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THE ENVIRONMENT AND THE ECONOMY: FROM SUSTAINABILITY TO GREEN GROWTH

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Abstract

Fundamental concerns over the environment's capacity to support continued economic growth dates as far back as 1798 when Thomas Malthus first proposed that the finite quantity of agricultural land, and the propensity of humans to reproduce, would impose a constraint on the human population. It seems that different eras have different scarcity factors to contend with. These limiting factors varied from land to oil but defined the flavor of sustainability issues over time. A general consensus emerged which considered an economy that pollutes its rivers, fouls its air and depletes its natural carrying capacities cannot be doing well. Unfortunately, using standard national accounting measures do not reflect this troubling reality. Many new measures have been constructed to quantify sustainability that include: Green GDP, Ecological Footprints, and Demonic Indices, each with its own metrics and problems. Sustainability is compounded by climate change. A few economies are particularly vulnerable to the impact of both climate events and of climate change response measures. The physical vulnerability of these economies is severe in climate sensitive zones, particularly those in low coastal lands, harsh environments, those with fragile ecosystems, those that have key sectors that are highly sensitive to weather and water stress problems. This is further exacerbated by socioeconomic vulnerability as reflected by a high dependence on the production and export of natural resources and other environmentally sensitive commodities. The dependence on natural capital and environmental resources reduces peoples' resilience and adaptive capacities to the consequences of climate change.

JEL Classifications: Q5, O2

Keywords: Weak and Strong Sustainability, Green GDP, Genuine Savings, Natural Capital, Climate Change, adaptation strategies, and Mitigation Measures.

ملخص

يعود الاهتمام الرئيسي بقدرة البيئة على دعم استمرار النمو الاقتصادي بقدر ما يعود إلى عام 1798 عندما اقترح توماس مالتوس أن كمية الأراضي الزراعية محدودة، ونزوع البشر على الإنجاب، قد تفرض قيود على السكان. وعلى ما يبدو أن على كل عصر مواجهة عوامل ندرة مختلفة. هذه العوامل تختلف بين الأراض أو النفط ولكنها قامت بتعريف قضايا الاستدامة مع مرور الوقت. ظهر توافق عام في الآراء أن الاقتصاد الذى يلوث الأنهار، يفسد الهواء، ويستنزف القدرات الطبيعية لا يمكن أن يصنف كاقتصاد جيد. وللأسف، فان استخدام معيار المحاسبة الوطنية لا يعكس هذا الواقع المزعج. تم بناء العديد من التدابير الجديدة لتحديد الاستدامة التي تشمل: الناتج المحلي الإجمالي الأخضر، الآثار الإيكولوجية، ولكل منها مقاييسها ومشاكلها. تتفاقم مشكلة الاستدامة بسبب تغير المناخ. وهناك بعض الاقتصادات المعرضة بشكل خاص لتأثير الظواهر المناخية على حد سواء وتدابير الاستجابة لتغير المناخ. والضعف المادي لهذه الاقتصادات يجعلها شديدة التأثر بالمناخ ، ولا سيما في الأراضي الساحلية المنخفضة، والبيئات القاسية، مع تلك النظم الإيكولوجية الهشة، وتلك التي لديها قطاعات رئيسية حساسة للغاية لمشاكل الطقس والمياه. ويزيد من تفاقم هذا الضعف من قبل العوامل الاجتماعية والاقتصادية على النحو المبين من قبل الاعتماد الكبير على إنتاج وتصدير الموارد الطبيعية وغيرها من السلع الحساسة بيئيا. الاعتماد على رأس المال الطبيعي والموارد البيئية يقلل من مرونة الشعوب وقدرات التكيف لعواقب تغير المناخ.

1. Introduction

The notion of 'sustainability' has so dominated public, political, and academic debates that it now possesses multiple definitions of varying validity, applicability, and consistency. Fundamental concern over the environment's capacity to support continued economic growth dates at least as far back as 1798 when Thomas Malthus first proposed that the finite quantity of agricultural land, and the propensity of humans to reproduce, would impose a constraint on the human population (Malthus 1798). Malthus argued that the population would grow until all available land was employed in food production, beyond which point, further population growth would result in decreased living standards, famine, and increased child mortality. Malthus' prediction that living standards would inevitably approach minimum subsistence levels has earned economics the unofficial title of 'dismal science' (Malthus 1798; Neumayer 2000; Krautkraemer 2005).

It seems that different eras have different scarcity factors to contend with. These limiting factors varied but defined the flavor of sustainability issues over time. William Stanley Jevons (1865) was worried in the late 19th century about the dependence of England's economy on the use of coal. Like Malthus, he cautioned that the prospects for sustained economic growth were limited by environmental bounds. His concern was that England's booming industrial economy would derail as a result of higher coal prices due to increased scarcity and extraction costs (Neumayer 2000; Alcott 2005; Jevons 1865). These concerns led to calls for increased efficiency, in response to which Jevons made his principal contribution by identifying a paradoxical relationship between efficiency and conservation. Also known as 'rebound,' Jevons' paradox is the notion that increased efficiencies in extraction and consumption, instead of eliminating coal scarcity, led to the vertical and horizontal intensification of coal's use. The greater efficiency on both the supply and demand sides of the market accelerated and exacerbated scarcity(Jevons 1865; Alcott 2005).The argument is simple but critical—increased production efficiency would lower extraction costs and increase supply while efficiency gains in consumption would lower costs and prices and intensify demand. Jevons writes, "It is the very economy of its use which leads to its extensive consumption… It is wholly a confusion of ideas to suppose that the economical use of fuel is equivalent to a diminished consumption. The very contrary is the truth..." (Jevons 1865; Alcott 2005).1 The continued relevance and importance of Jevons's work is readily apparent when we consider the production and consumption of current natural resources such as oil, water, and rare earth metals, and particularly the policy efforts to enhance their 'sustainability.'

In 1972 the Club of Rome published the Limits to Growth bringing renewed emphasis and concern to the nexus of natural resources, the environment, and the constraints they impose on economic prosperity (Meadows et al. 1972). In the context of rising oil prices and environmental destruction, Meadows et al. (1972) predicted resource scarcity and environmental destruction would lead to severe economic collapse in the early 21stcentury. The Limits to Growth conclusions were criticized strongly by economists for their failure to account for technological innovation and the possibility of substitution (Neumayer 2000; Krautkraemer 2005).

Collectively the 'dismal scientists' have been accused of failing to account for what have become fundamental elements of sustainability: substitution, technological progress, and the distinction between economic and physical scarcity (Neumayer 2000; Peskin 1994). Substitution, broadly defined, is perhaps the most important facet of sustainability (Hamilton et al. 2007; Solow 1994; Krautkraemer 2005). It refers to the idea that various commodities and forms of capital are to some degree interchangeable. As fossil fuels rise in price, an

[1] Quotation found in (Alcott 2005).

incentive is created to use wind, solar, or hydroelectric power instead. Similarly, economic activity can remain constant in the face of dwindling oil stocks (depletion of natural capital) so long as oil revenues are used to accumulate other types of productive potential (produced and human capital). The notion of preserving productive capacity by reinvesting exhaustible resource rents in 'produced capital' such as plant and equipment, infrastructure, and human capital is known as the Hartwick Rule (1977) and is the foundation of 'weak sustainability' (Neumayer 2000; Hamilton et al. 2007; Solow 1994; Pearce and Atkinson 1993). Furthermore, sustainability is inextricably linked to the advancement of technological innovation. Malthus warned of food shortages before the introduction of nitrogen based fertilizers, Jevons warned of coal shortages before the domination of petroleum, and the Club of Rome predicted economic collapse because they failed to incorporate technical progress in their calculations (Neumayer 2000). Peskin (1994) explored the distinction between economic and physical depreciation. Though subtle, the distinction has important relevance to the notion of economic sustainability. Economic depreciation refers to a reduction in the capacity to create value, while physical depreciation (or depletion) refers to a reduced capacity to provide services such as the provision of energy, minerals, or life support functions. It is possible for economic depreciation to occur without physical depreciation2 and vice versa3 (Peskin 1994).

These on-going debates have generated a rich literature from which three important definitions of sustainability have emerged. From the policy arena, we have the 1983 UN World Commission on Environment and Development whose 1987 report Our Common Future (also known as the Brundtland Commission) defines the sustainable economy as one that "fulfills the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987). This definition is of particular interest because it balances the needs of the present and those of the future, and because it allows the possibility of substitution. Similarly, Nobel Laureate Robert Solow states that sustainability "allows every future generation the option of being as well off as its predecessors" (Solow 1994). The distinction here is that in comparison to the Brundtland definition, Solow does not require that the needs of any particular generation are actually fulfilled. Interestingly, neither Solow nor Brundtland require that future generations actually are better off, or as well off, but rather that they have the potential to be as well off. Finally, Pearce et al. (1989) give us a definition of sustainability requiring that "real GNP per capita is increasing over time and the increase is not threatened by 'feedback' from either biophysical… or social impacts" (Pearce et al. 1989). This definition allows for a significant role for technological innovation and permits substitution, but also requires that environmental life support functions are preserved and postulates balanced relationships among social, environmental, and economic systems.

These definitions make clear that there is no valid separation between the environment and the economy. The two are reciprocally and inextricably linked. These links may take the form of competing trade-offs or of complimentary synergies, but 'sustainability' requires the recognition that the economy and the environment are not indifferent to each other, and as such, they cannot be evaluated independently.

Framing the environment as an asset of society to be conserved presents a challenge to the notion of substitutable capital. While it is reasonable to assume that certain elements of natural capital can be substituted for by investment in produced capital, it is also reasonable to assume that there is a limit to this possibility. Fiber optic cable substituted for copper wire, the electric light bulb substituted for whale oil, and genetically modified seeds can reduce

[2] Because of the electric light bulb, the value added by whale oil for lamps could fall (economic depreciation) even if the stock of whales rose (physical appreciation).

[3] As more tourists visit, a popular national park could become increasingly congested and polluted (physical depreciation) but still experience higher campsite, hotel room, and park fees (economic appreciation).

demand for water (Krautkraemer 2005). However, life support functions, biodiversity preservation, and other systemic services provided by the environment are particularly difficult to replace. The assumption that natural and produced capitals are infinitely substitutable requires the belief that given sufficient equipment, technology, and knowledge, the entire Earth's biomass could survive indefinitely on a single cup of water. However, the flexibility to permit at least some degree of substitution is not only practical, but is also a central element of sustainability, is supported by historical evidence, and encourages important innovation. The debate about weak and strong sustainability is still a raging one in ecological economics. The primary contention is whether and to what extent human made capital can substitute for 'natural capital' in production and/or as a source of well-being (Victor, Hanna and Kubursi 1995; World Bank 2006; Markandya and Pedroso-Galinato 2007). To assert that scarce nature is the limiting factor on the economy is to side with proponents of strong sustainability or at least a version of it that recognizes some important, non-substitutable functions and aspects of nature referred to in the debate as critical natural capital.

