralizing the electricity system to help the country accelerate its energy transition. The main focus is on large-scale renewable energy projects.

Another challenge is that a mixed regulated market for conventional production and a liberalized market for renewable energy supply creates complexity (Choukri et al., 2017). The electricity sector is highly monopolized by ONEE although to a lesser extent than before introducing the energy reforms of the 2010s. The delivery of renewable energy projects is mainly through calls for tenders from ONEE or MASEN (Choukri et al., 2017). So, although Law 13-09 provides significant renewable energy liberalization, ONEE still influences energy policy. One interviewee, a Senior Project Manager and Researcher in Energy and Sustainable Development at Maroc Telecom, explained the position of ONEE: 'there is opposition from ONEE which is under financial loss and will face more challenges after complete market liberalization of the renewable energy sector' (Interview 2). This interference from ONEE hinders the competitiveness of the renewable energy industry. Therefore, further reforms are needed to promote collaboration rather than competition between different stakeholders, especially for small projects and also to reduce interference from state-owned agencies.

Furthermore, the regulatory framework lacks definition for electricity tariff conditions supplied into the network (Bentaibi et al., 2019). The current grid access pricing does not establish the costs for different energy producers in a clear and transparent way (Choukri et al., 2017). The implementation of PPAs with fixed prices causes distortion of free competition and limits the flexibility of the electricity system needed to manage renewable energy production hazards (Choukri et al., 2017). Despite draft Law 40-19, proposed in December 2019 with further reforms to facilitate the delivery of renewable energy projects (as mentioned above), it is undetermined when the Law will pass. This increases uncertainty in the sector.

Second, technical challenges relate mainly to the less predictable and intermittent nature of renewable energy. Wind power is reliant on wind, PV solar panels operate only during sunlight instead of using the sun’s energy as in the case of CSP. Lacking consistency in an availability of wind and sun interrupts energy production. This issue affects the reliability of renewable energy supply and raises concerns about energy security (Chentouf and Allouch, 2018). For this issue, one interviewee explained that renewable energy’s intermittency needs to be addressed for large and small projects. By developing battery storage, for instance. But the technology is still not mature enough to be commercially feasible at scale, it is also beyond the capabilities of Morocco (Interview 3). This is not surprising given the fact that battery storage technology is not widely common yet. Worldwide installed battery capacity was estimated of around 10 GWh in 2017 (Figgener et al., 2020). Law 40-19, which is still to be passed, may contribute to increasing energy stability by introducing ‘system services’ as mentioned above.

Another interviewee mentioned that Morocco has created a monitoring unit to monitor the energy flow instantly for various renewable energy plants. This is particularly important to ensure stability of the electricity generated from different renewable and conventional sources (Interview 6, Head of Wind Power Section at MEME).

In addition, grid capacity and technical constraints of the transmission and distribution networks remain the main uncertainty (RES4MED, 2018b). The transmission and distribution costs amount for up to 30% of the cost of electricity. Again, a Distributed Generation system could help mitigate this technical problem by its applications in smaller areas. In the residential sector, it could combine, for example, solar PV panels, small wind turbines and backup generators. While in commercial and industrial sectors, it could include, for instance, combined heat and power systems, solar PV panels, wind, hydropower, fuel cells and backup generators, as explained by the President of OMNEEA. The interviewee also suggested that Morocco needs to develop new grid infrastructure to solve grid congestions issues. This will reduce energy loss and increase the reliability of renewable energy especially for small projects (Interview 9).

Third, in terms of economic challenges, Chentouf and Allouch (2018) state that Morocco is still facing complicated issues of attracting local and foreign investments in renewable energy. This situation is due to the intermittent nature of renewables, high construction and O&M costs, the long-time span of return on investment, and the lack of financial aids from the Moroccan government to develop renewable projects. However, my interviewees, who represent different institutions dealing with renewable energy, generally did not agree. They claimed that funding was an issue when the Energy Strategy was first introduced, but now energy developers are competing to win renewable energy bids. This is due to the established experience that Morocco has already gained accompanied by economic and political stability as well as clear strategy and government commitment. Also, the creation of dedicated renewable energy institutions has increased certainty for investors. This fact has been confirmed by the Minister of Energy during various interviews, who also emphasised the efforts that Morocco has made to attract investors and international financial institutions in the renewable energy sector (MEME, 2021).

On the other hand, the issue is different for small and micro projects. The accessibility and affordability of renewable energy technologies remain a major obstacle for the majority of households and commercial enterprises in Morocco (RES4MED, 2018b). The Head of Financing Sustainable Development Directorateat Groupe Crédit Agricole du Maroc explained that many people use old and outdated PVs. The interviewee added:

> Those who want to install solar panels will need to contact consultancy bureau to prepare a complete study based on their needs and available technologies. In fact, farmers are not aware of this, they install solar panels without any prior studies in place. Many of them are importing the solar panel products from Italy for example which could be old and not suitable for their use (Interview 5).

However, the interviewee also stated that Morocco recently introduced labelling regulation that insures minimum performance standards of products' energy efficiency (Interview 5).

Also, there is limited participation by local private investors and regional banks. Renewable energy is principally financed by the government and international players (RES4MED, 2018b). This affirms that Morocco's main focus is on large-scale projects, whereas smaller projects have been given less attention. Additionally, the budget allocated to R&D in relation to renewable energy remains relatively low (RES4MED, 2018b). This shows that Morocco is relying on technology transfer and expertise from international companies. It appears that this was more evident at the introduction of the first renewable energy projects, but later the country started to increase R&D activities locally in Morocco, but also abroad as mentioned by the Minister of Energy in one of his interviews. He said that the purpose of funding R&D outside the country is aimed at giving Morocco regional positioning and leadership (MEME, 2021).

An important point was raised by the President of OMNEEA. The interviewee asserts that the main challenge is to increase renewable energy's local content, generally, and solar projects, in particular, which remain very low. The country imports most of its projects' components rather than manufacturing and fabricating them locally (Interview 9). This demonstrates the capacity and capability gap of Morocco's supply chain companies. Strengthening supply chain companies is important, because increasing local content will support economic development and create local jobs. Morocco has achieved significant progress in increasing the local content of wind projects, reaching more than 60%, especially since Siemens Gamesa Renewable Energy established its turbine blade factory in 2017. The deal included manufacturing advanced wind turbine blades made in Morocco relying mainly on a local supply chain (Siemens Gamesa Renewable Energy, 2017). This will increase the local content of wind energy projects.

Fourth, the main environmental challenge is linked to water scarcity. This was highlighted by one interviewee (Interview 8, Head of Thermal Storage Group at IRESEN). Some renewables, such as solar PV and wind, require little water. Whereas solar projects which adopt CSP technology and use wet tower cooling systems depend largely on water to operate, which is more than double the water usage of a wet cooled coal power station and 23 times the water use per kWh of a dry cooled coal power station (IEA, 2020). For example, for NOOR I's CSP solar project, the design uses wet cooling and the need to regularly clean the reflectors means that the water usage is high (1.7 million m^3 per year or 4.6 litres per kWh). By comparison, NOOR II and NOOR III's CSP solar projects use dry cooling. This is expected to save around 3.6 million m^3 of water. Given the water scarcity in Morocco, this needs to be addressed for future solar projects that adopt CSP technology as stressed by the Interviewee 8.

Lastly, regarding the social challenges, one interviewee claimed that economic progress has not been translated into desired social and human development. Morocco has not invested in human resources as it has in infrastructure. The interviewee stressed the importance to invest in green energy skills; in particular, in technical and higher-level occupational groups, including civil engineering and electrical engineering which are in short supply in relation to renewable energy. This is in order to increase the productivity of labourers and support the delivery of renewable energy projects (Interview 2). Likewise, Chentouf and Allouch (2018) argue that there is lack of local expertise and qualified workers on renewable energy. Specifically, Šimelytė (2020) emphasises that Morocco lacks logistic and management skills in its renewable energy sector. This was agreed by another interviewee from the private industry sector who claimed, 'academic institutions focus only on theory and there are no adequate educational programmes on renewable energy, and the training institutions for renewable energy and energy efficiency are unknown' (Interview 4, President of Simulator Online SA/ Windhoist PTY Ltd). This is a standpoint from a representative of the private sector which takes the opposite view of the academic representative who claimed that collaboration between academia and industry exists.

Therefore, it appears that this collaboration is insufficient to satisfy the needs of businesses who want to maximize the opportunities arose from the projects across the supply chain and increase the local content of renewable energy projects. To this end, Interview 3 claimed that the low local content especially in solar energy projects is linked to limited capacity and capability of local businesses to deliver the projects. However, Interviewee 4 and Interviewee 9 disagree to a particular extent, claiming that local businesses are not appropriately aware of the work needed for the projects. Interviewee 4 added that ‘it is perhaps understandable to see the international businesses win the main contracts given their established experience, however local businesses could take smaller and sub-contracts as tier-two or tier-three businesses and work with the main contractors (tier-one businesses) to deliver the projects’ (Interview 3, Interview 4, Interview 9). This shows that the interviewees provided unique insight and some conflicting answers about the policy as they represent varying perspectives that are influenced by the industries and employment positions they hold.

Hence, a more coordinated approach between key players in the renewable energy sector including industry, national bodies, academia, and training providers needs to be developed. This approach has to address the supply chain gap and skills gap in renewable energy projects. For example, capacity building programmes should be developed to identify the supply chain and increase the capacity and capability of local businesses. Universities and training institutions should be encouraged to develop supporting curriculum considering not only theory, but also practice to meet the need of industry. This could include graduate apprenticeships and skills programmes, for instance, to ensure comprehensive provision to meet renewable energy’s skills needs during the lifetime of the projects.

It appears that many challenges are facing Morocco in the delivery of its strategy. These challenges need to be addressed to accelerate the energy transition to renewable energy. However, an important question needs to be debated on whether the complete delivery of the Energy Strategy, including its 2030 targets, is sufficient to support the country’s transition into a green economy. Specifically, what is the policy gap in its energy transition model that needs to be addressed to achieve its green ambitions?

The interviews highlighted some major shortcomings of the green economy model of Morocco. Interviewee 9 clarified that Morocco is focussing on decarbonisation of electricity system without notable efforts to reduce emissions from other sectors that are responsible for the large share of emissions such as transport, industry, and residential sectors. Moreover, Interview 1 added that decarbonisation of Morocco's economy requires an increase in electrification of sectors that are powered by fossil fuels and also development of not only large-scale solar and wind projects, but also hydrogen as potential energy source. Interviewee 3 agrees that discussion of using hydrogen in Morocco has been still limited, given the poor knowledge about this energy source (Interview 1, Interview 3, Interview 9). This disagreement on the policy provides unique insight into the shortcomings of the green economy model of Morocco. The next section further explores the policy gap in Morocco's model and examines the aspects raised by the interviewees.

5.5. Policy gap

Morocco's green economy was principally built on a transition to a renewable energy. The Energy Strategy was adopted in 2009, aimed at increasing the share of renewable energy to 42% of installed electrical power by 2020, and to 52% by 2030. The strategy was developed to support the country to overcome its development challenges and achieve significant benefits, as presented in the previous chapters. The strategy was also anticipated to help Morocco transition to a green economy and meet its global commitment according to the Paris Agreement and its NDC as stated by the King and Minister of Energy during various interviews.

The Paris Agreement suggests that countries need to achieve absolute-decoupling of economic growth from the carbon emissions, but also that this needs to be permanent and fast enough to prevent global warming. Because relative-decoupling is not enough to overcome climate change challenges. Chapter Four quantitively demonstrates that Morocco appears to have achieved absolute-decoupling of economic growth from carbon emissions since 1992. However, the overall trend of carbon emissions in Morocco continues to increase – absolute-decoupling has been insufficient to reduce its emissions. Importantly, this empirical study shows that economic growth in Morocco could be delivered in a more environmentally friendly and energy efficient way.

By comparing Morocco's Energy Strategy with recent global practices, the strategy suffers from important drawbacks in the context of a green economy from energy supply and energy consumption sides. Importantly, Morocco has largely ignored the role of the heating, transport, residential and industry sectors in generating increased carbon emissions. The country has only focused on the decarbonization of the electricity sector which accounts for a small share of total energy consumption. This will be discussed below. Hence, further efforts are required from the Moroccan government to improve its strategy to help the country meet its green agenda. This section provides a critical assessment of its NDC targets and energy transition and identifies the gap in its model.

As shown in Chapter Three, based on its NDC targets, Morocco is committed to reduce its GHG emissions by 17% with 4% coming from AFOLU actions compared to BAU levels unconditionally, and by 42% (considering AFOLU) conditionally to substantial support from the international community. This support includes, for example, technical, financial, operational and political aspects. Importantly, meeting these targets significantly rely on vast and rapid transformation of the country's energy sector. This is because the largest share of carbon emissions is energy-related. Figure 27 represents the emission pathways of NDC mitigation scenarios for Morocco between 2010 and 2030.

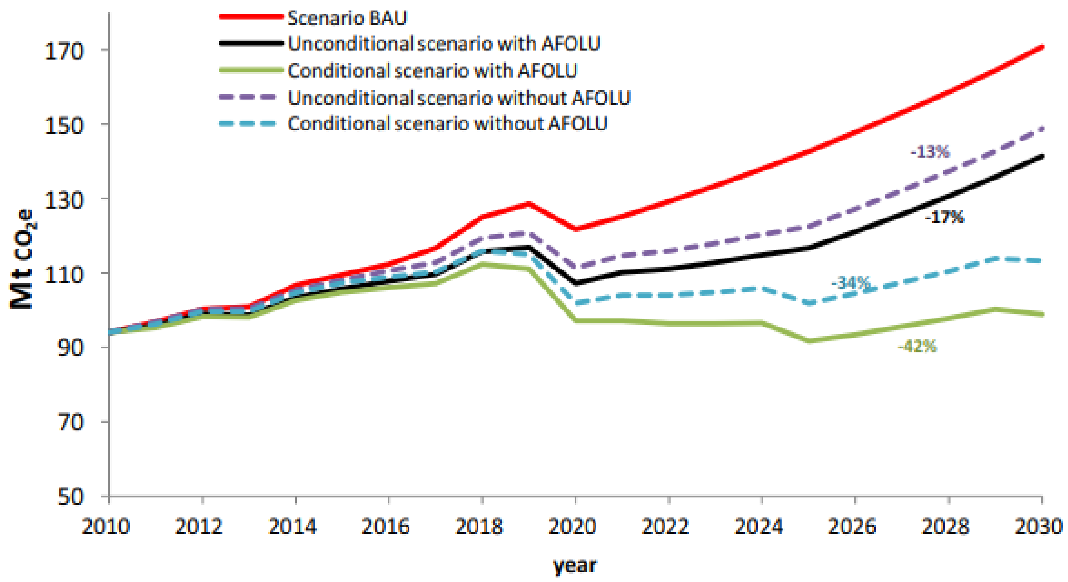

Figure 27: Emission pathways of NDC mitigation scenarios for Morocco.

Source: UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, 2016. *Morocco: Nationally Determined Contribution under the UNFCCC*. New York: United Nations Framework Convention on Climate Change (UNFCCC).

Based on its NDC, Table 18 below shows that Morocco's emissions under the BAU scenario are expected to grow by 82% between 2010 and 2030. Whereas under the Unconditional Scenario (with AFOLU) emissions are projected to grow by 50.6%. Under the Conditional Scenario (with AFOLU), they are anticipated to grow by 5.3% during the same period. Thus either conditional or unconditional scenarios (with or without AFOLU) does not lead to the reduction of Morocco’s emissions, relative to 2010 figures. This shows that NDC targets are not stringent enough to advise Morocco to reduce its growing emissions.

Table 18: Morocco's emission scenarios based on its NDC mitigation

MTCO2e	2010	2030	Growth 2010 - 2030
Emissions - BAU	93.9	170.8	81.9%
Emissions - Unconditional Scenario (with AFOLU)	93.9	141.4	50.6%
Emissions - Unconditional Scenario (without AFOLU)	93.9	148.7	58.4%
Emissions - Conditional Scenario (with AFOLU)	93.9	98.9	5.3%
Emissions - Conditional Scenario (without AFOLU)	93.9	113.2	20.6%

Source: Author's calculations based on UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, 2016. *Morocco: Nationally Determined Contribution under the UNFCCC*. New York: United Nations Framework Convention on Climate Change (UNFCCC).

Furthermore, the NDC base year of Morocco was set as 2010. Whereas, the base year for many developed and industrialized countries such as Germany, the UK, Switzerland, Italy, Finland, Denmark, Sweden, Norway and Russia was set as 1990. It is also 2005 for number of other countries such as the USA, Japan, India, Brazil and China (World Resources Institute, 2019). Morocco's carbon emissions grew by 147% between 1990 and 2010, they also grew by 105% between 1990 and 2005 (World Bank, 2021). Thus, it will be more challenging for Morocco to consider a base year of 1990 or even 2005, compared to the current base year of 2010.

According to RES4MED (2018b), Morocco's Energy Strategy targets will lead to a 32% reduction in GHG emissions by 2030. This is less than that of the 42% NDC conditional scenario with AFOLU, even considering hypothetically that Morocco will be able to fully deliver on its targets. This means that the current strategy is not solely expected to reduce the energy-related emissions needed to meet its conditional scenario of NDC targets, either with or without AFOLU.

The Energy Strategy also does not stop the country from increasing its power from fossil fuel sources. It does not set a plan to phase out or decrease existing coal-fired power plants nor set up new plants. Coal is the country's main electricity source (65%), and responsible for one third of its CO_2 emissions.[65] Morocco has three coal-fired electric power stations, and controversially the country increased this capacity by almost 50% in 2018 with

[65] Coal is the single largest source of global energy-related CO_2 emissions. At a global scale, limiting emissions by accelerating renewable energy projects would be insufficient to meet climate change targets, if existing coal-fired power plants continue to operate.

the construction of 1,386 MW Safi coal power station (IEA, 2021). This is even though the Safi Power Plant is more efficient and less polluting the environment than previous ones due to the new technology used. Another 1.3 GW coal-fired power plant is expected to be operational in 2023/24. Moreover, in early 2020, ONEE also agreed to extend its power purchase agreement from a 2 GW coal power plant from 2027 to 2044 (Climate Action Tracker, 2021). This brings significant concerns about the country's ability to meet its emission targets. This is despite the fact that by 2040, coal-based electricity needs to be phased out globally to meet the Paris Agreement's commitments (Fyson, 2021).[66] For the MENA region, coal-based electricity needs to be reduced by 80% by 2030 compared to 2010 and phased out by 2034 (Climate Action Tracker, 2021).

This could be explained by that the growing needs for energy require resources more than the country's ability to generate electricity from only clean sources. As clarified by one interviewee, 'we need to be realistic … we are unable to generate all electricity needed from only renewable energy'. He added 'we are not a big carbon producer' (Interview 9). So, regardless of the related emissions Morocco seeks to increase its installed capacity to generate electricity from different possible sources, including coal power not only from renewables. This is because the country considers itself a low emitter and has margins to increase its emissions as stated by another interviewee (Interview 7). This is contrary to the country's commitment to reduce its emissions. Figure 28 demonstrates that oil and coal energy sources are responsible for the bulk of energy-related emissions in the country between 1992 and 2019.

[66] During COP26, more than 40 countries pledged to phase out coal (The New York Times, 2021).

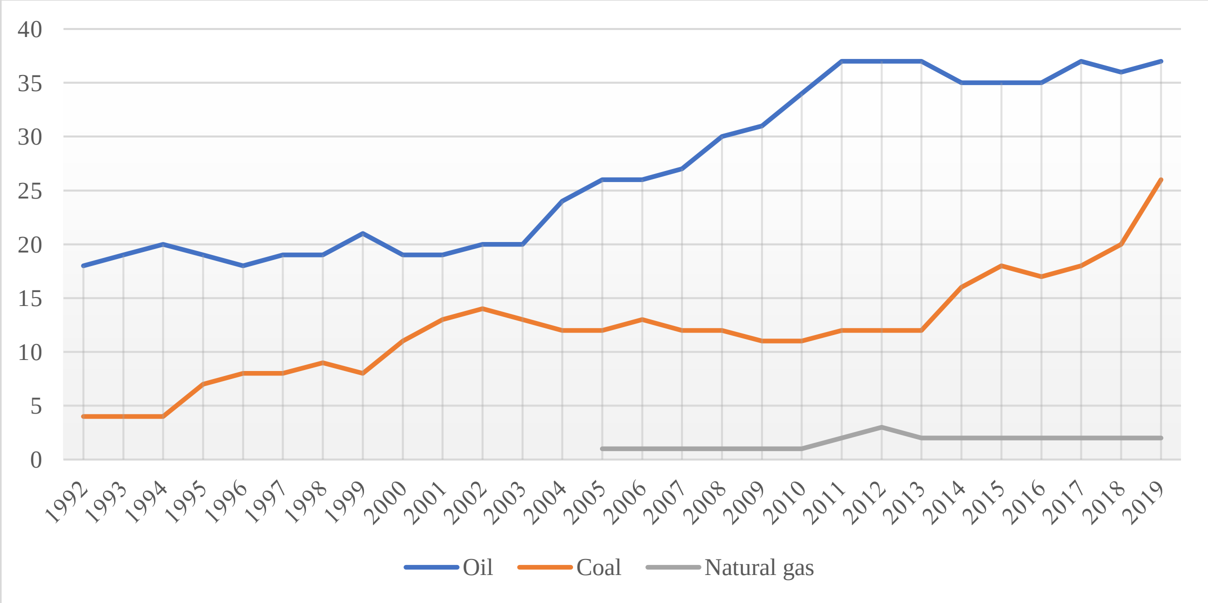

Figure 28: CO_2 emissions by energy source (MTCO2e) in Morocco between 1992–2019

Source: INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 25 December 2021]. Available from: https://www.iea.org/countries/morocco/

Furthermore, the Energy Strategy focuses on increasing renewable energy from solar and onshore wind. In addition, all wind power projects planned to achieve 2030 targets are only onshore, whereas offshore wind is missing from Morocco's strategy. Offshore wind potential in the country is ten times its onshore potential (El Hafidi, 2017) and is expanding rapidly worldwide as it has proven to be more efficient compared to onshore wind.[67]

The strategy also does not mention hydrogen as a source of energy, which could have an important role in the decarbonization of the economy, and therefore cut emissions.[68] Aurora Energy Research (2020) finds that globally, hydrogen could provide 50% of total final energy demand by 2050 in a high adoption scenario, and 25% if adoption is limited to hard to electrify sectors and heating applications (Gazis et al., 2020). Only recently, Morocco began to investigate becoming an important hydrogen exporter (Noussan et al., 2021). Also, one of the interviewees, the Renewable Energy and Energy Efficiency Engineer at MEME mentioned that there is some discussion around exploring the potential of using hydrogen in

[67] Offshore wind in UK is projected to contribute up to 30 GW of generating capacity by 2030. Scotland aims to deliver at least 8 GW of offshore wind in Scottish waters by 2030 (UK Government, 2020a).

[68] The UK government launched the Hydrogen Advisory Council in 2020 to accelerate the decarbonization of key sectors including industry, heat, flexible power and transport to meet net-zero targets by 2050 (UK Government, 2021b).

Morocco, but it is still at the very early stages (Interview 3). However, the science is still developing the use of hydrogen as an important source of commercially viable energy.[69]

On the other hand, we can look at CO_2 emissions not only from energy sources, but also emissions from different sectors including transport, industry, residential and heating. To this end, the strategy lacks objectives to decarbonize the economy and reduce the emissions from energy-intensive sectors which are responsible for most CO_2 emissions, as shown in Figure 29. The latest global approach to reduce emissions from an energy consumption side is electrification of the economy for transport, industry, heating and other sectors. This electricity needs to come from clean sources.

