Can the Caribbean Live within the Doughnut?

Environmental and Social Performance of Five Island Nations

by

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A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Master of Environment Studies in
Sustainability Management

Waterloo Ontario Canada 2019

AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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ABSTRACT

This study examines the social and environmental performance of five Caribbean nations (Trinidad & Tobago, Dominican Republic, Jamaica, Haiti and Cuba) using the *Safe and Just Space* (SJS) framework proposed by Kate Raworth (2012). For each country, values for 11 social and 7 environmental indicators are calculated. This is the first study that uses the *Safe and Just Space* framework for the Caribbean region, and with a focus on small island states.

Johan Rockström and colleagues first proposed the *Planetary Boundaries* (PB) framework in 2009, where they identify the urgency to remain within nine biophysical planetary boundaries if humanity must continue to thrive. The authors claim that by crossing these boundaries we would significantly risk our own survival and cause large-scale, abrupt or irreversible environmental changes. In 2012, Kate Raworth added the social dimension to the Planetary Boundaries framework, which she defines as the *Safe and Just Space* (SJS). She argues that humanity must not only remain within biophysical thresholds, but as part of the sustainability mandate, also aspire to achieve quality of life where no one is left behind. In other words, how can humanity achieve an acceptable quality of life at the lowest environmental costs, or in Raworth' s words, "can we live within the Doughnut?"

Drawing on the SJS framework, this study calculates 11 social and 7 environmental indicators for the 5 Caribbean nations to assess their sustainability performance. To this end, the method proposed by O'Neill et al. (2018) is taken as a starting point. The 11 social indicators include *Life Satisfaction, Social Support, Nutrition, Assess to Electricity (Energy), Access to Improved Sanitation, Health and Life Expectancy, Income, Equality, Democratic Quality, Education* and *Employment*. The 7 environmental indicators are: *Climate Change* (represented by *CO_2 emission*), *Phosphorous* Flows, *Nitrogen Flows, Blue Water, eHANPP* (embodied Human Appropriated Net Primary Production), *Ecological Footprint* and *Material Footprint*.

The results suggest that none of these five nations is in an ideal position within the doughnut of the environmentally safe and socially just space. Four of the nations (Trinidad Tobago, Dominican Republic, Jamaica and Cuba) exceed at least four out of seven planetary boundaries and none of them achieve more than half of the social outcomes. Haiti exceeds the boundary for CO_2 emission and functions slightly under the eHANPP boundary (that measures the intensity of use of biomass), but achieves none of the 11 social outcomes.

While the relationship between the environmental and social variables is multi-metric, a few patterns and correlation between environment and social indicators can be observed. In general, the achievement of most social outcomes such as access to electricity, sanitation, income, nutrition, employment, education, social support and life satisfaction are positively related to emission or material consumption, such as CO_2 emission, especially from emission from fossil fuels, phosphorous flow, eHANPP, ecological footprint and material footprint. Based on performances of these five nations, the achievement of social outcomes is not closely related to blue water as one of the environmental performance indicator. There does not exist clear positive relationship between environmental indicators and social indicators such as healthy life expectancy, equality and democratic quality.

Key Words: Small Island States, Sustainability, Vulnerability, Planetary Boundaries, Safe and Just Space

ACKNOWLEDGEMENT

I would first like to thank my supervisor, Professor Simron Singh. Without his trust and support, it would not be possible for me to start and complete this programme. Not only did Professor Singh guide me in my academic research but more importantly, his trust and support granted me the only opportunity to redirect my life. He helped me truly understand that having a strong theory framework in research is like having strong values in life, both of which will guide a person at crossroads of essential decisions. Thank you, Professor Singh, sincerely.

I would also like to thank my committee member Professor Michael Wood and my reader Professor Sean Geobey. You are always there when I need your help. Your knowledge, kindness and timely support have guided me every step of this journey.

I want to say "thank you" to Professor Goretty Dias and Professor Olaf Weber, whose kind help, knowledge and encouragement helped me tremendously when I was struggling with new concepts and methods.

I want to take this opportunity to thank Dr. Dan Moran from Norwegian University of Science and Technology, who has guided me in the calculation of indicator values related to the environmental performances of the five Caribbean nations by using data from Eora MRIO. I want to say thank you to Dr. Joep Schyns from Water Footprint Network, who gave me detailed explanation and clarification in response to my inquires on the consumption-based blue water value of Trinidad & Tobago. I sincerely appreciate it that Dr. Thomas Kastner from University of Klagenfurt has provided me with first-hand eHANPP values for the five Caribbean nations between 1995 and 2007. He also helped me understand the approach of analyzing land use change from the perspective of biomass change.

I want to say thank you to Amanda Watkins, Carl Tutton, Tasnia Syeda, Vasundhara Saravade, Goneet Sandhu and Maria Carmona whose friendship and support made me feel so warm in a country where winter lasts for six months.

Thank you, dad and James Jia, my brother. You are the best family who have always loved and supported me, whenever it is wherever I am.

I would also like to thank Tao Jiang, my best friend who loves me the most in this world. Thank you, Tao, for all the love and support you have given and will give me.

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1. INTRODUCTION

Over the past half century, the Earth's life-support system has been eroded by human activities in the efforts to satisfy social needs and ensure improved quality of life (Foley et al. 2005; Haberl et al. 2007; Hoekstra & Wiedmann, 2014; Likens, 1991; Steffen et al. 2007; Vitousek et al. 1997). Changes have occurred in global climate, biogeochemical cycles and land cover, and through biodiversity loss and environmental pollution (Rockström et al. 2009). The ecosystem degradation has resulted in a declining capacity to provide renewable supplies of natural resources; regulate climate, water delivery and the spread of diseases; and offer cultural, esthetic and recreational benefits for humanbeings (Chapin et al. 2011). It has been stated by numerous scholars that our life-support system has been changing from the stable Holocene state of the last 12,000 years to an uncertain state of Anthropocene because of the active and large-scaled human imprint on the global environment that rivals some of the forces of Nature in its impact on the earth's functions. The approaching Anthropocence is raising global concerns for continuous human-induced stress to the environment and the earth's continuing ability to provide services for viable human civilization (Carrington, 2016; Lockie, 2017, O'Neill et al. 2018; Rockströet et al. 2009; Steffen et al. 2007; Steffen et al. 2011a, Steffen et al. 2011b). Despite the increased effort for improved access to basic needs, and its consequential increased biophysical stress, currently one in five persons in developing regions still live on less than $1.25 a day, one in nine people in the world today are still undernourished, and 57 million children remain out of school. In addition, 2.5 million people lack access to basic sanitation services and 1.3 billion people, which is one in five globally, lack access to modren electricity. Global unemployment increases from 170 million in 2007 to nearly 202 million in 2012, an inease of 19% when the population increases by 6.3%. On average, income inequality has increased by 11% in developing nations between 1990 and 2010, and more than 75% of the households in those areas live in societies where income is more unequally distributed than in the 1990s (United Nations, 2015).

The increased stress on the biophysical system, combined with the uncertainties of the approaching Anthropocence and unsatisfactory social statistics and global change, challenges the current popular development model. Within such a context, sustainable development defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs", has become the international agenda (WCED, 1987). During the past decades, sustainable development, defined as the human use of natural resources in fulfilling basic human rights (Raworth, 2012), has been the political and academic focus of a wide range of governmental and nongovernmental organizations. It has become a new paradigm of development with many different meanings and responses (Lélé, 1991; Hopwood et al. 2005).

To define the environmental limits within which human society can safely operate, the concept of Planetary Boundary (PB) was developed by Rockström and Steffen et al. (2009). PB aims to integrate human development with the Earth's biophysical system, within accommodating boundaries. This framework provides a science-based analysis of the scale and magnitude of human perturbations that might destabilize the biophysical system, which is proved influential in global sustainability policy development. There are nine planetary boundaries for Ocean Acidification, Biochemical Flows, Freshwater Use, Land-System Change, Biosphere Integrity, Climate Change, Stratospheric Ozone Depletion, Atmospheric Aerosol Loading and Novel Entities, which define a safe operating space for humanity. The boundaries do not function in isolation, instead, they interact with each other with climate change and biosphere integrity as two core boundaries, which are connected to all other boundaries and either of which, alone, could drive the Earth's biosystem into a new state. Four out of these nine boundaries, Climate Change, Biosphere Integrity, Land-System Change and Biochemical Flows, have already been exceeded (Steffen et al. 2015).

The concept of Planetary Boundary provides a safe biophysical zone, beyond which there exists uncertainty that might endanger the existence of humanity. However, it only addresses the environmental aspect of sustainable development and does not include the necessary social dimension that addresses the concerns regarding quality of life. Raworth (2012) combines the concept of social foundation and the fulfillment of basic human rights, such as peoples' need for food, water, health care and energy, with that of PB and environmental limitations into a single framework, the Safe and Just Space Framework, also nicknamed "The Doughnut." This framework consists of an inner circle and outer circle, much like the shape of a doughnut, with each circle outlining a necessary set of foundations for sustainable development. Its inner circle represents social foundations, and the multi-dimensional requirements to avoid human deprivation. The outer layer of the doughnut is the environmental ceiling, representing the biophysical boundary beyond which indicates multi-metric environmental degradation. The zone between the environmental ceiling and social foundations is the environmentally safe and socially just space for human existence, the space where sustainable development takes place. Moving into the Safe and Just Framework coincides with the dual objectives of sustainable development, bringing everyone beyond social foundations and reducing the stress on the biophysical system within planetary boundaries. The Safe and Just Space framework provides a new perspective from which the sustainability of an individual country's development process can be assessed by both its social performances and its environmental performances.

1.1 Small Island States and Dimensions of Vulnerabilities

The Oxford dictionary defines island as "A piece of land surrounded by Water" and "A thing regarded as resembling an island, especially in being isolated, detached or surrounded in some way". Kelman (2006) describes islands as being isolated but inspiring, small yet fascinating. In his discussion about "islandness", Kelman (2003a & 2006) addresses "ambiguities" embedded in the Oxford definition and emphasizes both geographical and social perspectives of "islandness". Kelman interprets island as an intuitive concept of a comparatively small land mass, generally without strong land-based connections to a large land mass. Rather than using "island" as an external, academic and abstract label, Kelman (2003 & 2006) focuses more on the social attributes of islandness, i.e., the importance of people, communities and their heritage.

The term Small Island Developing States (SIDS) was first used at the Rio Earth Summit in 1992 (UN-OHRLLS, 2011), and again, shortly after at The Barbados Programme of Action (BPOA) in 1994, referring to the prioritization of action for small island development (United Nations General Assembly, 1994)**.** Small island states are often described as vulnerable special considerations, with smallness and remoteness as intrinsic qualities (Alonso, Cortez, & Klasen, 2014; UNCTAD Secretariat, 1985). The small land area and population, limited resources, susceptibility to natural disasters, vulnerability to external shocks, and excessive dependence on international trade have been identified as the inherent characteristics that contribute to their environmental and socioeconomic vulnerabilities (Briguglio, 1995, Boruff, et al. 2007). As pointed out by Kelman (2017), the relative small size of islands might lead to large proportional impacts from even small events, but small-size also permits kinship-based systems for dealing with extreme events to link with and strengthen national structures, which might be possible with larger economies. High-localized economies associated with isolation also build up the flexibility which larger economic structures cannot embrace. Whilst bringing about significant environmental and social challenges, isolation can also lead to the unique island environment and culture to nurture prosperity by creative livelihoods based on local tradition, identity and history. Vulnerability of island states is always a complex concept with embedded ambiguity, difficult to analyze from environmental, social or economic perspective without considering the interconnectedness of socioeconomic and environmental elements.

Environmental Vulnerability

Environmental vulnerability is concerned with the risk of damage to the natural environment (Kaly et al., 2003). Many small island states are in geologically or meteorologically tumultuous regions near the sea and are exposed at a greater rate to natural disasters, including cyclones, earthquakes and volcanic eruptions (Méheux, Dominey-Howes, & Lloyd, 2007). Small island states' smallness of physical size and population makes them sensitive to climate change (Pelling & Uitto, 2001). The smallness of small island states' land area also leads to their relatively smaller carrying capacities for natural resources, which results in the tightening feedback loops between social and ecological systems. For instance, limited waste absorption capacity combined with remoteness leads to high expenditure in exporting wastes off the island, making these states more vulnerable to land-based marine pollution (Eckelman et al., 2014; Petridis et al. 2013; Ring, 1997; Sarkar et al. 2011). In response to these challenges and concerns, the South Pacific Applied Geoscience Commission (SOPAC) and the United Nations Environment Programme (UNEP), alongside their partners, developed an Environment Vulnerability Index (SOPAC-EVI) to reflect the extent in which the natural environment is prone to damage and degradation (SOPAC, 2005). According to this index, empirical results indicate that the 15 most environmentally vulnerable countries are island nations (Kaly et al., 2003).

Economic Vulnerability:

There are two perspectives from which the economic vulnerabilities of small island states are interpreted (Briguglio, 2014). The first perspective conceptualizes economic vulnerability as inherent to islands' structure, mitigated only through resilience policy measures (Atkins, Mazzi, & Easter, 2001; Briguglio, 1995, 2014; Briguglio, Cordina, Farrugia, & Vella, 2009). The second perspective challenges empirical assertions that islands are inherently vulnerable, and purports that islands have inherent coping strategies (Armstrong et al., 1998; Armstrong & Read, 2002, 2006; Baldacchino, 2006; Bertram, 2006; Bertram & Watters, 1985; McElroy, 2006; McElroy & Hamma, 2010). From either perspective, the small island states' inherent characteristics are incorporated in discussion on either resilience policies or coping strategies.

The defined smallness of these island states is closely linked to their limited natural resources, which is reflected in their distinctive island economic profiles with overdependence on international trade, foreign aid, remittance, or the growth of one sole sector (Bertram & Watters, 1985; Baldacchino, 2000; McElroy, 2006). Such an economic profile differs from that of the more conventional economies in its skewed balance of payments and the imbalance between strategic imports and exports (Bertram & Poirin, 2007; Martinico-Perez, Fishman, Okuoka, & Tanikawa, 2016; West & Schandl, 2013). The overdependence on international trade causes an economic challenge because of the higher material and energy turnover required by extra transportation from global markets to remote locations. Small island states' relatively lower GNI per capita is usually related to their remoteness from main economies because of the relatively higher cost embedded in its economic activities (Armstrong et al.,1998; Briguglio, 1995; Briguglio & Galea, 2003; Guillaumont, 2010).

The heavy dependence on strategic imports challenges small island states' food and energy security because food and energy prices are income inelastic, which tend to be worsened by the relatively higher transportation cost associated with their remoteness (Briguglio, 2014). This type of resource-dependent coastal economy is believed to challenge small island states' livelihood opportunities especially when exposed to external natural or economic hazards (Barker, 2012; Corral et al. 2000; Delaney, 2003; Forster, 2010; Perch, 2012; Scott et al. 2012).

The small population sizes of small island states also have economic implications. Theoretically speaking, a smaller tax-base and the diseconomies for funding basic infrastructure and services might lead to failure to satisfy basic social needs. Similarly, the visible lack of economy of scale means the minimum efficient scale of output might lead to poorer competition and higher costs (Armstrong, De Kervenoael, Li, & Read, 1998; Armstrong & Read, 2002; Read 2001). However, in the case of small island states, the role population size or growth plays in the overall socioeconomic vulnerability should still be analysed in connection to other socioeconomic factors. For example, the relationship between urbanization and economic growth of small island states might differ from that of more conventional economies where urbanization usually drives economic growth. For small island states, population growth with no associated social progress and unplanned urbanization because of urban-rural disparity tend to intensify the land-use competition and lead to further deterioration of social infrastructure (UN-OHRLL, 2011).

Social Vulnerability:
Social vulnerability is defined as "the inability of human units (individuals, households or families) to cope with and recover from stresses and shocks, their inability to adopt to and exploit changes in physical, social and economic environment or to maintain and enhance future generations" (Bernard, 2004 &2007). Small island states are considered socially vulnerable due to demographic and social features that make them more susceptible to exposure (Brown, 2002; Kambon, 2002). Brown indicates that fertility rates, population structure, and migration are all closely related to the social dimension of small island states' vulnerability (2002). Bernard developed the Social Vulnerability Index (SVI) that is based on five institutional subs-systems: education; health; security, social order and governance; resource allocation; and communication technology (2004 & 2007). This index was tested with five Caribbean nations resulting in inconsistent and limited conclusion to understanding specific small islands social vulnerabilities. This was possibly because of the different implications of social factors on vulnerability within the small island contexts of the five nations.

Within the development context of small island states, from either the perspective of resilience policies and coping strategies, the severity of impacts of environmental hazards can be regarded as a function of the corresponding social infrastructure and capacity. Small island states' smallness in both size and natural resource reserves makes them sensitive to the leveraging role financial policies can play in transitioning the development to a more sustainable mode. For example, heavy government debts provide short-term support for economic growth by providing the capital, but often with long-term negative social implications (Andrian, 2013; Bovarnick et al., 2010). Social participation, social capitals and social and climate justice embedded in livelihood opportunities, especially for marginalized settlements, are all key elements to be incorporated into small island states' social vulnerability studies when exposed to the increasing climate change-related natural disasters, such as flooding, typhon and hurricane (Hyman, 2014; Pelling, 1998; Popke et al. 2014; Smith & Rhiney, 2015). In summary, rather than functioning in isolation, small island states' socioeconomic and environmental factors are integrated on multi-scale levels within their development processes, and into distinct vulnerability profiles.

1.2 Small Island States and Sustainable Development Process

During the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, small island states, for the first time, are categorized as Small Island Developing States (SIDS) with inherent characteristics and the resulted peculiar vulnerabilities. During the conference, member states agreed to commit themselves to addressing issues related to small island states' sustainable development. Agenda 21, adopted during this conference, recognizes the necessity to meet essential human needs, improve quality of life, maintain biodiversity, cope effectively and creatively with environmental changes and mitigate the threats posed to marine and coastal resources.

The Barbados Programme of Action (BPOA), adopted during the Global Conference on the Sustainable Development of SIDS held in Barbados in 1994, defines 14 priority areas[1] for actions, recognizing the importance of actions in three areas: capacity building and institutional development at the national, regional and international levels; collaboration in the transfer of environmentally sound technologies; trade and economic diversification and finance. The 22nd General Assembly Special Session, held in September of 1999 in New York, resulted in the State of Progress and Initiatives for the Future Implementation of the Programme of Action for the Sustainable Development of SIDS. Out of 14 priority areas, it identified 6 problem areas requiring urgent actions[2]. The Special Session also focused on the overall strategies to be adopted for the BPOA implementation, with specific attention on resource mobilization and finance, sustainable development strategies, resource development, capacity building, globalization and trade liberalization, transfer of environmentally-sound technology, development of a vulnerability index, information management through strengthening the SIDS Network, and international cooperation and partnership.

The Johannesburg Summit on Sustainable Development (WSSD) held in 2002 identifies small island states as a special case both for environment and development. It recognized the constraints imposed on small island states by the interplay of adverse factors, despite these nations' continuous efforts towards sustainable development. The consequential Johannesburg Plan of Implementation (JPOI) identified actions to be adopted to accelerate the implementation on national and region levels. The Mauritius Strategy of Implementation (MSI), a 10-year comprehensive review of the aforementioned BPOA, is adopted shortly after in 2005, during the Mauritius International Meeting, held in Port Louis. The MSI is. Limited financial resources and a reduction in official development assistance are recognized as the main challenges faced by

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[1] The 14 priorities, identified by the BPOA, are the following: climate change and sea- level rise, natural and environmental disasters, management of wastes, coastal and marine resources, freshwater resources, energy resources, tourism resources, biodiversity resources, national institutions and administrative capacity, regional institutions and technical cooperation, transport and communication, science and technology and human resource development.

[2] The identified areas were respectively: climate change, natural and environmental disasters and climate variability, freshwater resources, coastal and marine resources, energy and tourism.

small island states in the implementation of BPOA. During the 65th session of the General Assembly held in New York in 2010, member states undertook a 5-year review of the Mauritius Strategy for the Implementation of the BPOA. Priorities related to monitoring and evaluation were identified and the possibility of recognizing small island states as a special category within the UN was discussed. In the Future We Want, the outcome document issued by the United Nations General Assembly in 2012, member states reiterated the condition of SIDS as a special case for sustainable development in view of their unique and particular vulnerabilities and expressed their concerns around small island developing States having made less progress than most other groupings, or having even regressed, in economic terms, especially in regards to poverty reduction and debt sustainability. Therefore, member states reaffirm their commitment in assisting small island states in implementing the Barbados Programme of Action and the Mauritius Strategy. The Third International Conference on Small Island Developing States was held in September 2014 in Apia, Samoa. The overarching theme of the conference was the sustainable development of small island developing states through genuine and durable partnerships. The SIDS Accelerated Modalities of Action Pathway (Samoa Pathway) adopted at the Conference addressed priority areas for small island states and calls for urgent actions and support for their efforts to achieve their sustainable development.