In the past two decades several influential studies have underlined the emergence of scarce nature as a determining factor in our lives and the lives of future generations (Victor and Rosenbluth 2010). Below we mention three well known examples, and there are many more, that illustrate the emergence of nature as a limiting factor and that underline the strong sustainability concept. This presentation is along the lines that Victor and Rosenbluth (2010) present in their seminal work. There is first the estimate by Vitousek et al. (1986) that shows that humans were using 19% of the Earth's total net primary production and 31% to 38% (depending on assumptions) of the terrestrial total. This was followed by Wackernagel and Rees (1996) which introduced the widely resonant concept of the ecological footprint. Rees and Wackernagel (1996) estimated that two additional planet Earths would be required to support the world's population at North American levels of energy and resource using current technologies. Then in 2000 a group of high profile organizations (the United Nations Development Programme, the United Nations Environment Programme, the World Bank and the World Resources Institute) published a detailed and thoroughly documented report on the state of the world's ecosystems. "Nearly every measure we use to assess the health of ecosystems tells us we are drawing on them more than ever and degrading them as an accelerating pace."

The question then remains, how do we measure sustainability? The definitions described above maintain that sustainability entails non-decreasing living standards for future generations. This basic criterion of weak sustainability is met when the economy's capacity to create value, or 'capital stock', is preserved through time (Proops et al. 1999; Neumayer 2003; Pearce and Atkinson 1993; Hamilton and Clemens 1999). Here, the capital stock is broadly defined, and includes physical, human, and natural capital.

2. The Sustainability Rules

Despite the difficulty of agreeing on any one definition of sustainability and the emergence of many different definitions, there are well accepted rules that economies must satisfy before they are considered as moving towards sustainable resource consumption. These include:

First, in the case of renewable resources the following simple rule applies— harvesting of renewable yields must not exceed the Maximum Sustainable Yield (MSY). Fish stocks of Cod and Blue Fin Tuna have been depleted because the landed catch has exceeded the capacity of stock to naturally regenerate itself. Economists appreciate this concept as it simply represents maintaining Hicksian income, consuming the maximum increase in income without reducing capital.

Second, any draw down of nonrenewable resources must be matched by an equivalent investment in alternative capitals that can generate an equivalent renewable income. This is the Hartwick Rule (1977) discussed above that calls for reinvesting exhaustible resource rents in 'produced capital' such as plant and equipment, infrastructure, and human capital.

Third, the amount of waste generated by the economic system should not exceed the natural capacity to absorb it.

Fourth, a three dimensional perspective is a necessary context for every economic issue. It is inadmissible in a sustainable economy to separate economic values, issues and problems from their social and environmental implications. An interdisciplinary approach is the only meaningful approach.

These rules make clear that there is no valid separation between the environment and the economy. The two are inextricably and reciprocally linked. Figure 2 depicts these relationships by showing the environment (green) as an agent that affects consumer behavior and productions processes, and as an asset of society to be preserved for future generations. Figure 3 shows the interactions between the three systems and the implications of these intersections.

3. Economic Myths

Even when the perspective of weak sustainability is accepted, the four simple rules above are still considered as sufficient conditions for sustainability. Fish stocks may be drawn down but as long as other forms of capital are created to compensate for this depletion, weak sustainability is ensured. Therefore, the four rules above basically rest on the notion that human and produced capital can substitute totally for natural capital. However, it remains an open question that when a small part of natural capital is needed to sustain production and consumption in the economy whether or not sustainability can be assured through substitution. This proposition has provoked the reconsideration of many of the economists' assumptions about the economy and its processes. Three general propositions have been particularly challenged. These include:

First, the notion of natural capital as renewable capital. Particularly when accounting for ecosystem services, natural capital is essentially non-reproducible capital and therefore is not renewable with human investment. Any draw down of stocks represents total loss and depletion of non-renewable capital. To the extent that certain elements of natural capital are renewable, it must be acknowledged that they are only renewable in certain places, in certain qualities, and on certain time scales. It may take thousands of years for the stock to be replenished and it may not be replenishable at all, particularly when we account for environmental 'tipping points'.

Second, the proposition that natural capital and reproducible capital are infinitely substitutable. Surely, the notion that reproducible capital may and can replace natural capital is excessively optimistic and defies human experience. Even though there are margins at which this substitution has been and is possible, it remains at the margin of production and consumption and a not at the core of real economy. This point is particularly important when we consider the *systemic* relationships and life support functions provided by the environment.

Third, the proposition that the economy is separate, independent, or even in opposition to the environment. This is a false dichotomy. The economic system is embedded in the environment and in the broader social system of which it is only a part. The real issues are about the intersections of the three systems—the economic, social and environment. The only meaningful perspective in this context is the one that reveals the interactions and overlaps of these systems. The real questions are those that deal with all three aspects simultaneously.

The best strategy for achieving sustainability is one that highlights and exploits the synergies while recognizing and minimizing competing interests.

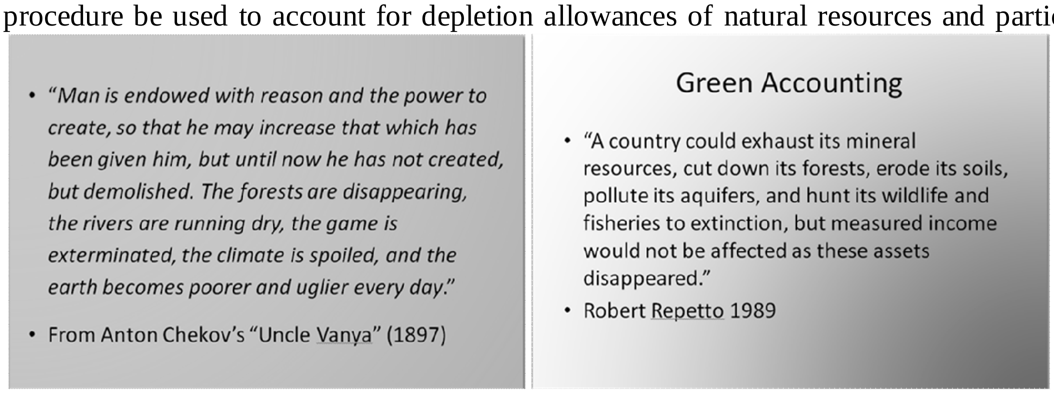
3. National Accounting and the Sustainable Economy

3.1 Green accounting

An economy that pollutes its rivers, fouls its air and depletes its natural carrying capacities cannot be doing well. Unfortunately, using standard national accounting measures the estimates that emerge from this accounting system do not reflect this troubling reality. GDP measures of economic performance could easily be higher and increasing. The major weakness in the conventional treatment of natural resources in national accounts is that the measured value of production does not take resource depletion into account and, as a result, is overstated (Repetto et al. 1989, El Serafy 1989). The conventional system also fails to treat appropriately defensive expenditures (expenditures incurred to clean the pollution and degradation of the environment). National accountants have suggested that depletion of natural resources be deducted from gross domestic product (GDP) in a manner similar to the deduction of capital consumption allowances (depreciation of fixed capital) in the calculation of net domestic product (NDP) (Repetto et al. 1989). Furthermore, for measuring sustainability, it is the *change* in wealth (productive base) rather than the absolute quantity that is of interest (Hamilton and Bolt 2007). This change in wealth is referred to as genuine savings or adjusted net savings.

Since fixed capital is a produced asset, i.e. a product of the economy in previous periods, it is reasonable to net out the depreciation of fixed capital against gross fixed capital formation to calculate the net increase or investment in fixed capital. Similarly, the depreciation can be subtracted from GDP to arrive at net domestic product (NDP), which reflects the fact that some fixed capital (a produced asset) has been used-up in the production process.

Repetto et al. (1989) and El Serafy (1989) among others have suggested that a similar procedure be used to account for depletion allowances of natural resources and particularly



for extracted mineral deposits. A charge should also be deducted from GDP in the calculation of NDP. However, mineral resources differ from fixed capital in two important ways. First, mineral resources are not products of the economy but instead are provided by nature. The concentration of molecules of metal in sufficient quantities to make extraction profitable was accomplished by nature and not by man. While the profitability of extraction of a particular deposit is affected by both technology and prices, the existence of the deposit is an act of nature. To the extent that the nature of the deposit can be altered by man in order to facilitate extraction, this should be considered as a part of the extraction process and, thus, as production. Second, mineral resources are completely transformed by production, and, in this way, are unlike fixed capital which continues to retain its characteristics and to provide the same services (perhaps at a declining rate) for many periods. In these ways mineral resources are like intermediate products. The closest analogue to mineral resources in the Standard National Accounts (SNA) framework is non-competitive imports. They are treated as a cost of production, but they represent neither domestically produced intermediate goods nor domestic value-added in production. The part of the value of the extracted mineral which represents the value of the mineral deposit or ore-in-the-ground (the resource rent) is not a result of extraction (a production activity) and should not be counted as a part of value-added in production. The mineral deposit is also not a domestically produced intermediate input (being rather a product of nature). These arguments suggest that the resource rents on minerals should be treated in a manner similar to the treatment of non-competitive imports.

To illustrate these concepts, we first present the standard system of accounting of natural resources as suggested by Repetto et al. (1989). The example we use is one of the simplest examples produced to illustrate the issues. Then we present the alternative measure of Adjusted Net Saving developed by the World Bank. The estimated World Bank values for Net Adjusted Savings (Genuine Savings) for several Arab countries are presented and discussed.

The traditional economic model is an open system in the sense that it does not permit feedbacks from the environment to the economy. The model in Figure 5 closes this gap but then a complete accounting for the environment would entail not only the depletion charges but also taking account of all aspects of defensive expenditures and waste disposal.

Repetto et al. (1989) uses the example of Indonesia in Table 1 to illustrate the necessary subtractions from GDP in order to arrive at Net Domestic Product (Sustainable Product). The subtractions include oil depletion, forestry depletion and soil depletion. It is clear that the net subtractions are large. NDP is significantly smaller than GDP. It is also clear that if defensive expenditures (clean-up of pollution, waste disposal and other environmental service losses) were also subtracted from GDP, the NDP would shrink further and a larger wedge would result between GDP and NDP.

In 1984, NDP was 83% of GDP. About 17% were deducted on account of depletion of non-renewable resources. In 1971, NDP was larger than GDP because of new oil discoveries that augmented the recoverable oil reserves.

There was a clear trend in Indonesia towards non-sustainability as depletions exceeded accumulations and discoveries. The attractiveness of Repetto's accounting is its flexibility and its capacity to take account of accumulations. Its shortcomings are on account of its negligence of defensive expenditures and the treatment of depletion as if it is equivalent to depreciation of reproducible capital.