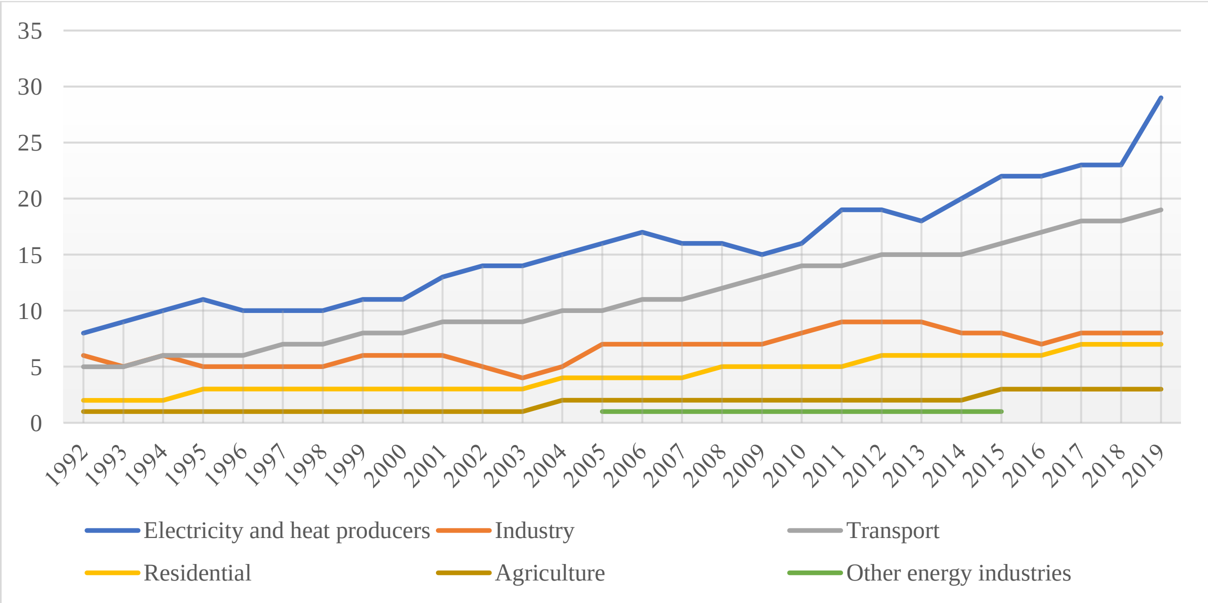

Figure 29: CO_2 emissions by sector (MTCO2) in Morocco between 1992–2019

Source: INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 25 December 2021]. Available from: https://www.iea.org/countries/morocco/

To this end, the strategy fails to consider increased electrification of the economy supplied from renewable energy sources. Electricity accounted only 17.2% of TFEC in 2019.

[69] Wouters (2017) reports that green hydrogen made from renewable electricity and water will play a crucial role in Europe's decarbonized future economy. Hydrogen can be produced in Morocco from sun, wind and water. A combination of solar and wind power can provide a high load factor for the electrolysis process, leading to the competitive cost of green hydrogen.

Whereas oil accounted 74.6% in the same year as shown in Figure 8 in Section 3.4 in Chapter Three.[70]

Hence, one could argue that by 2030 Morocco is planning to produce little of its total energy needs from renewable energy, even if the country will be able to reach its installed renewable energy targets as outlined in the Energy Strategy. Given the energy loss and intermittent nature of renewable energy, the actual electricity generated from renewable energy will be much less. This means that the strategy should have included targets not only to increase shares of renewable energy of installed electrical power, but also to increase the generated electricity as well as the electrification of the economy. In essence, the country needs to increase the renewable electricity share of its total energy consumption.

The strategy does not attempt to decarbonize the energy-intensive sectors, which are responsible for most CO_2 emissions. Figure 6 in Section 3.4 in Chapter Three presents the growth of TFEC by sector in Morocco since 1992. The Figure shows that transport, residential and industry sectors are the main energy users. They accounted for 81% of energy consumption and were responsible for 52% of emissions in 2019 as shown in Figure 30. Whereas electricity and heat were responsible for 44% of carbon emissions in the same year (IEA, 2021).

[70] Electricity accounted for 17% of final energy demand in UK in 2019. It is projected to provide more than half of final energy demand in 2050 (UK Government, 2020b). It is around 20% of TFEC in the UK, the USA and Germany in 2018. It is higher in France and Switzerland (25% and 28% respectively), and in Norway (50%) (IEA, 2021).

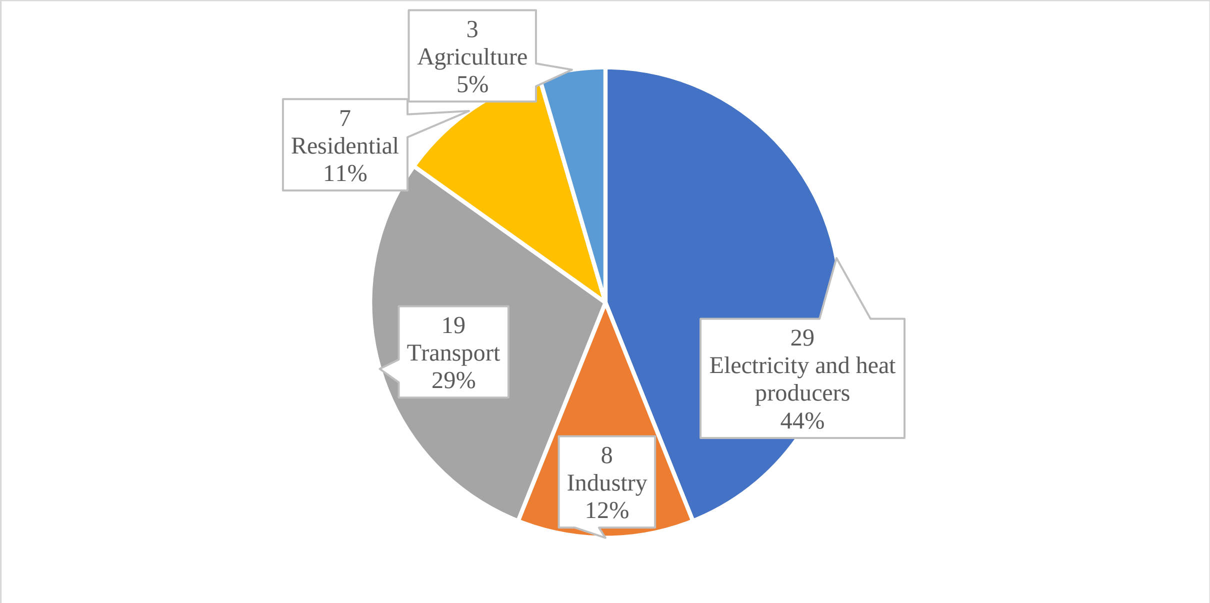

Figure 30: CO_2 emissions by sector (MTCO2) in Morocco in 2019

Source: Author's compilations based on: Source: INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 25 December 2021]. Available from: https://www.iea.org/countries/morocco/

Considering the details, the transport sector consumed 37% of TFEC (from oil products which accounted more than 99% in 2018) and was responsible for 29% of emissions in 2019 (IEA, 2021). Hence, electrifying the transport sector is key to cut a significant amount of its emissions (International Transport Forum, 2021). The main mitigation measures to reduce emissions in the transport sector in Morocco, as outlined in the National Plan Against Global Warming, focused on the improvement and renewal of fleets to be more energy efficient and also the use of more energy efficient fuels such as unleaded petrol (MEME, 2009). This fact was also agreed by one interviewee who added that energy efficiency efforts had gone into measures in the transport sector (Interview 7). Recently, Morocco has taken steps to encourage the uptake of electric vehicles (EVs). In December 2017 a protocol was signed to build an EV manufacturing plant close to Tangier (IEA, 2019). The country installed its first charging stations in 2018. However, there are no national targets for the development of electric mobility. The number of EVs in Morocco is low (Climate Action Tracker, 2021). In this regard, using hydrogen also has potential to decarbonize the transport sector, this is especially important for large vehicles such as buses and trains. Several countries have already started deploying hydrogen powered vehicles.[71] This is an important gap that needs to be addressed in Morocco to cut its carbon emissions substantially.[72]

Also, the strategy does not attempt to decarbonize industry. Industry is a large energy consumer and responsible for a significant share of emissions. In 2019, industry consumed 19.2% of TFEC and was responsible for 12% of emissions. CO_2 emissions from industry increased by around third between 1992 and 2019 (IEA, 2021). Morocco’s manufacturing sector grew steadily during the 2010s and it is expected to double between 2010 and 2022 (PwC, 2018). The Kingdom has a number of energy-intensive industries which are responsible for a large amount of emissions. The country is the second largest producer of phosphate in the world, with two thirds of global reserves. It contributes to 3% to 4% of its GDP and consumes 6% of its energy (The Africa Report, 2019). Cement is also an important sector in Morocco. In 2012, hydraulic cement production, which is the most common type of cement, reached 15,900 thousand metric tons, placing the country as the fourth largest producer in Africa. The large production of cement could be linked to major infrastructure projects, including highways, ports, airports, and railway, which caused increased energy demands as mentioned in Section 3.3 in Chapter Three.

The automotive industry is also growing fast. Vehicle production increased from 42.1 thousand units in 2010 to 345.1 thousand units in 2016, and is expected to grow by 17% until 2022 with the establishment of Renault, Hyundai and Ford. In addition, Morocco is an aircraft and aircraft equipment producer. The country’s aerospace exports have risen from $304 million to $676 million between 2010 and 2016, benefitting from the presence of global companies such as Bombardier, Boeing, Safran and Thales. Clothing and textiles is also an important sector. Its export generated $3.5 billion in 2016 (PwC, 2018).

Morocco has made some attempts to develop small-scale renewable energy projects (wind, solar and biomass) for certain industries, such as phosphate and cements, in addition to introducing energy efficiency measures and energy audits. But these are not sufficient to decarbonize the industry sector. Deployment of Carbon Capture, Utilisation and Storage (CCUS) and hydrogen could provide an important opportunity to cut emissions in high energy consumer industrial zones. This will require building additional infrastructure to transport captured carbon from industrial processes. However, the technology is not mature enough and not widely common yet.

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[71] A fleet of 15 zero-emission hydrogen-powered double-decker buses has been deployed in Aberdeen in Autumn 2020.

[72] The UK has announced it will end selling new petrol and diesel cars by 2030 and new hybrid cars by 2035.

Regarding the residential sector, energy consumption has increased constantly since 1992, accounting for 25% of TFEC and was responsible for 11% of CO_2 emissions in 2019 (IEA, 2021). Oil, mostly liquefied petroleum gas (or butane as a form of LPG), is the dominant fuel with 63% of total consumption in the sector as of 2018, followed by electricity (23%) and biofuels (14%).[73] From 2007 to 2017, LPG consumption increased by 50% and electricity consumption rose by 67%, replacing solid biofuels that were major sources for cooking and heating. The consumption of traditional forms of biomass (wood and charcoal) decreased by 43% in the residential sector over the same period. This reflects the efforts made by the Moroccan government to promote alternatives to biomass to prevent the deforestation and health problems associated with their use, including chronic respiratory diseases (IEA, 2019). Therefore, to reduce emissions from the residential sector in Morocco, it is important to replace gas with electricity powered by clean energy sources. This will also help the country further remove butane subsidies.

Although the Energy Strategy is aimed at increasing energy efficiency in buildings which will reduce indirect emissions through decreasing energy use, it does not mention increasing clean energy in the residential sector to reduce its emissions. Given the weather temperatures in Morocco, a mix of cost-effective technologies could be considered. For example, widespread deployment of reversible electric heat pumps that are able to cool in summer and heat in winter (Iberdrola, 2021), as well as district heating from low-carbon sources, could help cut emissions from the residential sector significantly. This will also need additional efforts to decentralise its electricity system to a great extent.

Accordingly, Morocco needs to revise its Energy Strategy and its related targets in order to achieve green transition. First, the country's NDC targets are insufficient to reduce emissions below the 2010 base year. Second, the strategy failed to include targets to increase the electrification of its economy and the decarbonization of its key energy-intensive sectors which are responsible for the majority of carbon emissions. These sectors include transportation, heating, building, industry. Lastly, the current targets to generate renewable electricity are not sufficient to help the country cut its energy-related emissions enough to meet its green agenda.

In order to enable the country to deliver these changes, radical transformation of the economy is expected on new ways to power the economy including increased electrification of the economy, introduction of hydrogen, decentralization of the electricity system and

[73] Liquefied Petroleum Gas (LPG), which is still subsidized, is main energy source used for cooking as more than a 90% of the population cooked with LPG in 2018 (IEA, 2020).

related reforms and financial and technical resources. Systematic change in the economy is expected to embrace recent technologies such as EVs, reversible electric heat pumps, district heating, and green hydrogen. Identifying the technical and financial resources and appropriate mix of technologies that are needed to enable this transition towards green economy in Morocco is not the purpose of this thesis.

Importantly, this transformation of the economy could be plausible in the short run. For example, the construction phase of large-scale offshore wind energy projects is expected to create a significant number of jobs across the supply chain and contribute to economic development in the country. Also a decentralized electricity system and introduction of EVs is practically becoming more achievable in the short run, thanks to the support of technological advances. Much of the activity needed to decarbonize the economy is labour intensive. Significant investment will be required in key areas such as energy retrofit. This provides major opportunities for economic growth and job creation.[74]

5.6. Conclusion

This chapter has provided a critical analysis of Morocco’s energy transition to renewable energy which was designed to be its main route to a green economy in order to help the country overcome its development challenges and deliver its green agenda. Morocco launched its Energy Strategy in 2009 setting targets on renewable energy and energy efficiency towards 2020 and 2030 with particular focus on solar and wind power. This strategy was considered a developmental milestone for Morocco and the country intended to achieve wide socioeconomic and environmental benefits from the delivery of the strategy, including diversification of its energy sources from renewable sources, promotion of energy efficiency, decrease of its energy dependency on foreign countries, job creation, economic growth, and environmental protection by reducing the emissions. The strategy was followed by important legal and institutional reforms to support the delivery of renewable energy projects. Nevertheless, many policy, technical, economic, environmental and social challenges are associated with the delivery of the strategy.

As a result, although Morocco has achieved some progress in terms of increases in solar and wind energy generation, the country has not reached its 2020 targets due to project delays. However, even if Morocco would have completely achieved its Energy Strategy targets by 2020 and 2030, due to important weaknesses in its approach it is not expected that

[74] Glasgow City Region has developed a strategy to be a net-zero region by 2030. The net-zero plan is largely reliant on energy retrofit and supporting its supply chain, decarbonization of transport system and a regional approach to EV charging, and the decentralization of electricity (Glasgow City Region, 2021).

the country will be able to reduce its emissions according to its NDC targets. This is even though its NDC consider 2010 as a base year, which is less challenging than 1990 or 2005. Morocco's model was built on increasing renewable electricity in its current electricity system which accounts for small share of its TFEC (17.2% in 2019). Therefore, it appears that the current Energy Strategy only attempts to meet a small share of total energy needs from renewable electricity.

Increasing the electrification of the economy, on one hand, and the decarbonization of key sectors which are responsible for large share of carbon emissions, on the other hand, are missing from its energy transition. In particular, the strategy fails to set targets to decarbonize the transport, heating, residential and industry sectors, which are largely powered by fossil fuels, through an increased electrification of these sectors. In addition, Morocco's energy transition does not consider the decentralization of the electricity system which could help overcome some technical challenges. Also, hydrogen and offshore wind power are missing from current renewable energy projects which could meet a significant share of the country's energy needs. Addressing these weaknesses in the Energy Strategy is essential for the country to significantly reduce its emissions, although the country seems to have been able to absolutely-decouple its economic growth from carbon emissions as shown in Chapter Four.

To this end, this chapter discussed some empirical contributions in relation to energy transition in Morocco from energy supply and energy consumption perspectives. Effective energy transition that is required to reduce emissions in Morocco needs to be built on increasing electrification of the economy, accelerating the delivery of renewable energy projects including offshore wind, phasing out coal-fired electricity generation, decentralizing the electricity system and introducing hydrogen. This fact was highlighted by the interviews and further supported by data in the policy gap section.

After this review, it is hard to say that a green economy in Morocco is achievable as business as usual. Radical transformation of the economy across various sectors is expected to help the country meet its green agenda and achieve a required transition to the green economy. Importantly, this economic transformation could be plausible in the short run. This analysis supports the argument that a green economy requires radical economic transformation. However, it appears that Morocco's model does not follow this approach.

In summary, the green economy model in Morocco is insufficient to deliver its green ambitions in terms of keeping the economy growing while reducing its emissions according to its NDC. Also, its model was designed to be delivered as business as usual without a radical change of its economy. These findings support the view of Richardson (2013), Mundaca (2016) and Paterson (2021) that the decarbonization of economies requires dramatic change. This also aligns with the claim of Barua and Khataniar (2016) and Loiseau et al. (2016) that transition to a green economy urges countries to follow a path of strong sustainability to deal with concerns about climate change issues.

Accordingly, this chapter answers the research questions on the possibility of the green economy of Morocco and also the expected level of transformation of the economy needed. The success of Morocco’s transition to the green economy requires effective management and monitoring from the government. This necessitates the development of a measurement framework that suits Morocco. The next chapter addresses this issue and develops a customised framework to measure the country’s progress towards green economy considering the discussion in this chapter.

Chapter Six

Morocco’s green economy measurement framework

6.1. Introduction

Chapter Five examined the energy transition in Morocco which is its main route to a green economy. The chapter concluded that Morocco's green economy model is insufficient to help the county meet its green commitments due to major drawbacks in its approach. However, it appears that the country has realized some benefits from its transition. It has been argued that a green economy provides short-term benefits to economies, as discussed in Section 2.3.3 in Chapter Two. This transition needs to be measured in order to be effectively delivered and value assessed. This requires the development of a measurement framework that suits Morocco's green economy transition and its particular green agenda. Therefore, this chapter tries to answer the research question regarding monitoring the benefits and progress Morocco has aimed to achieve through its green transition.

Although many benefits of Morocco's progress have been discussed in the previous chapter, this chapter systematically arranges the benefits in an integrated framework to evaluate the country's overall progress in achieving its green agenda, particularly after the introduction of the 2009 Energy Strategy which is considered to be the cornerstone of its green transition. Also 2010 is the base year of Morocco's NDC targets. A review of the literature confirms the need to develop a measurement framework to track the progress of a green economy (Barr, 2013). Nahman et al. (2016) argue that although there are attempts to adjust the GDP or to develop indicators to supplement or even replace it, none of these indicators, on their own, are sufficiently comprehensive to reflect the objectives of a green economy. In addition, there is a global interest in measuring green economy progress and identifying its indicators in order to maintain interest and guide economies to accelerate their green transition. The Rio+20 Conference asserted that new measures and metrics on green economy are needed (UNEP, 2012).

The OECD (2011) suggests three selection criteria for the development of green economy indicators: policy relevance, analytical soundness and measurability. Also, Schomaker (1997) and Kim (2014) emphasise that the selected indicators should be 'SMART': specific, measurable, achievable, relevant, and time-bound. Green economy metrics could be either comprised of a composite index or a dashboard set of indicators. The single index mode summarises complex issues and provides a big picture in a simple way, as well as help rank countries on these issues. Therefore, this single index method attracts public opinion and governments as they anticipate it would aid in the comparison of countries' relative performance on green economy progress. However, the single index may be misleading if poorly constructed or misinterpreted. Also, a composite index increases the data quantity needed for all the sub-indicators involved, resulting in a statistically significant analysis (Saltelli, 2007). Yet, the process of combining different data into a single numerical value to guide interpretation is a complicated exercise (Chen et al., 2011). Therefore, measuring the green economy through a set of indicators has an advantage over a single index.

A number of green economy measurement frameworks have been developed by international organizations, private institutions and scholars, in order to track countries' progress on green economy. These include the UNEP, the OECD, and the Green Growth Knowledge Platform who suggest dashboard set of indicators. Whereas others, such as the Global Green Growth Institute, Dual Citizen,[75] Barr (2013) and Nahman et al. (2016) propose the use of a single index. All the above approaches have been adopted based on different agendas and objectives for promoting a green economy. The appropriateness and suitability of a particular tool requires a good understanding of the determinants of a green economy in a given country, so that frameworks may vary depending on the particular conditions of each economy. In other words, there is no single green economy model that suits all countries. A green economy model needs to be tailored to country-specific circumstances as shown in Chapter One, Section 1.3. To this end, the Rio+20 Conference concluded that green growth is best defined and tailored according to an individual country's context (UNEP, 2012). Therefore, I argue that none of the established tools suits the model of Morocco and its motivations to pursue a green economy agenda.

Although international institutions' measurement frameworks would be useful to understand the global relative performance and positions of different countries, a country-specific tool would be more appropriate to identify the progress of each county considering its own circumstances and priorities. Also, international institutions generally do not require the consent of countries to be listed in their indexes, thus countries cannot argue about the appropriateness of the developed models used. The purpose of measurement framework I propose for Morocco is not meant to replace these existing frameworks, but to provide a more focused tool. Given the aim of this thesis in examining the green economy of Morocco, this chapter does not try to construct a single green economy index or a framework that could be used to compare the relative performance of different global economies. The aim of this chapter is to attempt to develop a customised measurement framework and to identify a key set of indicators that reflect Morocco's green economy model and its green priorities. This

[75] A private US-based consultancy (Dual Citizen, 2018).

framework may help track the progress of greening in Morocco's economy over time and assist the country to identify the gaps in its green transition.

In addition, this chapter is not intended to survey existing green economy measurement frameworks. However, as part of the process of creating a new measurement tool, this chapter reviews examples of existing models developed by a number of international institutions and scholars, identifies their main limitations and suitability to Morocco, and proposes a green economy measurement framework that better suits Morocco based on its current conditions and green priorities. Appendix D summarises the proposed model for Morocco, including the value and data sources of its indicators between two periods after the introduction of the 2009 Energy Strategy. This also considers 2010 NDC base year. Appendix E reviews the studied frameworks that have already been developed by a number of institutions and scholars.

Consequently, this chapter addresses the methodological issues related to developing a customised analysis framework for green economy transition in Morocco. This framework takes into consideration the development challenges and green ambitions of Morocco as well as related literature on measuring green economy. This chapter starts by reviewing a number of existing measurement frameworks in order to evaluate their suitability to Morocco's development challenges and green ambitions. This helps develop a customised measurement framework that better suits the current circumstances and priorities of Morocco in Section 6.3.

6.2. Existing frameworks

This section analyses a number of existing measurement frameworks developed by various international institutions and scholars concerned about the green economy agenda. These include the UNEP, the OECD, the Global Green Growth Institute, the Green Growth Knowledge Platform, Dual Citizen, Barr (2013) and Nahman et al. (2016). Table 19 compares the green economy frameworks of these institutions and scholars, and presents their main limitations in relation to Morocco's green economy model.

6.2.1. UNEP Framework

The UNEP has developed a manual outlining the selection criteria of green economy indicators. These criteria are: issue identification and agenda setting, policy formulation and assessment, and monitoring and evaluation (Bassi and Sheng, 2012). Based on these criteria, the UNEP suggests dashboard sets of indicators within five sets of frameworks which take into account different national circumstances, capacities and levels of development. These frameworks include land-locked dry and sub-humid country with dominant agriculture and in early phases of demographic transition and urbanization; tropical or sub-tropical small island developing states with dominant industries of tourism and fisheries; low-lying coastal middle income countries with rapid industrialization and urbanization, and relatively advanced demographic transition; mountainous coastal countries with mining, agriculture and fisheries; and developed countries with limited natural resources but the high potential and financial resources for efficiency improvement (UNEP, 2014).

It can be seen that the UNEP framework is issue-driven and may vary from country to country, taking into consideration the conditions of different economies. However, none of them fits the case of Morocco to a great extent. Perhaps the framework for a low-lying coastal middle-income country with rapid industrialization and urbanization appears to be the closest to Moroccan conditions, as presented in Table E.1 in Appendix E. This framework includes important indicators to Morocco on, for example, fossil fuel, carbon emissions and energy efficiency. But the framework also includes some general indicators on population and urbanization, manufacturing value added, and manufacturing GDP, which are not particularly a measure of green economy transition in Morocco. Also the framework does not include any indicator for renewable energy.

Instead, Morocco's transition is mainly built on the acceleration of renewable energy and its framework should consider the decarbonization of its key sectors. These areas are missing in all existing UNEP frameworks. In addition, Morocco has its own unique features and circumstances which are not even similar to any other northern African countries, such as lack of oil and gas resources. Hence, the UNEP framework does not suit the conditions of Morocco.

6.2.2. OECD Framework

The OECD identified a set of indicators to capture the main features of green growth and to monitor green progress based on the following definition of green growth:

> Green growth is about fostering economic growth and development while ensuring that the natural assets continue to provide the resources and the environmental services on which our well-being relies. To achieve this, it must catalyse investment and innovation which will underpin sustained growth and give rise to new economic opportunities (OECD, 2011, p.17).

According to this definition, the OECD developed its framework of 26 indicators covering four main areas: the environmental and resource productivity of the economy; the natural asset base; the environmental dimension of quality of life; and economic opportunities and policy responses, in addition to socioeconomic aspects (OECD, 2017). In this framework, OECD combines the main features of the green economy with the basic principles of accounting and the Pressure-state-response (PSR) model which is used in environmental reporting and assessment.[76] Some indicators of the framework are derived from the UN's System of Environmental-Economic Accounting (SEEA) central framework.[77] The framework also considers some SDGs (OECD, 2016).

Table E.2 in Appendix E reviews the OECD Framework. The framework includes proxy indicators for some aspects such as most biodiversity and ecosystems indicators. Also, the OECD indicates that some indicators are not currently measured, and the quality of some other indicators on environmental health and risks need to be improved. Yet, the OECD's framework has been used by various countries and been adjusted to their specific national contexts to analyse the implementation of green growth policies. These include the Slovak Republic (Guštafíková, 2014), Slovenia (Žitnik et al., 2014), the Czech Republic (Hájek et al., 2014), Denmark (OECD, 2012), Korea (Lee et al., 2012), the Netherlands (Statistics Netherlands, 2013) and Germany (Federal Statistical Office of Germany, 2012). Therefore, compared with the UNEP, the OECD's approach has been broadly used by governments to monitor their progress towards a green economy.