1.3 Small Island States and Climate Change

Since 1896 when it is concluded that industrial-age coal burning will enhance the greenhouse effect, human-induced climate change has transitioned from being regarded as a beneficial effect to future generation to a major change to the stability of the Earth's ecosystem (BBC, 2013). Rockström and Steffen et al. (2009) identify climate change as one core boundary which is connected to all other boundaries and, alone, can drive the Earth's biosystem into a new state. With one-third of the earth's population living on land that is less than five meters below sea level, the threat associated with climate change, such as sea level rise, storm surges and coastal destruction, pose existential risks to small island states (UNDP, 2018). Climate change and the associated sea level rise, destruction of the coral reefs, loss of biodiversity, drought and flooding all severely threaten small island states' food security and livelihood opportunities such as agricultural production, fisheries and tourism. The extreme weather spawned by climate change also destroys small island states' arable and habitable land, real estate and infrastructure with catastrophic social and economic implications. Kiribati in the Pacific Ocean has been preparing for its "Migration with Dignity" to confront the eventual large loss of habitable land (Walsh, 2017).

Small island states first address climate change as a socioeconomic development issue at the United Nations Security Council (UNSC) in 2007. Since then, small island states begin their plea for greater recognition at the UNSC for its mandate on human rights protection, security and integrity of states. With resources made available through channels such as Global Environment Facility and others obtained from multilateral and bilateral sources, small island states have been undertaking initiatives to take early action around climate change. Many small island states have established national climate change committees that guide national climate change action plans and mitigation strategies, and initiate education, training, and public awareness campaigns designed to engage the general populace on the problem of climate change. A series of regional cooperation activities have been initiated to help build capacity for conducting vulnerability and adaptation assessments, and to help turn climate change considerations into development planning for coping and adapting to the adverse effects of climate change. The Caribbean Planning for Adaptation to Climate Change (CPACC) programme is one of such regional initiatives to identify effective climate change adaptation strategies. There are a series of climate adaptation practices identified by small island states, including: management and infrastructure development in agricultural sector in Mauritius; efficient management of water resources demand and supply and improved monitoring and forecasting systems for floods and droughts in Seychelles; human settlement and infrastructure related to hazard mapping with improved forecasting and early warning systems and insurance provision in Antigua and Barbuda; development of a health surveillance and forecast system and strengthened data collection and reporting systems for vaccination campaigns and health education in Saint Kitts and Nevis; protection of essential facilities and infrastructure as part of the Integrated Coastal Zone Management strategy in countries such as Barbados, Grenada, Jamaica, Saint Lucia and Singapore where tourism and related services serve as economic pillar; and integrated, sustainable coastal zone resource management in Dominica. However, despite the wide range of adaptation options, so far three fundamental constraints have limited the choice of options and implementations: inadequate data or information and technical capacity for timely and effective adaptation planning; weak institutional capacity and limited financial resources (UNFCCC, 2005).

As for climate change mitigation, the small island states' actions toward mitigation can serve as a pilot case for the rest of the world (UNEP, 2014a). Small island states are among the first to complete initial national communications related to their efforts in Greenhouse Gas emission reduction (UNFCCC, 2005). 38 SIDS have ratified the United Nations Framework Convention on Climate Change, and a range of regional activities and partnerships have been developed, including the South Pacific Sea Level and Climate Monitoring Project, the Pacific Islands Global Ocean Observing System (PI-GOOS), the Pacific Climate Change Portal, and the Caribbean Community Climate Change Centre (CCCCC) (UNEP, 2014a & 2014b). After the 22nd Conference of the Parties on Climate Change (COP 22) in 2016, all small island states have submitted their intended climate commitments under the Paris Agreement (UNDP, 2018). However, since small island states contribute less than 1% to the world's greenhouse gas emissions, their most aggressive mitigation efforts will have almost no impact on global climate change, and instead their inclusion revolves around encouraging further global change (Schaik L.V. et al. 2018). A significant number of the countries have joined the Alliance of Small Island States (AOSIS) to advance action and push for a more ambitious global community, with Fiji being the first small island state to participate at a COP Conference, COP 23, during November 2017 in Bonn, Germany (UNDP, 2018). Later, during COP 24 in Katowice Poland, ministers from 44 small island states affected by rising seas and temperatures called for drastic action at UN climate talks. They made this request in respond to the IPCC report, unveiled in October 2018, that demands global CO_2 emissions drop by a quarter within 12 years to cap warming at 1.5 C°, which seen as a safer guardrail against catastrophic extreme weather. However, this proposal was blocked by the U. S. A., Saudi Arabia, Russia and Kuwait (Agency France Press, 2018).

1.4 Gaps within Research on Small Island States' Vulnerability and Sustainable Development

So far, the understanding of island vulnerability has not benefited from the integrated, multi-scaled, social-ecological understanding of vulnerability as conceptualized in global environmental change research. The approach of regarding small island states as a distinctive group with a linear relationship between being small and remote and being vulnerable fails to recognize that vulnerability is path-dependent and historically embedded (Turner et al. 2003a). Static indicators applied to assess small island states' vulnerability suffer from a lack of feedback loops, assuming that it is not an interactive system and subjectively assigning value judgments to indicators. For example, SOPAC-EVI, the environmental vulnerability index that ranks 15 small

island states on a scale of vulnerability, tends to hold all environmental stressors as equally harmful with no consideration about the coupled social and environmental systems and the two-way feedback loops within the diverse social systems (Singh et al. 2013). Such an approach fails to acknowledge that environmental stress on the social system can be very contextually-based, varying with different social systems and structures (Barker, 2012; Briguglio, 2014; Collymore,2011; Corral et al. 2000; Delaney, 2003; Forster, 2010; Gould, 2015; Hyman, 2014; Kambon, 2009; Pelling, 1998; Pelling & Uitto, 2001; Perch, 2012; Popke et al. 2014; Rahmstorf, 2012; Scott et al. 2012; Smith & Rhiney, 2015UNEP, 2002). The approach of focusing too much on small island states' geological fragility when faced with climate change also tends to depoliticize many other prominent development challenges and shift the necessary attention from the more fundamental reasons for the transformation of small island states' structural limitations into vulnerabilities when exposed to external hazards (Kelman, 2014 & 2017). Such an approach masks the fact that the so-called developed state of the "West" in a sense can be attributed to the "underdeveloped state" of the "rest" in the binary discourses of development (Banerjee, 2003; Hall, 1992; Adams, 2001).
Barnett and colleagues have been influential in challenging discourses on the vulnerability of small island states by examining the complexity of island systems (Barnett & Campbell, 2010; Barnett et al., 2008; Barnett & Waters, 2016). The socially constructed ideas of inherent smallness and remoteness do not necessarily dictate islands to a state of vulnerability. External drivers such as colonialism, capitalism and religious conversion to Christianity all eroded small island states' traditional coping strategies for extreme weather events, food shortages or drought, and detracted away from traditional forms of resilience like inter-community cooperation, settlement patterns and housing construction (Barnett & Campbell, 2010; Barnett & Waters, 2016). Faced with political, economic and religious interferences and environmental hazards such as human-induced climate change, social elements, such as poverty, social equity, gender, fertility rate, population structure and migration, are all interacted with their inherent characteristics in determining the small island states' systematic vulnerability (Attzs, 2008; Brown 2002; Kampecialbon, 2002; Lopez-Marrero & Wisner, 2012; Verrest,2013; Winchester & Szalachman, 2009).

Despite decades of sustainable development efforts and support from international collaborations, it is acknowledged that with other grouping, small island states have made less progress and even regressed in economic term. A framework within which their socioeconomic and environmental performances and the interactions can be analyzed is needed to identify the vulnerable aspects of their development process for prioritized actions. This is where this thesis aims to contribute.

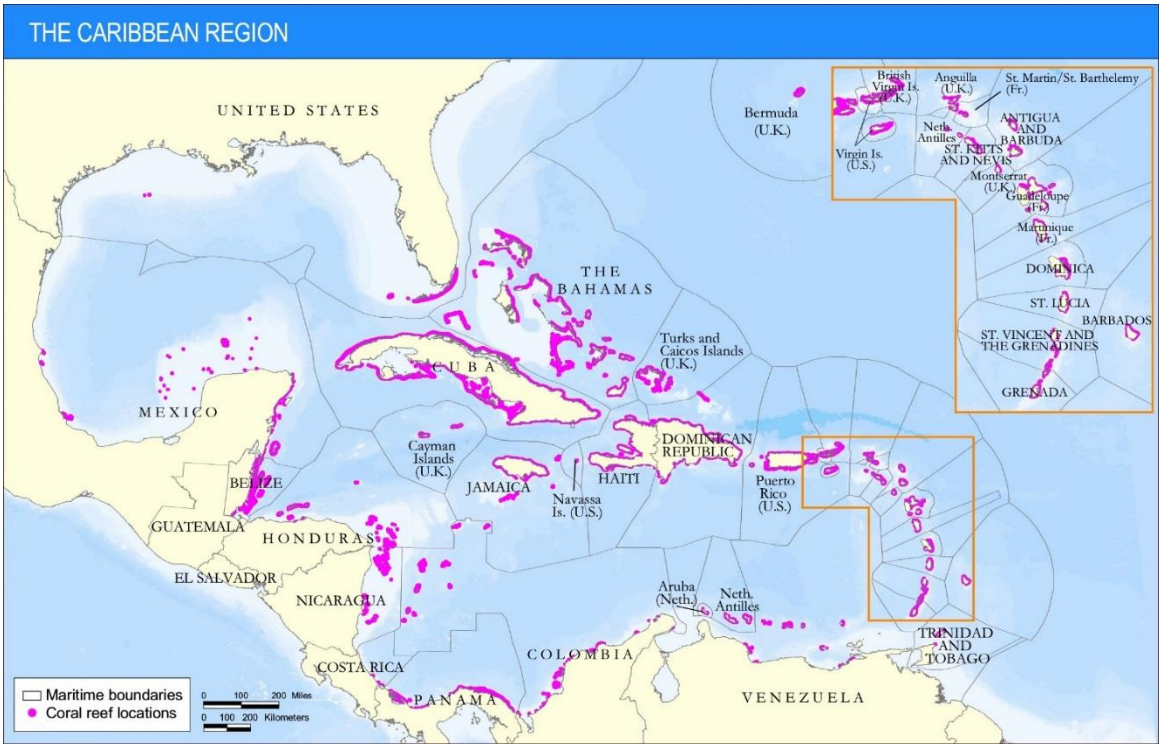
1.5 Study Area

It is in fact difficult to homogenize small island states' vulnerability and their sustainable development because of the diverse socioeconomic contexts varying in individual countries (Alonso et al., 2014). There exist four lists of small island states, categorized from political, economic, institutional and pragmatic perspectives (Blancard & Hoarau, 2012). Referencing these lists, this thesis selects five nations within the Caribbean region, as shown in Figure 1 below, to study the interactions between environmental and social performances of these five nations and their contextualized interconnections, aiming to explore systematic vulnerabilities embedded in their development processes and identify the key element to the transition to sustainability.

The Caribbean is a region of North America that consists of the Caribbean Sea, its islands, and the surrounding coasts. Geopolitically, the Caribbean islands are usually regarded as a sub-region of North

America, which is organized into 30 territories and sovereign states, overseas departments and dependencies. Its total area is 2,754,000 km² with only 239,681 km² as land area. The Caribbean Sea averages 2,200 m in depth plunging to 7,100 m in the Cayman trench and receives run-off from eight major river systems. The Caribbean islands range in size from 91 km2 (Anguilla) to 110,860 km 2 (Cuba) with highly varied topographies and geologies, including low-lying limestone and coral reef atolls and volcanic outcrops, and flora and fauna. The coastal ecosystems are a mixture of mangrove, sea-grasses and coral reefs while the terrestrial ecosystems are made up of 34 ecoregions all with high levels of endemism. Freshwater supplies are highly varied with Barbados as one of the world's top ten most arid countries. Its total population is around 43.6 million, with the density of 151.5 persons/km². The climate of the Caribbean region is tropical to subtropical with rainfall varying with elevation, size and water currents. The region enjoys year-round sunshine, with dry and wet seasons each taking 6 months of the year (UNEP, 2014b; WRI, 2017). The geographical location of the Caribbean region makes it sensitive to climate change. Scientific analysis shows climate of the Caribbean region is already changing in ways that seem to signal the emergence of a new climate regime, with "unfamiliar", "unprecedented" and "urgent" trend of change. Using Hurricane Irma and Matthews as examples, the severity of such regime shift can be reflected by the overnight intensification from a tropical storm to a category five hurricane with devastating intensity that lasts for several days (Taylor, 2015).

Figure 1: Map of the Caribbean



https://www.wri.org/resources/maps/caribbean-region

In 2016 Jessica Faieta, Assistant Secretary General of the United Nations and UNDP Regional Director for Latin America and the Caribbean, terms the Caribbean region as being structurally and environmentally vulnerable because of its high and increasing exposure to natural hazards, as well as open and trade-dependent economies with limited diversification and competitiveness. She emphasizes the sustainable development in the Caribbean demands "multidimensional progress" that entails overcoming structural obstacles beyond traditional measurements of living above or below the poverty line. For these small island states in the Caribbean, sustainable development demands social progress to be incorporated with the preservation of environment. However, despite their structural limitations and the acknowledged vulnerabilities when exposed to climate change, most of territories in the Caribbean region, with a few exceptions such as Haiti, rank relatively high in the United Nations' Developing Index ranking and belong to the high and upper middle-income groups (ChartsBin,2016). The seemingly high HDI ranking and per capita income might mask potential weaknesses, from both environmental and social perspectives, that tend to jeopardize their social foundation and sustainability. Such GDP-based indicators not only, in general, fail to incorporate elements related to the global challenges of the 21st century, such as climate change, poverty, natural resources depletion, human health and quality of life but specifically also do not consider many of the small island states' specific features (UNEP, 2014a; Blancard & Hoarau, 2013). There requires a framework that can assess small island states' development process by adequately capturing the interactions between cultural and social characteristics, priorities, unique natural environment and other non-monetary values.

1.6 Research Questions

This is the first study that aims to assess the environmental and social performances of five Caribbean nations and their contextualized interconnections, by using both biophysical and social indicators identified within the Safe and Just Space Framework (SJS). Two main questions guide this research:

1) Using indicators developed within the Safe and Just Space (SJS) framework, what are the environmental and social performances of the five selected Caribbean nations, and how do these performances interact?

2) Based on the analysis of these five Caribbean small island states' systematic vulnerabilities, what might be the key element of their transition to sustainability?

1.7 Thesis Structure

This thesis begins with the Literature Review (Section 2), exploring the link between a nation's vulnerability and sustainability of its development process to indicate why the vulnerability assessment preconditions the sustainable development study, followed by a theoretical background of studies on a variety of conceptual frameworks through which vulnerability is defined and analyzed. Section 3 describes in detail the development of the methodology used to evaluate environmental and social vulnerabilities and identify what might hinder these small island states' transition to sustainability. The results from the methodology are presented in Section 4, followed by discussion in Section 5 and conclusions of the key results in Section 6.

2 LITERATURE REVIEW:

The need to improve human well-being and social equity whilst reducing environmental risks and ecological scaricities requires a new vision for economic and social progress, also known as sustainable development (Steffen et al. 2011a & 2011b). The emergence of sustainable science is an effort to work towards an understanding of the duel objectives required to achieve social outcomes while also sustaining life-support functions of the coupled human-environment system (Turner et al. 2003a). The vulnerabilities of this coupled human-environmental system can be interpreted as both environmental vulnerabilities like stress on the ecosystem beyond its absorbing capacity, and social vulnerabilities like the failure to provide social foundation to the whole population. Aligning with this, the goal of sustainable development is to reduce both environmental and social vulnerabilities by connecting human development to the capacity of the bioshphere to sustain essential ecosystem services (Folke et al. 2011). To achieve this goal, a conceptual framework that can make vulnerability analysis consistent with the key concerns of sustainable development is needed. Such a framework helps account for the vulnerabilities with diverse and complex linkages on multidimensional scales and enable the identification of prioritized action areas for vulnverability reduction to facilitate a more sustainable development process.

2.1 Vulnerability Assessment and the Coupled Socioecological Framework

Dimensions and Factors Embedded in Vulnerability Assessment

Generally, vulnerability is defined as the probabilities of suffering from harm or being exposed to damage (Matson, Clark, & Andersson, 2016) while differentiating between human-induced risk and environmental hazards (Adger, 2006; Adger & Winkels, 2014; Turner et al., 2003b; Blaikie, et al., 2004). Vulnerability is applied widely and spans a variety of disciplines, interpreted from a wide range of perspectives, including livelihoods and development (Chambers & Conway, 1992; Scoones, 1998; Sen, 1999), hazards (Watts & Böhle, 1993), global environmental change (Smit & Wandel, 2006; Turner et al. 2003a) and resilience (Holling, 1973, 2001).

Scholars such Brooks (2003), Brook et al. (2013), Luers et al. (2005), Füssel (2004), Downing & Patwardhan (2004) and Metzger et al. (2005) suggest four fundamental dimensions in the description of a vulnerable situation: System, Attribute of Concern, Hazard, and Temporal Reference. Füssel (2006) summarises that "system" means the system through which vulnerability covers the coupled human-environmental interface, like a specific population group, an economic sector, a geographical location or a natural system. "Attribute of Concern" means the valued attribute(s) of the system that is/are exposed to a hazard. The United Nations (2004) defines hazard as "a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation". Temporal reference means the point of time or time-period at/during which the vulnerability of the system is being accessed.

Before categorizing vulnerability factors, two largely independent dimensions from which vulnerability factors can be interpreted, sphere (or scale) and knowledge domain, need to be explained (Füssel,2006). Sphere is about the attributes of being endogenous, such as geographical boundaries, or exogenous, such as the external power to influence. Sphere can shift with the scope of the assessment, in that endogenous factors on national level become exogenous ones when the assessment shifts to local level. Knowledge domain is associated with different branches of study area, including either natural and physical science or social science that covers economic resources, power distribution, social institutions and cultural practices. Knowledge domain determines the spheres of vulnerabilities of interest, and the vulnerability factors from different categories, either endogenous or exogenous. Where cross-disciplinary research is required, knowledge domains can also overlap.

Within the broader sphere of being endogenous or exogenous, vulnerability factors can be further categorized into "external stressors" and "internal factors", or "biophysical /natural factors" and "socioeconomic factors". External factors are usually socioeconomic ones that are normally covered by human ecology, political economy, and entitlement theory. Internal factors are mainly agency-oriented factors that are more often investigated by access-to-assets models, crisis and conflict theory, and action theory approaches (Bohle, 2001). Scholars tend to distinguish the external stressors to which a system is exposed from the internal factors that determine the impacts on the system (Chambers, 1989; Ellis, 2000; Sanchez-Rodriguez 2002, Pielke & Bravo de Guenni, 2003; Turner et al. 2003b). However, with the shift of knowledge domains, the categories of external and internal factors may also shift. For example, United Nations (2014) define physical, economic, social and environmental factors as internal because the focus is on the internal properties of the systems rather than those of the external stressors. On the contrary, Moss et al. (2001) regard physical-environmental and socioeconomic dimensions and their external assistance as external factors because the focus is on the characteristics of external stressors and the level of expected assistance.

With the shift of knowledge domains and the associated shifting perspectives from which vulnerability factors are analysed, the correlation between vulnerability factors of different categories also vary. For example, Klein & Nicholls (1999) believe "natural vulnerability" determines socioeconomic vulnerability whilst Brooks (2003) thinks "social vulnerability maybe viewed as one of the determinants of biophysical vulnerability". Cutter (1996) regards "biophysical" and "social" as being independent to each other. With the existence of the different knowledge domains from which vulnerability can be assessed, the concept of vulnerability presents a paradox of aiming to measure vulnerability yet being unable to offer a precise definition (Birkmann, 2006). There is no standard or "best" conceptualization or definition of vulnerability that fits all assessment contexts (Füssel, 2006; Gerlitz et al., 2016). The conceptual framework by which vulnerability is assessed varies in accordance with the shift of study context. Considering the social and environmental dimensions of sustainable development, a framework that acknowledges the two-way feedback loop between the biophysical system and human activities is needed for vulnerability assessment to precondition for decision-making on sustainable development strategies.