4. Genuine Savings

The notion that there are two sides to the ledger of sustainability is the hallmark of the Genuine Savings (GS) or Adjusted Net Saving (ANS) concepts. The basic tenants of these concepts is the criterion of weak sustainability which is met when the economy's capacity to create value, or 'capital stock', is preserved through time (Proops et al. 1999; Neumayer 2003; Pearce and Atkinson 1993; Hamilton et al. 2007). Within these concepts the capital stock is broadly defined, and includes physical, human, and natural capital. When GS or ANS are positive this means that this broader measure of capital is non-decreasing and the economy is said to be sustainable (Proops et al. 1999; Hamilton et al. 2007; Hamilton and Bolt 2007; Neumayer 2003; Pearce and Atkinson 1993). Savings are 'adjusted' because conventional accounting practices make no accommodation for depletion of natural capital (Repetto et al. 1989).

The definitions of GS and ANS are equivalent. It increases with net investment in produced capital and decreased with net foreign borrowing (debt). It is augmented by net official transfers, spending on education and decreases with depletion of natural capital. All forms of net investments raise the GS whether these investments are in human beings or produced capital or natural capital.

The World Bank maintains ANS data, and the difference between conventionally measured national savings (NS) and ANS in the region for 2002, 2005, and 2008 is shown in the figures below (WDI and GDF 2010). It is worth noting that some countries (Israel, Turkey, Tunisia and Morocco) tend to have ANS above NS, while others (Bahrain, Egypt, Jordan, and Kuwait) have ANS below NS but both rates are still positive. Furthermore, Oman, Sudan, and Syria appear to have suffered a change from being net positive to net negative savers when natural capital is taken into account. Saudi Arabia despite its large oil wealth appears to have small positive adjusted net savings that are measurably smaller than its net savings. Arab oil producers seem to deplete their natural capital faster than their investments in producible and human capital.

5. The Transition to a Sustainable Economy

Herman Daly through his numerous contributions to ecological economics has conceptualized a steady state economy that is an approximation of a sustainable one. Daly (1977) describes a steady-state economy by identifying its main features. He further elaborated on his views in Daly (1996) and several other publications. Tietenberg (2000, 570) provides a succinct summary of Daly's prescription for sustainable development:

According to Tietenberg (2000) Daly sees three institutional modifications as necessary for the rapid attainment of the steady state:

1. An institution for stabilizing population.
2. An institution for stabilizing the stock of physical (i.e. manufactured) wealth and throughput.
3. An institution to ensure that the stocks and flows are distributed fairly among the population.

He leaves the allocation of scarce resources among alternative uses to the market while collective decisions are made on scale and distribution, but allocation remains with the market. Daly, however, argues that the questions of scale, distribution, and allocation involve three separate policy goals and cannot all be served by the single instrument of prices. Market prices achieve the goal of efficient allocation; the other institutions are designed to achieve an optimal (sustainable) scale and an optimal (fair) distribution. There is no special mention of natural capital. It is implicit in his concerns for scale and distribution.

It is to be expected that prices in this economy may not be sufficient protection for the environment; there is a need for collective action to harmonize the bias towards consumption with the need to maintain the ecological capacities of the environment and the preservation of sufficient natural capital for future generations. Daly's steady state is necessary but not sufficient for establishing and guaranteeing a sustainable economy.

6. The Challenge of Climate Change

There is now a broad recognition of the pivotal role of the environment and the climate in shaping communities' capabilities for healthy living, wealth generation, employment creation, a sustainable fiscal base and the overall quality of life. This is especially so when key economic activities are vertically integrated with the resource base of the community, they are highly sensitive to the climate and act as export engines. The flip side of this interdependence is the vulnerability of these communities to climate change and severe weather events where adaptation and mitigation structures are absent to absorb the costs and avert the adverse consequences of climate related events.

A few economies are particularly vulnerable to the impact of both climate events and of climate change response measures. The physical vulnerability of these economies is severe in climate sensitive zones, particularly those in low coastal lands, harsh environments, those with fragile ecosystems, those that have key sectors that are highly sensitive to weather and water stress problems. This is further exacerbated by socioeconomic vulnerability as reflected by a high dependence on the production and export of natural resources and other environmentally sensitive commodities. This dependence on natural capital and environmental resources reduces their resilience and adaptive capacities to the consequences of climate change. Few economies in the world are as dependent on natural capital or are in a fragile ecology as those of Arab countries.

This section seeks to address the central question of how best to assess and model the economic impact of climate change. Such an endeavor necessarily raises multiple sub-questions for examination. For example, should econometric or computable general equilibrium (CGE) models or cost/benefit analysis be used? Are they binary choices? Which parameters and sectors should be included in the model specification? Should models focus on the economic effect of climate policy or on climate events? Should different models be used for different geographic regions?

The existing literature shows an important methodological rift between models created by developed and developing countries. The former often emphasize the potential impact of climate policy, whereas the latter tend to focus on the impact of changing weather on key industries such as agriculture (Bergman 2005).

A central reason for this distinction is the relative imbalance of adaptive capacity and resilience that exists between rich and poor countries. Due to the structure and size of wealthy, industrialized and service based economies, developed or richer countries are in a better position to dampen the economic effects of climate change through policy and adaptation strategies. Alternatively, poor, agrarian, and raw materials based economies which face different sets of development priorities, are particularly vulnerable to climate shocks, and possess less adaptive capacity, fewer resources, and weaker economic bases. The Arab world comprises both types of countries and therefore it calls for two types of analyses.

Rich or poor, climate change is already exacting a heavy economic toll on the Arab economies, social systems and human health. We cite three examples from the last decade as evidence that even rich industrialized nations are susceptible to extreme climate events precipitated by global climate change: the European heat wave of 2003[4]; the Russian heat wave of 2010; and the December snow storms of 2009 and 2010 in London, England.

World temperatures are expected to rise by between 1.1°C and 6.4°C during the 21st century (relative to the period 1980-1999), depending on the emissions scenario that is realized (the "best estimate" range is between 1.8°C and 4.0^0C). One of the likely early consequences of this rise in temperature is that sea levels will rise by 18–59 centimeters by 2100, with thermal expansion of the oceans being the single most significant contributor to the rise in sea level.

There is a greater than 90% confidence level that there will be more frequent warm spells, heat waves, and heavy rainfall and there is a greater than 66% confidence level that there will be an increase in droughts, tropical cyclones, extreme high tides, and storm surges.

Most of these projected changes in climate parameters and sea level are now regarded as being conservative (under-estimates). Even if greenhouse gas concentrations were to stabilize at existing levels, anthropogenic warming and sea level rise will continue for decades and

[4] Over 52,000 deaths are attributed to this extreme climate event, including over 33,000 from Italy and France (Larsen 2009; Kosatsky 2012; Sardon 2007; Vandentorren et al. 2004)

centuries to come respectively due to the time scales associated with climate processes and feedback effects.

But greenhouse gas concentrations are not about to stabilize at any levels. This is because of the following reasons:

- World primary energy demand is projected to increase by approximately 36% over the period 2010-2035 (from 12.3 to 16.7 Mtoe).
- The bulk of this increase will take place in developing countries (China and India in particular).
- Fossil fuels—oil, coal and natural gas—will continue to remain the primary source of energy.

The Copenhagen Accord (2009) sets a non-binding objective of limiting the increase in global temperature to 2 degrees Celsius. "The Copenhagen Accord (2009) falls a very long way short of what is required to set us on the path to a sustainable energy system. The speed of the energy transformation that would need to occur is such as to raise serious misgivings about the practical achievability of cutting emissions sufficiently to meet the 2 degrees Celsius goal." IEA, World Energy Outlook (2010).

The projected impacts of the expected rise in sea levels are presented below. The MENA region is shown to be particularly vulnerable. A key reason for this result is that a very large percentage of the urban population of MENA countries lives in coastal areas.

The projected SLR by country and by area, population, agriculture and GDP are presented below. Egypt is slated to be most affected. However, most Arab countries will also be affected albeit differentially. A key reason for this result is again the fact that a very large percentage of the urban population of MENA countries lives in coastal areas. The results are amplified for Egypt when satellite photos are presented of the extent to which sea level intrusions can be expected.

Of course these impacts are predicated on a low temperature rise, they could be worse if higher temperature increases are realized. And again, all of these impacts assume no adaptation strategies of any significance to confront these eventualities.

The current institutions and regimes surrounding global climate governance and their implications for both developed and developing countries are discussed in the next section by way of providing a background to issues of special significance for Arab countries. Crucially, these regimes define the context within which economic models for the region are developed and applied. Three approaches to modeling the economic impact of climate change of particular relevance to the region are present. We argue for an eclectic approach that combines the three brands and we are in favor of employing econometric methods to inform CGE models, and cost/benefit analysis to evaluate specific proposals. We elucidate formally the justification for this argument by employing two specific case studies in the MENA region.

7. The Institutions and Regimes of Climate Governance

The debate over anthropogenic versus natural causes of climate change is increasingly eclipsed by the recognition that economies are susceptible to climate events. Issues of adapting to and mitigating the adverse effects of climate change have now moved to the forefront of national and international policy agendas in many countries and international forums (Babiker et al. 2000; Jacoby et al. 2010). Economic models must account for these new policy regimes.

Global concerns about the risks of climate change have been crystallized in the creation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and the adoption of the Kyoto Protocol in 1997. The objectives of the Convention and the Protocol are twofold. First, is the stabilization of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with climate systems. Second, is to do so without curtailing developing countries' aspirations to economic growth and sustainable development (Jacoby et al. 2010).

The Kyoto Protocol was the first attempt towards meeting the UNFCCC objectives. The Protocol obliged industrial countries (Annex I) to reduce their greenhouse gas emissions by 5.2% on average from their 1990 levels during the period 2008-2012. The Protocol also designed a number of mechanisms to help countries meet their emission targets, and to encourage the private sector and developing countries to contribute to emission reduction efforts. The Protocol included three market-based mechanisms (called flexibility mechanisms)—Emissions Trading, the Clean Development Mechanism and Joint Implementation (unfccc.int/kyoto protocol/items/2830.php).

Until 2012, developing countries are exempted from taking GHG mitigation measures (unfccc.int/resource/docs/cop3/07a01.pdf, 1998). But these countries are not exempt from experiencing the negative impacts of climate change and the negative spillover effects from the implementation of mitigation policies and measures by the developed world.

The economies of the developing world are particularly vulnerable to the impact of both climate events and of climate change response measures. The physical vulnerability of Arab countries is particularly severe because large Arab populations live in low coastal lands (ESCWA 2005, 2009). This is further exacerbated by socioeconomic vulnerability as reflected by a high dependence on the production and export of natural resources and other environmentally sensitive commodities. This dependence on natural capital and environmental resources reduces their resilience and adaptive capacities to the consequences of climate change. It is here where an adaptation approach that jointly addresses both types of vulnerabilities in these countries is obviously required. Such an adaptation approach would require, in addition to the domestic effort, a parallel international effort focused on minimizing the impacts of response measures and strengthening the ecological resilience of these economies to cope with climate change and its related policies.