The framework covers several key areas of Morocco's green economy, such as CO_2, energy productivity and renewable energy in TPES. Nonetheless, this framework neglects important indicators on green economy transition in Morocco such as the decarbonization of transport and building. It also does not measure CO_2 emissions from most polluting sectors, or the level of fossil fuel energy sources. In addition, the model does not aim to capture the progress made on renewable energy in various sectors. Accordingly, the OECD's framework is impractical to measure green economy transition in Morocco.

6.2.3. Global Green Growth Institute's Green Growth Index

The Global Green Growth Institute (GGGI) has developed Green Growth Index since 2019. It is a composite index ranging between 0–100 (best) and measuring a country's performance in achieving sustainability targets, including SDGs, the Paris Agreement, and Aichi

[76] A PSR framework is proposed for environmental indicators and indicators of sustainable development (OECD, 2003).
[77] The SEEA Central Framework is an international statistical standard for measuring the environment and its relationship with the economy. The Central Framework measures three main areas: environmental flows, stocks of environmental assets, and economic activity related to the environment (UN, 2017).

Biodiversity Targets.[78] The index captures four green growth dimensions: efficient and sustainable resource use, natural capital protection, green economic opportunities, and social inclusion. Indicators are selected based on data relevance to green growth dimensions, the availability of time-series data, accessibility of the data, availability for a large group of countries, and data source credibility. All data are collected mainly from published online sources of international institutions' databases. However, the index does not capture fossil fuel energy consumption, in absolute or relative figures. Nevertheless, reducing reliance on fossil fuel energy is important to deliver a green economy.

The index covers 117 countries in its latest edition (Acosta et al., 2020). Based on its recent results, Morocco has improved from 45.02 to 51.52 between 2005 and 2019 as illustrated in Figure 31.

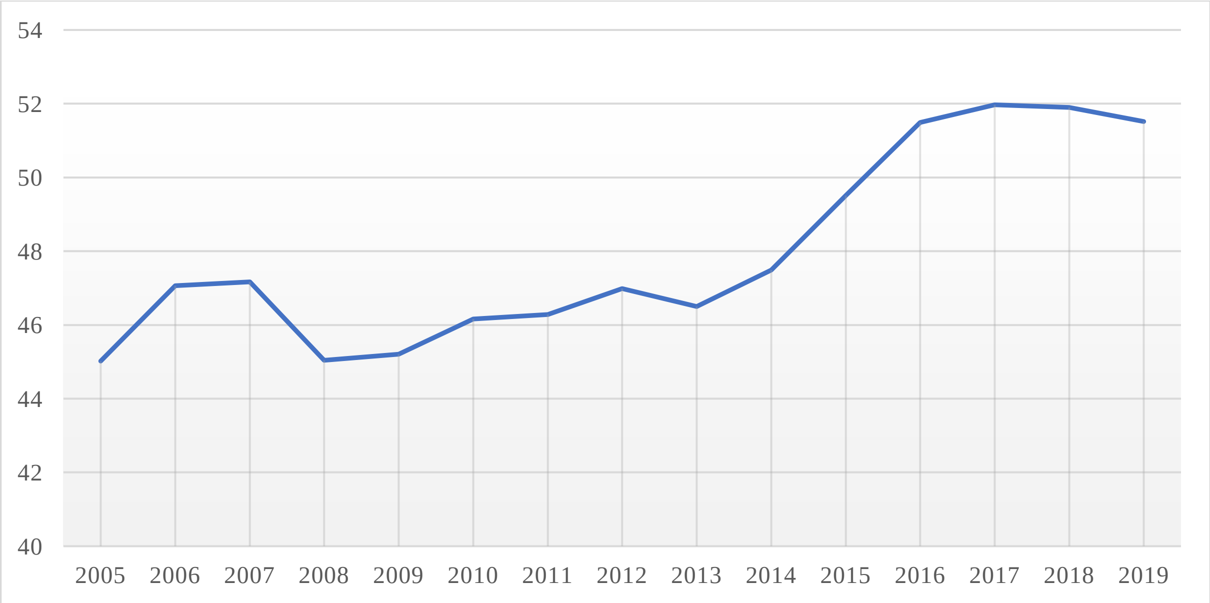

Figure 31: Morocco's performance in the Green Growth Index between 2005–2019

Source: ACOSTA, L.A., ZABROCKI, S., EUGENIO, J.R., SABADO Jr, R., GERRARD, S.P., NAZARETH, M. and LUCHTENBELT, H.G.H., 2020. *Green Growth Index 2020 -Measuring Performance in Achieving SDG Targets*. Seoul: Global Green Growth Institute.

[78] Aichi Biodiversity Targets are a set of 20 global targets under the Strategic Plan for Biodiversity 2011–2020. They are grouped under five strategic goals: addressing the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society; reducing the direct pressures on biodiversity and promote sustainable use; improving the status of biodiversity by safeguarding ecosystems, species and genetic diversity; enhancing the benefits to all from biodiversity and ecosystem services; and enhancing implementation through participatory planning, knowledge management and capacity building (Convention on Biological Diversity, 2021).

Accordingly, Morocco ranked second in Africa, behind Tanzania and ahead of Tunisia and South Africa. The index shows that Morocco's main strengths are social equity, material use efficiency, and GHG emission reductions; while the country's main weaknesses are more evident in green trade and green employment. Details of this framework are included in Table E.3 in Appendix E.

As the index was developed to benchmark the relative performance of different economies on green agenda, the index does not consider the specific conditions of each economy. Hence the GGGI Index is only useful to compare economies' progress on global sustainability targets. Moreover, the index does not measure progress on energy transition to renewable energy, including fossil fuel level, or the decarbonization of key economic sectors. In addition, there is a data gap for Morocco in two social inclusion indicators which accounts for 6% of the index. These are 'share of youth (aged 15–24 years) not in education, employment or training'; and 'proportion of population above statutory pensionable age receiving a pension'. However, these are not core issues for green economy transition in Morocco. Therefore, the GGGI's Index is impractical to measure Morocco's progress on green economy.

6.2.4. Green Growth Knowledge Platform Framework

The Green Growth Knowledge Platform (GGKP) is a global partnership established in 2012 between the UNEP, the OECD, the World Bank and the GGGI. GGKP framework was developed to measure the progress on green growth. The framework covers five areas: (i) natural assets underpinning economic activities, (ii) natural resource efficiency and absolute-decoupling from economic growth, (iii) socioeconomic resilience to ecological risks, (iv) economic opportunities and efforts related to environmental policies, and (v) inclusiveness of environmental policies (Narloch et al., 2016).

The first pillar, natural assets, relates to the natural resources used to generate economic growth and ecosystem services that support economic activities. This theme involves issues related to land and soil, forest and timber, water, minerals and energy resources, fish stocks, and air and climate. Example indicators measure the total available biophysical stock of natural assets and changes over time, their quality and economic values, risks related to depletion or scarcity, or threshold limits such as planetary boundaries. Second, the resource efficiency and decoupling pillar measures the extent of economic outputs which are efficiently produced and consumed. Efficiency indicators focus on the productivity and efficiency of natural resources, including land, water and energy. They also cover waste, recycling and renewables. Third, the risks and resilience pillar relates to how resilient the economic growth process is to ecological shocks and risks. Suggested indicators cover climate change and disaster risk impacts, exposure and vulnerability to risks, and government action and the capacity to manage disaster risks. Fourth, economic opportunities and efforts relate to the adoption and implementation of policies, enabling transformation towards inclusive green growth, and tracking the transformation itself. Proposed indicators measure areas on environmental regulation and taxes, green investments and jobs, R&D expenditure and green patents. Finally, inclusiveness relates to the social aspects of green growth, measuring how the costs and benefits of environmental policies are distributed among different groups. Suggested indicators include access to environmental goods and services, participation in environmental decision-making and distributional impacts of environmental policies (Narloch et al., 2016). Details on this framework are included in Table E.4 in Appendix E.

It can be seen that this framework captures some priority areas for Morocco's transition into a green economy such as CO_2 emissions, energy efficiency, renewable energy, and fossil fuel subsidies. However, the framework does not measure core aspects of Morocco's green economy in relation to the electrification and decarbonization of its key economic sectors for instance. The framework fails to consider fossil fuel energy consumption and related socioeconomic indicators, such as energy dependency and a reduction in electricity prices. Therefore, the framework does not appear to be appropriate to measure Morocco's progress on its green economy.

6.2.5. Dual Citizen's Global Green Economy Index

Dual Citizen (2018) developed the Global Green Economy Index (GGEI) since 2010 as a first attempt to construct a composite index for green economy. The value of the index ranges between 0–1 (best). The GGEI has been developed to measure how well each country performs on four equally-weighted elements of a green economy: leadership and climate change, efficiency sectors, markets and investment, and the environment. These areas are measured by 20 quantitative and qualitative indicators, presented in Table E.5 in Appendix E. They benchmark the performance of 130 countries in its latest edition including Morocco which has been listed since 2014.[79] In the 2018 report, Morocco ranked 48th, and scored 0.51 ahead of all MENA countries listed in the report.

The GGEI is designed to benchmark many global economies rather than taking into consideration the conditions of each economy. Some indicators are qualitative and calculated

[79] Full details of the 2018 indicators are unavailable, so the discussion will focus on the 2016 edition. However, there are no major changes between two indexes.

based on a perception survey. This raises concerns on the objectivity of these qualitative indicators. They may be subjective and not accurately reflect the progress on green economy in a given economy. They may vary from person to person, such as the indicator on ‘media coverage of green economy’. In addition, several indictors, on the tourism sector for instance, are not considered in Morocco’s energy transition. Even though the framework includes a number of key green indicators on emissions, renewable electricity and energy efficiency, nevertheless the framework is silent on the important issues of the electrification and decarbonization of key economic sectors such as transport, and heating and cooling. Thus, the Dual Citizen’s GGEI does not suitably measure green economy progress in Morocco.

6.2.6. Barr’s Framework

Barr (2013) suggests a number of green growth indicators to measure global progress towards greening economies. The framework covers three dimensions: economic inclusiveness, the greenness of the economy, and the green economy as the engine of growth. Based on these elements, the suggested indicators cover areas such as income per capita, health and well-being, equity, productive employment, natural resource productivity and efficiency, ecosystem health and resilience, green jobs, green technology and innovation, and the resilience of local and national economies. These indicators are listed in Table E.6 in Appendix E.

Barr’s suggested indicators capture some of Morocco’s key issues such as energy, water, carbon and fossil fuel subsidies. However, there is no emphasis placed on renewable energy which is a main path of green economy transition in Morocco. Also, the set of indicators does not include metrics on CO_2 emission reductions, either in absolute or relative figures, which is one of the main goals of the country in pursuing a green agenda. Some indicators are not available in Morocco such as ‘R&D expenditure of importance to green growth’. Whereas other indicators are already achieved to a great extent like ‘access to electricity’, as a result of Morocco’s rural electrification programme. The suggested socioeconomic indicators include metrics not particularly assessing the level of greening the economy, such as GDP growth, market regulation, income inequality, literacy rate, school enrolment, and access to sanitation and health. Nevertheless, these metrics are more relevant to SDGs. Thus, Barr’s framework is unsuitable for Morocco to measure its progress towards a green economy.

6.2.7. Nahman et al.'s Framework

Based on 11 UNDESA green economy principles,[80] Nahman et al. (2016) have built a composite index consisting of 26 indicators covering nine green economy principles. The framework measures areas not included in UNDESA principles such as green investments, green innovation, low-carbon, and emissions and zero waste. The criteria used in the selection of indicators followed the OECD method: policy relevance, analytical and validity, and measurability. Nahman et al. consider sustainable development pillars in the framework and exclude indicators that are highly country-specific and not relevant to all countries such as forestry, fisheries and mining sectors. The framework also excludes indicators that are not measured by all countries. Table E.7 in Appendix E lists the proposed indicators.

This framework captures important areas of Morocco's green economy transition such as fossil fuel subsidies, renewable energy consumption, energy efficiency and emissions. Nevertheless, the framework also measures general issues which are not particularly related to green economy transition in Morocco. For example, the framework includes indicators on good governance and organic agriculture which are not priority areas in Morocco's green economy model. In addition, the framework fails to capture some other important aspects on the decarbonization of transport, building and industry sectors, for instance. These areas are essential for green economy transition in Morocco. Furthermore, the framework was developed to benchmark global economies' progress on green economy and does not take into consideration the different stages of countries' development. Hence, Nahman et al.'s framework is not helpful to measure green economy transition in Morocco.

[80] UNDESA's principles have been identified from a review of eight publications prepared by the Green Economy Coalition, Stakeholder Forum, ICC, ITUC, ANPED, The Danish 92 Group, UNEMG, and Global Sustainability Panel. These principles include: 1) the green economy is a means for achieving sustainable development; 2) the green economy measures progress beyond GDP using appropriate indicators; 3) the green economy respects planetary boundaries or ecological limits or scarcity; 4) the green economy uses integrated decision making; 5) the green economy should create decent work and green jobs; 6) the green economy is resource and energy efficient; 7) the green economy is equitable, fair and just – between and within countries and between generations; 8) the green economy protects biodiversity and ecosystems; 9) the green economy delivers poverty reduction, well-being, livelihoods, social protection and access to essential services; 10) the green economy improves governance and the rule of law. It is inclusive; democratic; participatory; accountable; transparent; and stable; 11) the green economy internalises externalities (Allen, 2012).

Table 19: Comparison between various green economy frameworks

Framework	Type	Description	Main limitations
UNEP Framework	Dashboard set of indicators	Five different frameworks considering the conditions of countries. Includes a number of key indicators relevant to Morocco such as fossil fuel reserves, carbon emissions, energy efficiency.	The model measures general issues which are not necessarily related to green economy transition in Morocco. The framework does not capture a number of important areas of green economy transition in Morocco such as the decarbonization of key sectors and electrification of the economy.
OECD Framework	Dashboard set of indicators	Twenty-six indicators covering four main areas: the environmental and resource productivity of the economy; the natural asset base; the environmental dimension of quality of life; and economic opportunities and policy responses, in addition to socioeconomic aspects. Covers a number of key areas relevant to Morocco such as CO_2 productivity, energy productivity and renewable energy.	The framework does not measure key areas of green economy transition in Morocco such as the decarbonization of key sectors, renewable energy consumption in main sectors, CO_2 emissions from different sectors.
Global Green Growth Institute Framework	Composite index ranging between 0–100 (best) and benchmarking 117 countries, including Morocco	Measures countries' performance in achieving sustainability targets including SDGs, the Paris Agreement, and Aichi Biodiversity Targets. The index captures four green growth dimensions: efficient and sustainable resource use, natural capital protection, green economic opportunities, and social inclusion.	The index does not measure important elements of green economy in Morocco such as energy transition or the decarbonization of key economic sectors. Some data are not available for Morocco.
Green Growth Knowledge Platform Framework	Dashboard set of indicators	The framework covers five areas: natural assets; natural resource efficiency and absolute-decoupling from economic growth, socioeconomic resilience to ecological risks, economic opportunities and efforts related to environmental policies, and	The framework does not measure core aspects of green economy transition in Morocco such as the electrification and decarbonization of key economic sectors as well as fossil fuel energy consumption and related socioeconomic indicators.

Framework	Type	Description	Main limitations
		inclusiveness of environmental policies. Measures several priority areas for Morocco’s transition into green economy such as CO_2 emissions, energy efficiency, renewable energy, and fossil fuel subsidies.	
Dual Citizen Framework	Composite index ranging between 0–1 (best) benchmarking 130 countries, including Morocco	Measures how well economies perform on four elements of green economy: leadership and climate change, efficiency sectors, markets and investment and the environment. The framework captures 20 quantitative and qualitative indicators.	Some indicators are qualitative based on a perception survey which may be subjective. The framework does not include important indicators of green economy in Morocco such as the electrification and decarbonization of key economic sectors.
Barr's Framework	Composite index	The framework captures three dimensions: economic inclusiveness, the greenness of the economy, and the green economy as the engine of growth. The indicators cover income per capita, health and wellbeing, equity, productive employment, natural resource productivity and efficiency, ecosystem health and resilience, green jobs, green technology and innovation, and the resilience of local and national economies.	A number of indicators are already achieved to a great extent in Morocco like access to electricity. No emphasis on renewable energy and CO_2 emissions. The socioeconomic indicators are not particularly designed to measure the main objectives of green economy transition in Morocco. Some indicators are not available for Morocco.
Nahman et al.’s Framework	Composite index	Mainly based on 11 UNDESA principles on green economy. Twenty-six indicators covering nine green economy principles. The framework captures important areas of Morocco’s green economy transition such as fossil fuel subsidies, renewable energy consumption, energy efficiency and emissions.	The framework excludes indicators that are highly country-specific and not relevant to or measured by all countries. The framework measures general issues which are not priority areas on green economy transition in Morocco. The framework does not measure important elements of green economy in Morocco such as the electrification and decarbonization of key economic sectors.

6.3. Proposed framework

This section outlines the considerations of the framework I am proposing that better suits Morocco's green economy model. This section will translate these considerations into detailed indictors used to measure the progress of the country's green economy transition. It can be seen that the discussed models above do not appear suitable to monitor green economy transition in Morocco. The main limitations of the models are that they are mostly designed to be used at the global level rather than considering the conditions of national economies. They also fail to capture many key areas of green transition in Morocco. Its transition was mainly designed to reduce carbon emissions, to increase its installed capacity of renewable electricity, and also to achieve wide environmental socioeconomic benefits.

The interviews I have conducted highlighted major drawbacks of green economy model of Morocco that needs to be addressed to accelerate green transition in the country. These include increase in electrification of the economy, and also reduction of emissions from key sectors that are responsible for the large share of emissions. These aspects need to be considered in the proposed framework for Morocco.

Some of the existing tools were proposed some time before recent developments of decarbonization of economies. In fact, an increasing number of countries have set their own net-zero targets and developed strategies to be carbon neutral by 2050. For example, it is now possible to consider the decarbonization of transport sector supported by developments in the automobile industry. Many governments have already implemented policies to encourage EV uptake such as the UK, Germany and Norway.[81] Therefore recent global practice needs to be considered in green economy measurement framework.

Given the consequences of climate change and energy challenges in Morocco as presented in Chapter Three, the country's green economy approach mainly focuses on energy transition to renewable energy to overcome its development challenges and deliver its green agenda. Chapter Five outlined the main opportunities of green economy transition in Morocco and identified the policy gap in its model that is required to be addressed in order to help the country deliver its green ambitions and global commitments according to its NDC. Therefore, the proposed measurement tool needs to consider these ambitions and commitments and suggest relevant indictors to help monitor the country's progress.

[81] UK government have set net-zero targets by 2050, whereas Scotland's targets are set for 2045 with interim targets requiring a 75% reduction by 2030, and a 90% by 2040. Moreover, the UK government has committed to phase out the sale of new petrol and diesel cars and vans by 2030. Interestingly, electric cars uptake has risen to record 54% of market share in Norway in January 2021.

The framework I propose in this thesis follows the OECD criteria in development of green economy indicators on policy relevance, analytical soundness and measurability. Also, the indicators are also selected to be 'SMART': specific, measurable, achievable, relevant, and time-bound (Schomaker, 1997; Kim, 2014). This is important to ensure usefulness of the framework to advise Morocco on the progress of its green economy transition and address the gap in its current progress.

The proposed framework is divided into six pillars that capture the main aspects of Morocco's green economy model. These pillars are emissions, fossil fuel energy supply, renewable energy and electrification, energy efficiency, socioeconomic indicators, and biodiversity and ecosystem indicators, as illustrated in Figure 32. Each pillar includes a number of indicators that capture its main dimensions. As discussed in Section 6.2, these dimensions are not appropriately captured by the studied tools above in a way that suits Morocco's model.

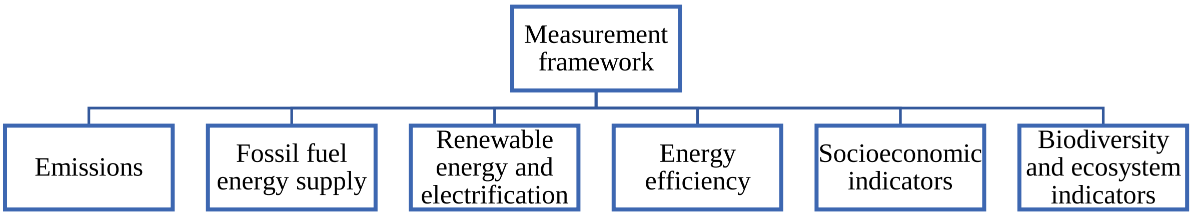

Figure 32: Pillars of Morocco's green economy measurement framework

Source: Author's proposal.

These indicators are selected to be hard data such as a 'share of renewable energy in TFEC'. This gives more objective results which are less biased than qualitative indicators would be. The latter might be subjective and open to argument; for example, interviewees might have different opinions on the country's efforts and progress in the greening of its economy. Qualitative indicators also take more time to be collected and tested, and therefore they might be costly. According to the existing tools, discussed in the previous section, the UNEP, OECD, GGGI, GGKP, and Barr frameworks rely on hard data, whereas the Dual Citizen tool includes various survey data. While, Nahman et al.'s set of indicators use available secondary data, although some of these selected indicators are collected through surveys by the institutions that they are derived from. For instance, Enforcement and Stringency of Environmental Regulations are collected by the World Economic Forum through their annual Executive Opinion Survey for its competitiveness reports. Therefore, survey data is not commonly used in the studied frameworks. For all the reasons above, hard data is considered in the proposed framework.

Furthermore, some indictors of the proposed tool overlap. This is necessary to measure the progress of Morocco throughout its different aspects. Some indicators are additive aggregations which help monitor the overall picture for particular issues. Whereas some indictors are more specific which is necessary to provide more detailed progress about these issues. For instance, share of electricity in TFEC captures the overall progress in the economy's electrification, whereas share of electricity consumption by sector provides more detail about the progress of each sector's electrification. This is useful to advise Morocco on the interventions that might be needed. The studied frameworks in the previous section consider a mix of additive aggregations and detailed indictors, but they do not combine these in examining same issue. Therefore, the proposed framework provides a clearer picture about the scopes of the green economy in Morocco.

In addition, a conflict does not arise between the proposed indicators, yet some of the proposed indicators are interlinked. For example, electrification of transport will replace oil products and reduce related emissions from the transport sector. It is important to increase the electrification of transport more than transport sector growth in order to reduce related carbon emissions from the sector in absolute figures. Also, the increased generation of renewable electricity will contribute to Morocco's reduction in demand from fossil fuel energy, a dependency on energy imports, and a reduction in electricity prices. The studied frameworks in the previous section do not include conflict indicators.

Furthermore, the proposed indicators are meant to measure the progress of the green economy transition of Morocco in both relative and absolute figures. For example, measuring total CO_2 emissions is important to understand the country's progress on its NDC. Whereas measuring CO_2 emissions per unit of real GDP which considers the economic cycle is also important to monitor. Improvement of this indicator means that the country genuinely moves towards greener growth and is not a consequence of economic slowdown. The studied tools above include example indicators in relative and absolute figures. Some of them are considered in the proposed framework, where appropriate to capture the key areas of green economy transition in Morocco.

The proposed framework suggests a dashboard set of indicators is appropriate for the purpose of this study. This provides flexibility to consider a variety of indicators to measure particular issues, either in absolute or relative figures. This is the case of the tools developed by the UNEP, the OECD, and the GGKP. In contrast, the composite index would be useful at the global scale for ranking and benchmarking different economies, which is not appropriate for this thesis. This single index requires statistical considerations and overlap avoidance which is not useful in the purpose of my specific case study, i.e. Morocco.

Many indicators are already available from international sources such as the IEA and the World Bank. Others are monitored by Morocco's national sources. Though, some indicators are needed to be collected such as the share of renewable electricity in industry sector, residential sector and agriculture sector. In addition, there are a lack of energy intensity metrics. This issue also exists in the studied tools as many indicators were not available. This needs to be addressed by future studies. It is important to note that there might be multiple data sources exist for the same indicators, this could create inconsistency between sources, due to different methods utilized by various institutions during data collection. This thesis relies mainly on the available data from prominent international institutions and Morocco's national sources, where available.

The proposed framework could be also useful to measure the progress of Morocco in achieving a number of its SDG targets. For instance, the energy intensity indicator and the renewable share of final energy consumption are two SDG indicators. Nevertheless, we should distinguish between green economy metrics and SDGs. Green economy indicators are issue-driven and may vary from country to country; therefore, the green economy framework needs to be tailored to each economy and consider its particular issues. In contrast, most SDGs tend to be more general and are not necessarily interlinked. In fact, SDGs reflect a global agenda on sustainable development.