Integrated Approach in Vulnerability Assessement Framework

Two most notable integrated apparoches in vulnerability assessment are the hazard-of-the-place model (Cutter, 1996) and the coupled social-ecological system vulnerability framework (Turner et al., 2003a).

Cutter (1996) defines vulnerabilty as the likelihood that an individual or group will be exposed to and adversly affected by a hazard. It is the interaction of the hazards of people with the social profile of communities. The hazard-of-the-place model merges the traditional view of vulnerability as either a pre-existing biophysical condition, or potential exposure to a biophysical risk with the social condition predisposing certain responses to environmental threats. Within this model, vulnerability is conceived as both a biophysical risk as well as a social response, but within a specific area or geographic domain. The place can be a geographic space where vulnerable people and places are located, or a social space, where certain groups of peole are deemed the most vulnerable. Interpreted within this framework, there has been no homogenized vulnerabity, instead, vulnerability factors interact to produce place-specific vulnerability. Such vulnerability tends to change over time in accordance to changes within contexts where human activities interact with environmental hazards.

The coupled socioeconomic framework incorporates human wellbeing, ecosystem service, and the interactions between human activities and the ecosystem. Human wellbeing is defined as an aggregate of basic material needs, health, security, good social relations, and freedom of choice and actions (Dolley, 2005). On the one hand, the distribution of human welfare generated by ecosystem services depends on the range of temporal and spatial scales across which social goods, both private and public, are made available, and are associated with (or hindered by) a variety of property rights and other institutional arrangements. The gainers and losers in any environmental change situation vary depending on not only the type and scale of ecosystem service provided, but also the mix of stakeholders involved, the socio-economic characteristics, and the socio-cultural context. Such embedded complexity determines that ecosystem conservation has both environmental and social dimensions, encompassing not just efficiency and effectiveness criteria, but also equity, justice and legitimacy criteria, among other ethical concerns (Adger et al. 2001; Paavola 2005). On the other hand, the social efforts to benefit from the ecosystem will have impacts and eventually affect the level and quality of services and goods provided by the ecosystem. Schleyer et al. (2017) define ecosystem service as the interdependencies between social and nature factors. They argue that ecosystem service is neither about nature nor about human wellbeing, but about the mutual dependencies between nature and human wellbeing. However, different scientific disciplines and different science and society groups do not come to agreement on these mutual dependencies. Instead of being a static outcome, human wellbeing is a dynamic process with interactions between human and the ecosystem, nature and society.

Turner et al. (2003a) credit the dual objectives of sustainable development for achieving human wellbeing and sustaining the earth's life support systems to the balanced functioning of the coupled socio-ecological systems. The socioecological framework focuses on the long term role healthy socioecosystems can play in the sutaianble provision of human wellbeing, economic development and poverty alleviation across the globe (Turner & Daily, 2008). Within this framework, sustainability and vulnerability are closely related since both can be predicted on the synergy between the human and biophysical subsystems as these subsystems are affected by processes operating at different spatiotemporal and social scales. Analysis of vulnerability preconditions sustainable development in the sense that such analysis reveals the lack of balanced coordination between the ecosystem and human interventions during the development process, as well as the possible cause for such lack of synergy. Vulnerability, within this framework, is registered not only by exposure to hazards but also resides in the sensitivity and resilience of the system as the result of the interactions between social and environmental factors. Such exposure and interactions are contextually sensitive and therefore, vulnerability is place-based and needs to be understood as a product of interactions between multiple biophysical and human processes, which responds in a stochastic and nonlinear way and produces multiple feedbacks across different spatiotemporal scales (Turner et al. 2003b).

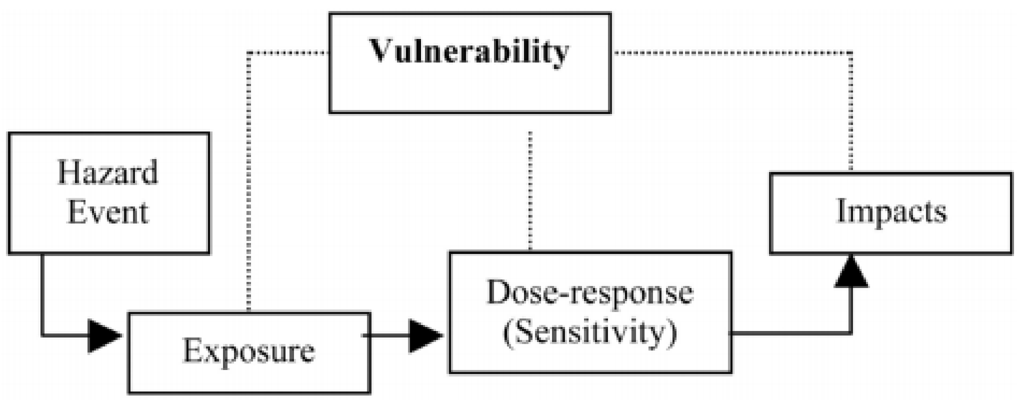
2.2 Other Conceptual Frameworks for Vulnerability Assessment

Besides the integrated vulnerability framework that is assessed by interactions between environmental and social performances, there are other conceptual frameworks, listed below, within which vulnerability can be explored from different perspectives, with possible overlaps between each framework.

Risk-Hazard Framework

The risk-hazard approach is the framework that is usually applied in technical literature, covering areas such as natural disaster study, epidemiology and macroeconomics. It is usually used to assess the risks of either physical systems or groups of people when exposed to hazards of certain types and magnitudes (Burton et al., 1978; Kates, 1985, Downing & Patwardhan, 2004; Füssel, 2006). Within this framework, hazard is defined as "a potentially damaging physical event, phenomenon or human activity that is characterized by its location, intensity, frequency and probability" (UN DHA, 1993; United Nations 2004). Risk is interpreted as "expected losses due to a particular hazard for a given area and reference period" (Adams, 2001) and "expected loss resulting from interactions between natural and human-induced hazards and vulnerable conditions" (United Nations, 2004). Vulnerability is the relationship between the severity of hazards and the degree of damage caused" (UN DHA, 1993; Coburn et al., 1994; United Nations, 2004). There does not exist clear boundary between risk and vulnerability since both are defined as loss or damage when exposed to hazards, with no special focus on the relationship between human behaviour and the level of its vulnerability. Human vulnerability is usually described as "exposure to hazards" (Hewitt, 1997) or "being in the wrong place at the wrong time" (Liverman, 1990). In line of this, hazards, risk and vulnerability are stationary, rather than evolving with the interaction between human and ecosystem.

Figure 2: Risk-Hazard Framework (Turner et al. 2003b)



In Region of Risk: A Geographical Introduction to Disasters,
Hewitt (1997) explores the field of risk and disaster from three perspectives: hazards, vulnerability and active perspective. Vulnerability is depicted as a concept to identify a "distinctive" view of risk and disaster. The focus of vulnerability analysis is not on the "severity of the damaging agent" but on "the conditions that influence" the relevant groups' "protection and coping capacities". Human actions are depicted as the desire to reduce human misery and material loss when exposed to nature or human-induced hazards, such as war, crime, or violence, rather than to reduce the level of exposure to hazards. Other research that applies this approach includes The Environment as Hazards (Burton et al. 1978); The Interaction of Climate and Society

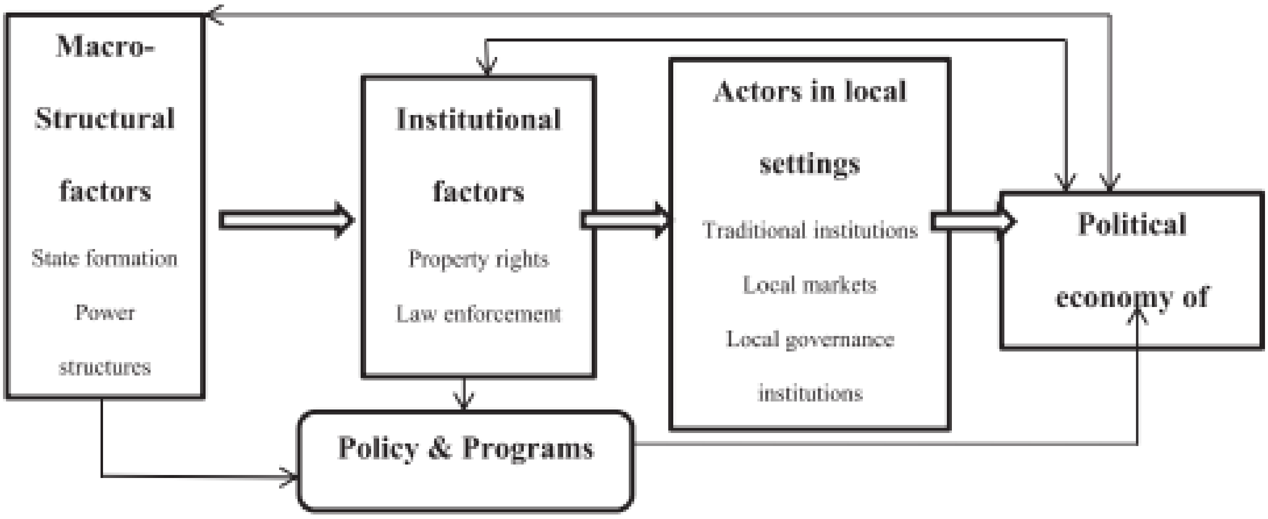
(Kates, 1985); Assessing Vulnerability for Climate Adaptation (Downing & Patwardhan, 2004); Climate, Change and Risk (Downing et al. 2001); Vulnerability and Risk Assessment (Coburn et al. 1994); Risk (Adams, 1995); The Need for Rethinking the Concepts of Vulnerability and Risk from a Holistic Review and Criticism for Effective Risk Management (Cardona, 2003); Defining Risk (Kelman, 2003) and Vulnerability and Risk: Some Thoughts from a Political and Policy Perspective (Sarewitz et al. 2004). Liverman (1990) states, "Since it seems unlikely that we will marshal the resources to prevent all global changes or to compensate everyone for their impacts. We need more precise estimates of who is vulnerable to decide where, when and how most effectively to focus our responses". Therefore, rather than deliberately ignoring the active role people can play in reducing their exposure to hazards, the risk-hazard approach focuses more on the relatively short-term solution to reduce damage of materials or loss of lives.

Political Economy Approach

The framework of political economy assesses vulnerability from the perspective of people, considering things like, who is the most vulnerable and why. Different from the risk-and-hazard approach that interprets human vulnerability when exposed to hazards from the perspective of physical systems such as location and built infrastructure, the political economy approach emphasizes people's coping and adaptation capacity as a result of their entitlements to resources, related to power structure and sociopollitical system. Vulnerability within this frameowrk "refers exclusively to people and it is based on an explanatory model of socioeconomic vulnerability to multiple stresses" and is defined as "the state of individuals, groups or communities in terms of their ability to cope with and adapt to any external stress placed on their livelihoods and well-being" (Adger & Kelly, 1999; Füssel, 2006). The relationship between ecosystem and political economy are usually interpretted as adaptive risk management associated with political and social power relations, resource consumption, and global economies (Smit & Wandel, 2006; Blaikie & Brookfield, 1987; Sen, 1981; Walker, 2005). People's adaptive capacity, termed also as coping capacity, response capacity or resilience, is assessed by access to entitlements and resources. Therefore this approach prevails in studies related to food security, poverty and development (Downing, 1991; Adger, 2000; Adger et al. 2001, Füssel, 2006).

Another definition for vulnerability within this framework is "the degree to which different classes in society are differentially at risk" (Susman et al. 1984). According to Liverman (1999), the theory of "social marginalization" shows how the "flow of resources out of a region, land expropriations, exploitative labor conditions, political oppression and other processes associated with colonialism and/or capitalism," have made poor peole more vulnerable and further degraded their environment. Albala-Bertrand (1995) concludes that, "poor societies and poor people within society generally are more vulnerable, suffer greater costs and have less capacity to take compensating action, than richer society or households". This framework is sometimes called the neo-Marxist approach because of its emphasis on the impacts of social classes of vulnerability. Adopting the ''astructural" appraoch, Garcia (1981; 1982; 1986) diagnoses the climate anomalies by analyzing the historical evolution of social systems in various regions and demonstrates how certain groups have become too disadvantaged and exploited to cope with the exposed hazards. De Castro (1975), Watts (1983) and Spitz (1977) also adopt this approach, emphasizing the strong links between development and the patterns of famine and suffereing in their literature. Within this framework, an individualu's coping capacity is restricted to his access to entitlement which is determined by his power or position in the social structure (Franke & Chasin, 1980; Copans 1975; Lappe & Collins, 1979; Sen, 1981). One key feasure of this approach is its belief that the coping capacity of individuals or groups is shaped and restrained by social, political and economic processes at higher scales (Smit & Wandel, 2006). Therefore the role of individuals or groups to cope with hazards are still passive, confined by their social positions within the overall power system.

Figure 3: Political Economy Analysis Framework (Bekele, 2017)

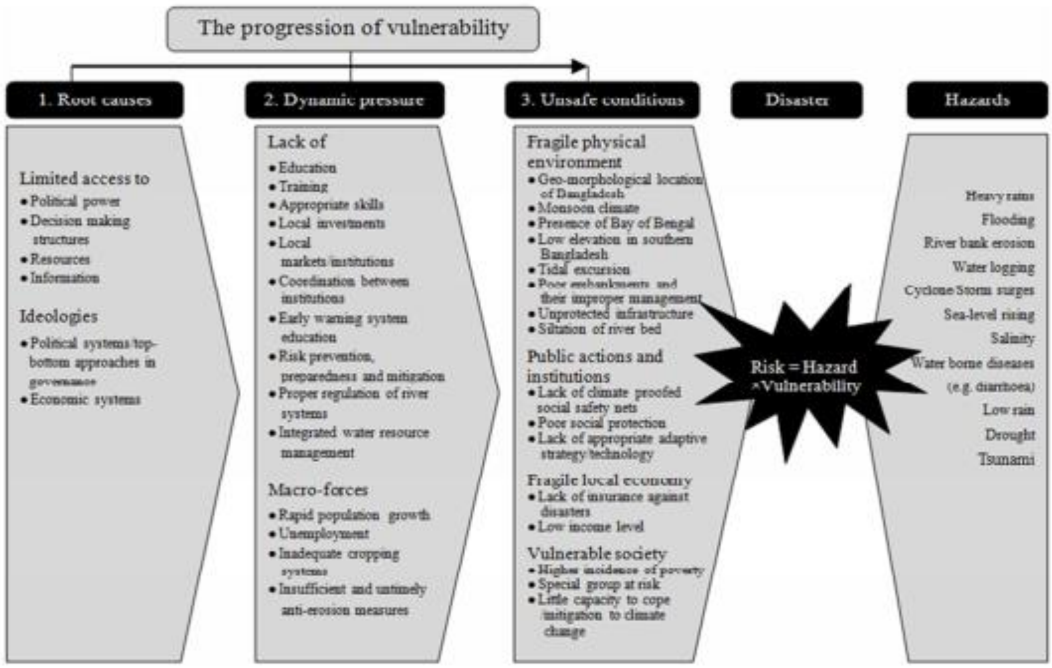


Pressure – and – Release Model

The pressure-and-release (PAR) framework is mainly applied to understand the different dynamics of vulnerability and the phases of interaction between vulnerability and hazard. Simiar to the risk-and-hazard framework, pressure-and-release model also defines risk as the product of hazard and vulnerability (Blaikie et al. 1994). What differs these two models is, instead of simply describing people's vulnerabilty when exposed to hazards and the resulted risks, the presure-and-release model aims to explore the global root causes, regional pressures, and local, vulnerable conditions that can be attributed to the evolution of vulnerability. Within this framework, vulnerability is composed of three levels: root cause, dynamic pressure, and unsafe condition. The root causes are related to economic, demographic and political processes, which can be interpreted as the function of economic and politicial structures, legal definition of rights of idelogical order and distribution of power. Joseph (2005) regards limited access to economic or political power as the root cause for vulnerability during a disaster and believes vulnerability is at the foundation of risk and recovery practices. The dynamic pressures are processes that transform the root causes into vulnerability when faced with unsafe conditions, including the specific forms in which vulnerabilities are expressed in time and space in conjunction with hazards. Release is used to conceptualize the mitigation of vulnerability and hazard impacts, which is to reverse the mechanism or process that translates the root causes of vulnerability into unsafe condition (Blaikie et al. 1994). Sometimes the access to resources model, which expands on the dynamics of changing decisions, options, livelihood opportunities, available resources and choices made by the population that is impacted by disaster(s) is used to complement the pressure-and-release model (Blaikie et al. 1994; Nirupama, 2012).

Awal (2015) integrates climate change shocks and stresses in the conceptual framework of pressure-and-release. Lack of access to political power and resources, insecure livelihoods, environmental degradation and ineffective disaster risk reduction practices are identified as the root causes for increasing climate vulnerability. It concludes that by coordinating disaster risk management and climate change adaptation, social safety net service might help relieve some climate change-related pressures. The framework of pressure-and-release is used to systematically evaluate Haiti in the context of the 2010 major earthquake (Martin, et al., 2010). In this research, vulnerability is evaluated from the perspectives of root causes, dynamic pressures and unsafe conditions with the assumption that disasters are caused by the intersecting of the process-generated vulnerability and exposure to hazards.

Figure 4: Pressure-and-Release Framework (Blaikie et al. 1994)



The pressure-and-release model is also applied in the area of epidemiology to identify the multiplicity and interaction of causes for the distribution and prevalence of human diseases (MacMahon et al., 1960). To identify environmental health indicators, Kjellström & Corvalan (1995) designed the Driving-Forces Pressure-State Effects-Action (DPSEA) framework by adding the element of "effect" into the traditional Pressure-and-Release model. "Effect" is incorporated because of the considerable impacts of changes in the state of environmental on health status or quality of life. It is argued by the researchers that in the case of the indicators being developed to assist informed decision-making for targeted actions, "action" should replace "response" since "response" tends to be construed as a passive reaction.

As its guidance for environmental review, OECD (1993) adjusts the pressure-and-release framework into the pressure-state-response (PSR) model to identify the environmental risk indicators. The PSR framework is based on the concept of causality in which human activities exert pressures on the environment and change its quality and the quantity of natural resources. The society responds to such human-induced changes through environmental and economic policies. Pressures refers to socio-economic activities and associated processes or products, such as emissions or biochemical flows, with impacts upon the ecosystem. Pressures lead to change in the state of the environment that requires responses in the forms of technology or policies. In its 1993 report, OECD points it out thatthat the feedback loop within this framework is between human-induced environmental changes and further human interventions as response to such environmental changes through policies. Vulnerability assessment within such a framework tends to suggest a linear relationship in human-environment interaction without incorporating the more complex relationships in ecosystems and in environment-economy interactions. Blaikie et al. (1994) state the main weakness of the pressure-and-release model is that the generation of vulnerability is not integrated with the ways in which natural hazards have impacts on people. Within this framework, hazards are isolated from causal forces of vulnerability.