The literature, however, has indicated that the magnitude of the negative spillover impacts can greatly be reduced if developed countries were to implement efficient market-based mitigation measures and adopt cooperative and enabling strategies that help the less fortunate countries to strengthen their resilience and reduce their vulnerabilities (Weyant and Hill 1999; Stiglitz et. al. 2009; Zabarenko 2007).

Looking beyond 2012, the ongoing post-Kyoto climate change negotiations have highlighted the role of developing countries and their growth trajectories in the future containment of GHG emissions. Given the established provisions of the UNFCCC and the 2007 Bali Action plan, any future major effort on emissions abatement from developing countries has to come through incentives and enabling policies and resources from the developed countries, e.g. technology transfer, development funds from international facilities, CDM, and emissions trading (unfccc.int/resource/docs/2007/cop13/eng/06a01.pdf, 2008).

Yet, it is also necessary that developing countries, particularly large emitters (e.g., China and India), take specific future mitigation targets as a part of a post-Kyoto climate change deal. In spite of the apparent setback, the Copenhagen Accord (COP15) of December 2009 seems to have, perhaps, paved the road for such a deal.

More specifically, COP15 provided some potential guidance of work for upcoming years, starting with COP16 in Mexico (www.denmark.dk/en/menu/Climate-Energy/COP15-Copenhagen 2009/AboutCop15dk; cc2010.mx/en/about/what-is-cop16cmp6/index.html/).

The Accord stipulated that the rise in global temperatures should be limited to two degrees, developed countries should transfer significant funds to mitigation in developing nations, and that countries should provide unilateral GHG mitigation pledges to the UN Secretariat.[5] Furthermore, the potential of trading mechanisms to reduce the cost of GHG abatement were recognized and it is expected that developed countries will use these mechanisms extensively to limit and contain the escalation of GHG emissions.

It is equally clear that the pledges of developed countries will not put the world on a sustainable trajectory consistent with the two degrees scenario. The pledges from emerging and developing countries should include mitigation projects that developed countries have funded for emissions credits. Moreover, reducing the increase of GHG gases from the large, fast growing developing countries' economies such as China and India is increasingly being seen as a necessary condition for any meaningful global climate policy.

8. Economic Approaches to Model Climate Change Impacts

Several strategies have been developed to model the potential economic impact of global climate change (for an extensive review, see Stern 2007). Though there are multiple ways to classify these models, at the highest level of resolution, the primary distinction has been between econometric and CGE models (Bergman 2005). We argue that this arbitrary distinction establishes an unnecessary and false dichotomous choice that masks either the direct or indirect effects of climate change on the economy and/or the complementary potential of these techniques. At secondary and tertiary levels, questions regarding geographic scope, the treatment of the time dimension, and the specification of the rest of the world serve to further differentiate the various approaches. Bergman (2005) makes a further distinction between 'externality' models, which focus on the impact of environmental policy, and 'resource management' models, which focus on the management of natural resources. It is worth reiterating that the former is more prevalent in developed countries, and that these types of models dominate the field (Bergman 2005).

Econometric techniques are now highly sophisticated and offer deep insight into the direct impact of specific climate events on equally specific economic indicators. For this reason, econometric models are frequently used to model the response of a particular industry to an exogenous climate shock, such as a decrease in precipitation or change in temperature on production and consumption. However, this approach neglects the broader indirect effects that this shock has on the economy as a whole. It is through these indirect channels that climate change can affect the entire economy.

In an attempt to address this shortcoming, CGE models have been developed to evaluate environmental policy because of their ability to capture the mutual sectoral and regional interdependencies inherent in today's economies. These models are becoming increasingly sophisticated in their ability to incorporate dynamics and time sensitive variables; however, in the context of the environment, some significant complications remain such as which parameters to include in the model and how to account for the 'rest of the world.

Both econometric and CGE models have specific strengths and weaknesses, and convention has left it to the model user to determine which approach is most capable of answering the question at hand. The primary contribution of this piece is to show that the two are not mutually exclusive, but that they can be used in conjunction with each other. That is, rather than choosing between the two, the model user can employ econometric analyses to inform CGE specification. Such an approach combines the precision of econometric estimation with the broad applicability of CGE modeling.

[5]Based on post COP15 official documents (http://unfccc.int/), developed countries have offered pledges to reduce emissions – 5 to 25 percent relative to 1990 – while China and India have offered to reduce carbon intensity per unit of GDP.

Finally, economic modeling, particularly in the medium and long term, is a complex task even when the model's input is conclusive observational data. Modeling the economic impact of climate change, however, requires the use of climate projections, which introduce another level of uncertainty.

One of the problems with climate modeling is the need to model over very long time periods. This refers to the length of time over which stocks and quality of key resources are affected as well as the time lag between the degradation of these stocks and their final environmental impact. These long time periods introduce two primary challenges (1) how do we deal with discounting over 50 – 200 year periods, and (2) how do we account for the changes in available technologies, consumption patterns, and legal frameworks that will take place during these times (Bergman 2005).

Dealing with changes in technologies can be particularly problematic when applied to the case of climate change. For example in the case of water, technological innovation could lead us to an increased capacity to supply water (better pumping, better purification, desalination) as well as a more efficient (and possibly smaller) demand for water (low flow toilets, taps, and shower heads; more efficient irrigation practices; and enhanced water recycling). However, this optimistic story is only relevant if there are incentives to invest in water specific technological innovation. Unlike other scarce natural resources for which private markets exist, water is typically highly regulated and publicly provided. The lack of competitive markets distorts the price of water and by extension, the (dis)incentives for its use and consumption (Kubursi and Agarwala 2012).

9. Climate Change: some Case studies and Applications

There are now many examples of estimated equations and models that deal directly with climate change. We will restrict the examples to two major ones. First, we concentrate on how climate affects agricultural production through its influence on precipitation and the length of the growing season. Second, we summarize the findings of a CGE application to show that the impacts may start in agriculture but will spread easily to every other sector.

The first application uses econometric techniques to highlight the structure and nature of these impacts. The analysis begins with a simple but representative production function specification that allows for partitioning the precipitation variable from capital and labor inputs.

Agricultural production:

$$QVA_{R,A} = \widehat{\alpha}_{R,A}\left(\sum_{F\in\Im}\sum_{R1\in\Re}\delta_{R1,F,R,A}\left(QF_{R1,F,R,A}\right)^{-\widehat{\rho}_{R,A}}\right)^{\frac{-1}{-\widehat{\rho}_{R,A}}}$$

$QVA_{R,A}$ quantity in value added terms

$\widehat{\alpha}_{R,A}$ are calibrated shift/yield parameters

$\Im$ is the set of factors

$\Re$ is the set of regions

$\delta_{R1,F,R,A}$ are share parameters

$QF_{R1,F,R,A}$ Factor employments

$\widehat{\rho}_{R,A}$ are calibrated elasticity of substitution parameters

R, R1 show regions, A shows activities, F shows factors

Elasticity of yield with respect to rainfall in YEAR

$$\widehat{\theta}_R = \frac{\ln\left(\alpha_{R,AGRI}\right)}{\ln\left(RF_R^{YEAR}\right)}$$

Agricultural Production Function

$$QVA_{R,AGRI} = \left(RF_R\right)^{\widehat{\theta}_R}\left(\sum_{F\in\Im}\sum_{R1\in\Re}\delta_{R1,F,R,AGRI}\left(QF_{R1,F,R,AGRI}\right)^{-\widehat{\rho}_{R,AGRI}}\right)^{\frac{-1}{-\widehat{\rho}_{R,AGRI}}}$$

Econometric Model

The generalized production function is used to estimate the impacts of climate change on precipitation and the growing season length.

$$Y = AX_1^{\beta_1}X_2^{\beta_2}\exp(\alpha_1X_1 + \alpha_2X_2) \tag{1}$$

Where Y represents agricultural yield and is dependent on X_1 (Growing Season Length (GSL)), and X_2 (total precipitation). β_1, β_2, α_1, α_2, are coefficients to be estimated by regression, A is a constant, and exp() represents an exponential term.

$$\frac{\partial Y}{\partial X_1} = \left[\frac{\beta_1}{X_1} + \alpha_1\right]Y = 0 \tag{2a}$$

$$\frac{\partial Y}{\partial X_2} = \left[\frac{\beta_2}{X_2} + \alpha_2\right]Y = 0 \tag{2b}$$

$$\frac{\partial Y}{\partial X_1} \quad and \quad \frac{\partial Y}{\partial X_2} \tag{2c}$$

Equations 2a and 2b identify the maximum of the production function and the terms in 2c represent the marginal productivity of GSL (X_1) and precipitation (X_2).

Solving 2a and 2b gives us the optimal X_1 and X_2 in equations 3a and 3b, denoted by the asterisks.

$$X_1^* = -\frac{\beta_1}{\alpha_1} \tag{3a}$$

$$X_2^* = -\frac{\beta_2}{\alpha_2} \tag{3b}$$

$$\frac{\partial^2 Y}{\partial^2 X_1} < 0, \quad \frac{\partial^2 Y}{\partial^2 X_2} < 0, \quad and \quad \frac{\partial^2 Y}{\partial X_1^2} \bullet \frac{\partial^2 Y}{\partial X_2^2} > \left(\frac{\partial^2 Y}{\partial X_1 X_2}\right)^2 \tag{4}$$

Finally, equation 4 defines the second order conditions.

$$LnY_1 = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \alpha_1 X_{1t} + \alpha_2 X_{2t} + \beta_3 X_{3t} + \varepsilon_t \tag{5}$$

$$GDD_1 = T_{mean} - T_{base}$$

$$T_{mean} < T_{base} \quad then \quad GDD_1 = 0$$

$$T_{\min} < T_{base} \quad then \quad GDD_2 = \left[W \cdot \cos(a)\right] - \left|\frac{\left(T_{base} - T_{mean}\right)\cdot\left(\frac{\pi}{2} - A\right)}{\pi}\right|$$

$$T_{mean} = \frac{T_{\max} - T_{\min}}{2}$$

$$W = \frac{T_{\max} - T_{\min}}{2} \qquad A = Arc\sin\frac{T_{\max} - T_{\min}}{W}$$

10. Estimation Results and Interpretations

Temperature increases and lower precipitation have had severe impacts on the length of the growing season and therefore on reducing agriculture productivity and production. Below we use two studies in Tunisia that showed how the decrease in growing season length (GSL) has influenced Tunisian agriculture in two geographic areas.

The increasing of temperature in the two districts causes the GSL to decrease in Beja and El-kef during the period 1977 to 2004 (Figures 12 and 13). The average of GSL was 91days in Beja district and 127 days in El-Kef district. Farmers would have to delay the date of plantation of durum wheat to December to avoid the negative impact of the increasing of temperature.

10.1 Climate Change Scenarios' Results

Temperature increases in the range of 0.5 - 3.5°C with steps of 0.5°C per 15 years (IPCC 2001). To forecast the impact of future increases in temperature in Beja and El-Kef districts under various climate change scenarios Faicel Gasmi, Mounir Belloumi and Mohamed Salah Matoussi (2011) estimated the transcendental production function as given in Eq.(6). The results are given in the Table 6 and Table 7.