The next section reveals the indicators that capture the six key areas of Morocco's green economy according to the considerations above. The available data has been collected between two periods, where available, since 2010, which is NDC base year, to monitor the progress which Morocco has made in its green transition after the introduction of 2009 Energy Strategy. Many proposed indicators are already discussed in prior chapters. The purpose of the proposed tool below is to put these relevant indicators in an integrated framework that helps us understand the overall picture of Morocco's green economy transition.

6.3.1. Emissions

Capturing emissions from various dimensions is central to monitoring Morocco's green economy transition. All the studied tools included one or more indicator on some aspects of

GHG or carbon emissions. The latter accounts for most of Morocco's GHG emissions and its data is more available and measured from various angles. A total GHG emissions indicator is important to assess the progress of the country towards meeting global commitments. According to its initial NDC targets, Morocco commits to reducing its GHG emissions below BAU levels by 2030: by 17% unconditionally and 42% conditionally as shown in Section 3.5 in Chapter Three.

Also, it is important to capture CO_2 emissions per unit of real GDP which measures the country's progress towards reducing emissions in relation to its economic output in terms of real GDP. This metric is also SDG 9.4. The importance of including this indicator is that during economic decline, CO_2 emissions will drop as the consequences of decreased economic activities but not as a result of successful decarbonization of the economy. For example, the global economy has enjoyed CO_2 emission cuts due to the impact of the COVID-19 crisis limiting economic activities, whereas countries have not necessarily taken deliberate actions towards greening their economies. Le Quéré et al. (2020) report that daily global CO_2 emissions reduced by 17% by early April 2020 compared with mean 2019 levels. Hence CO_2 emissions alone be an insufficient indicator to measure a country's progress, if not linked to GDP in constant prices to take into account the effects of inflation or deflation. It is important to note that this indicator does not show exactly if the country has achieved a relative or absolute-decoupling of GDP from CO_2 emissions. This needs an empirical approach using econometric estimation, as I have developed in Chapter Four.

Additionally, it is critical to monitor the CO_2 intensity of the country's energy mix which is the amount of CO_2 emitted per unit of energy. Morocco is moving towards lower-carbon energy sources and is using efficient technologies, and therefore the amount of carbon the country emits per unit of energy should fall. As shown in Section 4.4 in Chapter Four, reduce CO_2 emissions per unit of energy is important to accelerate the decoupling rate of carbon emissions from economic growth. Hence CO_2 intensity of energy mix was added to the framework.

Looking into emission sources, it is also important to capture the emissions from main sectors responsible for most emissions. These sectors include transport, electricity and heat, industry, residential and agriculture. Measuring the emissions from these sectors helps the country assesses its progress in decarbonizing these key economic sectors. Table 20 illustrates the proposed indicators related to emissions. Data shows that GHG and CO_2 emissions have generally increased in absolute figures since 2010. According to Climate Action Tracker (2021), GHG emissions rose from 75.9 Mt in 2010 to 87.5 Mt in 2018.

According to the UNCCC (2016), GHG emissions in Morocco were 93.9 Mt in 2010. Climate Watch (2021) reports different figures, GHG emissions were 77 Mt in 2010 and reached 94.3 in 2018. The contradiction between these sources raises concerns about data consistency between various institutions. Although it is hard to measure progress on NDC targets due to inconsistency between sources, the overall picture shows that GHG emissions have increased since the 2010 base year. This increase is bigger than any NDC mitigation scenario between 2010 and 2020 which projected that increased emissions would range between 19% for an Unconditional Scenario (without AFOLU) (a less optimistic scenario) and 4% for a Conditional Scenario (with AFOLU) (a more optimistic scenario).

CO_2 emissions were most significant in the electricity and heat producers, and the transport sectors. They reached 29 Mt and 19 Mt respectively in 2019. Whereas CO_2 emissions in the industry and residential sectors accounted for 8 Mt and 7 Mt respectively in the same year. Whereas agriculture's CO_2 emissions were the lowest among these sectors (3 Mt in 2019). The data demonstrates that Morocco needs to put particular efforts to decarbonizing the most polluting sectors, especially electricity and heat producers, and transport. Morocco's Energy Strategy ignored the role of transport and heating in generating increased CO_2 emissions.

Table 20: Proposed emissions indicators for Morocco

Indicator	Value		Trend	Source
1. Emissions				
1.1. Total emissions				
1.1.1. Total GHG emissions[82]	75.9 Mt (2010)	87.5 Mt (2016)	▲	Climate Action Tracker
1.1.2. Total CO_2 emissions[83]	46.4 Mt (2010)	65.9 Mt (2019)	▲	IEA
1.1.3. CO_2 emissions per unit of GDP $ (PPP)	0.2 kg (2010)	0.2 kg (2020)	-	IEA
1.1.4. CO_2 intensity of energy mix[84]	65.0 t CO2/Tj (2010)	70.7 t CO2/Tj (2019)	▲	IEA
1.2. CO_2 emissions by sector[85]				
1.2.1. CO_2 emissions from transport	14 Mt (2010)	19 Mt (2019)	▲	IEA
1.2.2. CO_2 emissions from electricity and heat producers	16 Mt (2010)	29 Mt (2019)	▲	IEA
1.2.3. CO_2 emissions from industry	8 Mt (2010)	8 Mt (2019)	-	IEA
1.2.4. CO_2 emissions from residential	5 Mt (2010)	7 Mt (2019)	▲	IEA
1.2.5. CO_2 emissions from agriculture	2 Mt (2010)	3 Mt (2019)	▲	IEA

Source: Author's proposal and data compilations from: CLIMATE ACTION TRACKER, 2021. *Morocco: Country Summary* [online]. Climate Action Tracker. [viewed 25 December 2021]. Available from: https://climateactiontracker.org/countries/morocco/ and INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 25 December 2021]. Available from: https://www.iea.org/countries/morocco/

The general trend of CO_2 emissions per unit of real GDP has been almost stable around 0.2 between 2010 and 2020. The CO_2 intensity of Morocco's energy mix increased from 65 to 70.7 t CO_2/Tj between 2010 and 2019. This shows that Morocco needs to use more efficient technologies in generating its energy. Accordingly, the results above are contrary to Morocco's NDC targets.

[82] Another source of data is Macrotrends (2021).
[83] The latest figures from IEA shows that total CO_2 emissions decreased to 62.4 in 2020. This appears to be due to the consequences of COVD-19 Pandemic.
[84] tCO_2/TJ is emission factors for CO_2 per unit of energy.
[85] The sum of CO_2 emissions by sectors listed in the table might not equal to total CO_2 emissions, because of potential emissions from other energy industries.

6.3.2. Fossil fuel energy supply

Reducing the country's reliance on energy supply from fossil fuel sources responsible for large share of carbon emissions is important to Morocco's energy transition, as shown in Chapter Five. Although one Energy Strategy objective is to diversify Morocco's energy sources without any mention to phase out or decrease fossil fuel power, my policy gap analysis shows that it is necessary to reduce the consumption of fossil fuel energy to help the country meet its global commitments according to its NDC.

Oil, coal and natural gas are the dominant energy sources in Morocco and are responsible for the majority of emissions as shown in Section 5.5. They have a negative impact on the environment. Critically, Morocco needs to decrease its energy consumption from oil products – mainly gasoline, diesel and jet fuel – which accounts for a large share of TFEC. So, it is important for the country to navigate away from these energy sources and advance cleaner forms in order to meet its growing demand for energy and achieve its climate change objectives. Therefore, it is crucial for the country to measure the shares of oil, coal, and natural gas in the TPES and strive to reduce reliance on fossil fuel energy. Surprisingly, only the UNEP framework includes a metric on the consumption of fossil fuels. It appears that at the time of developing the framework, it was not important to measure fossil fuel energy as it was not common to think about reducing its level. Table 21 represents the proposed fossil fuel energy supply indicators.

The data shows that fossil fuel energy supply increased from 622,876 Tj to 844,255 Tj between 2010 and 2019. Also its TPES share increased from 88.9% to 90.3% in the same period. Most of the increase came from coal. The establishment of coal power stations during the 2010s contributed to this increase. Therefore, the share of coal in TPES reached 29.8% in 2019, a rise from 16.7% in 2010. This demonstrates that renewable energy generation has not been sufficient alone to meet the growing demand of energy. This raises concerns about the ability of the country to reduce its emissions according to its NDC.

Table 21: Proposed fossil fuel energy supply indicators for Morocco

Indicator	Value		Trend	Source
2. Fossil fuel energy supply				
2.1. Total fossil fuel energy supply	622,876 Tj (2010)	844,255 Tj (2019)	▲	IEA
2.1.1. Total oil energy supply	482,133 Tj (2010)	528,566 Tj (2019)	▲	IEA
2.1.2. Total coal energy supply	116,888 Tj (2010)	279,054 Tj (2019)	▲	IEA
2.1.3. Total natural gas energy supply	23,855 Tj (2010)	36,635 Tj (2019)	▲	IEA
2.2. Fossil fuel energy in the TPES	88.9% (2010)	90.3% (2019)	▲	IEA
2.2.1. Share of oil in the TPES	68.8% (2010)	56.5% (2019)	▼	IEA
2.2.2. Share of coal in the TPES	16.7% (2010)	29.8% (2019)	▲	IEA
2.2.3. Share of natural gas in the TPES	3.4% (2010)	3.9% (2019)	▲	IEA

Source: Author's proposal and data compilations from INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 25 December 2021]. Available from: https://www.iea.org/countries/morocco/.

6.3.3. Renewable energy and electrification

The 2009 Energy Strategy set targets to increase renewable electricity levels in the country's installed electrical power to meet the growing demand for energy from clean sources. Therefore, the share of renewable energy in installed electrical power is a key indicator to be added to the framework.

Importantly, considering the intermittent nature of renewable energy and energy loss, the actual electricity generated from renewable energy is likely to be less than the installed capacity. Hence, renewable energy generation in total, the source, and the share of renewable energy in total electricity generation should also be monitored. In addition, the renewable energy share in the TFEC, which is SDG 7.2, is also useful to include in the framework. This will assess the progress of using renewable energy across all economic sectors.

Besides, as discussed in the previous chapter, it is important to the country to increase electricity in the TFEC, in other words, to increase the electrification of the economy. This means Morocco needs to expand its electricity consumption share in the total energy consumption of the industry, residential, commercial and public, agriculture and transport sectors. Particularly, the country needs to decarbonize these sectors. Decarbonization of transport is also an important element of Morocco’s green economy model by mainly encouraging EV uptakes. All these indicators are important to be observed in my framework, as illustrated in Table 22.

None of the studied frameworks, in the previous section, considers these detailed indicators which are crucially important to monitor green economy transition in Morocco, as discussed in Chapter Five. Again, perhaps at the time of developing the previous frameworks, it was hard to believe that electrification of the economy was possible, and that renewable energy would be feasible at a national scale. There is no mention of renewable energy or electrification in the UNEP, OECD, GGGI and GGKP frameworks. Whereas Dual Citizen and Barr include renewable electricity in their framework. Nahman et al.’s tool measures TFEC’s share of renewable energy consumption and renewable energy investment. Accordingly, my proposed indicators for renewable energy and electrification are more comprehensive to measure Morocco’s energy transition towards renewable energy.

Data shows that the share of renewable energy in installed electrical power increased to 34% in 2020, mainly through solar and wind power, but this figure is short of the Energy Strategy target of 42%. Renewable energy generation increased from 6,300 GWh to 9,422 GWh between 2010 and 2020 despite the notable decrease in hydropower energy. As shown in Section 5.2.1 in Chapter Five, extreme weather in terms of drought events have impacted the reliability and stability of hydropower generation in Morocco. However, the rise in renewable energy generation was insufficient to increase its TFEC share. This also demonstrates from a different angle that an increase in fossil fuel energy generation was more than that of renewable energy.

In terms of electrification, as discussed in Section 5.5 in Chapter Five, only a small proportion of the economy is powered by electricity (17.2% in 2019). The data indicates low electrification across sectors, especially transport. This is unsurprising given the low EV uptakes in Morocco, there is no data available for this indicator. Also some indicators on the shares of renewable electricity among sectors are not available, which needs to be addressed in future research.

Table 22: Proposed renewable energy and electrification indicators for Morocco

Indicator		Value		Trend	Source
3.	Renewable energy and electrification				
3.1.	Total renewable energy generation	6,300 GWh (2010)	9,422 GWh (2020)	▲	IEA
3.1.1.	Hydro energy generation	3,631 GWh (2010)	1,290 GWh (2020)	▼	IEA
3.1.2.	Wind energy generation	659 GWh (2010)	4,592 GWh (2020)	▲	IEA
3.1.3.	Solar energy generation (PV and thermal)	0 (2010)[86]	1,520 GWh (2020)	▲	IEA
3.2.	Share of renewable energy				
3.2.1.	Share of renewable energy in installed electrical power	31% (2010)	34% (2020)	▲	Alhamwi et al. (2015) for 2010 Interview 3 for 2020
3.2.2.	Share of renewable energy in total electricity generation	18.0% (2010)	18.5% (2020)	▲	IEA
3.2.3.	Share of renewable energy in TFEC	13.9 (2010)	10.8% (2018)	▼	IEA
3.2.4.	Share of renewable electricity in industry	N/A (2010)	N/A (2020)	-	N/A
3.2.5.	Share of renewable electricity in residential sector	N/A (2010)	N/A (2020)	-	N/A
3.2.6.	Share of renewable electricity in commercial and public services	N/A (2010)	N/A (2020)	-	N/A
3.2.7.	Share of renewable electricity in agriculture	N/A (2010)	N/A (2020)	-	N/A
3.3.	Electrification				
3.3.1.	Share of electricity in TFEC (total electrification of the economy)	15.4% (2010)	17.2% (2019)	▲	IEA
3.3.2.	Share of electricity consumption by industry in the total energy consumption by industry (electrification of industry)	26.1% (2010)	33.2% (2019)	▲	IEA

[86] Although solar energy was first introduced in Morocco through the Rural Electrification Programme in 1995, but the total generation has been negligible before completing the construction of Ouarzazate solar farms in 2015 as noted in Section 5.2.2 in Chapter Five.

3.3.3. Share of electricity consumption by residential in the total energy consumption by residential (electrification of residential)	20.3% (2010)	23.4% (2019)	▲	IEA
3.3.4. Share of electricity consumption by commercial and public services in the total energy consumption by commercial and public services (electrification of commercial and public services)	31.7% (2010)	37.8% (2019)	▲	IEA
3.3.5. Share of electricity consumption by agriculture/forestry in the total energy consumption by agriculture/forestry (electrification of agriculture/forestry)	24.5% (2010)	22.8% (2018)	▼	IEA
3.3.6. Share of electricity consumption by transport in the total energy consumption by transport (electrification of transport)	0.5 (2010)	0.5% (2019)	-	IEA
3.3.7. Share of EVs in total vehicles	N/A (2010)	N/A (2020)	-	N/A

Source: Author's proposal and data compilations from INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 25 December 2021]. Available from: https://www.iea.org/countries/morocco/; ALHAMWI, A., KLEINHANS, D., WEITEMEYER, S. and VOGT, T., 2015. Moroccan National Energy Strategy reviewed from a meteorological perspective. *Energy Strategy Reviews*, *6*, pp.39-47.; and Interview 3.

6.3.4. Energy efficiency

Energy efficiency is a key element of the 2009 Energy Strategy in Morocco. Energy efficiency gain has multiple socioeconomic and environmental benefits including reducing energy bills, tackling fuel poverty, improving energy security, increasing energy access and reducing emissions. Furthermore, improving energy efficiency is one of Morocco's SDGs. Thus, energy efficiency is an important part of energy transition in Morocco and its indicators are vital to assess the greening progress of the Moroccan economy.

Energy efficiency has different meanings from an economic or technical standpoint. Odyssee-Mure (2020) reports that there are about 200 energy efficiency indicators.

Depending on the chosen perspective, some indicators may be more appropriate than others. For instance, energy intensity provides an assessment of energy efficiency from an economic standpoint, whereas unit consumption is more focused on technical energy efficiency (Odyssee-Mure, 2020).

According to the Science for Environment Policy (2015), increasing energy efficiency involves using a reduced quantity of energy to generate the same or an improved product, process or service. It is generally measured as the ratio between energy output and energy input. The most common related indicators are energy consumption, energy productivity and energy intensity. Nahman et al. (2016), for instance, use energy consumption per capita to reflect energy efficiency; the UNEP (2012) considers energy productivity; the OECD (2017) measures energy intensity by sector; the Green Growth Knowledge Platform (2016) embraces primary and final energy intensity. In fact, energy consumption per capita, energy productivity and energy intensity do not literally reflect efficiency. Energy productivity is the ratio of economic output per unit of energy use (Atalla and Bean, 2017). Whereas energy intensity level of primary energy is the ratio between energy supply and GDP measured at purchasing power parity, it is an indication of how much energy is used to produce one unit of economic output. A lower ratio indicates less energy is used to produce one unit of output. Both energy productivity and energy intensity are linked to GDP, and therefore to the economic cycle.

Increasing energy productivity or reducing energy intensity is essential to reduce CO_2 emissions as most of emissions are energy related. They are better proxy for the energy efficiency than energy consumption. The latter might be misleading, i.e. decrease in energy consumption per capita in any country does not mean necessarily the economy has become greener, but potentially this is because of the economic recession or halt to the activities. For example, during COVID-19 Crisis lockdown, energy consumption in transport sector has declined sharply without taking deliberately energy efficiency measures. Nonetheless, energy efficiency leads to sustainability when it leads to reduced demand, emissions and costs. This needs technological advances in the economy. Therefore, either energy productivity or energy intensity is useful to monitor the progress of Morocco in reducing its energy related emissions.

Energy intensity is given more attention and available, and also it is an indicator used for SDG 7 which is on ‘double the global rate of improvement in energy efficiency by 2030 measured specifically by energy intensity in terms of primary energy and GDP’, In addition, reduce energy intensity per GDP is important to accelerate the decoupling rate of carbon emissions from economic growth in Morocco as shown in Section 4.4 in Chapter Four. Therefore, I include energy intensity indicator in the measurement framework for Morocco. Additionally, I use energy intensity at sector level in order to monitor Morocco's progress of the reduction of energy usage in its main energy-intensive economic sectors. These sectors are agriculture, industry, services, transport and residential.[87] Table 23 presents the proposed energy efficiency indicators for Morocco.

There is lack of data on energy intensity by sector. I included the available data from various sources, therefore the base year is not consistent. This needs further research to improve the quality of data.

Energy intensity level of primary energy reduced slightly to reach 3.155 MJ in 2015. Therefore, the progress Morocco has made in reducing overall energy intensity is minor. As discussed in Section 3.4 in Chapter Three, energy intensity in residential sector is the highest among other sectors, followed by transport sector. Whereas it is the lowest in services sector. Since the Moroccan economy has become more service-oriented since 1992, this contributed to helping the country decouple its economic growth from carbon emissions as discussed in Section 4.4 in Chapter Five.

[87] The national energy audit reports that more than 15% of the baseline industrial energy use could be saved in Morocco (Industrial Energy Accelerator, 2021).

Table 23: Proposed energy efficiency indicators for Morocco

Indicator		Value		Trend	Source
4.	Energy efficiency				
4.1.	Energy intensity level of primary energy (MJ/$2011 PPP GDP)	3.375 MJ/GDP (2010)	3.155 MJ/GDP (2015)	▼	World Bank
4.2.	Agriculture energy intensity	2.0 MJ/GDP (2010)	2.5 MJ/GDP (2013)	▲	Trading Economics
4.3.	Manufacturing energy intensity (MJ/$ PPP 2015)	2.7 MJ/GDP (2010)	2.5 MJ/GDP (2018)	▼	IEA
4.4.	Services energy intensity (MJ/$ PPP 2015)	0.5 MJ/GDP (2010)	0.4 MJ/GDP (2018)	▼	IEA
4.5.	Transportation energy intensity	15 MJ/GDP (2010)	13 MJ/GDP (2013)	▼	Trading Economics
4.6.	Residential energy intensity	16 MJ/GDP (2010)	18 MJ/GDP (2013)	▲	Trading Economics

Source: Author's proposal and data compilations from WORLD BANK, 2020. *World development indicators 2020* [online]. The World Bank. [viewed 25 December 2020]. Available from: https://data.worldbank.org/country/morocco; INTERNATIONAL ENERGY AGENCY, 2021. *Morocco* [online]. International Energy Agency. [viewed 25 December 2021]. Available from: https://www.iea.org/countries/morocco/; and TRADING ECONOMICS, 2018. *Morocco - Economic Indicators* [online]. Trading Economics. [viewed 17 December 2018]. Available from: https://tradingeconomics.com/

6.3.5. Socioeconomic indicators

Morocco aims to achieve wide socioeconomic benefits from its energy transition to renewable energy, as examined in Chapter Five. Critically, the country aims to reduce its large energy dependency by producing energy from its own renewable sources. This could contribute to the reduction of its energy bill overall. However, the latter is linked to international oil prices, and therefore reduction in such energy dependency will help the country become less volatile to international oil prices. Moreover, renewable energy provides a promising opportunity to export electricity and also to reduce electricity prices for households and businesses, as shown in Section 5.3 in Chapter Five. Electrification of the economy powered by renewable energy will help the country entirely remove fossil fuel subsidies which remain on butane and, in turn, strengthen its financial position.

Besides, the Kingdom's goal of encouraging renewable energy investments is to stimulate economic growth and create green sector jobs. Moreover, Morocco aims to strengthen its local renewable energy supply chain which will translate into an increase in local content of renewable energy projects principally solar and wind projects. Renewable energy investments are planned to promote rural areas to achieve inclusive green growth and create jobs in the least developed communities. This could be monitored by unemployment rates in rural areas. Although draft Law 40-19 removes the geographical requirements of solar energy projects, but projects should contribute to the local development. According to Decree No. 2657-11 as discussed in Section 5.3 in Chapter Five. Therefore, these indicators are important ones to include in the framework. Furthermore, Morocco considers integrating renewable energy with a desalination process to meet water demand and increase water security. Hence, the production capacity of renewable energy-powered desalination units is included in the measurement framework.

It is worth mentioning that the improvement in socioeconomic conditions as promised by the king, especially after the social unrest in 2011, will contribute to the political stability of the country. Table 24 presents the proposed socioeconomic indicators for Morocco. Socioeconomic indicators are common in the studied frameworks. However few indicators are directly linked to green economy transition in Morocco. For example, the UNEP and the OECD include energy prices. The GGGI, GGKP and Barr frameworks consider green employment. Also the GGKP and Nahman et al.'s frameworks capture renewable energy investment. However, as included in the proposed framework the output of this investment in terms of installed capacity or generation is more important.

Many of the proposed socioeconomic indicators are not currently measured. According to the available data, energy dependency in Morocco reduced from 98% to 92% between 2008 and 2019, and the country's electricity imports decreased by 93.5% between 2018 and 2019. This is linked to two factors. First, the launching of several power generation projects, notably the Safi Thermal Power Plant and other solar energy stations. Second, the reduction of the country's electricity consumption due to the daylight-saving time change. In October 2018, the Moroccan government decided to permanently move to the GMT+1 time zone which reduced its national electricity consumption by 0.3% (Hatim, 2020). These two factors enabled the country to increase its electricity exports by more than 670% between 2018 and 2019 (Hatim, 2020). Although this seems significant increase, but this is because the electricity exports were not actually large in 2018.

According to the latest data from Global Petrol Prices (2021), the electricity price in 2021 is $0.126 per kWh for households, and $0.116 for businesses. For comparison, the average global price of electricity is $0.135 for households and $0.124 for businesses. This shows that Morocco's electricity prices are near global prices. The country could benefit from the low auction prices of renewable energy as discussed in Section 5.3 in Chapter Five. Fossil fuel subsidies reduced from $5.2 billion in 2011 to $1.1 billion in 2016 (World Resources Institute, 2021). Also, the country has potential to increase its local content of renewable energy projects which is very low in solar projects as commented on by one interviewee (Interview 9). However data is unavailable to monitor this progress. In addition, there is no data on 'unemployment rate in rural areas' and 'production capacity of renewable energy-powered desalination units'. This needs to be addressed in future studies.