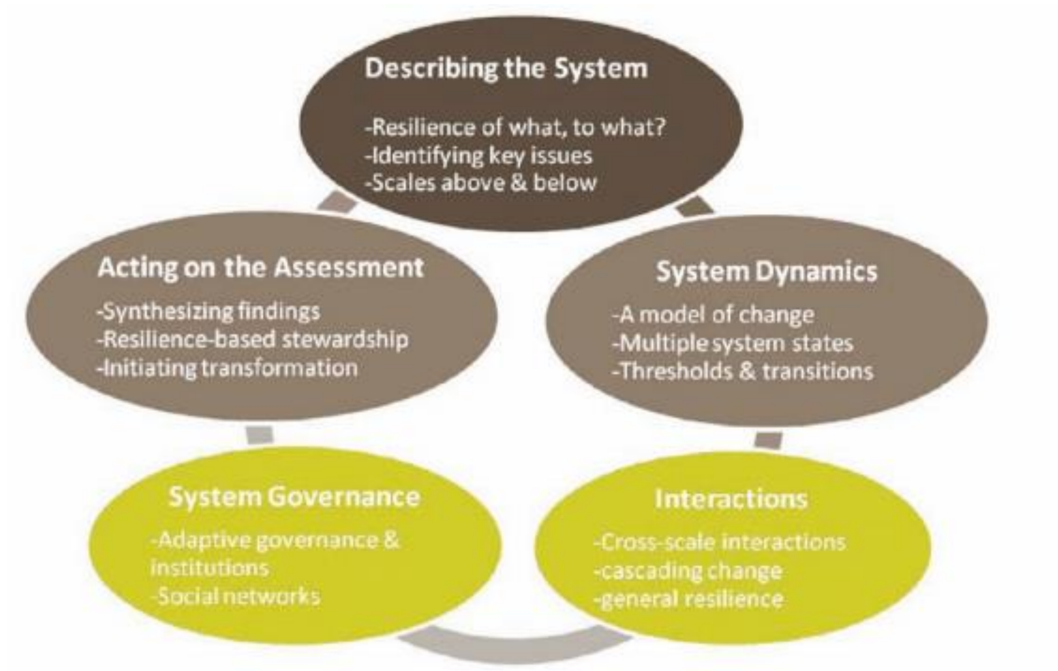
Resilience approach

The approach of assessing vulnerabilty by focusing on the concept of "resilience" can find its root in ecology (Füssel, 2006). The Resilience Allicance Group defines vulnerability as "the propensity of social and ecological systems to suffer harm from exposure to external stresses and shocks. It involves exposure to events and stresses, sensitivity to such exposures, and resilience owing to adaptive capacity measures to anticipate and reduce future harm". It defines the resilience framework as an approach to managing natural resource systems that considers social and ecological influences at multiple scales, incorporates continuous changes and acknowledges the potential of certain degree of uncertainly to increase a system's resilience to disturbance and the system's capacity to adapt to change (Resillience Alliance, 2010). Füssel (2006) points out that an important feasure of the resiliece approach is its consideration of the dynamic aspects of vulnerabiltiy since resilience denotes the ability of a system to return to an earlier stable state after perturbation.

Within this framework, Proag (2014) defines vulnerability as the degree to which a system may react adversely during a hazardous event. The concept of vulnerability implies a measure of risk associated with the physical, social and economic aspects and implications resulting from the hazardous event. He categorizes resilience into both hard resilience, the direct strength of structures or institutions when placed under pressure, and soft resilience, the ability of systems to absorb and recover from the impact of disruptive events without fundamental changes in function or structure. The distinction between social and ecological resilience and the validity of the integration of social and ecological dimensions have generated many discussions. The complexity embedded in adopting resilience within the social dimension can be traced to the fact that, different from an ecosystem, people have the capacity to consciously influence future outcomes and alter the interconnectedness for the existing benefits of certain social groups. Adger (2000) defines social resilience as the ability of groups or communities to cope with external stresses and disturbance caused by social, political and environmental changes, and ecological resilience as the characteristic of ecosystem to maintain itself in the face of disturbance. He acknowledges the link between social and ecological resilience, especially for social groups that depend on ecological resources for livelihoods. However, it remains unclear whether the resilience of the ecosystem will enable resilient communities when faced with external perturbations.

Brown (2014) states that resilience, as a concept, is "everywhere in contemporary debates about global environment debates. She points out, from many human geographers' points of view, what is missing is the social, political and cultural dynamics with which resilience can be associated. Brown's research on resilience is focused on three emerging topics, community resilience, transformations and resilience as an organizing concept for radical change. She concludes there lacks analysis of social difference and resilience and tensions between normative and analytical stances on resilience are continuing. It is argued that ecological models of resilience are antipolitical and this framework fails to accommodate the critical roles of politics when interpreting adaptation to changed environment or relationship (Evans, 2011; Swanstrom. 2008). Smith et al. (2010) talk about politics embedded in socioecological resilience and sustainable socio-technical transactions. They emphasize questions over who governs, whose system framings count, and whose sustainability and resilience are prioritized within the sphere of socioecological system. In the process of extending resilience thinking to society, the existence of social divisions and inequalities are downplayed and the initiative of adapting to the "status quo" is fundamentally conservative because it tends to protect the interests of those who benefit from the current structure at the expense of resilience of the rest. A social system with its supportive political structure can purposefully postpone the effects of ecological disruption to itself, spatially or temporally, causing greater disruption being imposed on people elsewhere or elsewhen (Catton, 1982). The exercise of power and privilege in society, which leads to the disproportional concentration of control of environment and resource decision-making, exerts great pressure on specific group's resilience. Besides "resilience of what", it is equally worthwhile to ask, "resilience for whom" (Freudenburg,2005).

Figure 5: Resilience Assessment Framework (Resilience Alliance, 2010)

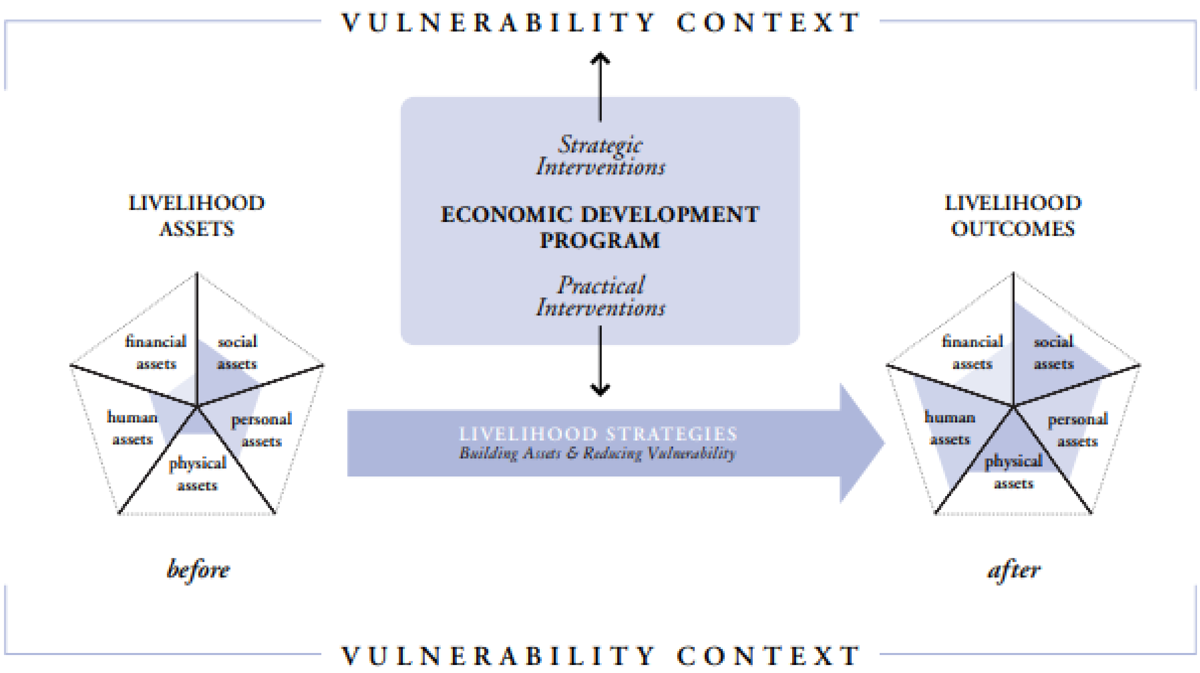


Sustainability Livelihood Approach

Chambers and Conway (1992) elaborate the concept of sustainable livelihoods as being about the idea of capability, equity and sustainability, each of which is both end and means. The key concepts embedded in this framework include poverty, vulnerability and livelihood. This framework provides an actor-centered concept of vulnerability that originates in development studies and builds on entitlement theory, with a rural propensity (Chambers, 1983; DFID, 1999; Sen, 1981; Sen 1984). It departs from the rural focus on agriculture and recognizes a variety of means through which an individual or household can make a living. Within this framework, vulnerability is the susceptibility to circumstances of not being able to sustain a livelihood or a livelihood at the cost of natural society. It is associated to external shocks and internal capabilities, including accesses to materials and social resources and activities required for a means of living, which are framed by institutional contexts. In contrast, sustainability means the ability of an individual or household to cope with and recover from stress and shocks, maintain and enhance the capabilities and assets without undermining the natural resource base. Such interchange is moderated by value considerations and contestations, property relations, and configurations of power within institutional contexts (Arce 2003; de Haan & Zoomers 2005).

UNDP has been a strong advocate for the application of sustainable livelihood framework. In its 2017 Guidance Note, it categorizes different aspects for consideration related to the application of this framework in development practices. Firstly, an understanding of vulnerability in a specific context is needed. Secondly, it requires an effective strategy to protect livelihoods, followed by an analysis of different types of capitals needed by the strategy, which include human, social, natural, physical and financial capitals. Human capital represents the intellectual and physical capabilities of people, including the experiences, skills and health that enable the populations to fulfil livelihood objectives. Social capital means social capacity, especially on local levels including networks, associations, authorities and officials that can provide the necessary support and guidance to the population. Natural capital refers to the stocks of naturally occurring resources like soil and water that can be consumed to create additional benefits, such as food chains or protection against soil or coastal erosion, to support livelihoods. Physical capital refers to the basic infrastructure and production processes to support livelihoods. Financial capital means financial resources that populations can employ to achieve their livelihood objectives.

Figure 6: Sustainable Livelihood Framework (Murray & Ferguson, 2001)



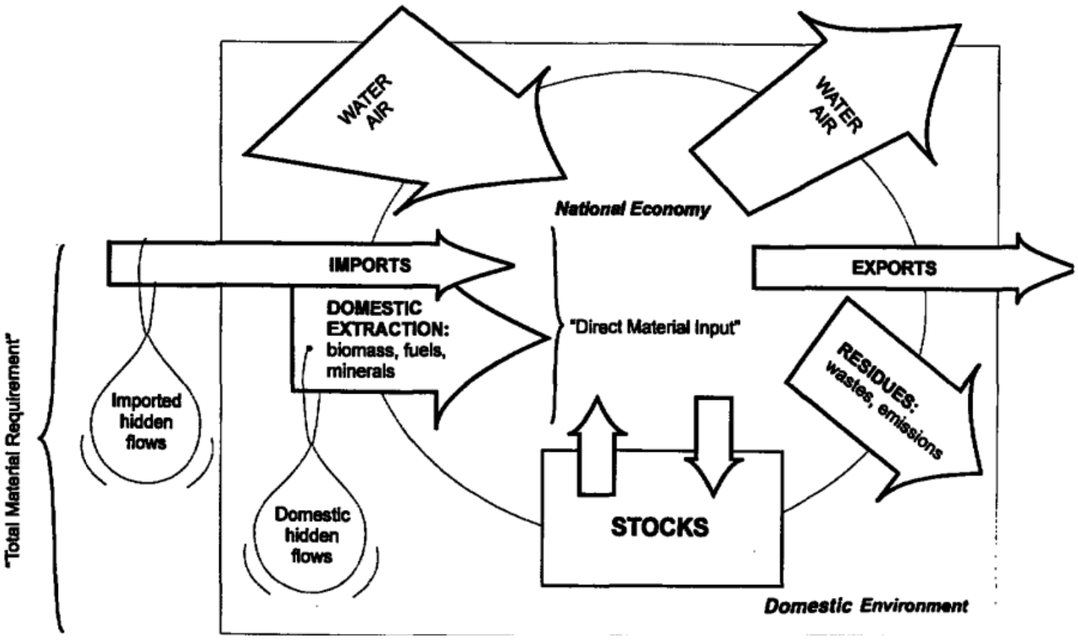
Murray & Ferguson (2001) follow the UNDP structure in discussing how women can transit out of poverty though sustainable livelihoods. They name the three dimensions of sustainable livelihoods as assets, vulnerability context and techniques and interventions. The five assets are the same as the five capitals identified in the UNDP Guidance, jointly representing the populations' capacity to cope with the challenges and satisfy their needs on a sustained basis. There are factors related to individual households and factors embedded in broader social contexts, both of which cause and perpetuate the vulnerable situation. Therefore, besides efforts to build assets on individual household scales, changes are also required on organizational, community and policy levels. Techniques and interventions refer to human activities that enable the population to build up assets required by sustainable livelihoods, which occur on both individual level to help low-income households build up livelihood assets and the higher and broader level for the overall technical improvement.

Social Metabolism Framework

Social Metabolism Framework aims to interpret environmental problems from social, economic and cultural perspectives. Within the framework of social metabolism, there are two basic concepts, socio-economic metabolism and colonization of nature, by which the notion of sustainable development is related to the key characteristic of the individual societies from socio-economic and cultural perspectives (Fischer-Kowalski, 1997; Fischer-Kowalski & Haberl,1998, Fischer-Kowalski & Haberl, 1999). Fischer-Kowalski & Haberl (1998) define social metabolism as the process in which social systems convert raw materials into manufactured products, services and finally into waste. There are two aspects from which a society's metabolism can be interpreted, material throughput and energy throughput. Material throughput includes the input and output related to the provision of nutrition, shelter, clothing, and buildings that follows the law of conservation of mass. The energy throughput means the energy turnover corresponding to the sum of the biological energy requirements of the members of the society. Any society's material and energy input per capita per year is determined, to a large extent, by the mode of production and the associated life style, which is categorized as the characteristic metabolic profile of a society. Socio-economic metabolism can be categorized into basic metabolism and extended metabolism. Basic metabolism means the material and energy flow between natural reproduction of resources, such as air, water and biomass, and natural recycling mechanisms that transform the releases from social metabolism into useable inputs again. The key sustainability issue related to this scale of metabolism is resource depletion when the rate of natural resource consumption exceeds that of natural resource reproduction. Extended metabolism refers to the mobilization of resources, such as fossil fuels, metals and other minerals, from geological locations into social energy flow. The extended metabolism, supported by technical innovation, can alleviate resource scarcity temporarily until the geological deposits are exhausted. Before the ultimate resource depletion, the mobilization of materials from subterrestrial sinks into biosphere disrupts the biogeochemical processes, which may overcharge the capacity of ecosystems for gradual evolutionary adaptation.

Colonization is defined as the conundrum of social activities that deliberately change important parameters of natural systems and actively maintain them in a state different from the conditions that would prevail in the absence of such interventions (Fischer-Kowalski, 1997, Fischer-Kowalski, 1999). Colonization of the natural system can be interpreted as the human invasion of the natural system to maximize social benefits by ensuring future material and energy flow. The maximization of human benefits goes beyond basic metabolism for survival that prevails in hunter gatherer and early agrarian societies. It requires continuous effort and materials to keep the colonized natural system in a socially devised state. Every innovation related to the control of the natural system leads to further social investment and therefore, more demanding control efforts (Sieferle & Müller-Herold, 1996). With no fundamental shift in the understanding about human wellbeing, the colonization process tends to evolve at an ever-accelerating pace with no consideration of capacity of the natural system.

Figure 7: Social Metabolism Framework (Fischer-Kowalski & Haberl, 1999)



Different from hunter gatherer and early agrarian societies that are restricted by the dilemma between increasing metabolism and depleting natural resources, industrial societies ensure their high material and energy throughputs by far-reaching exchanges and transport. Therefore, for industrial societies, the development towards sustainability demands scaling down per capita in terms of socio-economic metabolism, and lessening the level of colonization of the natural system. Fischer-Kowalski & Haberl (1998) provide a positive feedback-loop between quality of life, prosperity and metabolism and emphasize the importance of delinking metabolism from quality of life and prosperity, for the sake of sustainability. It is not economic prosperity or growth that stresses the ecosystem, but the growth in physical amounts of materials and energy a society processes. To delink metabolism from prosperity, instead of providing goods, more services should be provided to mitigate the direct growth impulse. In addition, material and energy throughputs will decrease if resource efficiency of technology improves quicker than the economy grows. However, without redefining quality of life and delinking it from metabolism, the benefits achieved from increased efficiency might be outbalanced by excessive consumption due to lower material and energy prices associated with improved efficiency.

The focus on delinking metabolism from quality of life reflects the cultural dimension of the social metabolism framework. Fischer-Kowalski & Haberl (1998) believe quality of life is mediated by modes of living, culturally defined models of a good life, and the modes of social distribution of goods and property. Within this framework, time is applied as an indicator related to quality of life and the overall social metabolic flow. Firstly, the shortage of time might prompt certain consumption behaviours that might lead to excessive consumption of materials and energy. For example, people tend to hire taxis or choose readymade meals because they do not have time for a more healthy or sustainable life style. Secondly the amount of disposable time spent in socializing and recreational activities is also closely related to the energy and material turnover. On a broader scale, what is regarded as mainstream social and recreational activities is determined by the overall cultural context. With the gradual dissolution of traditional values and exposure to an omnipresence of markets, bureaucracies and the media, as well as dwindling affection and social support, people tend to make increasing amount of effort to gain self-fulfilment and social recognition through excessive consumption, leading to a spectacular expenditure of energy and materials. To achieve a mindset shift that can support the overall reduction of material and energy turnover, Fischer-Kowalski & Haberl (1998) suggest the cultural and social shift of both individual lifestyle and the broader social system, such as vegetarianism, reduction of working hours, and a more equal income distribution model, which all share common areas with the recent concept of "degrowth" (Kallis, 2018).

2.3 Analytical Framework: Planetary Boundaries (PB) and Safe and Just Space (SJS)

As discussed earlier within this section, there does not exist standard definition for vulnerability or one correct conceptual framework by which vulnerability can be assessed. The choice of framework varies in accordance with the shift of the sphere of research and knowledge domain. Considering the need to facilitate small island state' development to a more sustainable mode, a framework that acknowledges the two-way feedback loop between biophysical system and human activities is needed to precondition decision-making on sustainable development strategies. The coupled socioecological system developed by Turner et al. (2003a & 2003b) provides the conceptual framework within which vulnerability responding to both environmental and social dimensions of sustainable development can be assessed. Analytical frameworks within this broader framework that recognize the interactions between ecosystem and human activities have been developed to operationalize vulnerability assessment by linking environmental and social performances. Among these analytical frameworks, Planetary Boundaries (Rockström et al. 2009) and Safe and Just Space (Rawarth, 2012) are two famous ones that have gained increasing international recognition.

Planetary Boundaries Framework (PB)

Rockström and Steffen et al. (2009) initiate the Planetary Boundary framework, which defines the zone within which humanity can safely operate, as an approach to guide global transition to sustainability. Since then, the Planetary Boundaries framework has become a reference point in high-profile publications and initiatives on global sustainability (Nykvist et al. 2013), including the United Nations High-Level Panel on Global Sustainability, the OECD report Towards Green Growth (OECD 2011) and the UNEP GEO 5 Report (UNEP 2012). Within the PB framework, the social impact of transgressing boundaries is regarded as a function of the social-ecological vulnerability of the affected societies. Rockström et al. and Steffen et al. (2009) identify nine interdependent planetary boundaries, including boundaries for Ocean Acidification, Biochemical Flows, Freshwater Use, Land-System Change, Biosphere Integrity, Climate Change, Stratospheric Ozone Depletion, Atmospheric Aerosol Loading and Novel Entities. These nine boundaries define a safe operating biophysical space for human operations and the transgression of one may shift the position of other boundaries or cause them to be transgressed. Climate Change and Biosphere Integrity are identified as two core boundaries, the shifting of which can cause the shifting of other boundaries. Four out of these nine boundaries, Climate Change, Biosphere Integrity, Land-System Change and Biochemical Flows have been exceeded. The process of human life has revealed repeated planetary-scale tipping points and the current risk of long-term damage to Earth systems that support humanity is increasing (Hughes et al.,2013; Steffen et al. 2015).

Chandrakumar & McLaren (2015) explore the linkages between the Sustainable Development Goals (SDGs) and Planetary Boundaries, using the Drive-Pressure-State-Impacts(s)-Response (DPSIR) framework[3]. The study demonstrates there is a substantive overlap between the SDGs and the Planetary Boundaries framework and suggests the science-based thresholds listed in PB be adopted as a complementary set of environmental boundaries for the SDG indicators. Mohajan (2015) emphasizes the scientific impact of the framework is based on the earth system's biological, physical and chemical structures, and suggests Planetary Boundary framework be applied as the basis for sustainable development policy.

Stockholm Resilience Centre states that the quality infrastructure of the Earth system, which is secured by the planetary boundaries, plays a key role in sustainable development (Cornell & Downing, 2014). Therefore, the achievement of Sustainable Development Goals depends on the balanced relationship between humanity and biophysical system from local to global scales. Steffen et al. (2011c) point out that despite planetary boundaries being explicitly designed for the global scale, efforts to reduce ecosystem degradation at local scales have become even more important because of the feedback loops between the global and local levels. Here arises the question of whether it is feasible and scientifically appropriate to downscale the planetary boundaries for regional or national vulnerability analysis.