In the two districts, the growing season length for durum wheat is reduced. If temperature increases by 1.5 °C the growing season length for Beja is reduced from 108 to 105 days (3% under the average of GSL). For this scenario wheat yield is reduced from 1959 to 1831 Kg/Ha (a decreasing of 7%). In El-Kef district we find that an increase of 1.5 °C in temperature for the next 45 years will reduce the growing season length from 127 to 125 days but we will note an increase of the yield from 1058 to 1507 Kg/Ha (an increasing of 30%). The last scenario (an increase of 3.5 °C) will reduce the growing season length for the two districts. This increase in temperature may reduce the yield of wheat in the Beja district from 1959 to 1642 Kg/Ha (a decrease of 16%) but in El-Kef district we note an increase of 6%.

Their empirical results show that the two climate variables (growing season length and rainfall) have a significant impact on durum wheat yield. Future increases in temperatures between 1.5 and 3.5 °C may reduce the yield of durum wheat in the Beja area between 16% and 19%. Hence we find that the observed climate change patterns and their impact were diverse both spatially and temporally. So the choice of good varieties of wheat and delaying the date of plantation to December will be the best solution to ameliorate the yield.

10.2 Computable General Equilibrium Models and Climate Change

The effects of climate change on the overall economy necessitate taking into account backward and forward linkages of agriculture. However, the number of studies that relate climate change to agricultural production through a sector or economy-wide model is limited. In the example below we adopt Hasan Dudu and Erol H. Cakmak's (2011) CGE model for Turkey. They have used the CGE methodology to capture the linkages between agriculture and the rest of the economy. Climate change impacts on precipitation, and the length of the growing season affect directly agricultural production, which in turn affect the entire economy.

Further quantification of the effects of climate change on agricultural production and the overall economy is required to estimate the holistic impacts of the climate change. The model disaggregates the Turkish economy into 12 NUTS regions. Results of global and regional climate models are used to run simulations about climate change. The results suggest that effects of climate change are significant and that regional interactions are important in understanding these effects. Their results support the contention that climate change mitigation should be considered as an integrated issue that cannot be dealt with in one sector without taking into account the intersection of the direct impacts with the rest of the sectors of the economy.

The simulation results suggest that effects of climate change will be insignificant in the first stage, but that the effects are significant in the second and third stages. Decline in GDP is mainly due to agriculture and its complementary sectors. The decline in real terms is compensated by the price increases in agriculture and the value added produced by agriculture turns out to be increasing in nominal terms. However, food production is seriously hit by the yield change in agriculture. Effects on the other sectors are relatively small but still significant.

10.3 Economic Analysis of Adaptation Strategies

Economic analysis is required for assessing strategies and the cost/benefit of alternative adaptation strategies. It is abundantly clear that the greatest difficulty in conducting an economic analysis of a climate-proofing investment is not with the economics; it is with the identification of projected changes in climate variables, and then of the physical impacts of these changes on infrastructure, health and productivity. Once these impacts are quantitatively identified, the economic analysis of climate-proofing investment is relatively straightforward.

Fortunately, there is no need to adapt economic analysis to climate change. The general framework of analysis works just fine.

Below is a representative sketch that frames choices and decisions about adaptation strategies within the broad cost/benefit analysis. Strategies to adopt must have a positive net present value (NPV).

If a particular infrastructure is going to be affected adversely by climate change it does not necessarily mean that it should be weather proofed. It should be weather proofed if and only if the net present value of its improvement is positive. That is if the present value of benefits (avoided costs) is larger than the present value of all the costs of the weather proofing.

In general, the economic analysis of development projects is weak. Often times, the economic analysis is not used to assess alternatives and guide decision-making about investment projects; it is often used to justify decisions which have been made.

“The percentage of Bank projects that are justified by cost-benefit analysis has been declining for several decades, owing to a decline in adherence to standards and to difficulty in applying cost-benefit analysis. (…) in many cases there is a lack of attention to fundamental analytical issues such as the public sector rationale and comparison of the chosen project against alternatives. The Bank’s use of cost-benefit analysis for decisions is limited because the analysis is usually prepared after the decision to proceed with the project has been made.” (World Bank 2010)

11. Conclusions

There will be escalating costs and damages as the climate changes and becomes warmer. More deaths and a lot more people will be affected by extreme weather events particularly in the developing world where adaptation is costly and ill afforded.

Climate resilience crucially depends on income per capita and education, these are in short supply in the poorer regions and that is why they will be more affected by the climate than richer regions. Besides they typically depend on a narrower industrial base and the base they depend on is more sensitive to climate change such as agriculture, forestry, fishing, etc.

Climate change cannot be wished away. The only option is to get ready for it. It makes sense to help the poor get prepared as they are in a significant way the victims of the production and consumption patterns in rich countries.

At this time there is virtually no work being carried out to prepare the Arab countries for climate change challenges. Specifically, no concerted data gathering and research efforts could be traced regarding the impacts of climate change on health, infrastructure, biodiversity, tourism, water, and food production. The economic impact seems to be totally ignored. This is the conclusion of a recent report published by Arab Forum for Environment and Development (Tolba and Saab 2009).

The World Bank estimates that adaptation costs could reach approximately USD 3.5 billion (in 2005 dollars) per year, for each year of the period 2010- 2050 in the MENA region (World Bank 2010).

Several limitations qualify the results. These include:

- Globally wettest and driest may not be wettest and driest for MENA region.
- There is only one warming scenario: 2 degrees Celsius.
- The nature of the adaptation options, their impacts and costs are based on literature reviews, not on actual estimates.

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Figure 1: The Dismal Scientists