Table 24: Proposed socioeconomic indicators for Morocco

Indicator		Value		Trend	Source
5.	Socioeconomic indicators				
5.1.	Energy dependency	98% (2008)	92% (2019)	▼	Interview 3
5.2.	Electricity exports[88]	180 GWh (2018)	1,207 GWh (2019)	▲	Morocco World News
5.3.	Electricity price for households	N/A (2010)	$0.126 kWh (March 2021)	-	Global Petrol Prices
5.4.	Electricity price for businesses	N/A (2010)	$0.116 kWh (March 2021)	-	Global Petrol Prices
5.5.	Fossil fuel subsidies	$5.2b (2011)	$1.1b (2016)	▼	World Resources Institute
5.6.	Economic output from renewable energy	N/A (2010)	N/A (2020)	-	N/A
5.7.	Green jobs	N/A (2010)	N/A (2020)	-	N/A
5.8.	Local content in solar projects	N/A (2010)	N/A (2020)	-	N/A
5.9.	Local content in wind projects	N/A (2010)	60% (2020)	-	Interview 9
5.10.	Unemployment rate in rural areas	N/A (2010)	N/A (2020)	-	N/A
5.11.	Production capacity of renewable energy–powered desalination units[89]	N/A (2010)	N/A (2020)	-	N/A

Source: Author's proposal and data compilations from HATIM, Yahia, 2020. *Morocco Remains Net Exporter of Electricity* [online]. Morocco World News. [viewed 25 December 2021]. Available from: https://www.moroccoworldnews.com/2020/02/292981/morocco-remains-net-exporter-of-electricity; WORLD RESOURCES INSTITUTE, 2019. *Morocco: Fuel Subsidy Reform Designed to Support a Just Transition to Renewable Energy* [online]. World Resources Institute. [viewed 15 December 2021]. Available from: https://www.wri.org/just-transitions/morocco-fuel-subsidy; GLOBAL PETROL PRICES, 2021. Morocco electricity prices [online]. Global Petrol Prices. [viewed 23 December 2021]. Available from: https://www.globalpetrolprices.com/Morocco/electricity_prices/; Interview 3 and Interview 9.

[88] Spain is the main country of electricity export (Morocco World News, 2021).
[89] The current share of renewable desalination is less than 1% of global desalination capacity (Ahmadi et al., 2020).

6.3.6. Biodiversity and ecosystem

As examined in Chapter One, biodiversity and ecosystem have been subject to increasing pressure by human and climate conditions in Morocco, characterised by a succession of drought. Therefore, protecting the environment, natural resources and biodiversity is also one of the 2009 Energy Strategy's objectives, through reducing emissions to particular extent.

This objective could be presented by a wide range of indicators as suggested by the studied frameworks. The OECD (2016) includes land resources, soil resources and wildlife resources in their set of indicators. The GGGI considers Aichi Biodiversity Targets in their Green Growth Index (Acosta et al., 2020). Barr (2013) suggests indicators on biodiversity, aquatic, forest, minerals and energy, land and soil, and water resources. Dual Citizen (2018) uses an Environmental Performance Index in their GGEI.[90] Finally, Nahman et al.'s set of indicators propose investment in natural capital, biodiversity and ecosystems in their framework.

What is critical to Morocco is that climate change is considered one of the main threats to the flora and forest ecosystem diversity of the country, as well as to its marine, coastal and freshwater biodiversity (Taleb, 2016). The country aims to protect its natural resources and biodiversity. Reducing carbon emissions through transition to renewable energy will contribute to the country's efforts to protect the natural environment as noted by a number of interviewees (Interview 3, Interview 7, Interview 9). The National Plan Against Global Warming indicates the importance of monitoring the resilience of species and protection of endangered species, including marine life (MEME, 2009). The plan suggests a reorganization of hunting and fishing practices. Therefore, Nahman et al.'s proposed indicators on biodiversity and ecosystems fit the case of Morocco. These indicators are the proportion of marine and terrestrial protected areas,[91] as well as threatened plant and animal species.[92]

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[90] The 2020 Environmental Performance Index (EPI) captures 32 performance indicators across 11 issue categories to rank 180 countries on environmental health and ecosystem vitality (Wendling et al., 2020).

[91] Marine protected areas are reserved locations to protect part or all of the enclosed environment. While terrestrial protected areas are protected areas of at least 1,000 hectares that are designated by national authorities as scientific reserves with limited public access, national parks, natural monuments, nature reserves or wildlife sanctuaries, protected landscapes, and areas managed mainly for sustainable use (World Bank, 2021).

[92] Counted threatened species include mammals, birds, reptiles, amphibians, fishes, molluscs, other inverts, plants, and fungi and protists. However, there are still many species that have not yet been assessed in the IUCN Red list and therefore their status is unknown. Therefore, the figures for these groups should be interpreted as the number of species known to be threatened within those species that have been assessed (IUCN, 2021).

These three indicators (Table 25) are added to the measurement framework. Data shows that the marine protected areas in Morocco were reported with a value of 0.26% in 2018 which is small in comparison with the world average (11.5% in 2018). Whereas the terrestrial protected areas in the country were 30.8% in 2018, above the world average (14.6%). The number of threatened species in Morocco were reported as 238 which accounted for 30% of total reported threatened species in North Africa (IUCN, 2021). Hence, it appears that Morocco needs to put further efforts into these aspects.

Table 25: Proposed biodiversity and ecosystem indicators for Morocco

	Indicator	Value		Trend	Source
6.	Biodiversity and ecosystem				
6.1.	Marine protected areas (% of territorial waters)	N/A (2010)	0.26 (2018)	-	World Bank
6.2.	Terrestrial protected areas (% of total land area)	N/A (2010)	30.778 (2018)	-	World Bank
6.3.	Threatened species	N/A (2010)	238 (2020)	-	IUCN Global Species Programme Red List Unit

Source: Author's proposal and data compilations from WORLD BANK, 2020. *World development indicators 2020* [online]. The World Bank. [viewed 25 December 2020]. Available from: https://data.worldbank.org/country/morocco; and INTERNATIONAL UNION FOR CONSERVATION OF NATURE, 2017. IUCN Global Species Programme Red List Unit, Red List version 2021-3, last updated 19 Mar 2020. Gland: International Union for Conservation of Nature.

6.4. Conclusion

By considering the country's particular green agenda, the aim of this chapter was to propose a customised analysis framework for green economy transition in Morocco. This analysis considered Morocco's green ambitions and a number of existing green economy measurement frameworks, including the UNEP, OECD, GGGI, GGKP, Dual Citizen, Barr and Nahman et al. frameworks. Since none of the existing frameworks studied above are sufficient to monitor Morocco's green economy transition, this chapter has proposed a tailored framework that suits its green economy model, and considers its main development challenges and green ambitions, which are discussed in the previous chapters. The proposed framework also considers the existing frameworks studied in Section 6.2.

The proposed framework was built on six pillars to capture the main objectives of Morocco's green economy transition. These include emissions, fossil fuel energy supply, renewable energy and electrification, energy efficiency, socioeconomic indicators, and biodiversity and ecosystem. These pillars monitor the country's NDC progress, energy transition and wide socioeconomic and environmental aspects. The available data, collected between two periods since 2010, shows the progress which Morocco has made in its green economy transition after the introduction of its Energy Strategy. The data of many of the proposed indicators is currently unavailable which needs to be addressed in future research, as it was not the purpose of this thesis.

Data shows that GHG and CO_2 emissions in Morocco increased across all sectors in absolute figures since 2010 as demonstrated in Table 20. This is not aligned with any of its NDC mitigation scenarios. The increase in emissions is more significant in the transport, and electricity and heating sectors. CO_2 intensity of energy mix also increased indicating a decrease in the efficiency of energy generating technologies. The above results are linked to the significant increase in fossil fuel energy supply in the country, particularly from coal, to meet growing energy demands, as shown in Table 21. This raises concerns on the ability of the country to reduce its emissions according to its NDC.

Furthermore, although Morocco's share of renewable energy in installed electrical power reached only 34%, this is below its Energy Strategy target of 42%. Based on this progress, the generation of renewable energy increased significantly between 2010 and 2020 by 50% mostly from wind power and some from solar power, whereas hydroelectricity power reduced, as illustrated in Table 22. However, the share of renewable energy in TFEC declined in the same period given the increase of fossil fuel energy generation. In addition, electrification of the economy is small (17.2% in 2019), despite some increase since 2010. Low electrification is evident across all sectors particularly in the transport sector which is not surprising.

Given the lack of recent data, it is hard to measure the energy efficiency gain in Morocco in many sectors. It appears that the overall energy intensity in the country has slightly reduced. The available data shows a decline in energy intensity in the manufacturing and services sector between 2010 and 2018. However energy intensity in the services sector is amongst the lowest, as demonstrated in Table 23.

Data on Morocco's socioeconomic indicators are generally unavailable. The available data as presented in Table 24 shows a significant decline in Morocco's energy dependency on foreign countries from 98% to 92% between 2008 and 2019. Also, electricity exports became evident in 2019. While fossil fuel subsidies significantly declined. However it is hard to evaluate this overall socioeconomic progress unless the data becomes available, which needs to be addressed in future research.

Finally, regarding Morocco's biodiversity and ecosystem, illustrated in Table 25, historical data is also unavailable, and therefore it is hard to assess the progress of the country. By comparing the figures of Morocco globally, its marine protected areas are very small while its terrestrial protected areas are above the world average. The threatened species in Morocco (reported as 238) accounted for 30% of total reported threatened species in North Africa.

In conclusion, Morocco has achieved mixed results of its green economy objectives in terms of limiting emissions and realizing wide socioeconomic benefits in the short run after the introduction of the Energy Strategy. On one hand, the data shows that Morocco is far from achieving its NDC commitments at any mitigation scenario towards limiting emissions. On the other hand, although it appears that the country has achieved some socioeconomic benefits from its green transition, the data is insufficient to assess the overall progress. Therefore, it is hard to support the claim of Porter and van der Linde (1995) that a win–win situation exists between economic growth and environmental protection. Yet these results are in line with the findings of van Leeuwen and Mohnen (2017) in terms of the absence of general consensus on the trade-off between economic growth and environmental protection.

These results answer the research questions on the possibility of Morocco's green economy and potential benefits from its transition. Nevertheless, the proposed framework is an attempt to develop a measurement framework that suits the existing conditions of Morocco and its current objectives in the greening of its economy. Hence, this could be further developed to capture emerging issues as the country progresses in its green agenda, and as technological advances provide broader opportunities in decarbonization of its economy. The proposed measurement framework contributes to the existing tools developed by Barr (2013), the UNEP (2014), Nahman et al. (2016), the OECD (2016), the Green Growth Knowledge Platform (2016), Dual Citizen (Tamanini et al., 2016), and the Global Green Growth Institute (Acosta et al., 2020).

Chapter Seven

Conclusion and implications

7.1. Introduction

The aim of this thesis was to examine the green economy of Morocco to answer the central research question on whether Morocco is able to meet its green agenda via its current green economy model. This research question was addressed through analyzing the country's time-series data of its carbon emissions, economic growth and energy consumption in Chapter Four, through scrutinizing its green economy model in Chapter Five, and through assessing its progress through a customised green economy measurement framework in Chapter Six

The thesis used a mixed methods approach of quantitative and qualitative analysis. The empirical approach, using econometric estimation, evaluated Morocco's green economy transition. Whereas nine interviews with officials and key sector informants provided some insight into Morocco's experience in the greening of its economy, and uncovered a number of challenges related to its energy transition. In addition, the research incorporated available data from national and international sources such as the World bank and IEA which provided a deep understanding of various socioeconomic and environmental aspects in relation to its green economy transition.

To the best of my knowledge, this thesis is a pioneer in examining the green economy model of Morocco taking into account the recent debates in this sphere and the latest initiatives to decarbonize the global economy. The importance of this thesis stems from the recent discourse on green economy transition in practice, and efforts being made by governments towards greening their economies. By studying the experience of Morocco, this thesis revisited the literature on the possibility of green economy (e.g. Hickel and Kallis, 2020), the level of transformation that a green economy requires (e.g. Ehresman and Okereke, 2015; Mundaca, 2016; Paterson, 2021), and the potential benefits of a green economy (e.g. Porter and van der Linde, 1995; Jacobs, 2012).

The thesis has examined the green economy concept and the relevant literature and theories around this notion in Chapter Two. Chapter Three has studied Morocco's main motivations to adopt its green agenda. This thesis has quantitatively measured Morocco's progress on decoupling economic growth from carbon emissions in Chapter Four. Chapter Five has assessed the green economy model of Morocco built on energy transition. Chapter Six has proposed a measurement framework that suits Morocco's green agenda to measure its progress.

This chapter begins with a summary of the key findings based upon the primary research question. Then discusses the possible theoretical and policy implications of this thesis. The final section highlights a number of limitations and suggests directions for a future research agenda.

7.2. Findings

This thesis has shown that Morocco's intended transition to a green economy is principally built on renewable energy. This energy transition to renewable energy is supported from the highest authority, King Mohammed VI who introduced the 2009 Energy Strategy. This transition has been envisaged as an opportunity for the country to overcome its development challenges and to meet its NDC targets. The country has invested notable efforts in its energy transition as recognized globally. Importantly Morocco's energy strategy aims to tackle the causes of climate change by providing clean energy to meet its growing energy needs, thus reducing its emissions, while delivering wide socioeconomic and environmental benefits – as shown in Chapter Three. However, the findings of this thesis show that the green economy model of Morocco is unlikely to be sufficient to help the country meet its global commitments and overcome its development challenges.

Chapter Four has shown that Morocco appears to have been able to absolutely-decouple its economic growth from carbon emissions after 1992. This result can be explained by the fact that the Moroccan economy has become more service-oriented since 1992, which is more energy efficient and generates less emissions than the agriculture and industry sectors. Although this result seems to be promising, the country's emissions have been rising. This indicates that the rate of decoupling has been insufficient to reduce emissions. The growing emissions does not align with Morocco's NDC targets and is insufficient to tackle the causes of climate change in the country as stressed in its National Plan Against Global Warming. Thus, although Morocco's economic growth has become greener since 1992, the country has been able to only slow the growth of its emissions and delink them from its economic growth. Two avenues could be explored to further accelerate the decoupling rate to help Morocco meet its targets: reduce CO_2 emissions per unit of energy through renewable energy and/or reduce energy intensity per GDP by improving energy efficiency. This quantitative analysis suggests that economic growth in Morocco could be delivered by more environmentally friendly and energy efficient means. Thus, Chapter Four empirically answers the research question on the extent to which Morocco has been able to achieve its green growth. Its progress has been insufficient.

Chapter Five has studied the energy transition to renewable energy in Morocco as its main route to a green economy. Despite Morocco's efforts to diversify its energy mix, from renewable energy sources and an increased generation of solar and wind energy, Morocco did not reach its energy strategy targets by 2020. Even though Morocco is able to achieve its energy strategy targets, the country is unlikely to meet its NDC ambitions mainly due to major drawbacks in its model. The country's model largely ignores important elements to decarbonize its key economic sectors which are responsible for a large share of carbon emissions, in particular in the transport, heating, industry and residential sectors. Electrification, offshore wind power, use of hydrogen and a decentralized electricity system, key approaches to reduce carbon emissions, are missing in its green economy model. Therefore, Chapter Five demonstrated that Morocco's green economy model is unachievable in its business-as-usual context. In contrast, a radical transformation of the economy across various sectors is needed to help the country meet its green agenda and achieve a required transition to the green economy. Global practice demonstrates that wide transformation of the economy is possible in the short-term to deliver green growth. Accordingly, Chapter Five answers the research questions on the possibility of the green economy of Morocco, and also the level of economic transformation needed: the current model is insufficient to deliver green economy, radical transformation of the economy is required.

Chapter Six has attempted to monitor Morocco's progress and benefits from its green economy transition, after the introduction of the energy strategy, through a customised measurement framework. The proposed framework is built on six pillars to capture the main objectives of Morocco's green economy transition: emissions, fossil fuel energy supply, renewable energy and electrification, energy efficiency, socioeconomic indicators, and biodiversity and ecosystem. Morocco has achieved mixed results for its green economy objectives in the short run in terms of limiting emissions and, in also realizing socioeconomic benefits. On one hand, the data shows that Morocco is far from achieving its NDC commitments to limit emissions in any mitigation scenario. On the other hand, it appears that the country has achieved some socioeconomic benefits from its green transition. However, the data is insufficient to assess Morocco's overall progress. Consequently, Chapter Six tried to answer the research questions on achievability of the green economy in Morocco and its benefits from the transition. The country could not generally achieve its green ambitions.

7.3. Implications for theory and policy

Based on the above analysis, examining the experience of Morocco in the greening of its economy, this thesis offers new insights on the green economy discourse. To the best of my knowledge, this thesis is a pioneer in examining Morocco's green economy model which was built on an energy transition to renewable energy. This section argues that this thesis makes original theoretical and practical contributions to the green economy discourse.

7.3.1. Implications for theory

This thesis claims to make five theoretical contributions to the existing literature as explained below:

First, this thesis contributes to the literature on steady-state economy and degrowth theory as discussed by Victor (2010, 2012), and Dietz and O'Neill (2013). In particular, the thesis attempted to challenge the assumption that it is impossible to reduce emissions to tackle climate change while growing the economy. Examining the experience of Morocco, the findings do not provide evidence that green economy has been achievable in the country because although the economic growth in Morocco has become greener since 1992, the country has been only able to slow the growth of its emissions and delink them from its economic growth. The country has not been able to reduce its emissions while delivering economic growth. Given that absolute-decoupling of economic growth from the carbon emissions in Morocco has been insufficient to reduce its emission, this result supports the claim of Hickel and Kallis (2020) and Lenaerts et al. (2021) that the rate of absolute-decoupling needs to be sufficient to reduce emissions.

Second, this thesis supports the conclusion of Barua and Khataniar (2016) that middle-income economies follow a path of weak sustainability to achieve economic growth. As shown in Chapter Four, Morocco achieved absolute-decoupling of its economic growth from carbon emissions in 1992. This progress has been delivered as business as usual without radical transformation of its economy in terms of the energy sector. However, its efforts have been insufficient to reduce the country's emissions. This supports the view of Richardson (2013), Mundaca (2016) and Paterson (2021) that the decarbonization of economies requires dramatic change. This also aligns with the claim of Barua and Khataniar (2016) and Loiseau et al. (2016) that transition to a green economy urges countries to follow a path of strong sustainability to deal with the concerns about climate change issues. This finding adds to the green economy literature.

Third, the thesis extends the application of the Porter Hypothesis to the country level by exploring additional avenues derived from different disciplines. Environmental solutions, through energy transition to renewable energy, could foster technological innovations in countries' renewable energy industry while reducing emissions. Renewable energy transition could offer a more effective solution for governments to tackle climate change beyond the narrow view on the traditional environmental policies, such as carbon taxes or tradable emissions, which were outlined in Porter Hypothesis theory. Studying the green economy model of Morocco, the country has achieved mixed results concerning its green economy objectives in the short run. Morocco could not reduce its emissions through its model, but the country has achieved limited progress in some socioeconomic benefits. The available data is insufficient to assess the overall progress. Therefore, it is hard to support the claim of Porter and van der Linde (1995) that a win–win situation exists between economic growth and environmental protection. Yet the results of the thesis align with the findings of van Leeuwen and Mohnen (2017) in terms of the absence of general consensus on the trade-off between economic growth and environmental protection. This also adds to the discussion raised by Petroni et al. (2019) about the validity of Porter Hypothesis theory at the country level.

Fourth, to the best of my knowledge, this thesis is a pioneer in applying EKC theory to understand the relationship between economic growth, environment and energy in Morocco. It provides strong evidence for the existence of the EKC theory in Morocco. Analyzing the historical data of the country in Chapter Four shows that carbon emissions per capita do initially increase with rising GDP per capita, then peak and decline after a threshold level of income per capita is reached. This conclusion is consistent with the results of other studies on MENA countries such as Tunisia (Fodha and Zaghdoud, 2010; Farhani et al., 2014; Shahbaz et al., 2014) and Saudi Arabia (Alkhathlan and Javid, 2013).

Finally, by proposing a customised green economy measurement framework for Morocco in Chapter Six, this thesis addresses the methodological issue in the literature on the need to develop a measurement framework to track green transition. The proposed measurement framework was built on Morocco's green ambitions and reflects recent global practices, particularly on the electrification of economies and the decarbonization of energy-intensive sectors. The proposed measurement framework is a pioneer in assessing the progress of Morocco's green economy transition. This contributes to the existing tools developed by Barr (2013), the UNEP (2014), Nahman et al. (2016), the OECD (2016), the Green Growth Knowledge Platform (2016), Dual Citizen (Tamanini et al., 2016), and the Global Green Growth Institute (Acosta et al., 2020).

7.3.2. Implications for policy

The key implications of green economy in practice have been primarily discussed in Chapter Five. Although no single green economy model suits all economies, which vary based on their own resources and circumstances, the analysis framework of the energy transition policy gap in Morocco as well as the measurement tool I have proposed may be considered by other countries with similar circumstances to Morocco which are in the transition towards green economy. Essentially, this would help these countries develop their own models. Following the discussion in Chapter Five, it appears that a green economy could become achievable in Morocco in terms of reducing emissions while delivering economic growth. To this end, four key actions could be considered to increase the possibility of green economy in Morocco and deliver short-term benefits. This would require radical transformation of its economy in how to power the country. The policy recommendations derived from this research are summerized below.

First, since electricity accounts for only a small share of the TFEC in Morocco, its green economy model requires increased electrification of the economy powered by renewable energy. In other words, a green economy in Morocco necessitates increasing its use of renewable electricity in the industry, residential, commercial and public services, agriculture, and transport sectors. At present, these sectors mainly rely on fossil fuel energy sources in the country. For instance, introducing EVs is important to decarbonize the transport sector which responsible for a large share of carbon emissions. Whereas marginal changes in terms of generating part of its current electricity production from renewable sources are insufficient to deliver green economy in Morocco.

Second, given that the green economy entails reducing reliance on fossil fuel energy sources, especially oil and coal which are responsible for the largest share of emissions in Morocco, the country needs to accelerate the energy sector's shift from fossil fuel to various types of renewable energy sources, such as onshore and offshore wind, solar power and hydrogen. In particular, offshore wind provides true potential to increase renewable electricity in Morocco which is currently missing in its energy transition. This is particularly important to respond to the increase in the electrification of its economy as pointed above.

Third, a decentralized electricity system provides an important opportunity to decarbonize Morocco's economy. This will reduce pressure on the national electricity grid in responding to the increased electrification of the economy. For example, an integrated green energy network such as district heating powered by heat pumps could be used in specific areas that are large energy consumers, such as large industries. Finally, use of hydrogen may be considered in Morocco in sectors that are hardly to be electrified such as large vehicles or heating and cooling.

7.4. Research limitations and future scope

Although the scope of the thesis has covered certain aspects of Morocco's green economy and it may claim several theoretical and practical contributions, I acknowledge several shortcomings and suggest possible areas for future work.

The analysis of this thesis was primarily based on the available data as of February 2020 when the nine interviews were conducted. Due to the COVID-19 pandemic, it was hard to conduct more interviews. However, some more recent sources such as published reports and data were considered where available and accessible to the researcher. The interviewees provided their understanding of the challenges Morocco faces in delivering its energy strategy which focuses on renewable electricity. This narrow view does not take into consideration wide decarbonization of the economy. Therefore, some issues are not answered in terms of the discussion on electrification and the decarbonization of fossil fuel energy intensive sectors (principally transport, heating, industry, and agriculture) and associated challenges. Addressing these issues will likely reveal other serious challenges for Morocco. Also, some aspects need further investigation including financial arrangements to fund renewable energy projects and international organizations' efforts to support Morocco's transition towards a green economy. In addition, more discussion might be needed on inclusive green growth, environmental regulations to protect biodiversity and ecosystems, and water security which are important issues facing Morocco's development.

Besides, the size of the sample of interviews and its representation may be improved in future research to cover additional players in energy transition and climate change. In addition, since most interviews were conducted in Arabic, another concern is related to the translation process to English. A bias could have arisen from, for instance, choosing the appropriate vocabularies to reflect the opinion of the interviewees.

Also, given the decoupling rate of carbon emission from GDP growth in Morocco has been insufficient to reduce emissions, it would be useful for future studies to advise on the sufficient decoupling rate that is needed to reduce emissions in the country according to its NDC.

The analysis and proposed measurement framework was built on Morocco's current green ambitions. It also considered recent global practices on green economy and took into consideration a number of existing frameworks developed by international institutions and scholars. Future research on Morocco's green economy measurement framework and analysis may address emerging issues as the country progresses in its green agenda, and as technological advances provide broader opportunities in the decarbonization of economies. Also not all proposed indicators are currently measured or consistent from various sources which needs to be addressed. In addition, future research may consider new or updated versions of existing frameworks especially when additional indicators will be measured and available.

Furthermore, this thesis may stimulate a number of other avenues for research in relation to green economy and, in particular, energy transition in Morocco. Future research can investigate the best mix of renewable energy technologies, such as an integrated green energy network, that may be required to decarbonize Morocco's economy. Identifying the mix of technology options and related technical and financial resources will require developing economic modelling. In addition, a road map to facilitate the delivery of energy transition in Morocco may be developed. This needs to consider capacity building programmes aimed at Morocco's supply chain and skills in order to increase the local content of renewable energy projects and support economic growth.

Finally, an updated definition of green economy to reflect the recent developments in this sphere might be useful to be developed in future research. This is in order to provide a clearer and focused direction to green economy transition. The new definition might consider the economy that is energy efficient and net-zero emissions powered by renewable energy. This requires increased electrification and decarbonization of fossil fuel energy intensive sectors, increased decentralization of the electricity system, and radical transformation of the economy, while providing wide socioeconomic and environmental benefits.