Efforts to address decision-making on local levels within the PB framework, have happened and are on going. Commissioned by the Swedish Environmental Protection Agency, Nykvist et al. (2013) tested whether the concept of Planetary Boundaries can be applied to assess the international dimensions of Sweden's national environmental quality goals. They developed a methodology to downscale the planetary boundaries into a corresponding set of meaningful national boundaries and identify appropriate data series that consider both territorial (i.e., domestic production-related) and consumptive (i.e., domestic consumption-related) performances. The differentiation between 'territorial" and "consumptive" performances aims to reflect emissions and the consumption of natural resources embedded in trade. Pisano & Berger (2013) provide an overview of the planetary boundaries framework and reflect on possible associations of planetary boundaries with sustainable development. They discuss the opportunities for adopting this framework for sustainable development both within the context of international governance and on national and regional levels. McLaughlin (2018) analyses the differences of planetary boundaries between global and local scales where many impacts and solutions originate. Häyhä et al. (2016) believe PB framework provides the quantitative limits to the anthropogenic perturbation of crucial Earth system processes and mark out a biophysical safe operating space for human interventions. To operationalize the planetary boundaries on decision-making level, they develop a framework that addresses the "biophysical, socioeconomic and ethical dimensions" of bridging across scales. This framework provides a "constantly applicable approach" to translate the planetary boundaries into fair shares of earths safe operating space on national and sub-national levels. Fanning & O'Neill (2016) define biophysical ceilings by translating the planetary boundaries into 10 indicators on national and sub-national levels in a biophysical framework that links the sustainability of resource flows from the biosphere to final consumption. The set of 10 indicators provides a quantitative guidance that can be applied on local levels for prioritizing environmental pressures that need to be reduced for biophysical stability. Hoornweg et al. (2016) believe the achievement of global sustainable development

[3] DPSIR is a framework that is parallel to the Coupled Socioecological Framework within which vulnerability can be assessed. The fact it can be used to analyze the relationship between Planetary Boundaries and Sustainable Development indicates the possible overlaps between different frameworks because of the overlaps between knowledge domains.

goals subject to planetary boundaries are mostly determined on municipal level because it is the human activities on city level that drive cultures, economies, material use and waste generation for the aggregated effects on higher levels. The modified methodology proposes biophysical boundaries from a city's perspective and incorporates socioeconomic boundaries derived from Sustainable Development Goals. Trialed for five cities, Toronto, Shanghai, Sao Paulo, Mumbai and Dakar, this locally applied quantitative methodology captures the complexity of infrastructure systems and external pressures on planetary boundaries on urban levels that can be upgraded to either national or global levels.

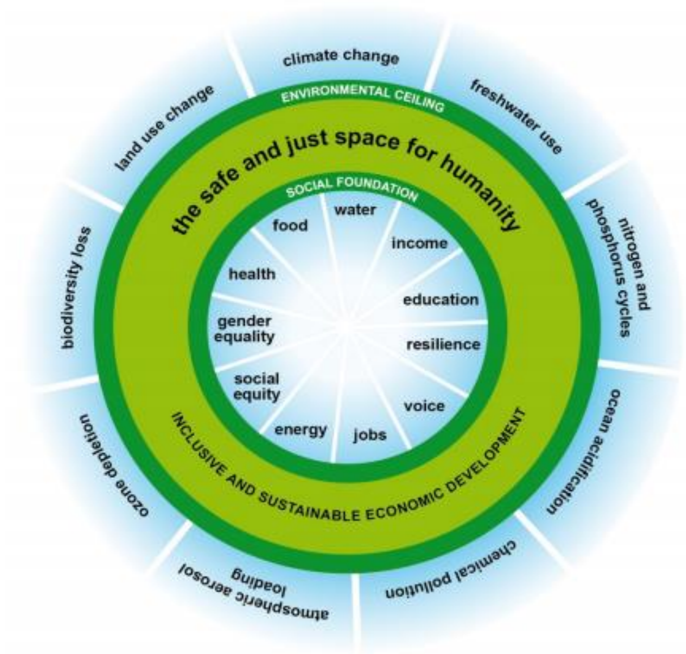
Safe and Just Space (SJS)

Coupled with rapid human-induced environmental changes, the prevalence of poverty, hunger and social inequality has brought unprecedented attention to the challenge of achieving both social and environmental sustainability. It calls for an analytical framework, incorporating both planetary boundaries and social wellbeing, within which the pathway to equitable and sustainable development can be identified (Leach, et al. 2013). Hoornweg et al. (2016) derive socioeconomic boundaries from Sustainable Development Goals and incorporate them into biophysical boundaries to assess the level of sustainable development on the municipal level. Raworth (2012 & 2017) incorporates social well-being and equity into the Planetary Boundary framework and creates a Safe and Just Space (SJS) between the environmental ceiling, i.e., the planetary boundaries based on normative perceptions of risk and desirability of staying within the Holocene, and social foundation.

It has been argued that there are a finite number of basic human need satisfiers that are universal, satiable and non-substitutable. These need satisfiers might vary between individuals and cultures and determine the levels of human wellbeing. However, they arguably share certain characteristics that allow empirical measurement (Gough, 2015). Before Raworth, there existed two main theories on human needs, both developed in the early 1990s. Max-Neef (1991) differentiates between needs, which are regarded as universal, and need-satisfiers, which might vary depending on social structure and cultural context. He identifies 9 fundamental human needs, including substance, protection, affection, understanding, participation, leisure, creation, identify and freedom. Doyal & Gough (1991) insist on the universal goal of "minimally impaired participation" for human activities. To achieve this goal, physical health and autonomy of agency, which covers concepts such as mental health, cultural understanding and opportunities to participate, are critical. Doyal & Gough (1991) agree with Max-Neef (1991) on the universality of the basic needs but argue the universal characteristics of some needs-satisfiers can also be empirically determined. Doyal & Gough (1991) identify 11 satiable and non-substitutable "intermediate needs", including nutritional food and clean water, protective housing, a non-hazardous work environment and living environment, appropriate healthcare, security in childhood, significant primary relationships, physical and economic security, safe birth control and child bearing and basic education. Out of 80 submissions of national governments during the Rio + 20 Conference on Sustainable Development, Raworth (2012) selects 11 social priorities to include in the social foundations as basic human needs, which overlap substantially with the United Nations' Sustainable Development Goals. These social priorities include Food Security, Income, Water and Sanitation, Health Care, Education, Energy, Gender Equality, Social Equality, Voice (population living in countries perceived not to permit political participation or freedom of expression), Jobs and Resilience (population facing multiple dimensions of poverty). These basic needs identified by Raworth overlap considerably with what Max-Neef (1991) and Doyal & Gough (1991) propose and are more "democratic" and "closely aligned with contemporary policy" (O'Neill, et al., 2018).

Raworth (2012) states in her work that there are important characteristics that planetary boundaries and social thresholds share. Firstly, both planetary boundaries and social thresholds serve as the fundamentals of sustainable development. Secondly, social and environmental ceilings are developed through widely agreed social norms. And thirdly, staying within biosphere boundaries and reaching social thresholds matter for both the global and the local scale. One significant difference between the planetary boundaries and social thresholds is their initial states of stress. The aim, for planetary boundary, is to move backward into the pre-industrial "safe space," but for social threshold, it is to move forward into the "just space" that not all humanity has reached by now. The desired relationship between planetary boundaries and social foundation is the resource use, or, the level of pressure on the biosphere or environment. This should be high enough to meet basic needs, but not so high as to exceed the planetary boundaries. The Safe and Just Space framework aligns with the duel objectives of sustainable development in both environmental and social dimensions. Figure 8 below presents the safe and just space, defined by Raworth, in the shape of a double-layered "doughnut".

Figure 8: A Safe and Just Space for Humanity to Thrive In: A First Illustration (Oxfam)



Within this framework, the social foundation forms an inner boundary, below which is multi-dimensional human deprivation. The environmental ceiling forms an outer boundary, beyond which is environmental degradation from a variety of ecological perspectives. The "doughnut-shaped" area between the two boundaries lies the environmentally safe and socially just space where inclusive and sustainable development can take place for human prosperity. The Safe and Just Space Framework has gained global recognization since the premmises of Planetary Boundaries and the Safe and Just Space frameworks are considered socially well-embedded in the sustainable development discourse (Pisano & Berger, 2013). Hoornweg et al. (2016) incorporate socioeconomic elements into the planetary boundaries in their analysis of sustainable development on municipal levels. Cole et al. (2014) downscale the "Safe and Just Space" framework to a national level, creating a barometer that combines 20 indicators for environmental stress and social deprivation, tracking and assessing the progress of national sustainable development in South Africa. They conclude that social and environmental concerns are intrinsically scale-dependent and local circumstances need to be taken into consideration if priority areas need to be identified for action on national levels. Targeting two Chinese rural localities, Dearing et al. (2014) propose a framework to define the safe and just operating space for humanity that lies within the environmental ceilings and social wellbeing and equity for application. One popular set of research conducted within this framework was A Good Life for All within the Planetary Boundaries by Dan O'Neill and colleagues (2018) that quantifies the consumption of natural resources and emission flow that occur in the processes of satisfying basic human needs in 152 countries. This thesis builds on the approach in O'Neill et al.'s research (2018), developing the research methodology that assesses five Caribbean small island states' social and environmental vulnerabilities and explores the key element to a more sustainable development mode.

3. RESEARCH METHODOLOGY

This thesis aims to analyze the systematic vulnerabilities of five Caribbean small island states by assessing their environmental and social performances and the interactions between these performances within individual countries' development processes. Among a wide range of frameworks in which vulnerability can be interpreted, the Safe and Just Space framework is selected to conduct a vulnerability assessment because it addresses both environmental and social aspects, incorporating the two-way feedback loops between biophysical and human systems. This thesis builds on O'Neill et al.'s (2018) approach in assessing individual countries' environmental and social performances by using indicators identified within the SJS framework. By comparing five individual Caribbean nations' performances with the planetary boundary and social threshold values, their systematic vulnerabilities can be assessed and the root cause that hinders the transition to a more sustainable mode can be explored.

The thesis uses O'Neil et al.'s approach as a starting but deviate in several aspects because of difference in research scope and certain characteristics specific to these five island nations. Firstly, besides the most recent data, I collected data for the period between 1995 and 2008 to identify possible trend of change. Secondly for CO_2 emission, besides the emission from burning of fossil fuels, I include emission from burning of biomass. For biochemical flow, besides the flow amount from application of synthetic fertilizers, I include the flow from farm animals. Finally, all values related to biochemical flows are from Eora MRIO. At this database values of domestic contribution to biochemical flows are only for the year 2000. To get the upscaled per capita value for 2011, O'Neil and colleagues estimate a factor to multiply with the relevant 2000 value. In their estimation, the population increase between 2000 and 2011 is neglected. The population increase is an element that should be incorporated into the estimation of the factor since it is the per capita value they aim to upscale. I took a few measures to incorporate the population increase into the estimation of the factor used for upscaling.

3.1 Selection of Five Caribbean Nations

Five small island states in the Caribbean region, Trinidad & Tobago, Dominican Republic, Jamaica, Haiti and Cuba, were selected for this research. These five nations were selected because from the demographic and socioeconomic perspectives, such as land area, population size, nature of economy, socioeconomic status and political system, these nations present a holistic and diverse regional profile. These five nations form an arch shape in the Caribbean region, covering 88.9% of the region's land area and 87.8% of its population[4]. In terms of economic status, this selected group includes one country that belongs to the high-income group, Trinidad & Tobago, three upper-middle-income countries, Dominican Republic, Jamaica and Cuba, and one low-income country, Haiti (UNDP, 2018b). From the perspective of energy structure, it includes Trinidad & Tobago and Jamaica, where fossil fuels play a dominating role and Haiti, where biomass is still the main energy source, and countries such as Cuba and Dominican Republic where, in association with economic growth, fossil fuels has been playing an increasingly important role, compared with that of bio-mass. Considering political system, this selected group includes Cuba, one of the few socialist countries under one-party leadership where the political system and the resulted social structure play an important role in its development process. Table 1 presents basic demographic and socioeconomic information (CIA, 2018).

[4] This covers 19 countries in the Caribbean region with 2017 data from the World Bank, not including values for Anguilla, Montserrat and St. Barthelemy.

Despite the diversity embedded in their socioeconomic status and energy structure, these countries share similar structural limitations such as the exposure to climate change-related natural disasters, heavy dependence on strategic imports and the dominating role played by the service sector in the economy. The analysis of individual nations' social and environmental vulnerabilities can demonstrate the impact of contextualized interactions between environmental and social factors on sustainable development, and present a regional profile with the required diversity.

3.2 The Selection of Indicators, Definition and Value Calculation

Instead of indicating a one-way relationship between the consumption of resources and the satisfaction of human needs, O'Neill et al. (2018) manage to reflect the dependence of social outcome on the functioning of the ecosystem and its mitigation of the transgression of the planetary boundaries. Their research extends the Safe and Just Space frameworks by representing the connection between resource use and social outcomes in terms of "provisioning systems" which consist of infrastructure, technologies, efficiencies and institutional capacities, communities and markets. The provisioning system provides the development context and mediates the impacts of pressure associated with social outcomes on biophysical resources. The nature of individual countries' provisioning system or more generally its development context, reflects the relationship between the resource use and emission flow and the achievement of social outcomes, determining each country's position within the safe and just space of the "doughnut."

Table 1: Demographic and Socioeconomic Status of the Five Caribbean Small Island Developing States

	Cuba	Dominican Republic	Haiti	Jamaica	Trinidad & Tobago
Population	11,147,407	10,734,247	10,646,714	2,990,561	1,218,208
Land Area (sqkm)	109,820	48,670	27,560	10,831	5,128
GDP per capita ($)	12,300	16,900	1,800	9,200	31,400
GDP Composition					
Agriculture	3.9%	5.5%	21.9%	7.6%	0.4%
Industry	21.5%	33.8%	20.8%	23.2%	48.6%
Service	74.2%	60.8%	57.3%	69.2%	50.8%
Export ($)	2.885 billion	10.33 billion	960.1 million	1.31 billion	10.19 billion
Import ($)	10.84 billion	19 billion	3.621 billion	5.82 billion	9.668 billion

O'Neill et al. (2018) use 18 indicators designed to measure environmental and social performances to assess vulnerabilities embedded in an individual country's development process. They compare individual countries' biophysical and social performances to downscaled planetary boundaries and social thresholds. The 7 environmental indicators include four out of the nine biosphere boundaries initiated by the Steffen et al. in 2009: climate change, land system change, fresh water consumption and biochemical flows. Besides, two separate footprint indicators, ecological footprint and material footprint, are also included. Climate change is represented as CO_2 emissions and land system change as the embodied Human Appropriation of Net Primary Product (eHANPP). The environmental indicator values for each country are consumption-based and account for international trade. Compared with the production-based values that only include the amount of emissions embedded in domestic production, the consumption-based values reflect the responsibility for the ecological effects of both production and consumption and lengthen the link between consumption and its consequences (Zsófia, 2013). For social performance, O'Neill et al. (2018) identify 11 social outcome indicators, including Life Satisfaction, Healthy Life Expectancy, Nutrition, Sanitation, Energy (Access to Electricity), Education, Income, Equality, Democratic Quality, Employment and Social Support, which vary only slightly from Raworth's (2012) social foundation indicators. Each threshold value corresponding to individual social outcome constitutes "a reasonable assessment of a level of performance consistent with meeting basic needs" (O' Neill et al. 2018). Table 2 and Table 3 below provide brief definition of each indicator, as well as the boundary and threshold values.

Table 2: Definition and Boundary Values for Environmental Performance Indicators

	Definition	**Boundary Value**
CO_2 Emission	The remaining amount of accumulated CO_2 emission until 2100, in total 2900 Gt CO_2, to ensure the probability of >66% of limiting the human-induced temperature increase to less than 2°C relative to the period of 1861–1880 by 2100 (IPCC, 2014).	By 2011, about 1000Gt CO_2 remains as the emission amount available by 2100. The per capita boundary value of 1.61 t CO_2 per year is the result of dividing 000 Gt CO_2 with the 2011 world population (O'Neill et al. 2018).
Biochemical Flow	The maximum amount of phosphorous and nitrogen flow that leaches into surface water because of human interventions before pushing marine and aquatic systems across ecological thresholds of their own.	
Phosphorous Flow	The boundary is defined as a flow of 6.2 Tg phosphorous leaching per year from fertilizers (mined P) to erodible soils (Steffen et al. 2015). The per capita boundary value of 0.89 kg per year is the result of 6.2 Tg by the 2011 world population.	
Nitrogen Flow	The boundary is 62 Tg N per year from industrial and intentional biological N fixation (de Vries et al. 2013). The per capita value of 8.9 kg N per year is the result of dividing 62 Tg N per by the 2011 world population.	
Blue Water	The maximum amount of consumptive use of blue water without regime shifts in the functioning of flow-dependent ecosystems (Steffen et al. 2015).	The per capita boundary value per year is 574 m^3, dividing the maximum annual global withdrawal of 4000 km^3 of blue water (Rockström, et al., 2009) by the 2011 global population
eHANPP	The embodied Human Appropriated Net Primary Production because of green plants' photosynthesis	2.62 t C per person per year.
Ecological Footprint	The amount of biologically productive land and sea area needed by a population to produce biotic resources and the absorption of the generated CO_2 emission (Borucke, et al. 2012)	1.72 global hectares per person per year, the total of 12 billion hectares of biologically productive land and water available on Earth in 2013 (Global Footprint Network, 2015), divided by the 2013 population.
Material Footprint	The amount of used material extraction (minerals, fossil fuels, and biomass) associated with the final demand for goods and services, regardless of where that extraction occurs.	7.2 t per person per year, the value of not exceeding 50 Gt per year (Dittrich et al. ,2012) divided by 2011 world population (O'Neill et al., 2018)

Table 3: Definition and Boundary Values for Social Performances Indicators

	Definition	Threshold Value
Life Satisfaction	People's self-assessment of their social wellbeing (Gallup World Happiness Report, 2015).	6.5 out of a scale of 0 – 10, with 0 indicating not satisfied at all and 10, very satisfied (O'Neill, et al. 2018)
Healthy Life Expectancy	The number of years that an individual is expected to live in good health (without major debilitating disease of infirmity).	65
Nutrition	Average calorific intake of food and drink per person per day, measured in kilocalories (kcal).	2700 kcal per person per day
Sanitation	The percentage of population who have access to improved sanitation.	95%
Energy	The percentage of population who have access to electricity.	95%
Education	General Enrollment Rate in Secondary Education	95%
Income	The percentage of population that lives on more than $1.90 a day.	95%
Equality	Social wealth distribution assessed by Gini Index.	70% (1- Gini Index of 30%)
Democratic Quality	The unweighted average of two Worldwide Governance Indicators: Voice & Accountability and Political Stability & Absence of Violence (Kaufmann et al. 2010).	0.8 (for a scale between -2.5 and 2.5)
Social Support	The percentage of population who believe they have someone to rely on when necessary	90%
Employment	The percentage of employed population among available labor force.	94%

The next section provides information on more detailed definition of each environmental and social indicator, the calculation of both the boundary and threshold values and the values relevant to individual countries' performances.

CO_2 Emission

CO_2 emission is directly related to the 13th Sustainable Development Goal of taking urgent action to combat climate change and its impacts. Besides the amount of CO_2 emission can also be used to assess the level of population's access to affordable, reliable, sustainable and modern energy, the 7th Sustainable Development Goad and the sustainability embedded in the consumption and production pattern, the 12th Goal of the Sustainable Development. CO_2 emissions, used to represent climate change, is defined as the remaining amount of accumulated CO_2 emission until 2100, in total 2900 Gt CO_2, to ensure the probability of >66% of limiting the human-induced temperature increase to less than 2°C relative to the period of 1861–1880 by 2100 (IPCC, 2014). By 2011, about 1900 Gt CO_2 had already been emitted, with 1000Gt CO_2 remaining as the emission amount available by 2100. The per capita boundary of 1.61 t CO_2 per year in O'Neill et al.'s research (2018) is to divide the total remaining 1000 Gt CO_2 with the 2011 world population, around 7 billion[5].