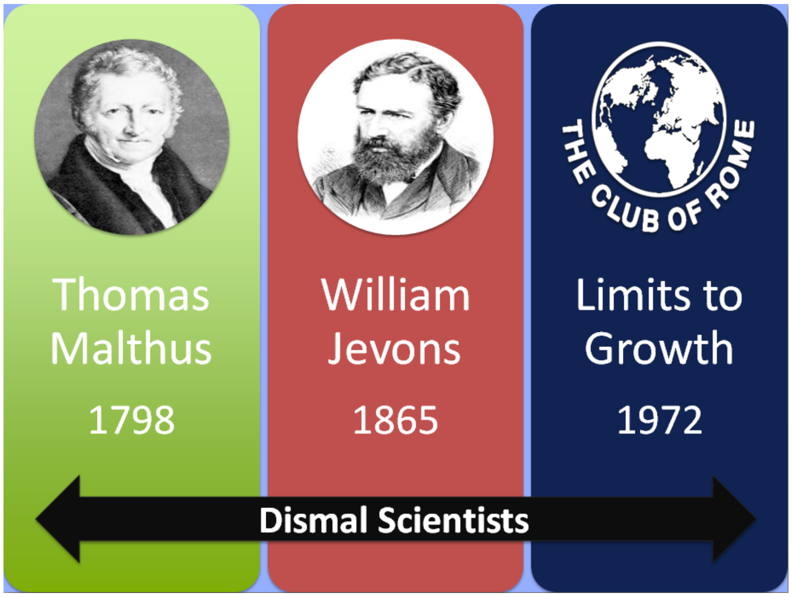


Figure 2: The Sustainable System

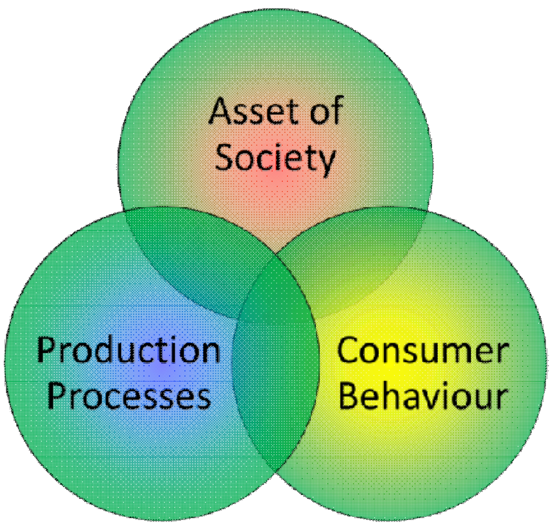


Figure 3: The Three Dimensions of Sustainability

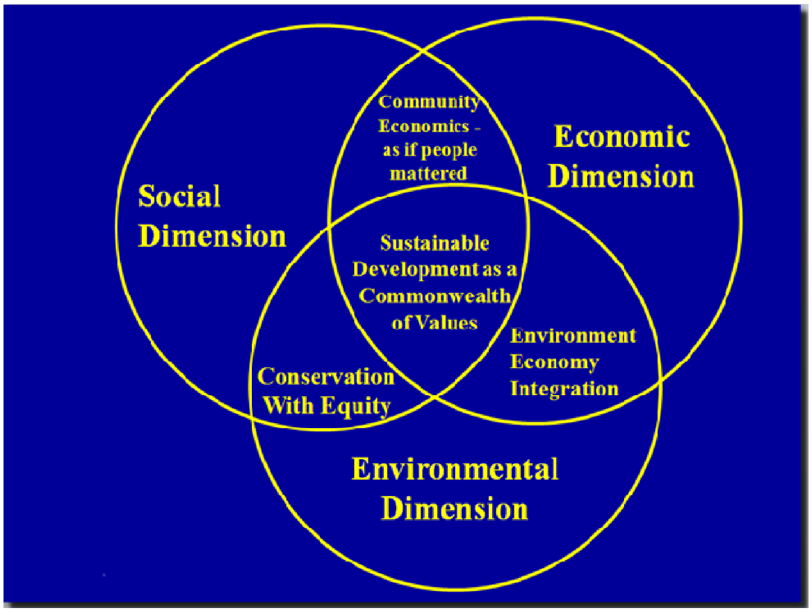


Figure 4: Economic Myths about the Environment and the Economy

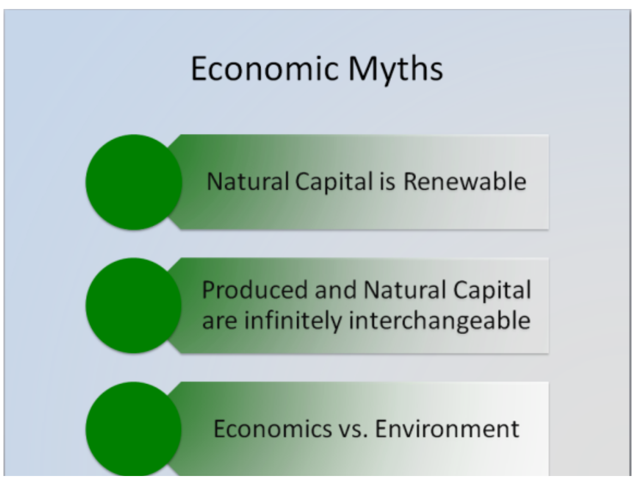


Figure 5: Economy-Environment Linkages

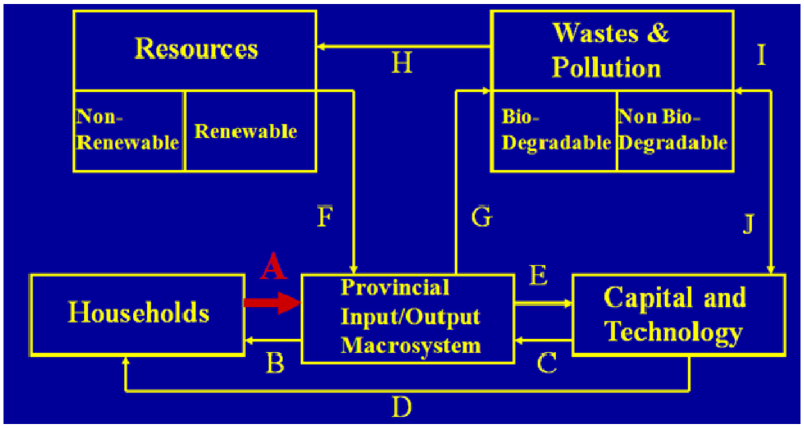


Figure 6: Genuine Savings

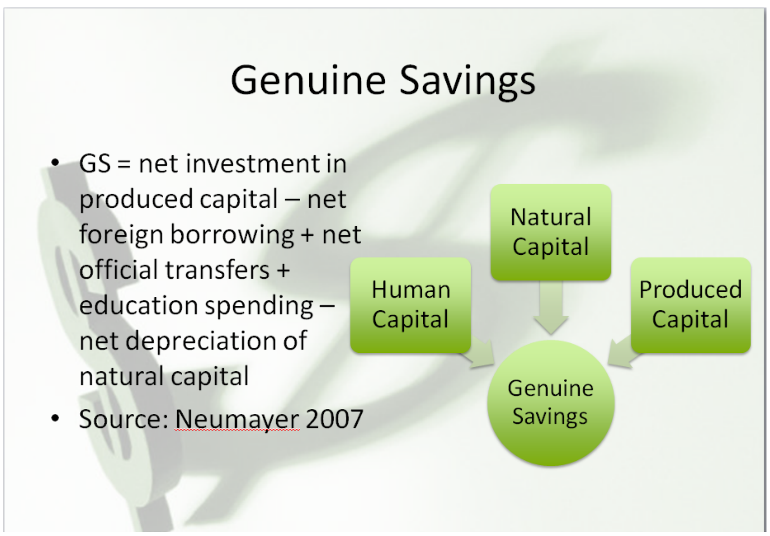


Figure 7: Net and Adjusted National Savings in the Arab World, 2002-2008

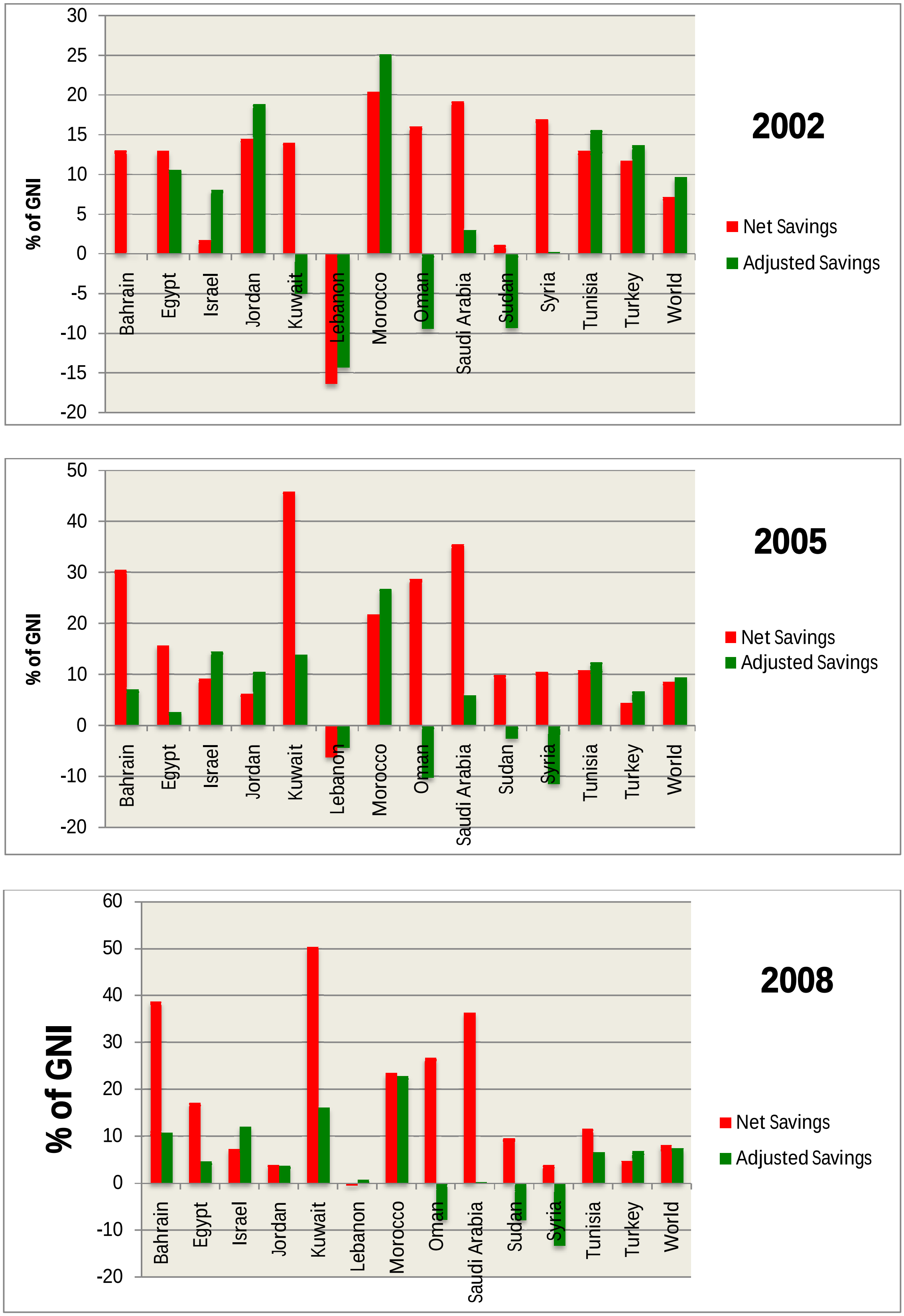


Figure 8: Projected impacts of SLR – Country area (% impacted)

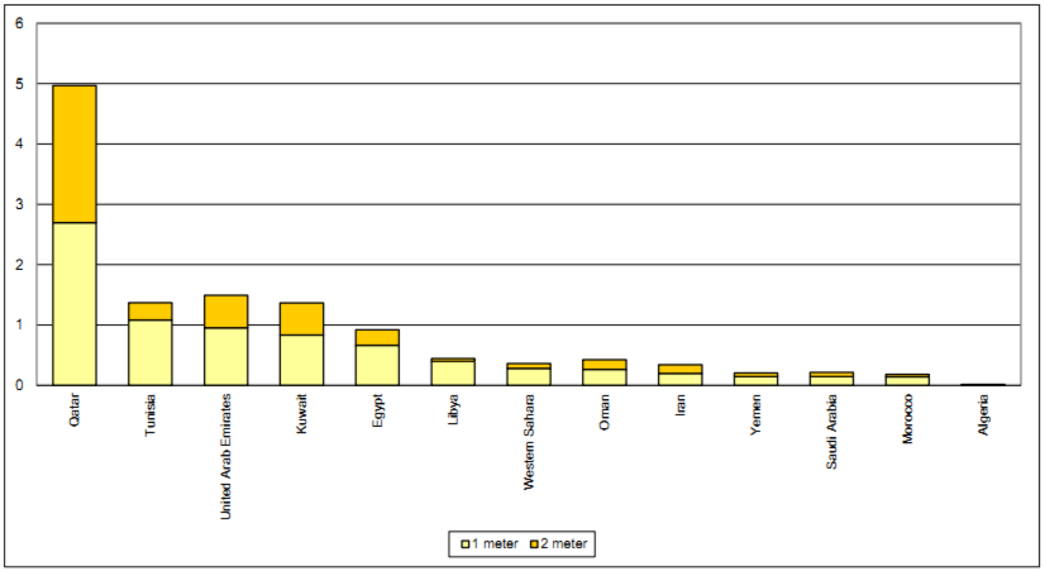


Figure 9: Projected impacts of SLR – Population (% impacted)

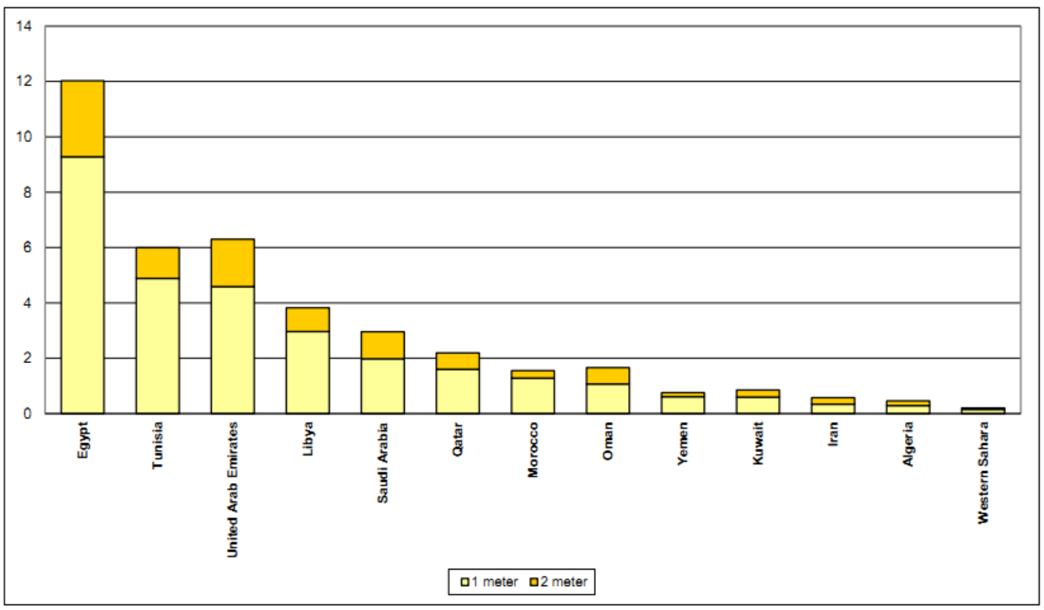


Figure 10: Projected impacts of SLR – Agriculture (% impacted)