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Appendix A

Qualitative data collection

Interview questions

Group 1:

1. To what extent does the government have a clear understanding and implementation plan for green economy?
2. What are the main challenges that Morocco face in transition towards green economy? And how could these challenges be overcome?
3. How would you assess the governance and capacity of institutions in adopting the green economy?
4. How will the government finance green activities? How important is the establishment of Public Investment Bank?
5. What challenges does Morocco face in keeping energy bills affordable to the low-income households while reforming fuel subsidies?
6. To what extent is the government effective in achieving inclusive and balance development?
7. How would you assess the World Bank and other international organisations efforts to support Morocco in transition towards green economy?

Group 2:

1. How would you assess the stringency and enforcement of regulations particularly with regard to the environment and green economy?
2. To what extent does the government effectively protect biodiversity and ecosystems?
3. To what extent will carbon market change the production and consumption patterns and promote sustainable behaviour and lifestyles?
4. How would major economic operators of Morocco contribute to the national efforts to reduce carbon emissions under Paris Agreement?
5. How would you interpret the relationship between the environment and economic growth in Morocco?

Group 3:

1. How would you assess the green growth strategy especially with regard to transitioning towards renewable energy? Is it transition or only enlargement and diversifying of energy sources?
2. How would you assess the policies aiming at improving energy intensity?
3. How would you describe the collaboration and coordination between the various bodies concerned with governing the renewable energy sector?

4. How would you assess the government policies aiming at improving the water productivity and wastewater treatment?

Profile of informants

Table A.1: Profile of informants

Informant code	Job title	Sector	Date of interview
Interview 1	Professor at Ibnou Zohr University	Academia	24/01/2020
Interview 2	Senior Project Manager and Researcher in Energy & Sustainable Development at Maroc Telecom	Public Private sector	26/01/2020
Interview 3	Renewable Energy and Energy Efficiency Specialist at MEME	Public sector	27/01/2020
Interview 4	President of Simulator Online SA/ Windhoist PTY Ltd	Private sector	31/01/2020
Interview 5	Head of Financing Sustainable Development Directorate at Groupe Crédit Agricole du Maroc	Banking sector	31/01/2020
Interview 6	Head of Wind Power Section at MEME	Public sector	07/02/2020
Interview 7	Senior Researcher at IRESEN	Public sector	09/02/2020
Interview 8	Head of Thermal Storage Group / Responsible of the Storage laboratory at IRESEN	Public sector	14/02/2020
Interview 9	Professors at ENSA and President OMNEEA	Academia and private sector	23/02/2020

Consent form

University of Glasgow

College of Social Sciences

Consent Form

Study title:

The Role of the Green Economy in Building Competitiveness and Achieving Sustainable Development

Researcher Details:

Rami Zaatari
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Name of supervisors:

Dr. Duncan Ross - Duncan.Ross@glasgow.ac.uk

Prof. James Tomlinson - Jim.Tomlinson@glasgow.ac.uk

I confirm that I have read and understood the Participant Information Sheet for the above study and have had the opportunity to ask questions.

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

I consent to interviews being audio-recorded.

I acknowledge that participants will be referred to by pseudonym, only if I consent:

I consent to disclose my name and position in the study ☐

I do not consent to disclose my name and position in the study ☐

I acknowledge that there will be no effect on employment arising from my participation or non-participation in this research.

The material will be treated as confidential and kept in secure storage at all times.

All personal details will be destroyed once the project is complete in the event I do not consent to be named, all research data will follow the University of Glasgow guidelines in keeping the data secured and guaranteed for a minimum of 10 years and governed by the General Data Protection Regulation. Hence all research data will be destroyed on 01/07/2030.

I agree to take part in this research study ☐

I do not agree to take part in this research study ☐

Name of Participant ……………………………… Signature …………………… Date ……………………

Name of Researcher ……………………………… Signature …………………… Date ……………………

_____________________ End of consent form _____________________

Ethical approval

University of Glasgow

College of Social Sciences

21 May 2019

Dear : Rami Zaatari

College of Social Sciences Research Ethics Committee

Project Title: The Role of the Green Economy in Building Competitiveness and Achieving Sustainable Development

Application No: 400180201

The College Research Ethics Committee has reviewed your application and has agreed that there is no objection on ethical grounds to the proposed study. It is happy therefore to approve the project, subject to the following conditions:

- Start date of ethical approval: 01/06/2019
- Project end date: 01/07/2020
- Any outstanding permissions needed from third parties in order to recruit research participants or to access facilities or venues for research purposes must be obtained in writing and submitted to the CoSS Research Ethics Administrator before research commences. Permissions you must provide are shown in the *College Ethics Review Feedback* document that has been sent to you as the Collated Comments Document in the online system.
- The data should be held securely for a period of ten years after the completion of the research project, or for longer if specified by the research funder or sponsor, in accordance with the University's Code of Good Practice in Research: (https://www.gla.ac.uk/media/media_490311_en.pdf)
- The research should be carried out only on the sites, and/or with the groups and using the methods defined in the application.
- Any proposed changes in the protocol should be submitted for reassessment as an amendment to the original application. The *Request for Amendments to an Approved Application* form should be used:

  https://www.gla.ac.uk/colleges/socialsciences/students/ethics/forms/staffandpostgraduateresearchstudents/

Yours sincerely,

Dr Muir Houston

College Ethics Officer

Appendix B

Model data

Table B.1: Model data

Year	GDP per capita (constant 2010 USD)	CO_2 emissions per capita (metric tons)	Energy use per capita (kg of oil equivalent)
1971	1053.65	0.50	180.70
1972	1057.25	0.48	190.64
1973	1072.59	0.57	206.71
1974	1109.00	0.64	219.43
1975	1166.94	0.62	222.57
1976	1263.89	0.63	235.18
1977	1309.19	0.68	252.73
1978	1306.47	0.69	261.72
1979	1336.04	0.82	272.67
1980	1351.21	0.80	270.48
1981	1295.50	0.77	265.17
1982	1377.42	0.81	269.38
1983	1363.27	0.83	273.56
1984	1417.28	0.81	275.61
1985	1469.20	0.79	274.69
1986	1571.64	0.82	277.31
1987	1535.14	0.86	278.78
1988	1684.41	0.88	287.05
1989	1699.96	0.94	305.93
1990	1725.71	0.95	307.10
1991	1816.84	0.99	316.94
1992	1747.30	1.01	329.83
1993	1704.70	1.08	336.48
1994	1854.47	1.11	354.53
1995	1727.31	1.12	345.92
1996	1913.11	1.14	358.39
1997	1857.73	1.15	364.49
1998	1966.51	1.14	366.77
1999	1962.99	1.16	385.22
2000	1976.09	1.18	382.68
2001	2095.17	1.29	401.04
2002	2134.85	1.30	403.09
2003	2235.42	1.26	396.89
2004	2315.19	1.44	465.67
2005	2363.44	1.50	487.40
2006	2512.86	1.54	490.04
2007	2571.26	1.61	499.59

Year	GDP per capita (constant 2010 USD)	CO_2 emissions per capita (metric tons)	Energy use per capita (kg of oil equivalent)
2008	2691.27	1.67	512.61
2009	2771.05	1.64	509.96
2010	2839.93	1.73	528.10
2011	2948.85	1.76	561.42
2012	2995.45	1.88	561.48
2013	3087.12	1.75	555.94
2014	3125.08	1.74	555.14

Source: WORLD BANK, 2019. *World development indicators 2019*. The World Bank. [viewed 30 June 2019]. Available from: https://data.worldbank.org/country/morocco

Appendix C

EViews results

Lag length

Table C.1: Lag length of ln CO_2 emissions per capita

VAR Lag Order Selection Criteria
Endogenous variables: CO_2
Exogenous variables: C
Date: 06/30/19 Time: 23:28
Sample: 1971 2014
Included observations: 38

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-7.953833	NA	0.093798	0.471254	0.514349	0.486587
1	64.45712	137.1997*	0.002187*	-3.287217*	-3.201028*	-3.256552*
2	65.40300	1.742412	0.002194	-3.284369	-3.155086	-3.238371
3	66.00829	1.083148	0.002241	-3.263594	-3.091217	-3.202264
4	66.08755	0.137662	0.002354	-3.215134	-2.999662	-3.138471
5	66.10300	0.026010	0.002482	-3.163316	-2.904749	-3.071320
6	66.19989	0.158090	0.002607	-3.115784	-2.814123	-3.008455

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

This table shows that 1 is the optimum lag length for ln CO_2 emissions per capita according to Schwarz Information Criterion by estimation of Vector Autoregressions. The table indicates that 1 is also the optimum lag length according to the other criteria.

Table C.2: Lag length of ln real GDP per capita

VAR Lag Order Selection Criteria
Endogenous variables: GDP
Exogenous variables: C
Date: 06/30/19 Time: 23:31
Sample: 1971 2014
Included observations: 38

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-4.336942	NA	0.077539	0.280892	0.323986	0.296224
1	71.27368	143.2622	0.001528	-3.645983	-3.559794	-3.615318
2	79.25245	14.69775	0.001059	-4.013287	-3.884004*	-3.967289
3	79.27994	0.049177	0.001115	-3.962102	-3.789724	-3.900771
4	81.41701	3.711765	0.001051	-4.021948	-3.806476	-3.945285
5	81.84661	0.723524	0.001084	-3.991927	-3.733360	-3.899931
6	85.93094	6.663913*	0.000923*	-4.154260*	-3.852599	-4.046931*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

This table shows that 2 is the optimum lag length for ln real GDP per capita according to Schwarz Information Criterion by estimation of Vector Autoregressions. The results of this table also confirm that SIC is the best technique to determine lag lengths as it has the lowest value among other criteria.

Table C.3: Lag length of ln real GDP per capita square

VAR Lag Order Selection Criteria
Endogenous variables: GDPS
Exogenous variables: C
Date: 06/30/19 Time: 23:34
Sample: 1971 2014
Included observations: 38

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-107.7203	NA	17.89029	5.722123	5.765217	5.737455
1	-31.43564	144.5394	0.340272	1.759771	1.845959	1.790436
2	-23.31853	14.95258	0.234017	1.385186	1.514469*	1.431184
3	-23.29643	0.039533	0.246489	1.436654	1.609032	1.497985
4	-21.04995	3.901795	0.231010	1.371050	1.586522	1.447713
5	-20.64507	0.681892	0.238630	1.402372	1.660938	1.494368
6	-16.80942	6.258177*	0.205873*	1.253127*	1.554788	1.360456*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

This table shows that 2 is the optimum lag length for ln real GDP per capita square according to Schwarz Information Criterion by estimation of Vector Autoregressions. The results of this table also confirm that SIC is the best technique to determine lag lengths as it has the lowest value among other criteria.

Table C.4: Lag length of ln energy use per capita

VAR Lag Order Selection Criteria
Endogenous variables: EU
Exogenous variables: C
Date: 06/30/19   Time: 23:35
Sample: 1971 2014
Included observations: 38

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3.048000	NA	0.072453	0.213053	0.256147	0.228385
1	75.80087	149.3979*	0.001204*	-3.884256*	-3.798067*	-3.853591*
2	75.82268	0.040179	0.001268	-3.832773	-3.703489	-3.786775
3	76.19240	0.661614	0.001311	-3.799600	-3.627223	-3.738270
4	76.51283	0.556521	0.001360	-3.763833	-3.548361	-3.687170
5	77.00153	0.823077	0.001399	-3.736922	-3.478356	-3.644927
6	77.74344	1.210488	0.001420	-3.723339	-3.421678	-3.616010

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

This table shows that 1 is the optimum lag length for ln energy use per capita according to Schwarz Information Criterion by estimation of Vector Autoregressions. The table indicates that 1 is also the optimum lag length according to the other criteria.

Unit Root Tests

Table C.5: Unit Root Test for ln CO_2 emissions per capita at level (Trend and Intercept included)

Null Hypothesis: CO_2 has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.438108	0.0053
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	
	10% level	-3.191277	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CO_2)
Method: Least Squares
Date: 07/15/19 Time: 20:49
Sample (adjusted): 1973 2014
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2(-1)	-0.583813	0.131546	-4.438108	0.0001
D(CO2(-1))	0.078705	0.138812	0.566993	0.5741
C	-0.306546	0.083505	-3.670979	0.0007
@TREND("1971")	0.015650	0.003785	4.134625	0.0002

R-squared	0.395599	Mean dependent var	0.030708
Adjusted R-squared	0.347883	S.D. dependent var	0.050884
S.E. of regression	0.041091	Akaike info criterion	-3.455668
Sum squared resid	0.064162	Schwarz criterion	-3.290175
Log likelihood	76.56902	Hannan-Quinn criter.	-3.395008
F-statistic	8.290721	Durbin-Watson stat	1.899870
Prob(F-statistic)	0.000229		

This table shows the Augmented Dickey-Fuller test results for ln CO_2 emissions per capita, incorporating trend and intercept at level. The probabilities of coefficients of ln CO_2

emissions per capita, trend and intercept are significant. Since the Null Hypothesis can be rejected at 1% level, the order of integration of ln CO_2 emissions per capita is I(0). Hence, this variable at level can be included in ARDL test.

Table C.6: Unit Root Test for ln real GDP per capita at level (Trend and Intercept included)

Null Hypothesis: GDP has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 2 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.884376	0.6444
Test critical values:	1% level	-4.198503	
	5% level	-3.523623	
	10% level	-3.192902	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(GDP)

Method: Least Squares

Date: 07/15/19 Time: 21:00

Sample (adjusted): 1974 2014

Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	-0.263874	0.140032	-1.884376	0.0676
D(GDP(-1))	-0.295893	0.187378	-1.579128	0.1231
D(GDP(-2))	0.175306	0.166265	1.054376	0.2987
C	1.859869	0.968194	1.920967	0.0627
@TREND("1971")	0.006426	0.003408	1.885863	0.0674

R-squared	0.343565	Mean dependent var	0.026083
Adjusted R-squared	0.270627	S.D. dependent var	0.037455
S.E. of regression	0.031988	Akaike info criterion	-3.933085
Sum squared resid	0.036836	Schwarz criterion	-3.724113
Log likelihood	85.62824	Hannan-Quinn criter.	-3.856989
F-statistic	4.710414	Durbin-Watson stat	2.147921
Prob(F-statistic)	0.003680		

This table shows the Augmented Dickey-Fuller test results for ln real GDP per capita, incorporating trend and intercept at level. Value of t-Statistics is larger than its critical values which indicates one cannot reject the Null Hypothesis of unit root test for ln real GDP per capita. Therefore, this test will be performed at first difference.

Table C.7: Unit Root Test for ln real GDP per capita at first difference (Trend and Intercept included)

Null Hypothesis: D(GDP) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.956414	0.0013
Test critical values:	1% level	-4.198503	
	5% level	-3.523623	
	10% level	-3.192902	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDP,2)
Method: Least Squares
Date: 07/15/19 Time: 21:01
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP(-1))	-1.409884	0.284456	-4.956414	0.0000
D(GDP(-1),2)	-0.075446	0.162935	-0.463045	0.6460
C	0.035580	0.012994	2.738200	0.0094
@TREND("1971")	5.50E-05	0.000438	0.125382	0.9009

R-squared	0.763204	Mean dependent var	-5.33E-05
Adjusted R-squared	0.744004	S.D. dependent var	0.065365
S.E. of regression	0.033072	Akaike info criterion	-3.887797
Sum squared resid	0.040469	Schwarz criterion	-3.720619
Log likelihood	83.69983	Hannan-Quinn criter.	-3.826920
F-statistic	39.75083	Durbin-Watson stat	2.031771
Prob(F-statistic)	0.000000		

This table shows the Augmented Dickey-Fuller test for ln real GDP per capita, incorporating trend and intercept at first difference. Value of t-Statistics is smaller than its critical values, however, the probability of coefficient of Trend is not significant, therefore this test will be performed again without Trend at level.

Table C.8: Unit Root Test for ln real GDP per capita at level (only Intercept included)

Null Hypothesis: GDP has a unit root
Exogenous: Constant
Lag Length: 2 (Fixed)

			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-0.102347	0.9424
Test critical values:	1% level		-3.600987	
	5% level		-2.935001	
	10% level		-2.605836	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDP)
Method: Least Squares
Date: 07/15/19 Time: 21:02
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	-0.001844	0.018014	-0.102347	0.9190
D(GDP(-1))	-0.481293	0.164935	-2.918073	0.0060
D(GDP(-2))	0.079273	0.163651	0.484400	0.6310
C	0.050464	0.134186	0.376076	0.7090

R-squared	0.278715	Mean dependent var	0.026083
Adjusted R-squared	0.220232	S.D. dependent var	0.037455
S.E. of regression	0.033074	Akaike info criterion	-3.887655
Sum squared resid	0.040475	Schwarz criterion	-3.720477
Log likelihood	83.69692	Hannan-Quinn criter.	-3.826778
F-statistic	4.765772	Durbin-Watson stat	2.037875
Prob(F-statistic)	0.006587		

This table shows the Augmented Dickey-Fuller test results for ln real GDP per capita, incorporating intercept at level. Value of t-Statistics is larger than its critical values which indicates one cannot reject the Null Hypothesis of unit root test for ln real GDP per capita. Therefore, this test will be performed at first difference.

Table C.9: Unit Root Test for ln real GDP per capita at first difference (only Intercept included)

Null Hypothesis: D(GDP) has a unit root				
Exogenous: Constant				
Lag Length: 1 (Fixed)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-5.031028	0.0002
Test critical values:	1% level		-3.600987	
	5% level		-2.935001	
	10% level		-2.605836	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(GDP,2)				
Method: Least Squares				
Date: 07/15/19 Time: 21:02				
Sample (adjusted): 1974 2014				
Included observations: 41 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP(-1))	-1.406656	0.279596	-5.031028	0.0000
D(GDP(-1),2)	-0.077175	0.160235	-0.481637	0.6328
C	0.036761	0.008836	4.160586	0.0002
R-squared	0.763103	Mean dependent var		-5.33E-05
Adjusted R-squared	0.750635	S.D. dependent var		0.065365
S.E. of regression	0.032641	Akaike info criterion		-3.936152
Sum squared resid	0.040486	Schwarz criterion		-3.810769
Log likelihood	83.69112	Hannan-Quinn criter.		-3.890495
F-statistic	61.20368	Durbin-Watson stat		2.034792
Prob(F-statistic)	0.000000			

This table shows the Augmented Dickey-Fuller test results of ln real GDP per capita, incorporating intercept at first difference. Since the Null Hypothesis can be rejected at 1% level, the order of integration of ln real GDP per capita is I(1). Hence, this variable at first difference can be included in ARDL test.

Table C.10: Unit Root Test for ln real GDP per capita square at level (Trend and Intercept included)

Null Hypothesis: GDPS has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.502847	0.8124
Test critical values:	1% level	-4.198503	
	5% level	-3.523623	
	10% level	-3.192902	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDPS)
Method: Least Squares
Date: 07/15/19 Time: 21:03
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDPS(-1)	-0.196832	0.130972	-1.502847	0.1416
D(GDPS(-1))	-0.345893	0.189191	-1.828271	0.0758
D(GDPS(-2))	0.152991	0.169349	0.903405	0.3723
C	9.847962	6.228443	1.581128	0.1226
@TREND("1971")	0.073977	0.047723	1.550145	0.1299

R-squared	0.330243	Mean dependent var	0.391892
Adjusted R-squared	0.255825	S.D. dependent var	0.556510
S.E. of regression	0.480076	Akaike info criterion	1.484107
Sum squared resid	8.297043	Schwarz criterion	1.693079
Log likelihood	-25.42419	Hannan-Quinn criter.	1.560203
F-statistic	4.437706	Durbin-Watson stat	2.118177
Prob(F-statistic)	0.005107		

This table shows the Augmented Dickey-Fuller test results for ln real GDP per capita square, incorporating trend and intercept at level. Value of t-Statistics is larger than its critical values which indicates one cannot reject the Null Hypothesis of unit root test for ln real GDP per capita square. Therefore, this test will be performed at first difference.

Table C.11: Unit Root Test for ln real GDP per capita square at first difference (Trend and Intercept included)

Null Hypothesis: D(GDPS) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.979872	0.0012
Test critical values:	1% level	-4.198503	
	5% level	-3.523623	
	10% level	-3.192902	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDPS,2)
Method: Least Squares
Date: 07/15/19 Time: 21:04
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDPS(-1))	-1.423266	0.285804	-4.979872	0.0000
D(GDPS(-1),2)	-0.071957	0.163243	-0.440799	0.6619
C	0.491702	0.188288	2.611434	0.0129
@TREND("1971")	0.002908	0.006520	0.445911	0.6583

R-squared	0.767168	Mean dependent var	-0.000105
Adjusted R-squared	0.748290	S.D. dependent var	0.973024
S.E. of regression	0.488173	Akaike info criterion	1.496174
Sum squared resid	8.817578	Schwarz criterion	1.663352
Log likelihood	-26.67157	Hannan-Quinn criter.	1.557051
F-statistic	40.63772	Durbin-Watson stat	2.031589
Prob(F-statistic)	0.000000		

This table shows the Augmented Dickey-Fuller test for ln real GDP per capita square, incorporating trend and intercept at first difference. Value of t-Statistics is smaller than its critical values, however, the probability of coefficient of Trend is not significant, therefore this test will be performed again without Trend at level.

Table C.12: Unit Root Test for ln real GDP per capita square at level (only intercept included)

Null Hypothesis: GDPS has a unit root
Exogenous: Constant
Lag Length: 2 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.242826	0.9721
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDPS)
Method: Least Squares
Date: 07/15/19 Time: 21:06
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDPS(-1)	0.004354	0.017929	0.242826	0.8095
D(GDPS(-1))	-0.494213	0.166279	-2.972198	0.0052
D(GDPS(-2))	0.074804	0.164700	0.454185	0.6523
C	0.312015	0.993364	0.314100	0.7552

R-squared	0.285537	Mean dependent var	0.391892
Adjusted R-squared	0.227608	S.D. dependent var	0.556510
S.E. of regression	0.489093	Akaike info criterion	1.499941
Sum squared resid	8.850859	Schwarz criterion	1.667119
Log likelihood	-26.74880	Hannan-Quinn criter.	1.560818
F-statistic	4.929061	Durbin-Watson stat	2.036170
Prob(F-statistic)	0.005582		

This table shows the Augmented Dickey-Fuller test for ln real GDP per capita square, incorporating intercept at level. Value of t-Statistics is larger than its critical values which indicates one cannot reject the Null Hypothesis of unit root test for ln real GDP per capita square. Therefore, this test will be performed at first difference.

Table C.13: Unit Root Test for ln real GDP per capita square at first difference (only intercept included)

Null Hypothesis: D(GDPS) has a unit root
Exogenous: Constant
Lag Length: 1 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.023374	0.0002
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDPS,2)
Method: Least Squares
Date: 07/15/19 Time: 21:07
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDPS(-1))	-1.403778	0.279449	-5.023374	0.0000
D(GDPS(-1),2)	-0.082056	0.159951	-0.513008	0.6109
C	0.551044	0.131787	4.181315	0.0002

R-squared	0.765917	Mean dependent var	-0.000105
Adjusted R-squared	0.753597	S.D. dependent var	0.973024
S.E. of regression	0.483000	Akaike info criterion	1.452753
Sum squared resid	8.864964	Schwarz criterion	1.578137
Log likelihood	-26.78144	Hannan-Quinn criter.	1.498411
F-statistic	62.16786	Durbin-Watson stat	2.045101
Prob(F-statistic)	0.000000		

This table shows the Augmented Dickey-Fuller test results of ln real GDP per capita square, incorporating intercept at first difference. Since the Null Hypothesis can be rejected at 1% level, the order of integration of ln real GDP per capita square is I(1). Hence, this variable at first difference can be included in ARDL test.

Table C.14: Unit Root Test for ln energy use per capita at level (Trend and Intercept included)

Null Hypothesis: EU has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.851171	0.1882
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	
	10% level	-3.191277	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EU)
Method: Least Squares
Date: 07/15/19 Time: 21:08
Sample (adjusted): 1973 2014
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EU(-1)	-0.301588	0.105777	-2.851171	0.0070
D(EU(-1))	0.124652	0.152466	0.817574	0.4187
C	1.623311	0.557835	2.910022	0.0060
@TREND("1971")	0.006915	0.002583	2.677538	0.0109

R-squared	0.190487	Mean dependent var	0.025449
Adjusted R-squared	0.126578	S.D. dependent var	0.033813
S.E. of regression	0.031601	Akaike info criterion	-3.980864
Sum squared resid	0.037948	Schwarz criterion	-3.815372
Log likelihood	87.59814	Hannan-Quinn criter.	-3.920204
F-statistic	2.980605	Durbin-Watson stat	1.973313
Prob(F-statistic)	0.043343		

This table shows the Augmented Dickey-Fuller test results for ln energy use per capita, incorporating trend and intercept at level. Value of t-Statistics is larger than its critical values which indicates one cannot reject the Null Hypothesis of unit root test for ln energy use per capita. Therefore, this test will be performed at first difference.