To get the per capita CO_2 emission value for individual countries, consumption-based CO_2 emission footprint data from Eora MRIO are used in O'Neill et al.'s research (2018). Eora MRIO database provides both production-based and consumption-based emission values. Production-based value is termed as "Territorial," meaning CO_2 emission from domestic production. Consumption-based CO_2 emissions, termed as the footprint values, includes the sum of territorial emission and emission embedded in imported goods, subtracted by the amount embedded in exported goods. There is also a category of emissions termed as "emissions from Direct Consumption", the part of emission from household activities, such as heating and cooking, which is not included in domestic production. The total CO_2 consumption-based emission value, or the footprint value, for each country, is the total of the consumption-based emission value and the amount from household activities, for instance, emission from direct consumption. In Eora MRIO, the most up-to-date territorial data is from 2008, while the emission amount embedded in trade was updated in 2015.

Because of its research scope covering 152 countries, O'Neill et al. (2018) use the "footprint" values from Eora MRIO. The footprint values were calculated using the "territorial", "import", "'export" and "direct consumption" values provided at Eora MRIO. Considering the situation specific to these five states, I also adjust the type of data that should be included in the calculation. The following paragraph provides more detailed information.

1) CO_2 emissions and CO_2 b emissions:

According to the Eora MRIO database, CO_2 emissions includes both CO_2 emissions from burning of fossil fuels, and CO_2 b Emission from burning of biomass. Only CO_2 emissions from the burning of fossil fuels is included in O'Neil et al.'s research when estimating individual countries' emission value. Despite that lower income countries start using more modern forms of energy, biomass and waste still account for 14% of worldwide energy output (World Atlas, 2017). The approach of neglecting the emissions from biomass burning is not appropriate for countries such as Haiti where the emissions from biomass burning is 5 times

[5] In O'Neill et al.'s research (2018) the 2011 world population is estimated as 7 billion without indicating the source of data. I my calculation of individual country's performance, population data is from the open database at the World Bank.

the emission from the burning of fossil fuels in Cuba, even though the two values appear to be similar. Such an approach fails to fairly represent the contribution to global GHG emission from countries with similar energy structure to that of Haiti and Cuba.

In my thesis, both emissions from the burning of biomass and fossil fuels are included for a more accurate presentation of the CO_2 emissions contribution from the five Caribbean states. For each state, the following calculation applies:

Consumption-based CO_2 emission (per capita) = (Consumption-based CO_2 emission + Consumption-based CO_2 b emission)/Population
Consumption-based CO_2 emission = Territorial + Import – Export + Direct Consumption
Consumption-based CO_2 b emission = Territorial + Import – Export + Direct Consumption

2) Negative values for emission amount embedded in imported goods

3) There are some negative values in the Eora MRIO database when certain countries' CO_2 and CO_2b emissions in imported goods are concerned. Confirmed by the database provider, these values are treated as faulty values and have been adjusted to zero. Because of the negative emission values embedded in imported goods, the "footprint" values in Eora MRIO are lower than the actual footprint values. Table 4 includes the states covered by this thesis with the negative imported emission values:

Table 4: Countries with Negative Imported CO_2 Emission Values in Eora MRIO

CO_2 Emission	
Country	Year
Trinidad & Tobago	1995 – 2015
Dominican Republic	1999 – 2005
CO_2 b Emission	
Cuba	1995 – 2005; 2008 – 2015
Dominican Republic	1995 – 2010
Haiti	1995 – 2015

Biochemical Flow

Biochemical Flow as the planetary boundary is defined as the maximum amount of phosphorous and nitrogen flow that leaches into surface water because of human interventions before pushing marine and aquatic systems across ecological thresholds of their own. The assessment of the amount of the Biochemical Flows into the aquatic systems is essential to the achievement of the 14th Sustainable Development Goal of Life Below Water because the conservation and sustainable use of marine resources is closely related not only to fishery but also to the stress on the overall aquatic system.

As for phosphorous flow, the boundary has been designed to avert widespread eutrophication of freshwater systems, at a flow of 6.2 Tg phosphorous leaching per year from fertilizers (mined P) to erodible soils (Steffen et al. 2015). O'Neill et al. (2018) estimate the boundary value by dividing the annual 6.2 Tg by the 2011 world population to get the per capita annual value of 0.89 kg. In terms of nitrogen flow, the boundary for eutrophication of aquatic ecosystem is estimated at 62 Tg N per year from industrial and intentional biological N fixation, using the most stringent quality criterion (de Vries et al. 2013). O' Neil et al. estimate the per capita value as 8.9 kg N per year by dividing the boundary value of 62 Tg N per year by the 2011 world population. O'Neill et al. (2018) use consumption-based phosphorous and nitrogen flow data, i.e., the footprint data, from Eora MRIO. The definitions for "territorial", "import", "export", and "footprint" are the same as those related to the CO_2 emission[6]. Due to situations specific to these selected countries, the type of data that should be included has been adjusted, as well as the calculations themselves. The following section provides detailed information on the calculation of individual countries' performances relevant to this indicator.

1) Phosphorous Flow

The underlying phosphorus fertilizer data provided in Eora MRIO were compiled by Potter et al. (2010) and are available from the NASA Socioeconomic Data and Applications Center (SEDAC). The phosphorus territorial data were based on estimates from the harvested area for the period 1997–2003, and fertilizer application rates for the period 1994–2001. There is only territorial data for the year 2000 in Eora MRIO datasets whilst data related to trade volumes are updated to the year 2015.

O'Neill et al. (2018) account for the difference in time periods between the phosphorus (territorial) data (ca. 2000) and the year considered in their study (ca. 2011), by scaling up the phosphorus data with a factor of 1.42 to account for the difference in temporal scale. The factor of 1.42 is the current global phosphorous use of 14.2 Tg P per year, as reported by Steffen et al. (2015), divided by the 10.00 Tg P per year of the Eora MRIO global phosphorous use in the year 2000. There is one outstanding issue associated with this "scaling-up" approach because it fails to consider the population increase between 2000 and 2011 when per capita value is calculated. Besides, it is not appropriate to apply the same factor to reflect the change of phosphorous flow associated with the time scale for individual countries with different agricultural profiles.

The second outstanding issue embedded in O'Neill et al.'s approach (2018) is when calculating the phosphorous flow, they only include contributions from synthetic fertilizer but ignore the flow from farm animal manure that is either used as organic fertilizer or left unattended on the pasture. This approach does not suit four out of five Caribbean countries, namely Cuba, Dominican Republic, Haiti and Trinidad & Tobago. They are still included in this thesis though because the contribution to phosphorous flow from farm animals in these countries exceeds the amount of flow from the application of the synthetic fertilizers. Table 5 below lists the countries and the amount of flow embedded in imported goods, using both synthetic fertilizer and manure, which are negative for different periods of time. As a result, the footprint values provided in Eora MRIO for these countries tend to be lower than the actual values for the period when the values embedded in imported goods are negative. The data provider suggests treating negative values as zero.

Calculation of Phosphorous flow from Individual Nations

To get a relatively more accurate per capita domestic phosphorous flow footprint value for the period between 1991 and 2015 by using the Eora MRIO 2000 value, the following steps have been taken in this thesis, varying between different countries.

[6] There has been no biochemical flow from household activities (i.e. contribution from direct consumption in Eora MRIO).

Table 5: Countries with Negative Phosphorous Flow Embedded in Imported Goods

Phosphorous Flow from Fertilizer	
Dominican Republic	2003 – 2004
Haiti	1998 – 2006
Phosphorous Flow from Manure	
Cuba	1995 – 2015
Dominican Republic	1995 – 2009
Haiti	1995 – 2015

Cuba & Dominican Republic:

The following data were collected from the Food and Agriculture Organization of the United Nations' open database (FAOSTAT, 2018) between 1995 and 2015:
--- Amount of phosphate fertilizer used as nutrients in agricultural use
--- Amount of manure that is used as organic fertilizer in agricultural use
--- Amount of manure that is left on the pastor

The calculation includes comparing the amount of phosphate fertilizers used as agricultural nutrients and the amount of manure used as organic fertilizers and left on the pastor of individual years between 1995 and 2015; with the corresponding values from 2000, and considering the population change between each individual year and 2000. In this way, the factors by which the individual years' per capita phosphorous flow from both fertilizer and manure can be estimated based on the 2000 values, assuming that the proportion of phosphorous leaching into erodible soil remains constant. Using Cuba as an example, the following steps are taken to get the 2014 footprint value of phosphorous flow from only synthetic fertilizer:

- Divide the amount of phosphate fertilizers used as agricultural nutrients in 2014 by the 2000 value and get ratio A (there is ratio A for each individual year)
- Divide the population of 2014 by 2000 population and get ratio B (there is ratio B for each individual year)
- Divide ratio A with ratio B and get Factor C (there is a Factor C for each individual year)
- Multiply Factor C with the per capita territorial value of phosphorous flow from fertilizer in 2000 to get the 2014 value
- Multiply the 2014 per capita value of phosphorous flow from fertilizer with the 2014 population to get the territorial value of phosphorous flow on a national level
- Sum up the territorial value with the value embedded in imported goods and subtract the amount embedded in exported goods to get the footprint value of phosphorous flow from the application of synthetic fertilizer and divide the result by the 2014 population to get the final per capita value

By taking the same approach, Cuba's 2014 consumption-based phosphorous flow (footprint value) from manure, either used as organic fertilizer or left unattended on the pasture, can be calculated. By adding the footprint value of phosphorous flow from synthetic fertilizer with the value from manure, Cuba's 2014 consumption-based phosphorous flow value is calculated. In this way, per capita footprint value of phosphorous flow from both synthetic fertilizer and manure is calculated for each year between 1995 and 2015. The same approach has been taken for Dominican Republic to calculate the final per capita footprint value of phosphorous flow from both synthetic fertilizer and manure for each individual year between 1995 and 2015.

Haiti

For Haiti, data related to the use of phosphate fertilizers are available only for the period between 1995 and 2002 at FOA. Several extra steps were taken to get a more accurate factor, by which the per capita footprint value of phosphorous flow from fertilizers and manure for each individual year between 1995 and 2015 can be calculated. Using the phosphorous flow from synthetic fertilizer as an example, the follow steps are taken in this thesis:

- To collect data related to the use of phosphate fertilizers in each individual year between 1995 and 2002
- Divide the value of each year with that of 2000 to get ratio A (there is ratio A for each individual year)
- Divide the population of each individual year with that of 2000 to get ratio B (there is ratio B for each individual year)
- Divide ratio A with ratio B to get Factor C (there is Factor C for each individual year)
- Factor C is the factor by which the per capita territorial value of phosphorous flow from fertilizer of each individual year between 1995 and 2002 is estimated by multiplying Factor C with the value of 2000
- Use the average per capita territorial value of phosphorous flow from fertilizer between 1995 and 1998 as the “beginning value” and the average per capita territorial value of phosphorous flow from fertilizer between 1999 and 2002 as the “end value” to calculate the Compound Annual Growth Rate (CAGR)
- By using the Compound Annual Growth Rate for the per capita territorial value of phosphorous flow from fertilizer, the corresponding per capita territorial value for each individual year between 2003 and 2015 is estimated
- The national territorial value of phosphorous flow from synthetic fertilizer between 1995 and 2015 can be estimated by multiplying the per capita value of each year by the corresponding population size
- Sum up the territorial value with the value embedded in imported goods and subtract the amount embedded in exported goods for each individual year to get the footprint value of phosphorous flow values from the application of synthetic fertilizer and divide the result by the population of the relevant year to get the final per capita value (there is no phosphorous flow from direct consumption, i.e., household activities)

The same approach is taken in this thesis to calculate the per capita footprint of phosphorous flow from manure of farm animals for each individual year between 1995 and 2015 in Haiti. The total of the per capita value of phosphorous flow from synthetic fertilizer and manure for a specific year is Haiti’s final per capital footprint phosphorous flow for that year.

Trinidad & Tobago and Jamaica

The territorial phosphorous flow from both fertilizers and manure is zero for Trinidad & Tobago and Jamaica. The value of zero means there is no recorded territorial phosphorous contribution in 2000 in these two countries, either from the application of synthetic fertilizer or farm animal manure, at Eora MRIO. This contradicts with FAO data that indicate the amounts of phosphate fertilizers applied and the amount of manure, when used both as organic fertilizer or left unattended on the pasture, in both Trinidad & Tobago and Jamaica in 2000. In this thesis, domestic contribution in these two countries is treated as zero. As a result, the estimated phosphorous flow values for these two countries are lower than the actual values.

2) Nitrogen Flow

The underlying nitrogen fertilizer data provided in Eora MRIO are also compiled by Potter et al. (2010) and available from the NASA Socioeconomic Data and Applications Center (SEDAC). The nitrogen territorial data are based on estimates of harvested area for the period 1997–2003, and fertilizer application rates for the period 1994–2001. There is only territorial data for 2000 in Eora MRIO datasets, while data related to trade volume (both import and export) are updated to 2015 at Eora MRIO database.

O'Neill et al. (2018) take the same approach to account for the differences in time periods between the nitrogen (territorial) data (ca. 2000) and the year considered in the study (ca. 2011). They scale up the nitrogen data to match current global nitrogen use (150 Tg P y-1) as reported by Steffen et al. (2015). However, the factor used for the scaling up is not indicated in their paper. Just as with the calculation of the phosphorous flow change, the same outstanding issue remains. The change is calculated based on the 2000 value because their approach fails to incorporate the increase of population between 2000 and 2011 when estimating the per capita value. Secondly, O'Neill et al. (2018) only include the nitrogen fixation that leaches into erodible soil from the application of synthetic fertilizers, but neglect the leaching from farm animal manure that is either used as organic fertilizer or left unattended on the pasture. In Trinidad & Tobago and Jamaica, the leaching of nitrogen fixation from manure embedded in imported goods exceeds the amount from the application of synthetic fertilizers. Therefore, the practice of neglecting the flow from farm animal manure fails to represent the true contribution of nitrogen flow in these two countries.

The nitrogen flow from both synthetic fertilizer and manure embedded in imported goods are negative at Eora MRIO for Cuba, Dominican Republic and Haiti for periods between 1995 and 2015. The negative values are treated as zero as suggested by the data provider. The actual N fixation embedded in imported goods might probably be higher than zero and therefore the footprint values presented in this thesis might be lower than the actual values for years when the imported values are recorded as being negative. Table 6 lists detailed information.

Table 6: Countries with Negative Nitrogen Flowerbed in Imported Goods

Phosphorous Flow from Fertilizer	
Dominican Republic	2003 – 2004
Haiti	1998 – 2006
Phosphorous Flow from Manure	
Cuba	1995 – 2015
Dominican Republic	1995 – 2009
Haiti	1995 – 2015

Finally, the domestic nitrogen flow amount from synthetic fertilizer and manure for Trinidad & Tobago and Jamaica is recorded as zero for the year 2000 in Eora MRIO. Despite the actual status of their agricultural sectors, there should be nitrogen fixation that leaches into the erodible soil because of the domestic synthetic fertilizer application and farm animal manure[7], as indicated by the FAO data.

The calculation of the final per capita footprint value of nitrogen flow between 1995 and 2015, including the contribution from both the application of synthetic fertilizers and farm animal manure, is the same as the calculation of the per capita footprint phosphorous flow for each of these five Caribbean states.

Blue Water

Blue water is defined as water from rivers, lakes, reservoirs and renewable stores (Falkenmark, 1997). The application of blue water as an environmental indicator can be traced to two Sustainable Development Goals, the 6th Goal of Water and Sanitation and the 11th Goal of safe, resilient and sustainable cities and human settlement. The boundary is defined as the maximum amount of consumptive use of blue water without regime shifts in the functioning of flow-dependent ecosystems (Steffen et al. 2015). The boundary value for blue water is the maximum annual global withdrawal of 4000 km^3 of blue water (Rockström, et al., 2009), and the per capital boundary value estimated by O'Neill et al. (2018) is 574 m^3 per year by dividing the maximum amount of 4000 km^3 with the 2011 global population.

Recent research complements the blue water consumption boundary, 4000 $km^3\ y^{-1}$, originally proposed by Rockström et al. (2009) with a basin-scale boundary in recognition of the heterogeneity in hydrological characteristics of river basins around the world (Weiskel, et al. 2014). The basin-scale boundary draws on the concept of minimum "environmental flow requirements" needed by healthy riparian/coastal ecosystems and incorporates the monthly flow variation to reflect seasonal changes in freshwater availability by tracking monthly flows (Pastor, et al. 2014). However, due to the lack of monthly basin-scaled data that include blue water consumption embedded in international trade of water-intensive products, the original 4000 $km^3\ y^{-1}$ boundary value is used in the thesis, consistent with the approach taken by O'Neill et al. (2018).

National water use data in the thesis are obtained from the Water Footprint Network (WFN, 2018), which are an average for the period 1996–2005 (the most recent period available). The data measured the consumption and pollution of blue water related to the domestic water supply, plus virtual-water imports and minus virtual-water exports, and therefore is a consumption-based measurement. The blue water data were scaled up to match current global freshwater use (2600 km3 y-1), as reported by Steffen et al. (2015). It is not indicated by O'Neill et al. (2018) in their research what factor is used when scaling up the national blue water consumption value to reflect changes associated with the time-scale. The average global blue water consumption between 1996 and 2005 is 943325 Mm^3/year[8]. By dividing Steffen et al. (2015)'s estimation of 2600 km^3 in 2011 with 943325Mm^3, incorporating the population increase between 2005 and 2011, I work out the factor of 2.56, by which the possible 2011 values for the five nations can be scaled up based on the average value between 1996 and 2005.

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[7] FAO indicates in 2000, the amount of phosphate fertilizer application as nutrients in Trinidad & Tobago was 686 tons, and 7278 Tons for the amount of nitrogen fertilizer application as nutrients. The total amount of manure both as organic fertilizer and left on the pasture was 3121 Tons in 2000. For Jamaica, the amount of phosphate fertilizer used as nutrients was 5200 tons and 9900 tons for nitrogen. The total amount of manure was 9291 tons. However, FAO collected such data from a variety of sources, such as survey and national statistics, and the data values over the years do not indicate a clear trend.

[8] Data Source: Water Footprint Network, the same data source for the consumption-based blue water value used in this thesis.

eHANPP

The original planetary boundaries framework proposes a maximum of 15% of ice-free land being used for crops as the measure for change in land use (Rockström, et al. 2009). A more recent land-system change boundary is defined as a minimum of 75% of global original forest cover (Steffen et al. 2015). However, the distribution of forests varies substantially among countries, and the area of forested land associated with the consumption of goods and services is a difficult indicator to measure. A more nuanced indicator, Human Appropriation of Net Primary Production" (HANPP) has been developed that integrates land-system change, biosphere integrity, freshwater use and biogeochemical cycles and measure land use intensity (Running, 2012). It measures the amount of biomass harvested through agriculture and forestry, as well as biomass that is killed during harvest, but not used, as well as biomass that is lost due to land use change (Kastner, et al. 2015). Built on HANPP, embodied Human Appropriation of Net Primary Production (eHANPP), a consumption-based resource indicator, is developed to incorporate biomass change embedded in trade and reveal the portion of biomass change that can be traced back to the final consumers (Haberl et al. 2012). Haberl et al. (2012) believe only half of the variation in national eHANPP can be explained by differences in national land-use system, which suggests a considerable influence of trade on the national land use intensity. O'Neill et al. (2018) adopts national eHANPP in their research to recognize the role played by trade in land use intensity on national level. The assessment of eHANPP is closely related to the 15th Sustainable Development Goal of protection, restoration and sustainable use of terrestrial ecosystems, sustainable management of forests and the halting and reversion of land degradation and biodiversity loss.

To fully understand eHANPP as an indicator for biomass change, it is necessary to explain some basic concepts related to it. Haberl, et al. (2014) defines Net Primary Production (NPP) as the amount of biomass produced by green plants through photosynthesis per unit of time (usually one year) and space. ΔNPP_{LC} is the change of biomass because of land use conversion, such as forest being cleared off for more croplands. NPP_h means the biomass flow as a result of the extraction or destruction of a fraction of the NPP for human purposes (i.e. through biomass harvest or grazing of livestock). Human Appropriation of Net Primary Production (HANPP) is the amount of productivity of ecosystems that is appropriated by human, including ΔNPP_{LC} , the part of NPP that is appropriated by the replacement of pristine ecosystems with human-modified landscapes and NPP_h, the part of NPP that is removed from ecosystems as food, feed, fiber or bioenergy projection (Haberl et al. 2007; Imhoff et al. 2004; Kastner, et al., 2015; Vitousek et al., 1986). eHANPP can be interpreted as the consumption-based HANPP on national level, it is the sum of the domestic production-based HANPP and the part of HANPP embedded in imported goods, subtracted by the amount embedded in exported goods. eHANPP reflects the impact of international trade on human appropriation of the net primary production as a result of green plants' photosynthesis. On a global level, the annual HANPP and eHANPP amounts are the same, both representing the appropriation of net primary production of human intervention.