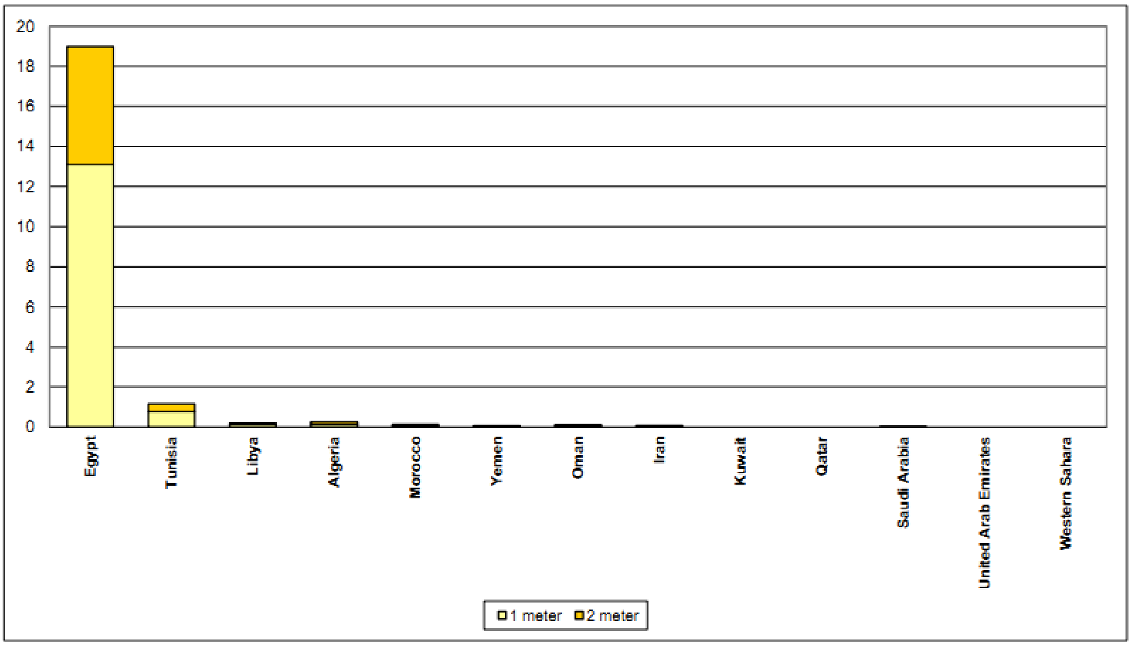
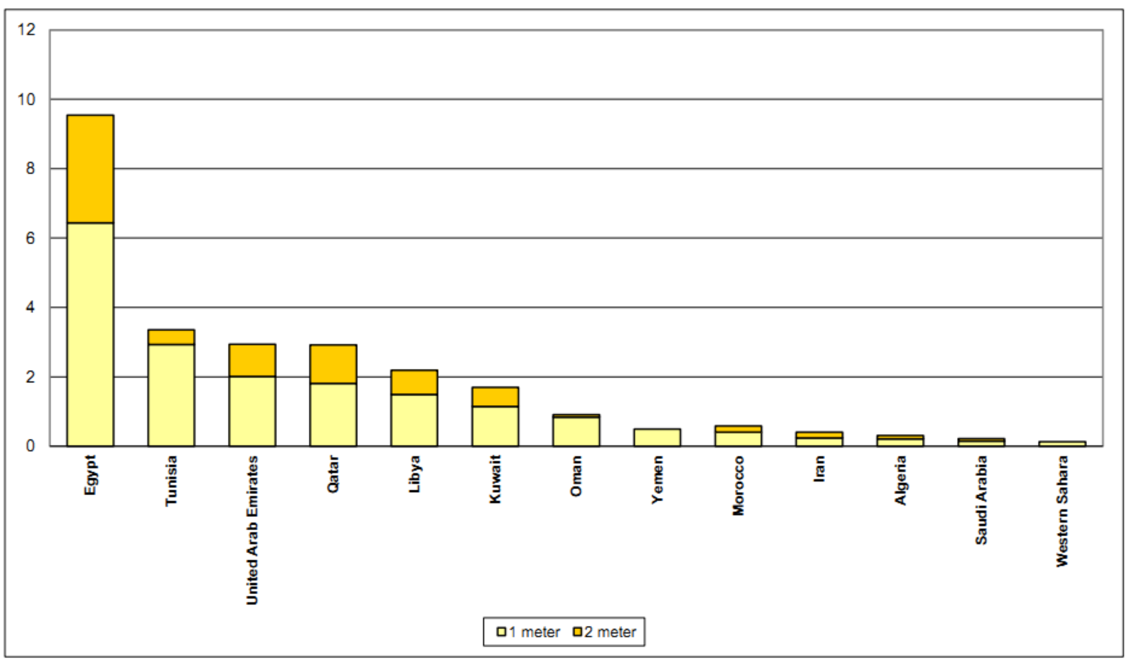
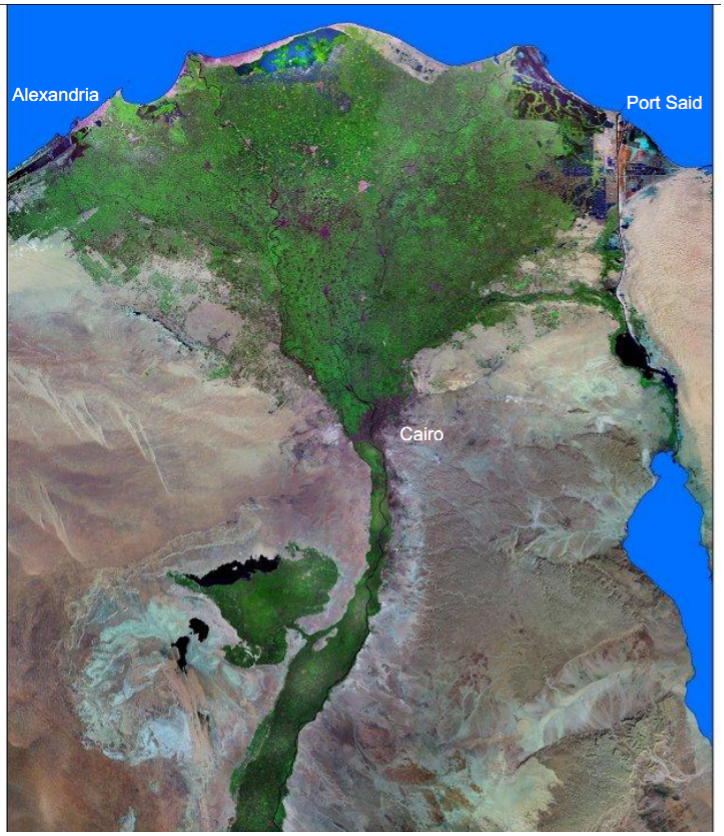


Figure 11: Projected impacts of SLR – GDP (% impacted)