Table C.15: Unit Root Test for ln energy use per capita at first difference (Trend and Intercept included)

Null Hypothesis: D(EU) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.171843	0.0000
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	
	10% level	-3.191277	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EU,2)
Method: Least Squares
Date: 07/15/19 Time: 21:09
Sample (adjusted): 1973 2014
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EU(-1))	-0.988266	0.160125	-6.171843	0.0000
C	0.033167	0.012499	2.653632	0.0115
@TREND("1971")	-0.000357	0.000441	-0.808936	0.4235

R-squared	0.494109	Mean dependent var	-0.001309
Adjusted R-squared	0.468165	S.D. dependent var	0.047127
S.E. of regression	0.034368	Akaike info criterion	-3.834623
Sum squared resid	0.046066	Schwarz criterion	-3.710504
Log likelihood	83.52709	Hannan-Quinn criter.	-3.789129
F-statistic	19.04582	Durbin-Watson stat	1.982286
Prob(F-statistic)	0.000002		

This table shows the Augmented Dickey-Fuller test results for ln energy use per capita, incorporating trend and intercept at first difference. Value of t-Statistics is smaller than its critical values, however, the probability of coefficient of Trend is not significant, therefore this test will be performed again without Trend at level.

Table C.16: Unit Root Test for ln energy use per capita at level (only intercept included)

Null Hypothesis: EU has a unit root

Exogenous: Constant

Lag Length: 1 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.223577	0.6554
Test critical values:	1% level	-3.596616	
	5% level	-2.933158	
	10% level	-2.604867	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(EU)

Method: Least Squares

Date: 07/15/19 Time: 21:10

Sample (adjusted): 1973 2014

Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EU(-1)	-0.021884	0.017885	-1.223577	0.2285
D(EU(-1))	0.011818	0.157690	0.074946	0.9406
C	0.152609	0.104768	1.456629	0.1532

R-squared	0.037762	Mean dependent var	0.025449
Adjusted R-squared	-0.011584	S.D. dependent var	0.033813
S.E. of regression	0.034009	Akaike info criterion	-3.855653
Sum squared resid	0.045107	Schwarz criterion	-3.731534
Log likelihood	83.96872	Hannan-Quinn criter.	-3.810159
F-statistic	0.765252	Durbin-Watson stat	1.979006
Prob(F-statistic)	0.472075		

This table shows the Augmented Dickey-Fuller test results for ln energy use per capita, incorporating intercept at level. Value of t-Statistics is larger than its critical values which indicates one cannot reject the Null Hypothesis of unit root test for ln energy use per capita. Therefore, this test will be performed at first difference.

Table C.17: Unit Root Test for ln energy use per capita at first difference (only intercept included)

Null Hypothesis: D(EU) has a unit root
Exogenous: Constant
Lag Length: 0 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.145207	0.0000
Test critical values:	1% level	-3.596616	
	5% level	-2.933158	
	10% level	-2.604867	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EU,2)
Method: Least Squares
Date: 07/15/19 Time: 21:11
Sample (adjusted): 1973 2014
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EU(-1))	-0.971307	0.158059	-6.145207	0.0000
C	0.024681	0.006765	3.648249	0.0008

R-squared	0.485620	Mean dependent var	-0.001309
Adjusted R-squared	0.472761	S.D. dependent var	0.047127
S.E. of regression	0.034219	Akaike info criterion	-3.865603
Sum squared resid	0.046839	Schwarz criterion	-3.782857
Log likelihood	83.17766	Hannan-Quinn criter.	-3.835273
F-statistic	37.76356	Durbin-Watson stat	1.982181
Prob(F-statistic)	0.000000		

This table shows the Augmented Dickey-Fuller test results of ln energy use per capita, incorporating intercept at first difference. Since the Null Hypothesis can be rejected at 1% level, the order of integration of ln energy use per capita is I(1). Hence, this variable at first difference can be included in ARDL test.

Consequently, the Augmented Dickey-Fuller test results show that the order of integration of variables are I(0) for CO_2 emissions per capita and I(1) for the other variables. Trend and intercept are included in unit root tests in the case of CO_2 emissions per capita, whereas only intercept is included in the tests for the other variables following the results of the tests. This mix results of level of integration along with no variable is greater than I(1) justify using ARDL cointegration approach.

ARDL

Table C.18: ARDL results

Dependent Variable: CO_2
Method: ARDL
Date: 07/15/19 Time: 21:30
Sample (adjusted): 1972 2014
Included observations: 43 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Schwarz criterion (SIC)
Dynamic regressors (4 lags, automatic): GDP GDPS EU
Fixed regressors: C
Number of models evalulated: 500
Selected Model: ARDL(1, 0, 0, 0)
Note: final equation sample is larger than selection sample
Huber-White-Hinkley (HC1) heteroskedasticity consistent standard errors and covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
CO2(-1)	0.238294	0.098155	2.427728	0.0200
GDP	2.470089	0.903445	2.734078	0.0094
GDPS	-0.164807	0.060535	-2.722482	0.0097
EU	0.890905	0.149773	5.948369	0.0000
C	-14.40088	3.611218	-3.987818	0.0003

R-squared	0.992841	Mean dependent var	0.041824
Adjusted R-squared	0.992087	S.D. dependent var	0.355850
S.E. of regression	0.031654	Akaike info criterion	-3.958967
Sum squared resid	0.038075	Schwarz criterion	-3.754177
Log likelihood	90.11780	Hannan-Quinn criter.	-3.883447
F-statistic	1317.492	Durbin-Watson stat	1.817859
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Considering 4 maximum automatic selection lags and following SIC selection method, this table indicates that ARDL test shows that the ideal model is ARDL (1, 0, 0, 0). This means that the model will use 1 lag for CO_2 emissions per capita and 0 lag for other variables. The trend is not included in the model justified by that its coefficient probability is not significant.

ARDL Long-Run Form and Bounds Test

Table C.19: ARDL Long Run Form and Bounds Test

ARDL Long-Run Form and Bounds Test
Dependent Variable: D(CO2)
Selected Model: ARDL(1, 0, 0, 0)
Case 3: Unrestricted Constant and No Trend
Date: 07/15/19 Time: 21:33
Sample: 1971 2014
Included observations: 43

Conditional Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-14.40088	3.507792	-4.105398	0.0002
CO2(-1)*	-0.761706	0.095971	-7.936875	0.0000
GDP**	2.470089	0.863219	2.861486	0.0068
GDPS**	-0.164807	0.055829	-2.951979	0.0054
EU**	0.890905	0.130453	6.829321	0.0000

* p-value incompatible with t-Bounds distribution.
** Variable interpreted as Z = Z(-1) + D(Z).

Levels Equation
Case 3: Unrestricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP	3.242837	1.188225	2.729145	0.0096
GDPS	-0.216365	0.079361	-2.726344	0.0096
EU	1.169617	0.122260	9.566644	0.0000

EC = CO_2 - (3.2428*GDP -0.2164*GDPS + 1.1696*EU)

F-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	18.20197	10%	2.72	3.77
k	3	5%	3.23	4.35
		2.5%	3.69	4.89

		1%	4.29	5.61
			Finite Sample:	
Actual Sample Size	43		n=45	
		10%	2.893	3.983
		5%	3.535	4.733
		1%	4.983	6.423
			Finite Sample:	
			n=40	
		10%	2.933	4.02
		5%	3.548	4.803
		1%	5.018	6.61

t-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-7.936875	10%	-2.57	-3.46
		5%	-2.86	-3.78
		2.5%	-3.13	-4.05
		1%	-3.43	-4.37

The table illustrates that ARDL Long-Run Form and Bounds Test shows that null hypothesis of no level relationship is rejected as F-statistic value is higher than the upper bound of 5% significance and also of 1% significance concluding the existence of cointegration. T-statistic also confirms the result. The results of ARDL Long-Run Form show that real GDP per capita has positive coefficient and it is statistically significant. While real GDP per capita square coefficient is negative and statistically significant. Therefore, the data available for Morocco supports the theory of EKC, i.e. an inverted U-shaped relationship between CO_2 emissions per capita and GDP per capita.

The table also shows that an increase of 1% in real GDP per capita from 2014 levels will be associated with a long-run decrease of 0.22% in CO_2 emissions per capita. The coefficient of energy use per capita is positive and significant concluding the positive relationship between energy use per capita and CO_2 emissions per capita. An increase of 1% in the energy use per capita from 2014 levels will be associated with a long-run increase of 1.17% in CO_2 emissions per capita. The long-run equation can be estimated and presented as:

$$CO_2 = - 18.9061 + 3.2428*GDP - 0.2164*GDPS + 1.1696*EU$$

ARDL Error Correction Regression

Table C.20: ARDL Error Correction Regression

ARDL Error Correction Regression
Dependent Variable: D(CO2)
Selected Model: ARDL(1, 0, 0, 0)
Case 3: Unrestricted Constant and No Trend
Date: 07/15/19 Time: 21:35
Sample: 1971 2014
Included observations: 43

ECM Regression
Case 3: Unrestricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-14.40088	1.628085	-8.845286	0.0000
CointEq(-1)*	-0.761706	0.085941	-8.863175	0.0000

R-squared	0.657064	Mean dependent var	0.029066
Adjusted R-squared	0.648700	S.D. dependent var	0.051415
S.E. of regression	0.030474	Akaike info criterion	-4.098502
Sum squared resid	0.038075	Schwarz criterion	-4.016586
Log likelihood	90.11780	Hannan-Quinn criter.	-4.068294
F-statistic	78.55587	Durbin-Watson stat	1.817859
Prob(F-statistic)	0.000000		

* p-value incompatible with t-Bounds distribution.

F-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	18.20197	10%	2.72	3.77
k	3	5%	3.23	4.35
		2.5%	3.69	4.89
		1%	4.29	5.61

t-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-8.863175	10%	-2.57	-3.46
		5%	-2.86	-3.78
		2.5%	-3.13	-4.05
		1%	-3.43	-4.37

This table illustrates that ARDL Error Correction Regression shows that the speed of adjustment (ECT) is having negative sign and it is highly significant. ECT coefficient (-0.76) confirms that if there is disturbance in the short-run equilibrium, and the Model will converge to long-run equilibrium path with 76% adjustment speed on yearly basis, i.e. in almost 9 months.

Granger causality test

Table C.21: Granger causality test

Pairwise Granger Causality Tests
Date: 07/01/19 Time: 00:44
Sample: 1971 2014
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
GDP does not Granger Cause CO_2	43	7.33195	0.0099
CO_2 does not Granger Cause GDP		2.99901	0.0910
GDPS does not Granger Cause CO_2	43	6.64381	0.0137
CO_2 does not Granger Cause GDPS		2.60231	0.1146
EU does not Granger Cause CO_2	43	13.3454	0.0007
CO_2 does not Granger Cause EU		0.78883	0.3798
GDPS does not Granger Cause GDP	43	0.17195	0.6806
GDP does not Granger Cause GDPS		0.16110	0.6903
EU does not Granger Cause GDP	43	2.59058	0.1154
GDP does not Granger Cause EU		5.92165	0.0195
EU does not Granger Cause GDPS	43	2.36110	0.1323
GDPS does not Granger Cause EU		6.18074	0.0172

The results of Granger causality test show that in the long run, a unidirectional Granger causality is running from real GDP per capita towards energy use per capita at 5% significant level, from energy use per capita to CO_2 emissions per capita at 1% significant level, and from real GDP per capita towards CO_2 emissions per capita at 1% significant level. Based on these strong Granger causality results in the long run, evidence shows that economic growth precedes energy usage and emissions. Also, energy consumption precedes carbon emissions.

Diagnostic tests

Table C.22: Serial Correlation test

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.330823	Prob. F(2,36)	0.7205
Obs*R-squared	0.776035	Prob. Chi-Square(2)	0.6784

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 07/01/19 Time: 00:50
Sample: 1972 2014
Included observations: 43
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2(-1)	-0.017019	0.129887	-0.131030	0.8965
GDP	0.067847	0.925312	0.073324	0.9420
GDPS	-0.003499	0.060071	-0.058253	0.9539
EU	0.005016	0.169855	0.029534	0.9766
C	-0.340632	3.946977	-0.086302	0.9317
RESID(-1)	0.077832	0.220802	0.352496	0.7265
RESID(-2)	-0.119473	0.176550	-0.676710	0.5029

R-squared	0.018047	Mean dependent var	6.60E-16
Adjusted R-squared	-0.145611	S.D. dependent var	0.030109
S.E. of regression	0.032226	Akaike info criterion	-3.884156
Sum squared resid	0.037388	Schwarz criterion	-3.597449
Log likelihood	90.50936	Hannan-Quinn criter.	-3.778428
F-statistic	0.110274	Durbin-Watson stat	1.977063
Prob(F-statistic)	0.994675		

This table illustrates that the results from residual diagnostic tests reveal that no first-order serial correlation is present and the null hypothesis is not rejected, i.e. there is no serial correlation exists.

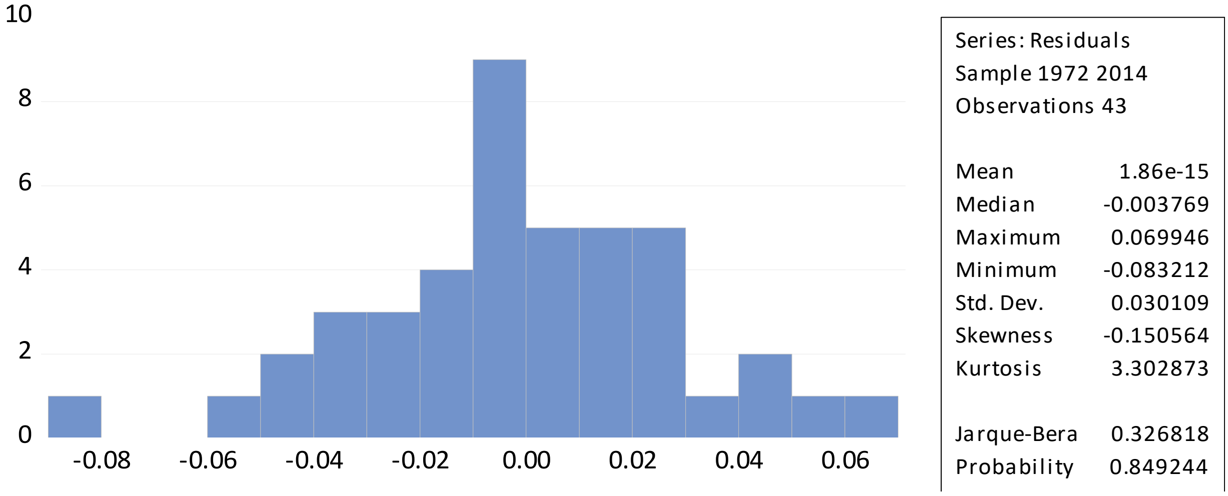

Figure C.1: Normality test

This figure show that the null hypothesis of a normal distribution for the residuals is not rejected. This means that the model passes the Jarque–Bera’s normality test suggesting that the errors are normally distributed.

Table C.23: Heteroskedasticity test: ARCH

Heteroskedasticity Test: ARCH				
F-statistic	1.845138	Prob. F(2,38)		0.1719
Obs*R-squared	3.629175	Prob. Chi-Square(2)		0.1629

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 07/21/19 Time: 20:23
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments
Huber-White-Hinkley (HC1) heteroskedasticity consistent standard errors and covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000506	0.000164	3.081803	0.0038
RESID^2(-1)	0.238469	0.133004	1.792949	0.0809
RESID^2(-2)	0.117748	0.185692	0.634105	0.5298

R-squared	0.088516	Mean dependent var	0.000819
Adjusted R-squared	0.040544	S.D. dependent var	0.001356
S.E. of regression	0.001328	Akaike info criterion	-10.34003
Sum squared resid	6.70E-05	Schwarz criterion	-10.21465
Log likelihood	214.9707	Hannan-Quinn criter.	-10.29438
F-statistic	1.845138	Durbin-Watson stat	1.831235
Prob(F-statistic)	0.171881		

This table presents that according to the Heteroskedasticity Test (ARCH test), there is no autocorrelation of the error terms.

Stability tests

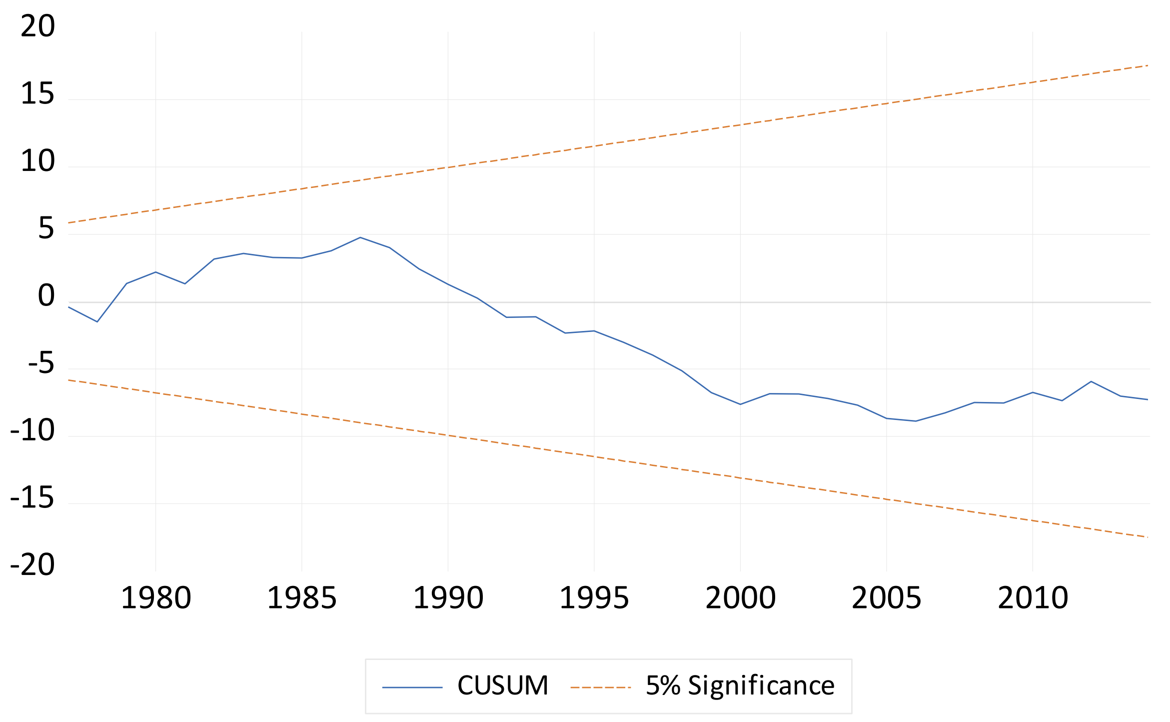

Figure C.2: CUSUM test

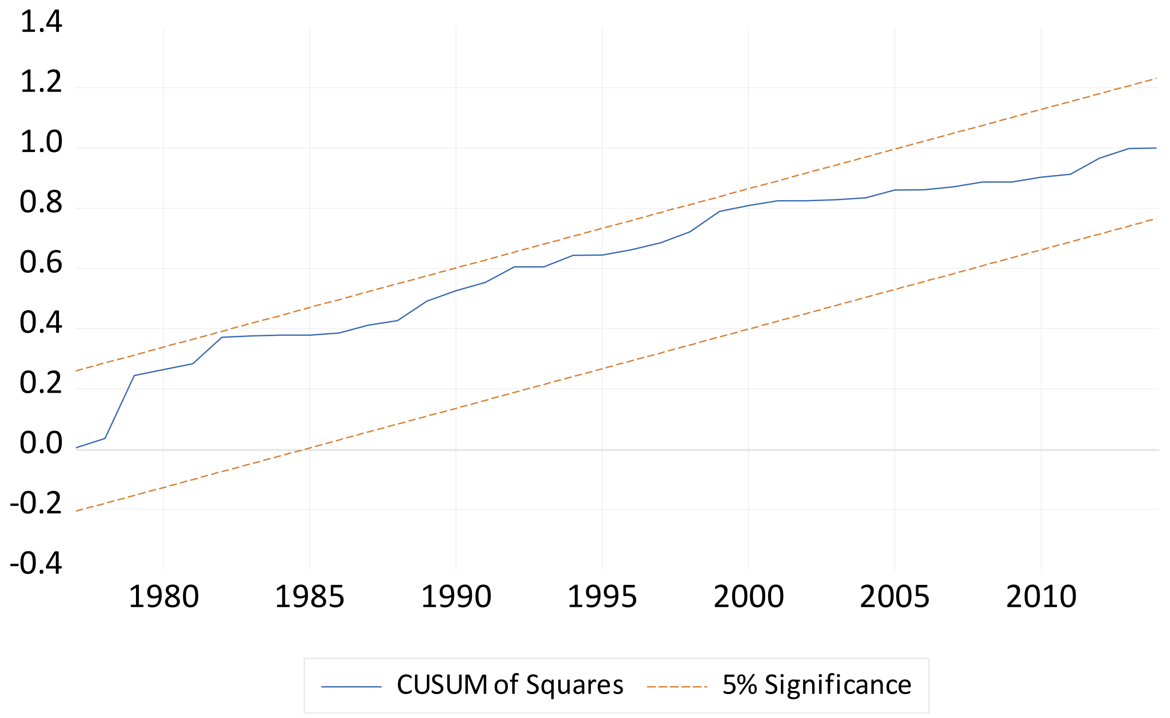

Figure C.3: CUSUMSQ test

These two figures on CUSUM and CUSUM square tests for stability tests show that the variables in the model are stable over the long period of time as their statistics are within the critical bound of the 5% level of significance. These two tests also confirm that there is no structural break during the studied period. Thus, overall model is reliable for policy analysis.

Robustness

Table C.24: Dynamic Least Squares (DOLS) test

Dependent Variable: CO_2
Method: Dynamic Least Squares (DOLS)
Date: 07/15/19 Time: 22:06
Sample (adjusted): 1972 2014
Included observations: 43 after adjustments
Cointegrating equation deterministics: C
Static OLS leads and lags specification
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2(-1)	0.238294	0.098155	2.427728	0.0200
GDP	2.470089	0.903445	2.734078	0.0094
GDPS	-0.164807	0.060535	-2.722482	0.0097
EU	0.890905	0.149773	5.948369	0.0000
C	-14.40088	3.611218	-3.987818	0.0003

R-squared	0.992841	Mean dependent var	0.041824
Adjusted R-squared	0.992087	S.D. dependent var	0.355850
S.E. of regression	0.031654	Sum squared resid	0.038075

This table shows that the result from Dynamic Least Squares is consistent with the ARDL results according to the sign and significance of the coefficients.

Table C.25: Fully Modified Ordinary Least Squares

Dependent Variable: CO_2
Method: Fully Modified Least Squares (FMOLS)
Date: 07/01/19 Time: 01:04
Sample (adjusted): 1973 2014
Included observations: 42 after adjustments
Cointegrating equation deterministics: C
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2(-1)	0.261012	0.094384	2.765436	0.0088
GDP	2.189482	0.900487	2.431441	0.0200
GDPS	-0.138835	0.058901	-2.357082	0.0238
EU	0.744305	0.132028	5.637463	0.0000
C	-12.90240	3.665568	-3.519890	0.0012

R-squared	0.992523	Mean dependent var	0.060192
Adjusted R-squared	0.991714	S.D. dependent var	0.338902
S.E. of regression	0.030849	Sum squared resid	0.035211
Long-run variance	0.000966		

This table illustrates that Fully Modified Least Squares is consistent with the ARDL reults in the long-run and confirms the validity of EKC. Hence the results are robust.