Running (2012) indicates that per year only 5 GT NPP, represented as NPP potential or NPPpot, remains available for further appropriation by human activities. The 2007 global HANPP, based on Kastner et al.'s (2015) estimate, is 13.2 Gt C y-1, which is 10% lower than other published data, since this value does not include NPP change embedded in human-induced fires and infrastructure. The boundary value for biomass available for human activities, 18.2 Gt C per year, is calculated as the sum of NPPpot and the already appropriated NPP of 2007. The annual per capita boundary value for biomass change, 2.62 t C, is estimated by dividing the total value of 18.2 Gt C by the 2011 world population, which is roughly equivalent to 33% of NPPpot, 5 GT NPP (O'Neill, et al. 2018).

The eHANPP data for the five subject nations in the Caribbean region are provided directly by Dr. Kastner upon request. Kastner also provided the eHANPP data relevant to 152 countries for O'Neill et al. (2018) in the unit of dry matter. Suggested by Dr. Kastner, a factor of 0.5 is applied when converting the dry matter into carbon fixation[9] to remain consistent with the unit used by O'Neill et al. in their research (2018). The most recent eHANPP data provided by Dr. Kastner are for 2007.

Ecological Footprint
The concept of ecological footprint (EF) is initially conceived by Rees & Wackernagei (1996) and defined as the total area of productive land and water required continuously to produce all the resources consumed and to assimilate all the wastes produced, by a defined population, wherever on Earth that land is located. It is a land-based surrogate measure of the population's demands on natural capital that measures the amount of biologically productive land and sea area needed by a population to produce biotic resources and the absorption of the generated CO_2 emission (Borucke, et al. 2012; Rees & Wackernagei, 1996). As an environmental indicator, ecological footprint is permeated into the majority of Sustainable Development Goals because of its relevance to climate change, land and marine resources use and the overall integrity of the ecosystem. The ecological footprint is the sum of six components, including cropland, forest land, fishing grounds, grazing land, built-up land, and carbon, which can be compared to the total amount of available area of biologically productive land and sea area (O'Neill, et al. 2018). There are about 12 billion hectares of biologically productive land and water available on Earth, according to data from 2013. The per capita boundary value, 1.72 global hectares, is estimated by dividing the total 12 billion hectares by the number of people alive in that year (Global Footprint Network, 2015). The per capita ecological footprint values of the five Caribbean small island states between 1995 and 2014 used in the thesis are from the Global Footprint Network, the same source for data used by O' Neil et al.

Material Footprint
Material footprint, also known as "raw material consumption" (RMC), measures the amount of used material extraction (minerals, fossil fuels, and biomass) associated with the final demand for goods and services, regardless of where that extraction occurs. Being a fully consumption-based measure, it includes the upstream (embodied) raw materials related to imports and exports (Wiedmann et al. 2015). As an environmental performance indicator, material footprint is directly related to sustainable development because the footprint level determines the overall stress on the ecosystem, material consumption and resulted emission. The non-exceeding value of 50 Gt per year, as suggested by Dittrich et al. (2012), is adopted as the boundary value and the per capita value of 7.2 t per year. This was estimated by dividing 50 Gt by the 2011 world population by O'Neill et al. (2018). Data for each national material footprint in this thesis are from Eora MRIO, the same source used by O' Neil et al. which is based on Wiedmann et al.'s research (2015). The definitions for "Territorial", "Import" and "Export" material consumptions are the same as those related to CO_2 emissions and biochemical flow. There has been no recorded material consumption embedded in household activities. The territorial values are updated to the year 2008 and the material consumption embedded in trade has been updated until 2015.

[9] As confirmed by Dr. Kastner, one ton of dry matter equals 0.5 ton of carbon fixation.

Some data errors exist since the material consumption values embedded in imported goods are negative for some countries for certain periods between 1995 and 2015. Table 7 below lists detailed information. Confirmed by the data provider, all negative values are treated as zero in this thesis. The material footprint values used in this thesis might be lower than the actual values for countries that heavily depend on imported goods but have recorded negative values of material consumption embedded in imported goods[10].

Table 7: Countries with Negative Value of Material Consumption Embedded in Imported Goods

Country	Year (when the material consumption embedded in imported goods is negative and adjusted to zero)
Cuba	1996 – 2002; 2004
Dominican Republic	2001 – 2005
Haiti	1995 – 2009
Jamaica	1995 – 2015
Trinidad & Tobago	1995 – 2015

The calculation of material footprint for each individual country is the sum of territorial material, consumption and consumption embedded in imported goods, subtracted by the amount of material consumption embedded in exported goods. The result is divided by the population size of the relevant year to get the per capita value.

Life Satisfaction

A single life satisfaction measure, known as the Cantril life ladder, is used when measuring life satisfaction (O'Neill et al. 2018). The English-language wording of the question is: "Please imagine a ladder, with steps numbered from 0 at the bottom to 10 at the top. The top of the ladder represents the best possible life for you, and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time?" This question is copied from the Gallup World Poll, as published in Gallup's 2015 World Happiness Report. The value for life satisfaction, or "Subjective Wellbeing" in the World Happiness Report, is the national average response to the question of life evaluation. The sample size ranges between 2000 and 3000 for individual countries and the 2015 score is the 3 or 2-year average survey result for each country.

Usually a score of 7 out of 10 is chosen to indicate a "high" level of subjective human wellbeing (ONS, 2015). A value of 6.5 out of 10 is chosen to represent the minimum threshold for the life satisfaction indicator by O'Neill et al. (2018). The lower threshold is adopted because scores derived from the Cantril ladder question are found to be 0.5 points lower on average than scores derived from the question used by many statistical agencies (O'Neill, et al.,2018). The researchers use relevant values in the Gallup 2015 World Happiness Report to assess individual countries' life satisfaction. In this thesis, data values from the 2018 Gallup World Happiness Report are used, which include the 2017 results for Trinidad & Tobago, Dominican Republic and Jamaica.

[10] As shown later in this thesis, these five countries are heavily dependent on imported goods for food supply. Therefore, there should be biomass consumption embedded in imported goods.

Healthy Life Expectancy
This indicator is closely related to life expectancy at birth, which on average is nine years lower than overall life expectancy (with a standard deviation of 1) (O'Neill et al., 2018). In their research, healthy life expectancy values are from the Gallup 2015 World Happiness Report, which are based on data from the World Health Organization, World Development Indicators, and statistics published in academic articles. O'Neill et al. (2018) set the threshold at 65 years for a healthy life. In 2011, 40% of the countries for which data were available for this indicator achieved this threshold. In this thesis, the more up-to-date data in the 2018 Gallup World Happiness Report are used.

Nutrition
Nutrition is measured by O' Neill et al. using the UN Food and Agriculture Organization's "food supply" indicator (FAOSTAT, 2014). This indicator is measured in kilocalories (kcal) per capita per day and represents an average calorific intake of food and drink. It is stated in O'Neill et al.'s research (2018) that the physiological requirements for an average adult range between 2100 and 2900 kcal per day. However, considering the caloric requirements connected with labor or athletic activities, this limit can easily be exceeded. They consider an average of 2500 kcal per person per day as an individual minimum average level, below which is facing undernourishment. A value of 2700 kcal per person per day is used by O'Neill et al. (2018) as a population-wide threshold, to allow for some inequality in distribution. In this thesis, data values between 1995 and 2013 are collected from FAOSTAT (2014) for the five subject Caribbean states.

Sanitation
This indicator measures the percentage of the population that has access to improved sanitation facilities. It is argued by Raworth (2012) that 100% of the population should have access to improved sanitation because it is a fundamental aspect of a life free of deprivation. The target adopted in the Millennium Development Goals to provide about 80% of the global population with access to improved sanitation has been achieved (UN, 2015). O' Neill et al. use the threshold of 95% of the population having access to improved sanitation because of the recognized difficulty associated with extending universal access to the last 5% of a population, often located in very rural areas. In this thesis, data was collected from the same data source, World Development Indicators, for values between 1995 and 2015 for the five Caribbean small island states.

Energy (Access to Electricity)
This indicator measures the percentage of population that has access to electricity. A threshold value of 95% of the population having access to electricity is used by O'Neill et al. (2018). In this thesis, the same indicator is used, and data are from the same source, World Development Indicator (World Bank, 2015a). Values between 1996 and 2015 are collected for the five subject states in the Caribbean.

Education
O'Neill et al. (2018) measure individual countries' performances in education by using the Gross Enrolment Rate in Secondary Education. This refers to the ratio of total enrolment, regardless of age, to the population that are of secondary-school age. This indicator is selected because it is suggested without more subject or skill-oriented education during teenage years, young people tend to be not only ill-prepared for tertiary education or the workforce, but are also more likely to be attracted to activities with negative effects on well-being, such as juvenile delinquency, teenage pregnancy and radicalization by militants (Cohen, 2008). In addition, based on evidence from developing countries, women completing secondary education have, on

average, at least one child fewer per lifetime compared to women who complete only primary education. Secondary education seems to have the potential to reduce population growth (Holsinger & Cowell, 2000). A threshold value of 95% of Gross Enrolment in secondary education is applied by O'Neill et al. (2018). The gross enrolment rate data used in O'Neill et al.'s research (2018) are from the World Bank's World Development Indicators (World Bank, 2015a). This thesis collects data from the same source, with proxy data for Haiti.

Income

This indicator measures the percentage of the population that lives on more than USD $1.90 a day. A threshold value of 95% is used in Good Life for All within the Planetary Boundaries, given the fact that not many countries report this indicator above 95%. Using $1.90 a day as a standard is more associated with countries that have the target of eradicating extreme poverty (O'Neill, 2018). Data sparsity is a serious issue for this indicator when the five subject states are concerned. Dominican Republic is the only country with data available between 2000 and 2015. Jamaica has data for only 1996, 1999, 2002 and 2004. There are no data relevant to this indicator for Trinidad & Tobago, Cuba and Haiti at the World Bank database. Different measures have been taken to get proxy values for these three nations.

Social Support

The social support indicator used in O'Neill et al.'s research (2018) measures whether or not people have someone to count on in times of need. This indicator is selected because it is believed that having social support is essential to achieving long, happy and healthy lives (Cobb, 1976). Social support is assessed by measuring whether people believe they have someone to rely on in times of difficulty or need. Relevant data are from the Gallup 2015 World Happiness Report, which is the national average binary response (0 or 1) to the question, "If you were in trouble, do you have relatives or friends you can count on to help you whenever you need them, or not". In O'Neill et al.'s research (2018), a value of 0.9 or 90% is chosen as the minimum threshold for this indicator. The relatively lower threshold value is chosen to accommodate availability heuristic, which is biased towards emotionally charged, memorized, differentiate, long-term and short-term lack of social support (Tversky & Kahneman, 1974). This thesis used data from the same source, however, instead of data from the 2015 Gallup World Happiness Report, values from the more recent 2018 report are used.

Democratic Quality

This indicator used by O'Neill, et al. (2018) is comprised of an unweighted average of two Worldwide Governance Indicators: Voice & Accountability and Political Stability & Absence of Violence (Kaufmann et al. 2010). Voice & Accountability and Political Stability & Absence of Violence indicators are built upon multiple sources, such as household surveys and interviews with experts, firms, and nongovernmental organizations, and are scaled between roughly -2.5 (poor democratic quality) and 2.5 (strong democratic quality), along which a threshold value of 0.80 is chosen. This is the approximate value for the United States and the United Kingdom. The reason why the score of these two countries is chosen as the threshold value is that that democratic systems of these two countries are by no means ranked as the highest performing but are nonetheless well-known in terms of their strengths and weaknesses. To be consistent, instead of using the original data values for the two indicators from the World Bank Database and calculating the unweighted average, this thesis uses values from the 2018 Gallup World Happiness Report since O'Neill et al. (2018) use values from the 2015 report.

Equality
Social wealth distribution is used to assess equality by O'Neill et al. (2018) in line with the belief that more equal societies have fewer health and social problems than less equal ones (Wilkinson & Pickett, 2009). The Gini coefficient, the value estimated by using equivalized (square root scale) household disposable income (the amount of income after tax and transfers) is used to measure the distribution of societal wealth. Following the rationale of a higher value of the social indicators representing better performance, O'Neill et al. (2018) calculate equality as one minus the Gini coefficient[11], the higher the GINI index, the lower social equality. In O'Neill, et al.'s research (2018), a maximum Gini coefficient of 0.30 is used in the calculation of the threshold value of equality. This value of 0.30 falls in between the Gini coefficients associated with "low" and "medium" total income inequality (0.26 and 0.36, respectively), as characterized by Piketty (2014). The threshold value for equality therefore is 0.70 or 70%, calculated as 1 minus the selected maximum Gini coefficient of 0.30 or 30%. When assessing equality, O'Neill et al. (2018) use data from the October 2014 release (v5.0) of the Standardized World Income Inequality Database (Frederic Solt dataverse, 2014). This thesis uses data from the same database, however, instead of using the version 5.0, a more center version of 6.1 (which was released in October 2017) is used (Frederic Solt dataverse, 2016).

Employment
Employment is measured by O'Neill et al. (2018) because of the important role it plays in enabling social and economic autonomy (Doyal & Gough, 1991). It is assessed as one minus the unemployment rate, with the unemployment rate as the share of the labor force that is without work but available for and seeking employment. An unemployment rate of 6% is used as the threshold value by O'Neill et al. (2018) since it is roughly equivalent to the average non-accelerating inflation rate of unemployment (NAIRU) for OECD countries (OECD, 2000). Therefore, the threshold value of employment rate is set at 94% of its working population being employed. O'Neill et al. (2018) use data from harmonized unemployment rates from World Bank's World Development Indicators (World Bank, 2015a) to assess the employment situation of individual countries covered by their research. In this thesis, the 1995- 2016 harmonized unemployment data related to the five Caribbean states are collected from the same database and the employment ratio is calculated by subtracting 1 with the relevant unemployment ratio.

Assessment of Individual Countries' Environmental and Social Performances
In O'Neill et al.'s research (2018), each country's environmental performances are assessed by dividing each indicator's most recently available value, with the boundary value. A ratio larger than 1 indicates the country exceeds the boundary value, while a ratio less than 1 means the country performs within the boundary. The actual value of the ratio signifies the magnitude of individual countries' stress on the ecosystem.

As for social performances, individual countries are assessed by dividing each social outcome indicator value with the threshold value. A ratio larger than 1 indicates the country satisfies the relevant social outcome and a ratio less than 1 means the country currently fails to achieve the goal. The actual value of the ratio signifies the degree by which individual countries succeed or fail in their efforts to achieve the social outcomes.

[11] A Gini Coefficient of 0 indicates total equality, with everyone having the same amount of wealth, while a value of 1, means one person owns all social wealth. The higher the value, the less equal the society (a lower value of the Gini Coefficient indicates better performance). Therefore, equality is estimated by 1 minus the Gini Coefficient, rather than the Gini Coefficient, to be consistent with the estimation of other indicators.

My thesis adopts the same approach, using data relevant to individual countries' environmental and social performances from the same sources. Besides the assessment of the most recent environmental and social performances, contingent to data availability, the trend of change for the period between 1995 and 2017 or alternatively, between 1995 and 2008, depending on data availability, has also been analyzed.

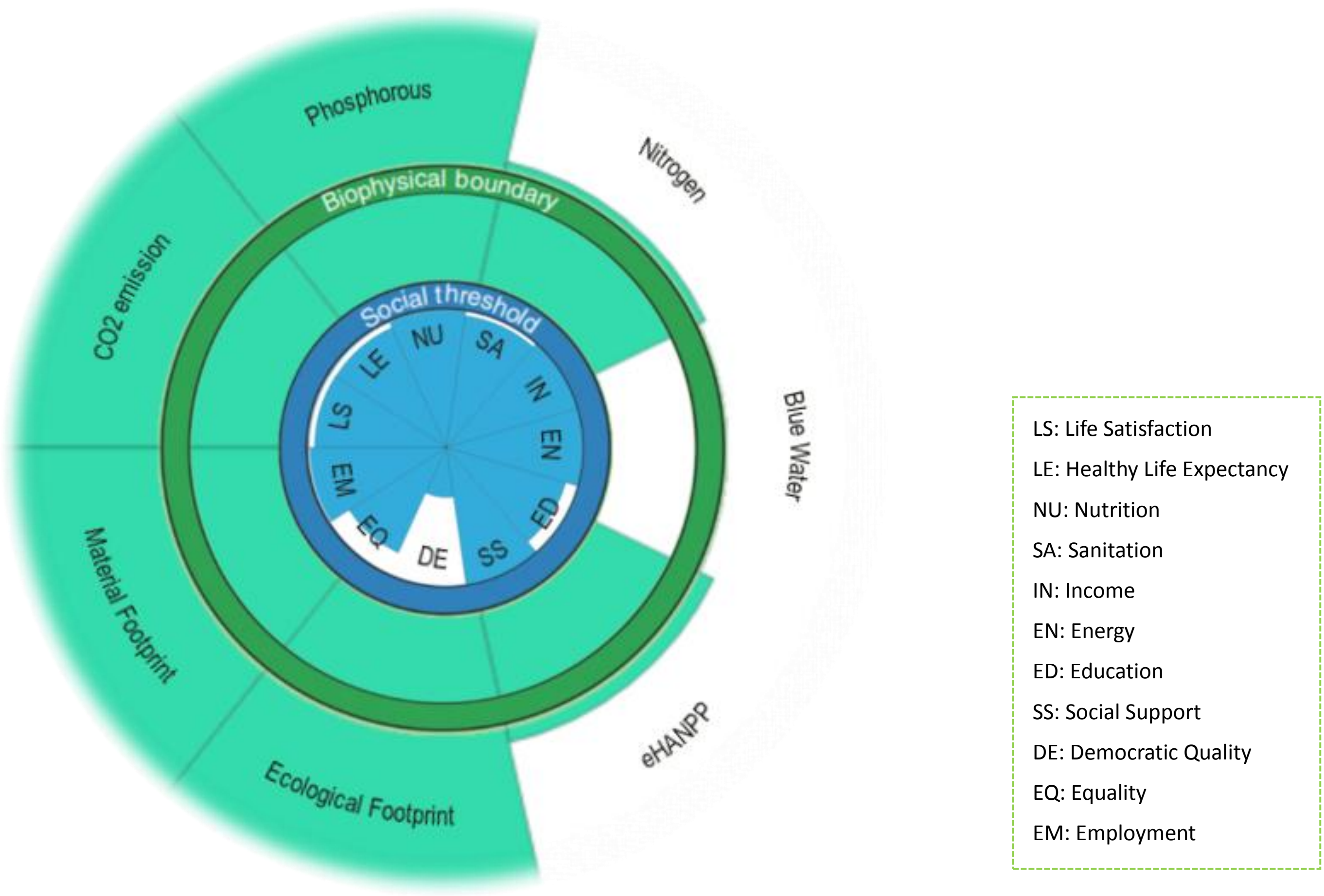
4 RESULTS

Individual countries' environmental and social performances are compared with the biosphere boundaries and social outcome threshold values. The section below is to present findings relevant to each individual country.

4.1 Trinidad & Tobago

As shown in Figure 9, Trinidad & Tobago exceeds 6 out of 7 planetary boundaries and achieves 5 out of 11 social outcomes. The only planetary boundary Trinidad & Tobago has not exceeded is the one associated with blue water, based on the estimated 2011 value. Table 8 below quantifies the level of stress on the ecosystem and the extent to which social outcomes have been satisfied.

Figure 9: Trinidad & Tobago's position within the Safe and Just Space of the Doughnut



The 2008 CO_2 emissions footprint and material footprint values of Trinidad & Tobago are 34 times and 9 times the boundary values respectively. The CO_2 emissions from burning of fossil fuels is 40 times the amount from burning of biomass. After reaching its peak in 2009, the country's ecological footprint starts decreasing until 2014, when the value is still more than 4 times the boundary value. Trinidad & Tobago exceeds the biochemical boundaries for both phosphorous and nitrogen flows. Both phosphorous and nitrogen flows are values embedded in imported goods because data related to domestic contribution is not available.