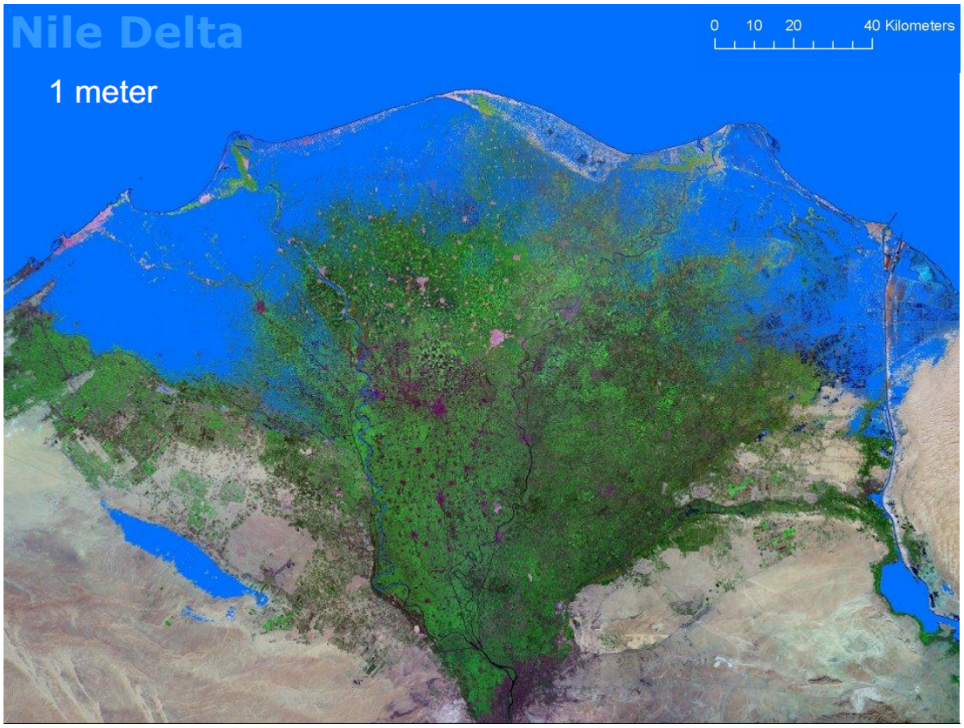


Egypt



NASA/USGS
Landsat Geocover

Nile Delta


Nile Delta
0 10 20 40 Kilometers
1 meter

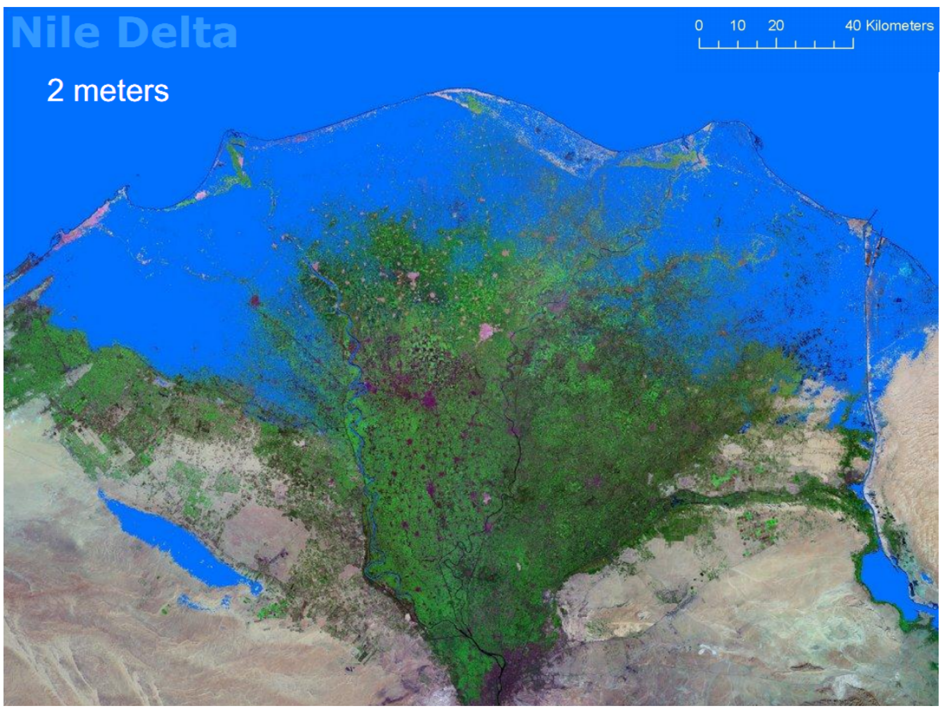

Nile Delta
0 10 20 40 Kilometers
2 meters

Figure 12: Growing Season Length in the Beja District in Tunisia

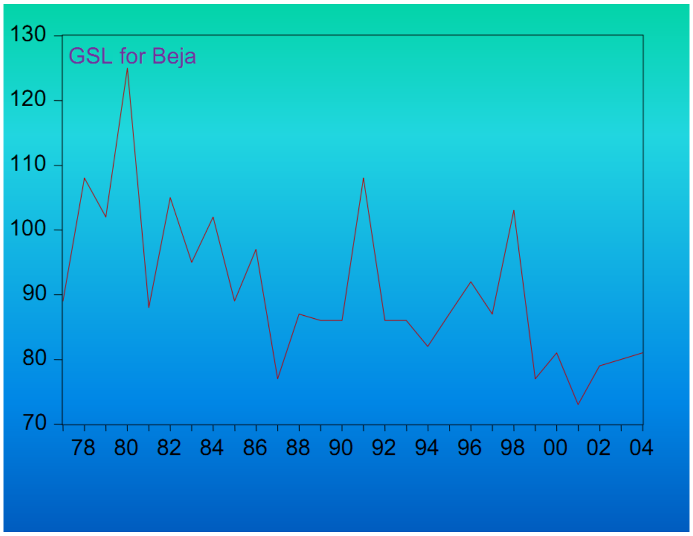


Figure 13: Growing Season Length in the Elkef District in Tunisia

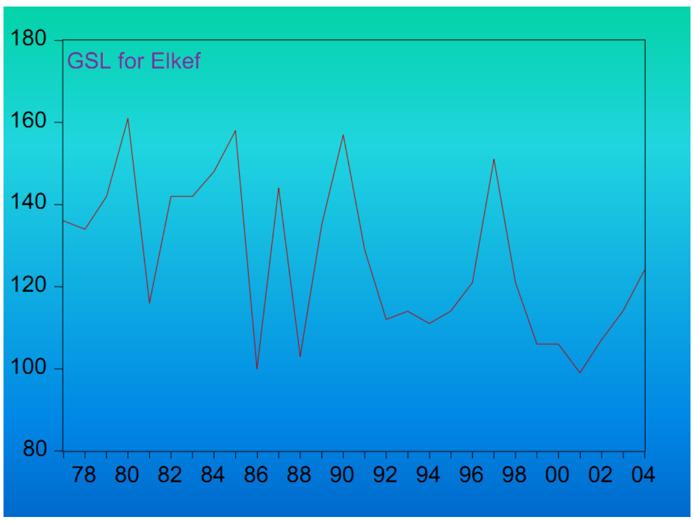


Figure 14

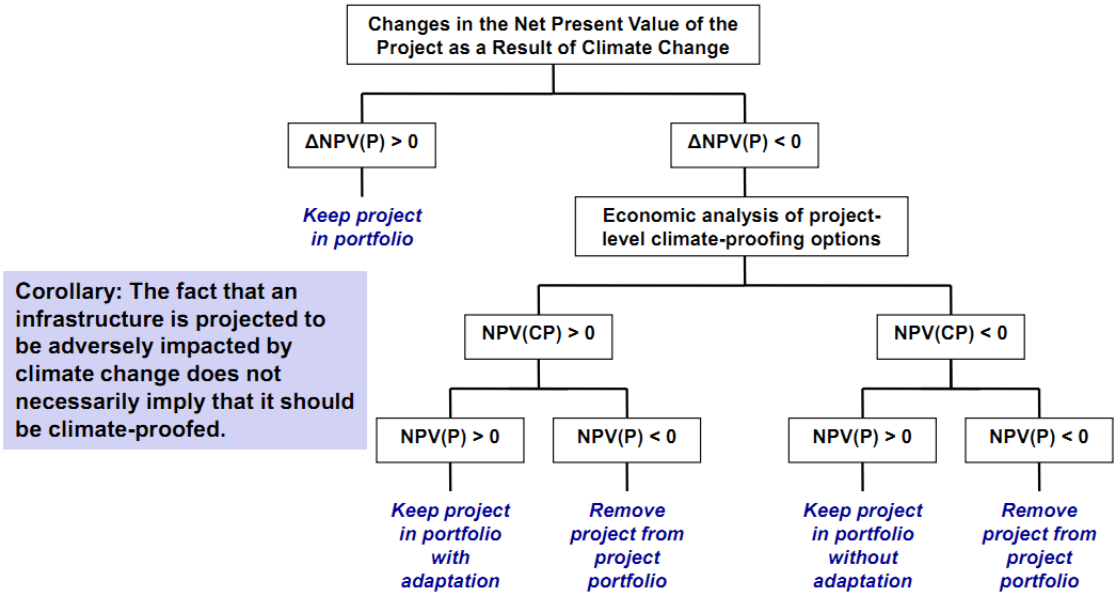

Changes in the Net Present Value of the Project as a Result of Climate Change
ΔNPV(P) > 0
ΔNPV(P) < 0
Keep project in portfolio
Economic analysis of project-level climate-proofing options
Corollary: The fact that an infrastructure is projected to be adversely impacted by climate change does not necessarily imply that it should be climate-proofed.
NPV(CP) > 0
NPV(CP) < 0
NPV(P) > 0
NPV(P) < 0
NPV(P) > 0
NPV(P) < 0
Keep project in portfolio with adaptation
Remove project from project portfolio
Keep project in portfolio without adaptation
Remove project from project portfolio

Table 1: Resource Accounting

Year	GDP	Net Change in Natural Resource Sectors Petroleum	Forestry	Soil	Net Change	NDP
1971	5,545	1,527	-312	-89	1,126	6,671
1972	6,067	337	-354	-83	-100	5,967
1973	6,753	407	-591	-95	-279	6,474
1974	7,296	3,228	-533	-90	2,605	9,901
1975	7,631	-787	-249	-85	-1,121	6,510
1976	8,156	-187	-423	-74	-684	7,472
1977	8,882	-1,225	-405	-81	-1,711	7,171
1978	9,567	-1,117	-401	-89	-1,607	7,960
1979	10,165	-1,200	-946	-73	-2,219	7,946
1980	11,169	-1,633	-965	-65	-2,663	8,506
1981	12,055	-1,552	-595	-68	-2,215	9,840
1982	12,325	-1,158	-551	-55	-1,764	10,561
1983	12,842	-1,825	-974	-71	-2,870	9,972
1984	13,520	-1,765	-493	-76	-2,334	11,186

Table 2: Electricity Generation Mix in 2005 and 2030

	Coal		Oil		Natural Gas		Hydro		Nuclear		Other	
Region*	**2005**	**2030**	**2005**	**2030**	**2005**	**2030**	**2005**	**2030**	**2005**	**2030**	**2005**	**2030**
CWA	17.4	17.5	12.6	11.1	38.2	41.4	30	27.4	1.8	2.6	n.a.	n.a.
EA	72.1	60.3	3.3	0.5	4	6.8	12.8	11.5	7.6	16.3	0.3	4.6
Pacific	n.a.	n.a.	64.9	50.9	n.a.	20.8	35.1	23.6	n.a.	n.a.	n.a.	4.7
SA	65.2	61.2	4.8	2.1	11.1	13.8	15.1	10.8	2.4	8.5	1.2	3.5
SEA	23.6	34.6	14	1.4	47	43.9	11.5	13.7	n.a.	1.8	3.9	4.5
DMCs	**62.3**	**54.8**	**5.3**	**1.6**	**11.8**	**15**	**14.1**	**12.5**	**5.6**	**12**	**0.8**	**4.1**
Developed	36.5	32.9	10.1	5	20.6	23.1	8.4	7.3	22.1	27.6	2.3	4
A&P	56.5	52	6.4	2	13.8	16	12.8	11.9	9.3	14	1.1	4.1

Notes: * CWA: Central and West Asia; East Asia; SA; South Asia; SEA: Southeast Asia; A&P: Asia and Pacific

Table 3: Projected impacts of SLR (% of indicators impacted)

Indicators	World	LA	MENA 1m SLR	SSA	EA	SA
Area	0.31	0.34	0.25	0.12	0.52	0.29
Population	1.28	0.57	3.2	0.45	1.97	0.45
GDP	1.3	0.54	1.49	0.23	2.09	0.55
Urban Extent	1.02	0.61	1.94	0.39	1.71	0.33
Ag. Extent	0.39	0.33	1.15	0.04	0.83	0.11
Wetlands	1.86	1.35	3.32	1.11	2.67	1.59

Table 4: The Regression Results for Durum Wheat Yield in Beja District Using Time Series Data (1976/1977-2003/2004)

Variable	coefficients	Std.error	t-statistics	probability
Ln A (β0)	-24.52	20.43	-1.20	0.20
Ln growing season length (β1)	8.87	5.81	1.52	0.10
Ln rainfall (β2)	0.12	0.15	0.77	0.44
growing season length (α1)	-0.08	0.05	-1.41	0.10
Rainfall (α2)	-0.00008	0.00007	-1.21	0.23
time (year number) (β3)	0.03	0.008	3.72	0.00
DW=1.99				
GDL= 110 days				
R^2= 0.46				

Table 5: Regression Results for Durum Wheat Yield in El-Kef District Using Time Series Data (1976/1977-2003/2004)

Variable	coefficients	Std.error	t-statistics	probability
Ln A (β0)	-130.74	72.17	-1.81	0.10
Ln growing season length (β1)	40.74	19.47	2.09	0.06
Ln rainfall (β2)	4.50	2.83	1.59	0.10
growing season length (α1)	-0.30	2.83	-2.02	0.07
Rainfall (α2)	-0.01	2.83	-1.85	0.10
time (year number) (β3)	-0.0009	0.04	-0.02	0.98
DW=1.99				
GDL= 136 days				
R^2= 0.62				

Table 6: Growing Season Length for Durum Wheat Crop in Beja and Elkef Districts under Various Climate Change Scenarios

Increase in average temperature (℃)	GSL (days) Beja	GSL (days) Elkef
0	105	136
1.5	83	125
2	79	72
2.5	74	84
3	71	80
3.5	68	76
Average of GSL of 28 years (Days)	91	127

Table 7: Regression Results for Durum Wheat Yield in Beja and Elkef Districts under Various Climate Change Scenarios

Increase in average temperature (℃)	Durum wheat yield in Beja district (Kg/Ha)	Durum wheat yield in Elkef district (Kg/Ha)
0	1652	1197
1.5	1831	1507
2	1784	963
2.5	1722	625
3	1592	1237
3.5	1642	1125
Average of GSL of 28 years (Kg/Ha)	1959	1058