Appendix D

Morocco’s green economy measurement framework

Table D.1: Proposed green economy measurement framework for Morocco

Indicator	Value		Trend	Source
1. Emissions				
1.1. Total emissions				
1.1.1. Total GHG emissions	75.9 Mt (2010)	87.5 Mt (2016)	▲	Climate Action Tracker
1.1.2. Total CO_2 emissions	46.4 Mt (2010)	65.9 Mt (2019)	▲	IEA
1.1.3. CO_2 emissions per unit of GDP $ (PPP)	0.2 kg (2010)	0.2 kg (2020)	-	IEA
1.1.4. CO_2 intensity of energy mix	65.0 t CO_2 /Tj (2010)	70.7 t CO_2/Tj (2019)	▲	IEA
1.2. CO_2 emissions by sector				
1.2.1. CO_2 emissions from transport	14 Mt (2010)	19 Mt (2019)	▲	IEA
1.2.2. CO_2 emissions from electricity and heat producers	16 Mt (2010)	29 Mt (2019)	▲	IEA
1.2.3. CO_2 emissions from industry	8 Mt (2010)	8 Mt (2019)	-	IEA
1.2.4. CO_2 emissions from residential	5 Mt (2010)	7 Mt (2019)	▲	IEA
1.2.5. CO_2 emissions from agriculture	2 Mt (2010)	3 Mt (2019)	▲	IEA
2. Fossil fuel energy supply				
2.1. Total fossil fuel energy supply	622,876 Tj (2010)	844,255 Tj (2019)	▲	IEA
2.1.1. Total oil energy supply	482,133 Tj (2010)	528,566 Tj (2019)	▲	IEA
2.1.2. Total coal energy supply	116,888 Tj (2010)	279,054 Tj (2019)	▲	IEA
2.1.3. Total natural gas energy supply	23,855 Tj (2010)	36,635 Tj (2019)	▲	IEA
2.2. Fossil fuel energy in the total primary energy supply	88.9% (2010)	90.3% (2019)	▲	IEA
2.2.1. Share of oil in the total primary energy supply	68.8% (2010)	56.5% (2019)	▼	IEA
2.2.2. Share of coal in the total primary energy supply	16.7% (2010)	29.8% (2019)	▲	IEA
2.2.3. Share of natural gas in the total primary energy supply	3.4% (2010)	3.9% (2019)	▲	IEA
3. Renewable energy and electrification				
3.1. Total renewable energy generation	6,300 GWh (2010)	9,422 GWh (2020)	▲	IEA
3.1.1. Hydro energy generation	3,631 GWh (2010)	1,290 GWh (2020)	▼	IEA
3.1.2. Wind energy generation	659 GWh (2010)	4,592 GWh (2020)	▲	IEA

Indicator	Value		Trend	Source
3.1.3. Solar energy generation (PV and thermal)	0 (2010)	1,520 GWh (2020)	▲	IEA
3.2. Share of renewable energy				
3.2.1. Share of renewable energy in installed electrical power	31% (2010)	34% (2020)	▲	Alhamwi et al. (2015) for 2010 Interview (3) for 2020
3.2.2. Share of renewable energy in total electricity generation	18.0% (2010)	18.5% (2020)	▲	IEA
3.2.3. Share of renewable energy in total final energy consumption	13.9 (2010)	10.8% (2018)	▼	IEA
3.2.4. Share of renewable electricity in industry	N/A (2010)	N/A (2020)	-	N/A
3.2.5. Share of renewable electricity in residential sector	N/A (2010)	N/A (2020)	-	N/A
3.2.6. Share of renewable electricity in commercial and public services	N/A (2010)	N/A (2020)	-	N/A
3.2.7. Share of renewable electricity in agriculture	N/A (2010)	N/A (2020)	-	N/A
3.3. Electrification				
3.3.1. Share of electricity in total final energy consumption (Total electrification of the economy)	15.4% (2010)	17.2% (2019)	▲	IEA
3.3.2. Share of electricity consumption by industry in the total energy consumption by industry (Electrification of industry)	26.1% (2010)	33.2% (2019)	▲	IEA
3.3.3. Share of electricity consumption by residential in the total energy consumption by residential (Electrification of residential)	20.3% (2010)	23.4% (2019)	▲	IEA
3.3.4. Share of electricity consumption by commercial and public services in the total energy consumption by commercial and public services (Electrification of commercial and public services)	31.7% (2010)	37.8% (2019)	▲	IEA
3.3.5. Share of electricity consumption by Agriculture/forestry in the total energy consumption by Agriculture/forestry (Electrification of Agriculture/forestry)	24.5% (2010)	22.8% (2018)	▼	IEA
3.3.6. Share of electricity consumption by transport in the total energy consumption by transport (Electrification of transport)	0.5 (2010)	0.5% (2019)	-	IEA

Indicator		Value		Trend	Source
3.3.7.	Share of EVs in total vehicles	N/A (2010)	N/A (2020)	-	N/A
4.	Energy efficiency				
4.1.	Energy intensity level of primary energy (MJ/$2011 PPP GDP)	3.375 MJ/GDP (2010)	3.155 MJ/GDP (2015)	▼	World Bank
4.2.	Agriculture energy intensity	2.0 MJ/GDP (2010)	2.5 MJ/GDP (2013)	▲	Trading Economics
4.3.	Manufacturing energy intensity (MJ/$ PPP 2015)	2.7 MJ/GDP (2010)	2.5 MJ/GDP (2018)	▼	IEA
4.4.	Services energy intensity (MJ/$ PPP 2015)	0.5 MJ/GDP (2010)	0.4 MJ/GDP (2018)	▼	IEA
4.5.	Transportation energy intensity	15 MJ/GDP (2010)	13 MJ/GDP (2013)	▼	Trading Economics
4.6.	Residential energy intensity	16 MJ/GDP (2010)	18 MJ/GDP (2013)	▲	Trading Economics
5.	Socioeconomic indicators				
5.1.	Energy dependency	98% (2008)	92% (2019)	▼	Interview 3
5.2.	Electricity exports	180 GWh (2018)	1,207 GWh (2019)	▲	Morocco World News
5.3.	Electricity price for households	N/A (2010)	$0.126 kWh (March 2021)	-	Global Petrol Prices
5.4.	Electricity price for businesses	N/A (2010)	$0.116 kWh (March 2021)	-	Global Petrol Prices
5.5.	Fossil fuel subsidies	$5.2b (2011)	$1.1b (2016)	▼	World Resources Institute
5.6.	Economic output from renewable energy	N/A (2010)	N/A (2020)	-	N/A
5.7.	Green jobs	N/A (2010)	N/A (2020)	-	N/A
5.8.	Local content in solar projects	N/A (2010)	N/A (2020)	-	N/A
5.9.	Local content in wind projects	N/A (2010)	60% (2020)	-	Interview 9
5.10.	Unemployment rate in rural areas	N/A (2010)	N/A (2020)	-	N/A
5.11.	Production capacity of renewable energy–powered desalination units	N/A (2010)	N/A (2020)	-	N/A
6.	Biodiversity and ecosystem				
6.1.	Marine protected areas (% of territorial waters)	N/A (2010)	0.26 (2018)	-	World Bank
6.2.	Terrestrial protected areas (% of total land area)	N/A (2010)	30.778 (2018)	-	World Bank
6.3.	Threatened species	N/A (2010)	238 (2020)	-	IUCN Global Species Programme Red List Unit

Appendix E

Existing green economy measurement frameworks

UNEP Framework

Table E.1: UNEP's framework on low-lying coastal middle-income country with rapid industrialisation and urbanisation, and relatively advanced demographic transition

Steps	Indicator samples
Issue identification	
1. Identify potentially worrying trends	• Air pollution • Water pollution • Electricity price
2. Assess the issue and its relation to the natural environment	• Fossil fuel reserves • Consumption of fossil fuels • Forest land cover
3. Analyze more fully the underlying causes of the issue of concern	• Population (people) • Urbanization (% of urban population) • Energy intensity in manufacturing
4. Analyze more fully how the issue impacts society, the economy and the environment	• Manufacturing GDP • Access to basic services in urban settings (%) • Waste generation
Policy formulation	
1. Identify desired outcomes: define policy objectives	• Carbon emissions (% reduction in CO_2 emissions) • Waste collection, recycle and reuse • Access to basic services
2. Identify intervention options and output indicators	• Subsidies: energy efficiency improvement • Investment: public transport infrastructure • Incentive: waste collection, recycle and reuse
Policy assessment	
1. Estimate policy impacts across sectors	• Manufacturing value added • Avoided cost for fossil fuel and water purification • Water stress and access to sanitation
2. Analyze impacts on the overall well-being of the population	• Health (number of water and air pollution related diseases/year) • Employment (number of new jobs in green manufacturing) • Urban poor (% of population)
3. Analyze advantages and disadvantages and inform decision-making	• Total investments, i.e., incentives, infrastructure, capacity building • Manufacturing GDP • Reduction in water and electricity prices (%)
Policy monitoring and evaluation	
1. Measure policy impacts in relation to the environmental issue	• Carbon emissions (% reduction in CO_2 emissions) • Water pollution • Energy bill
2. Measure the investment leveraged	• Total costs of interventions • Manufacturing GDP

Steps	Indicator samples
	• Energy and water intensity in manufacturing
3. Measure impacts across sectors and on the overall well-being of the population	• Health (number of water and air pollution related diseases/year) • Employment (number of new jobs in green manufacturing) • Urban poor (% of population)

Source: UNITED NATIONS ENVIRONMENT PROGRAMME, 2014. *Using Indicators for Green Economy Policymaking*. Nairobi: UNEP.

Table E.2: OECD set of green indicators

The socioeconomic context and characteristics of growth
Economic growth, productivity and competitiveness
Economic growth and structure
GDP growth and structure
Net disposable income (or net national income)
Productivity and trade
Labour productivity
Multi-factor productivity
Trade weighted unit labour costs
Relative importance of trade: (exports + imports)/GDP
Inflation and commodity prices
Consumer Price Index
Prices of food; crude oil; minerals, ores and metals
Labour market, education and income
Labour markets
Labour force participation
Unemployment rate
Socio-demographic patterns
Population growth, structure and density
Life expectancy: years of healthy life at birth
Income inequality: GINI coefficient
Educational attainment: level of and access to education
The environmental and resource productivity of the economy
Carbon & energy productivity
1. CO_2 productivity
1.1. Production-based CO_2 productivity GDP per unit of energy-related CO_2 emitted
1.2. Demand-based CO_2 productivity Real income per unit of energy-related CO_2 embodied in final demand
2. Energy productivity
2.1. Energy productivity GDP per unit of TPES
2.2. Energy intensity by sector (manufacturing, transport, households, services)
2.3. Share of renewable energy sources in TPES, in electricity production
Resource productivity
3. Material productivity (non-energy)
3.1. Demand-based material productivity Real income per unit of materials embodied in final demand, materials mix

3.2. Production-based (domestic) material productivity GDP per unit of materials consumed, materials mix • Biotic materials (food, other biomass) • Abiotic materials (metallic minerals, industrial minerals)
3.3. Waste generation intensity and recovery ratios by sector, per unit of GDP or value added, per capita
3.4. Nutrient flows and balances • Nutrient balances in agriculture per agricultural land area and change in agricultural output
4. Water productivity Value added per unit of water consumed, by sector
Multifactor productivity
5. Environmentally adjusted multifactor productivity
The natural asset base
Natural resource stocks
6. Index of natural resources Comprehensive measure expressed in monetary terms
Renewable stocks
7. Freshwater resources Available renewable natural resources (groundwater, surface water) and related abstraction rates (national, territorial)
8. Forest resources Area and volume of forests; stock changes over time
9. Fish resources Proportion of fish stocks within safe biological limits (global)
Non-renewable stocks
10. Mineral resources Available (global) stocks or reserves of selected minerals: metallic minerals, industrial minerals, fossil fuels, critical raw materials; and related extraction rates
Biodiversity and ecosystems
11. Land resources Land cover conversions and cover changes from natural state to artificial state • Land use: state and changes
12. Soil resources: Degree of topsoil losses on agricultural land, on other land • Agricultural land area affected by water erosion, by class of erosion
13. Wildlife resources (to be further refined) • Trends in farmland or forest bird populations or in breeding bird populations • Species threat status, in percentage of species assessed or known • Trends in species abundance
The environmental dimension of quality of life

Environmental health and risks
14. Environmentally induced health problems and related costs (e.g. years of healthy life lost from degraded environmental conditions) • Population exposure to air pollution, and the related health risks and costs
15. Exposure to natural or industrial risks and related economic losses
Environmental services and amenities
16. Access to sewage treatment and drinking water
16.1. Population connected to sewage treatment
16.2. Population with sustainable access to safe drinking water
Economic opportunities and policy responses
Technology and innovation
17. Research and development expenditure of importance to green growth • Renewable energy sources (% of energy-related R&D) • Environmental technology (% of total R&D, by type) • All-purpose business R&D (% of total R&D)
18. Patents of importance to green growth (% of a country's patent families worldwide) • Environment-related and total patents • Structure of environment-related patents
19. Environment-related innovation in all sectors
Environmental goods and services
20. Production of environmental goods and services (EGS) Gross value added in the EGS sector (% of GDP) Employment in the EGS sector (% of total employment)
To be complemented with: Environmentally related expenditure (level and structure)
International financial flows
21. International financial flows of importance to green growth % of total flows and % of GNI
21.1 Official development assistance
21.2 Carbon market financing
21.3 Foreign direct investment
Prices and transfers
22. Environmentally related taxation and subsidies
Level of environmentally related tax revenue (% of GDP, % of total tax revenues; in relation to labour-related taxes)
Structure of environmentally related taxes (by type of tax base)
Level of environmentally related subsidies
23. Energy pricing (share of taxes in end-use prices)
24. Water pricing and cost recovery (tbd)
Regulations and management approaches

25. Indicators to be developed
Training and skill development
26. Indicators to be developed

Source: ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, 2016. *Measuring the transformation of the economy: green growth indicators. Policy Perspectives.* Paris: OECD.

Global Green Growth Institute's Green Growth Index

Table E.3: Morocco's performance in 2020 Green Growth Index

Dimension	Scores (2019) (0-100 best)
Index	51.52
Regional Rank	2
Efficient and Sustainable Resource Use	50.34
Efficient and sustainable energy	52.33
Efficient and sustainable water use	26.41
Sustainable land use	50.58
Material use efficiency	91.85
Natural Capital Protection	73.63
Environmental quality	84.91
GHG emission reductions	90.95
Biodiversity and ecosystem protection	46.74
Cultural and social value	81.41
Green Economic Opportunities	26.35
Green investment	78.68
Green Trade	7.23
Green employment	17.56
Green innovation	48.23
Social Inclusion	72.16
Access to basic services and resources	70.04
Gender balance	55.72
Social equity	92.18
Social protection	75.37

Source: ACOSTA, L.A., ZABROCKI, S., EUGENIO, J.R., SABADO Jr, R., GERRARD, S.P., NAZARETH, M. and LUCHTENBELT, H.G.H., 2020. *Green Growth Index 2020 -Measuring Performance in Achieving SDG Targets*. Seoul: Global Green Growth Institute.

Green Growth Knowledge Platform Framework

Table E.4: Green Growth Knowledge Platform Framework

Natural assets	
Land and Soil Resources	Agricultural land area and value
	Land degradation (e.g. topsoil loss or change in net primary productivity)
Forests and Timber	Forest area and forest cover change
	Value of timber stocks
	Value of forest resource depletion
Water Resources	Available renewable freshwater resources
	Areas/ population exposed to water scarcity
	Water resources exposed to harmful pollution levels
Minerals and Energy Resources	Available stocks and reserves (e.g. minerals, crude oil, gas)
	Value of remaining stocks and reserves
	Value of energy extraction and depletion
Oceans and Fish Stocks	Sustainable seafood production
	Proportion of fish stocks overexploited or collapsed
	Value of fish stock depletion
Biodiversity	Species abundance
	Number of threatened species
Air	Air pollution
	Cost of air pollution
Climate	CO_2 and other GHG emissions
	Remaining CO_2 or GHG emission budget to stay within certain climate goals
Resource efficiency and decoupling	
Productivity/ Efficiency and Resource Preservation	Natural resource productivity
	Environmentally adjusted multifactor productivity
	GHG intensity and GHG footprint
	Energy efficiency and energy footprint
	Land productivity and biodiversity damage potential caused by direct and indirect land use
	Water intensity; nitrogen balances and water footprint
	Material productivity and material footprint
Waste	Waste generation
	Waste collection
	Waste treatment
Recycling and Renewables	Reuse and recycling rates (households, construction sector and phosphorus, among others)
	Use of renewables
Risks and resilience	
	Fatalities (loss of life, injured, homeless)

Climate and Disaster Risks Impacts	Economic damages
	Propensity to experience climate and disaster impacts
Exposure and Vulnerability to Risks	People/ assets in high-risk areas (e.g. low-elevation coastal zones)
	Population with exposure to harmful levels of air pollutants
	Economic production sensitive to environmental impacts (e.g. agricultural production in water-scarce areas)
	Assets vulnerable to environmental and climate risks
	Adoption of climate resilient building standards
	People with access to early warning systems
	People with climate-risk insurance
Responsiveness/ Adaptation	Government action for disaster risk prevention
	Government capacity to manage disaster risks
	Time to rebuild/ reconstruct physical capital
Economic opportunities and efforts	
Environmental Regulation and Planning	Environmental action plan or strategy in place
	Measures of environmental policy stringency
	Extent of protected areas
	Environmental standards
	Renewable energy feed-in tariffs
	Adoption of environmental accounts
	Number of international environmental treaties signed
Environmental Taxes and Government Spending	Environmentally related taxes
	Fossil fuel subsidies
	Public environmental expenditure
Innovation and Business Environment	R&D expenditure (green, total, public and private)
	Green patent counts
Green Transformation/ Opportunities	Green investments (e.g. renewables, public and private)
	Green jobs
	Value added of environmental goods and services sectors
	Adoption of certified products from sustainable value chains (e.g. as market share or number of companies)
	Exports of environmental goods and services sectors
Inclusiveness	
Access to Environmental Goods and Services	Air pollution (exposure by socioeconomic group)
	Water services (access by socioeconomic group)
	Sanitation services (access by socioeconomic group)
	Sewage treatment (access by socioeconomic group)
	Modern energy (access by socioeconomic group)
	Representation in environmental agencies and bodies (e.g. by minority, location, gender)

Participation in Environmental Decision-Making	Control over environmental resource (e.g. land) by social groups (e.g. minorities, indigenous people, gender)
Distributional Impacts of Environmental Policies	Distribution of costs and benefits of energy subsidies or environmental taxes, e.g. focusing on low-income groups
	Types of jobs created and destroyed, skill requirements
	People benefiting from payments for ecosystem services

Source: NARLOCH, Ulf et al., 2016. *Measuring Inclusive Green Growth at the Country Level: Taking Stock of Measurement Approaches and Indicators*. GGKP Research Committee on Measurement & Indicators, Green Growth Knowledge Platform Working Paper 02. Nairobi: UNEP.

Table E.5: Dual Citizen's Global Green Economy Index 2016

Indicator	Type	Description
Leadership & Climate Change		
Head of State	Qualitative	Head of State's advocacy for green issues
Media Coverage	Qualitative	Positive media coverage of national green economy
International Climate Forums	Qualitative	National positions & statements in international forums
Climate Change Performance	Quantitative	Performance on climate change (emissions per capita, emissions per unit GDP, emissions per unit primary energy)
Efficiency Sectors		
Buildings	Quantitative	LEED certification of commercial buildings
Energy	Quantitative	Renewable electricity as a percentage of national total
Tourism	Qualitative	Ranking of national tourism ministry efforts
Transport	Quantitative	Emissions from transport and 10-year trend
Resource Efficiency	Quantitative	National recycling rates
Markets & Investment		
Renewable Energy Investment Attractiveness	Quantitative	Country attractiveness for renewable energy investment
Cleantech Innovation	Quantitative	Business climate for cleantech innovation
Corporate Sustainability	Qualitative	Adoption of sustainability reporting by top 3 national companies (market capitalization)
Green Investment Facilitation	Qualitative	National efforts to facilitate green investment
Environment		
Agriculture	Quantitative	Assesses policies related to the effects of intensive agriculture, specifically nitrogen use efficiency and nitrogen balance
Air Quality	Quantitative	Measures population weighed exposure to fine particulate matter and percentage of the population burning solid fuel for cooking
Water	Quantitative	Tracks how well countries treat wastewater from households and industrial sources before releasing it back into the environment
Biodiversity & Habitat	Quantitative	Tracks the protection of terrestrial and marine areas as well as threatened or endangered species
Fisheries	Quantitative	Assesses countries' fishing practices - both the use of heavy equipment and the size of the catch

Indicator	Type	Description
Forests	Quantitative	Measures the loss in forest area from 2000 to present using satellite-derived data

Source: TAMANINI, Jeremy et al., 2016. *The Global Green Economy Index 2016: Measuring National Performance in the Green Economy*. 5th Edition, September 2016. New York: Dual Citizen LLC.

Table E.6: Barr's common green growth indicators

Theme	Indicator
1. Examples of natural asset indicators	
Aquatic resources	- Proportion of fish stocks within safe biological limits
Forest resources	- Areas and volume of forests
Minerals and energy resources	- Available stocks/reserves of minerals - Volume and value of natural resource stocks
Land and soil resources	- Land cover types, conversions, and cover changes - Degree of topsoil losses on agricultural land, other land
Water resources	- Volume and quality of available renewable resources
Biodiversity	- Area under effective protected area status (including marine protected areas) - Areas of forest, agricultural and aquaculture ecosystems under sustainable management
2. Examples of environmental and resource productivity/intensity indicators	
Innovation	- R&D expenditure of importance to green growth - Patents of importance to green growth - Environment-related innovation in all sectors - R&D investment
Energy	- GDP per unit of TPES (or the inverse) - Energy consumption per capita - Energy productivity
Material	- Domestic material productivity (GDP/DMC) - Material productivity at appropriate level of aggregation
Carbon	- GDP per unit of energy-related CO_2 emitted (or the inverse) - Renewable energy (share of electricity power generation)
Water	- Water productivity
Waste	- Waste collection - Waste recycling and reuse - Waste generation or landfill area
3. Examples of environmental life quality and safety indicators	
Health	- Population exposure to harmful levels of air pollution - Number of people hospitalized due to air pollution
Risks	- Exposure to natural or industrial risk and related economic losses
Water	- Proportion of total freshwater resources used - Proportion of the population using improved water services - Water quality in aquatic ecosystems used for drinking water provision - Population connected to sewage treatment - Population with sustainable access to safe drinking water - Level of harmful chemicals in drinking water

Theme	Indicator
Ecosystem services	- Trends in benefits that humans derive from ecosystem services
4. Examples of GG/GE policies and opportunities indicators	
Employment	- Green job skill training expenditure - Number of people trained
Policy Instruments	- Level of environmentally related tax revenues - Energy pricing (share of taxes in end-use prices) - Water pricing and cost recovery - Environmentally related subsidies - Fossil fuel, agricultural, water and fishery subsidies - Fossil fuel taxation - Renewable energy incentives
International cooperation	- International financial flows of importance to green growth
5. Examples of socio-economic indicators	
Macroeconomy, Trade and Regulation	- GDP growth and structure - Net Disposal income - Relative importance of trade - Product market regulation
Distribution	- Income inequality: GINI coefficient
Labour market	- Labour productivity
Education	- Literacy rate, adult total (age 15 and above) - Primary, secondary and tertiary school enrolment
Health and Sanitation	- Access to sanitation - Access to health care - People provided with access to improved sanitation facilitates
Development	- Access to electricity

Source: BARR, J., 2013, November. Exploring the Feasibility of an Inclusive Green Economy Index. In *background paper for the "UNEP workshop on developing an Inclusive Green Economy Index," Geneva* (pp. 6-7).

Nahman et al.'s Framework

Table E.7: Nahman et al. set of indicators

Principle	Criterion	Index	Indicator
1. The green economy requires good governance and uses integrated environmental, social and economic decision-making	Good governance	1.1	Governance and public policy in disaster risk management
		1.2	Enforcement of environmental regulations
		1.3	Stringency of environmental regulations
2. The green economy internalises externalities; stimulates green investment and innovation; and incentivises sustainable behaviour and lifestyles	Remove harmful subsidies and Internalise externalities	2.1	Fossil fuel subsidies as a percentage of GDP
	Green investment	2.2	Renewable energy investment as percentage of total investment
	Green innovation	2.3	Corporate and government R&D investment in renewable energy
3. The green economy invests in greening economic activity and infrastructure	Organic agriculture	3.1	Organic farming area as percentage of total agricultural area
	Renewable energy	3.2	Renewable energy consumption (% of total final energy consumption)
	Sustainable consumption	3.3	Ecological footprint of consumption in global hectares per capita
4. The green economy is resource and energy efficient	Energy efficiency	4.1	Energy efficiency
	Water use efficiency	4.2	Water productivity
	Materials use efficiency	4.3	Domestic materials consumption per unit GDP
5. The green economy is low carbon, low emissions and zero waste	Low carbon	5.1	Greenhouse gas emissions per capita
	Zero waste	5.2	Treatment of waste per capita
	Air quality	5.3	Air quality
	Water resources	5.4	Wastewater treatment level weighted by connection to wastewater treatment rate
6. The green economy protects biodiversity and ecosystems	Investment in natural capital	6.1	Proportion of marine and terrestrial protected areas
	Biodiversity	6.2	Threatened plant and animal species as a proportion of total species assessed
	Ecosystems	6.3	Total of agricultural, planted forest and urban land area as a percentage of total land area

Principle	Criterion	Index	Indicator
7. The green economy delivers poverty reduction, well-being, livelihoods, social protection and access to essential services	Quality of life and wellbeing	7.1	Population exposure to air pollution
8. The green economy should create decent work and green jobs	Job creation	8.1	Employment in the environmental goods and services sector
9. The green economy is equitable, fair and just – between and within countries and between generations	Inter-generational equity	9.1	Adjusted net savings as percentage of gross national income (GNI)

Source: NAHMAN, A., MAHUMANI, B.K. and DE LANGE, W.J., 2016. Beyond GDP: towards a green economy index. *Development Southern Africa*, *33*(2), pp.215-233.