Table 8: Environmental and Social Performances of Trinidad & Tobago

Environmental Performances: A ratio <1 means the country functions within the boundary level; a ratio > 1 means the country exceeds the boundary level. Areas shaded in red means areas where the country exceeds the boundary level.			
	Boundary Level (per capita per year)	**Trinidad & Tobago's Performance (per capita per year)**	**Ratio (Trinidad & Tobago performance/ Boundary Value)**
CO_2 Emission	1.61 t	52.24 t	32.45
Phosphorous Flow	0.89 kg	1.92 kg	2.15
Nitrogen Flow	8.9 kg	9.36 kg	1.05
Blue Water	574 m^3	282 m^3	0.49
eHANPP	2.62 t C	2.84 t C	1.08
Ecological Footprint	1.71 gha	6.69 gha	4.80
Material Footprint	7.2 t	69.57 t	9.66
Social Performances: A ratio < 1 means the country fails to achieve the social outcome; a ratio >1 means the country satisfies the social outcome. Areas shaded in green means areas where the country fails to satisfy the social outcomes.			
	Threshold Value	**Trinidad & Tobago's Performance**	**Ratio (Trinidad & Tobago performance/ Threshold value)**
Life Satisfaction	6.5	6.192	0.95
Healthy Life Expectancy	65	61.738	0.95
Nutrition	2700	3052	1.13
Sanitation	95%	91.5%	0.96
Access to Electricity	95%	100%	1.05
Income	95%	100%	1.05
Education	95%	85.51%	0.9
Social Support	90%	91.6%	1.01
Democratic Quality	0.8	0.288	0.36
Equality	70	58.46	0.84
Employment	94%	95.29%	1.01

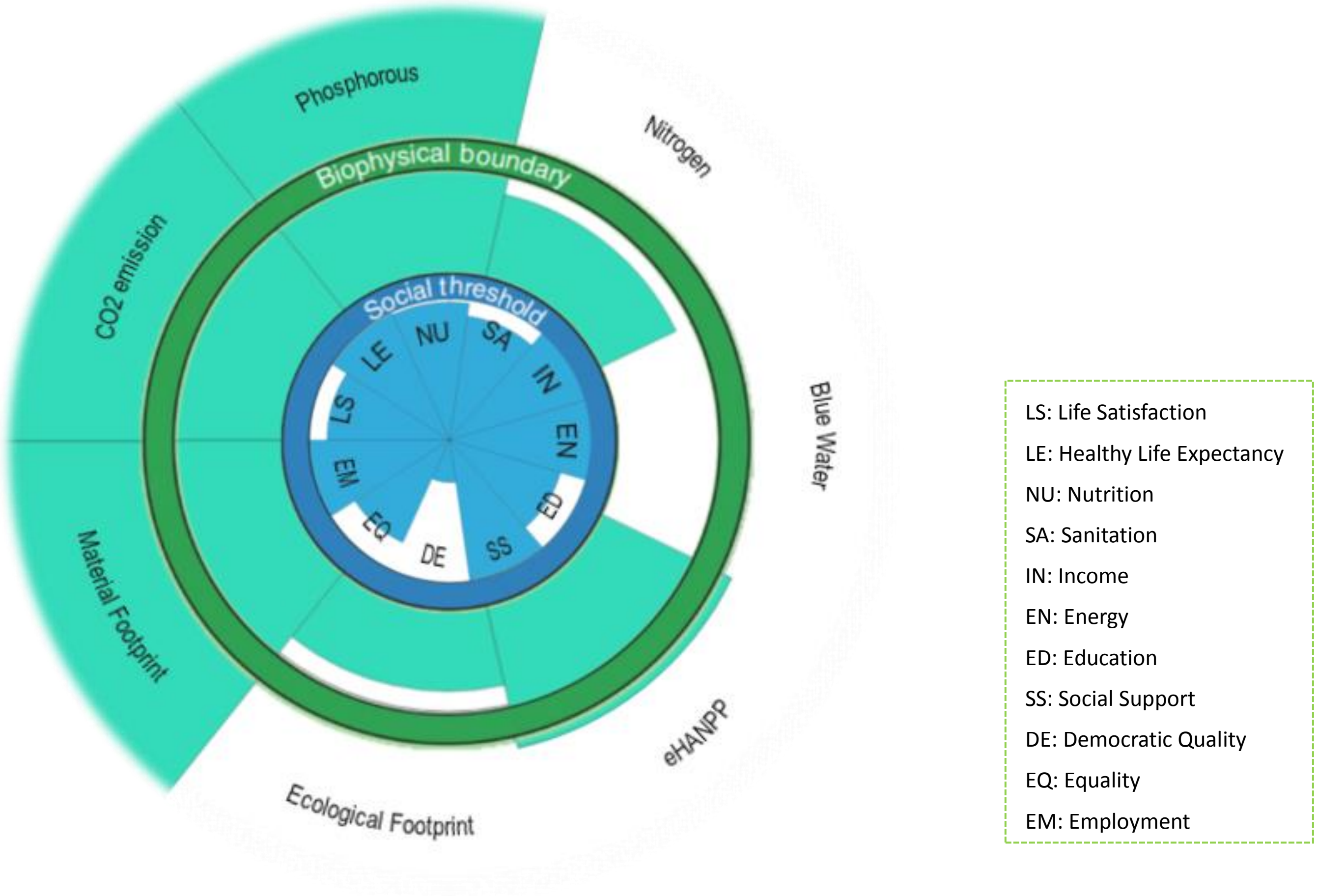
From the social perspective, Trinidad & Tobago exceeds the threshold values for nutrition, income, energy, social support and employment. As for Income, there is no recent data available related to the percentage of population in Trinidad & Tobago who lives on more than $ 1.90 a day. This thesis follows O' Neill et al.'s assumption that, as a member of the high-income country (World Bank, 2018), 100% of Trinidad & Tobago's population lives on more than $1.90 a day. Trinidad & Tobago's score for life satisfaction decreases from 6.7 in 2008, above the threshold value of Cantrill score of 6.5, to approximately 6.2 in 2013, 0.3 point below the threshold value of 6.5. Since 2012, the value remains relatively consistent until 2017. Its score for social support drops from 88.7% in 2006 to 85.8% in 2008. Since 2008 it starts to rise until reaching the highest value of 91.6% in 2017, slightly higher than the threshold value of 90%.

Although healthy life expectancy has increased from 60.2 in 2006 to 61.3 in 2017, Trinidad & Tobago has not met the threshold value of 65. Data on gross enrolment in secondary school are not available for Trinidad & Tobago for most years between 1995 and 2015, except 2004 when the value is recorded as 85.5%, 10% lower than the threshold value of 95%. Trinidad & Tobago's equality value ranges between 0.59 and 0.58 during the period of 1997 – 2005, with the most recent value being 83% of the threshold value of 0.7. In general, its equality value is relatively constant between 1997 and 2005, with gradual decrease between 2002 and 2005. After increasing from 0.19 in 2006 to 0.33 in 2011, Trinidad & Tobago's score for democratic quality decreases to 0.29 in 2013, 36% of the threshold value of 0.8. The employment rate has been increasing between 1995 and 2016, and in 2016, about 97.8% of the total labour force were employed. It starts the slight downward trend in 2016 and decreases by 2.7% to 95.2% in 2018.

4.2 *Dominican Republic*

As shown in **Figure 10,** Dominican Republic exceeds 4 out of 7 planetary boundaries, including CO_2 emissions, phosphorous flow, eHANPP and material footprint, and operates marginally within the boundary of nitrogen flow and ecological footprint. From social perspective, Dominican Republic achieves 3 out of 11 social outcomes: energy, income and employment.

Figure 10: Dominican Republic's position within the Safe and Just Space of the Doughnut



The 2008 CO_2 emissions from the burning of fossil fuels and biomass is nearly three times the planetary boundary value. It increases from 4.02 ton per person in 1998 to 4.39 ton per person in 2003 and then decreases to 4.18 ton per person in 2005. This increase resumes in 2006 and reaches 4.73 ton per person in 2008. As for household activities, CO_2 emissions from the burning of biomass was around 1.6 times the amount of the emissions from the burning of fossil fuels between 1995 and 2003. Starting from 2004, emissions from the household burning of biomass increased until 2008. The CO_2 emissions from the household burning of fossil fuels remained constant between 1995 and 2008. Both phosphorous and nitrogen flow from the application of synthetic fertilizer and farm animal manure were relatively constant between 1995 and 2015. The amount of nitrogen flow, from both synthetic fertilizer and manure embedded in imported goods, increased by 235%, from 6866 ton in 2010 to 16145 ton in 2011. The amount of phosphorous flow, embedded in imported goods, has similar trend of change but on a smaller scale.

Table 9: Environmental and Social Performances of Dominican Republic

Environmental Performances: A ratio <1 means the country functions within the boundary level; a ratio > 1 means the country exceeds the boundary level. Areas shaded in red means areas where the country exceeds the boundary level.			
	Boundary Level (per capita per year)	**Dominican Republic Performance (per capita per year)**	**Ratio (Dominican Republic performance/ Boundary Value)**
CO_2 Emission	1.61 t	4.74 t	2.94
Phosphorous Flow	0.89 kg	1.58 kg	1.77
Nitrogen Flow	8.9 kg	8.27 kg	0.93
Blue Water	574 m^3	334.08 m^3	0.58
eHANPP	2.62 t C	2.78 t C	1.06
Ecological Footprint	1.71 gha	1.59 gha	0.99
Material Footprint	7.2 t	12.68 t	1.76
Social Performances: A ratio < 1 means the country fails to achieve the social outcome; a ratio >1 means the country satisfies the social outcome. Areas shaded in green means areas where the country fails to satisfy the social outcomes.			
	Threshold Value	**Dominican Republic's Performance**	**Ratio (Dominican Republic performance/ Threshold value)**
Life Satisfaction	6.5	5.605	0.86
Healthy Life Expectancy	65	63.496	0.98
Nutrition	2700	2614	0.97
Sanitation	95%	84%	0.88
Access to Electricity	95%	100%	1.05
Income	95%	98.1%	1.03
Education	95%	77.17%	0.81
Social Support	90%	89.44%	0.99
Democratic Quality	0.8	0.239	0.30
Equality	70	55.41	0.79
Employment	94%	94.22%	1.00

Material footprint in Dominican Republic fluctuated between 1995 and 2008. It was relatively constant between 1995 and 2001, and then increased from the per capita value of 11.61 t in 2001 to 17.15 t in 2002, an increase of 147%. The value started decreasing in 2002 until 2006 when it fell to 11.61 t, roughly the same as the 2001 value. It resumes increasing in 2007, with the 2008 value 1.76 times the boundary value. Material consumption embedded in imported and exported goods was constant between 1995 and 2000[12]. The value embedded in imported goods increased to 37 million ton in 2011, nearly 6.6 times the 2001 value. After 2011, the total material consumption embedded in imported goods has been decreasing, from 37

[12] No relevant data for the period between 2001 and 2006 for Dominican Republic at Eora MRIO.

million ton in 2011 to 31 million ton in 2015. Both the eHANPP and ecological footprint values were constant between 1995 and 2007, 1995 and 2014, respectively. Its most up-to-date eHANPP value in 2007 exceeds the boundary value by 6% and its ecological footprint in 2014 is marginally lower than the boundary value.

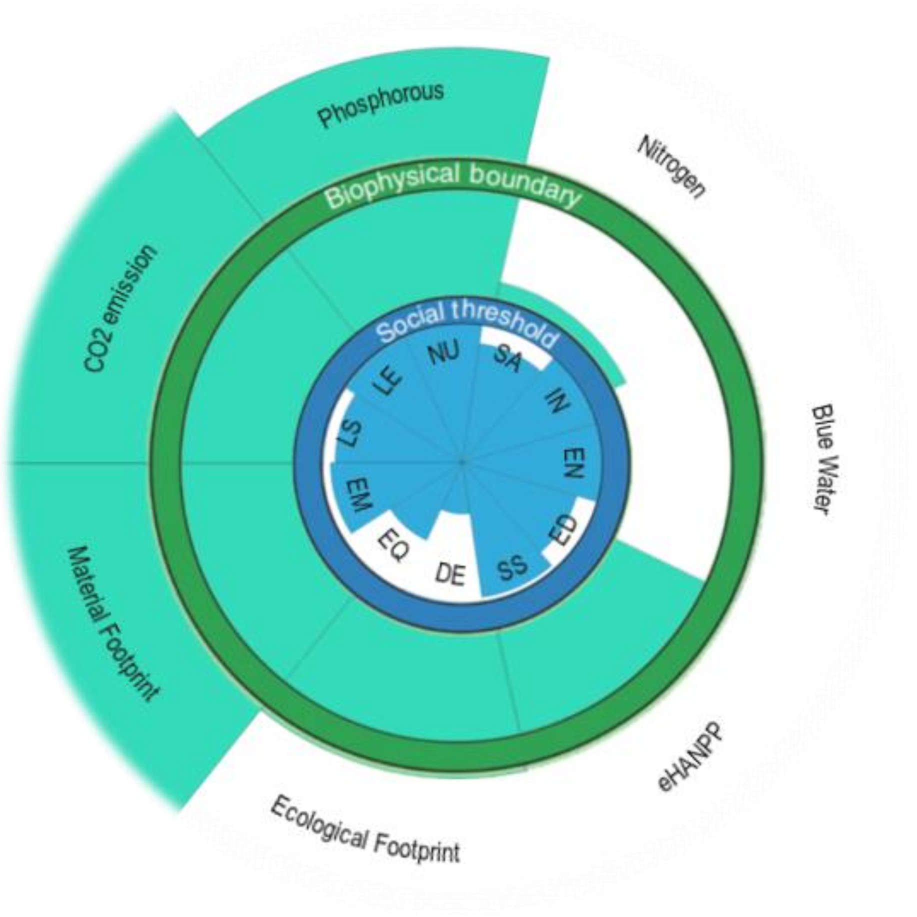
From the social perspective, in 2016, 100% of its population has access to electricity. Its per capita daily intake of calorie increased from the 2256 kcal in 1995 to 2614 kcal in 2013, an annual increase rate of 0.88% but still lower than the threshold value of per capita 2700 kcal. Sanitation improved from 75.2% of the population having access to improved sanitation in 1995 to 84% in 2014, an annual increase rate of 0.62%, still lower than the threshold value of 95%. Gross enrollment rate in secondary school increased from 40% in 1995 to 78% in 2007. The ratio has remained almost static since then with the most updated data being 77% in 2016, 19% lower than the threshold value of 95%. Healthy life expectancy increased from 61.6 in 2005 to 63.5 in 2017, an increase of 1.9 during a 12-year period, but still 1.5 years lower than the threshold value of 65.

Despite the fluctuations between 1995 and 2015/2016, the most recent data indicates that Dominican Republic exceeds the threshold values for both income and employment. Its equality value was only 79% of the threshold value of 0.7 in 2015. Dominican Republic's most recent democratic quality score in 2016 was 5 times the 2011 value, however, still only 30% of the threshold value. Its value for life satisfaction has been fluctuating during the 12-year period between 2005 and 2017 with the highest score of 5.6 in 2017, only 86% of the threshold value. Its social support value was the highest in 2005 with nearly 92% of its population believing they have someone to rely on when necessary. It dropped to its lowest value of 84.6% in 2006, and gradually increased to 89.4% in 2017, approaching the threshold value of 90%.

4.3 Jamaica

As shown in Figure 11, Jamaica exceeds four out of seven planetary boundaries and achieves five out of 11 social outcomes. Table 10 quantifies the level of stress on the ecosystem and the extent to which social outcomes are satisfied.

Figure 11: Jamaica's position within the Safe and Just Space of the Doughnut



LS: Life Satisfaction
LE: Healthy Life Expectancy
NU: Nutrition
SA: Sanitation
IN: Income
EN: Energy
ED: Education
SS: Social Support
DE: Democratic Quality
EQ: Equality
EM: Employment

Jamaica's CO_2 emissions from the burning of fossil fuels and biomass was constant between 1995 and 2005, about five times the boundary value. It increased gradually from the per capita value of 6.58 t in 2005 to 8.04 t in2007, four times the boundary value, followed by a slight decrease of 0.43 t to 7.61 t in 2008, still 4.7 times the boundary value. CO_2 emissions embedded in imported goods fluctuated between 1995 and 2015, with a trend of a two-to-three-year increase, followed by a two-to-three-year decrease with the peak value in 2008. It decreased sharply in 2009 and resumed gradual increase in 2011. The 2015 value was approximately the same as the 1995 value. For data related to its domestic contribution to biochemical flow, both phosphorous or nitrogen, is unavailable at Eora MRIO. The biochemical flows of Jamaica between 1995 and 2015 included emission values only embedded in imported goods. Phosphorous flow from fertilizers and manure that is embedded in imported goods were relatively constant between 1995 and 2015. The nitrogen flow from fertilizers and manure decreased by 17% from 1995 to 2015.

Table 10: Environmental and Social Performances of Jamaica

Environmental Performances: A ratio <1 means the country functions within the boundary level; a ratio > 1 means the country exceeds the boundary level. Areas shaded in red means areas where the country exceeds the boundary level.			
	Boundary Level (per capita per year)	**Jamaica Performance (per capita per year)**	**Ratio (Jamaica performance/ Boundary Value)**
CO_2 Emission	1.61 t	7.61	4.73
Phosphorous Flow	0.89 kg	1.21	1.36
Nitrogen Flow	8.9 kg	5.83	0.65
Blue Water	574 m^3	230.4	0.4
eHANPP	2.62 t C	2.56	0.98
Ecological Footprint	1.71 gha	1.77	1.20
Material Footprint	7.2 t	21.9	3.04
Social Performances: A ratio < 1 means the country fails to achieve the social outcome; a ratio >1 means the country satisfies the social outcome. Areas shaded in green means areas where the country fails to satisfy the social outcomes.			
	Threshold Value	**Jamaica Performance**	**Ratio (Jamaica performance/ Threshold value)**
Life Satisfaction	6.5	5.89	0.91
Healthy Life Expectancy	65	65.819	1.01
Nutrition	2700	2746	1.02
Sanitation	95%	81.8%	0.86
Access to Electricity	95%	98.2%	1.03
Income	95%	98.3%	1.03
Education	95%	80.6%	0.85
Social Support	90%	91.3%	1.01
Democratic Quality	0.8	0.294	0.37
Equality	70	42.79	0.61
Employment	94%	88.3%	0.94

eHANPP is relatively constant between 1995 and 2001. It rises from per capita 2.66 Ct in 2001 to 3.06 Ct in 2002, and after experienced a temporary drop to 2.68 Ct in 2003, it increased to the peak value of 3.12 Ct in 2004. It started decreasing in 2005 and the 2007 value was per capita 2.56 Ct, marginally below the boundary value. Jamaica's ecological footprint is relatively constant between 1995 and 2006. In 2007, it jumped to per capita 2.12 gha from 1.64 gha in 2006, followed by the abrupt drop to 1.4 gha in 2008. It started increasing in 2009 and in 2011 it almost resumed its 2007 value. It started decreasing again in 2012 and in 2014, its ecological footprint was per capita 1.77 gha, slightly higher than the boundary value of 1.72 gha. Its material footprint underwent three periods of gradual change. The first period was between 1995 and 2000, during which the material footprint was relatively constant, with the 2000 per capita value 94% of the 1995 value. The second period was between 2000 and 2006, during which the material footprint gradually increased to the 2006 per capita value of per capita 24.1 t, an increase of 28% compared with the

2000 value. The third period was between 2006 and 2008, during which the footprint value decreased by 9% to the most up-to-date value of per capita 21.9 t in 2008, three times the boundary value.

From social perspective, Jamaica's healthy life expectancy in 2006 was 63.7 and it increased to 65.8 in 2017, exceeding the threshold value of 65 by 1.26%. In 1995, only 80.26% of the population had access to electricity. In 2016, 98.2% of the population had access to electricity, exceeding the threshold value of 95% by 3.4%. In 1995, 80.3% of its population had access to improved sanitation. After 21 years, the percentage increased by 1.87% to 81.8% of its population having access to improved sanitation. The change of nutrition value can be divided into three stages. The first stage was between 1995 and 2000 when the per capita calorie intake increases from 2684 kcal per day to 2729 kcal per day, slightly higher than the threshold value of 2700 kcal per day. The second stage started with a 2.4% increase from 2000 to 2001 and remained constant until 2007. The third stage was between 2007 and 2013 when the per capita calorie intake value dropped by 1.7% in 2008 and remained constant until 2013. The most recent 2013 value of per capita 2746 kcal per day is almost the same as the 2000 value, slightly higher than the threshold value.

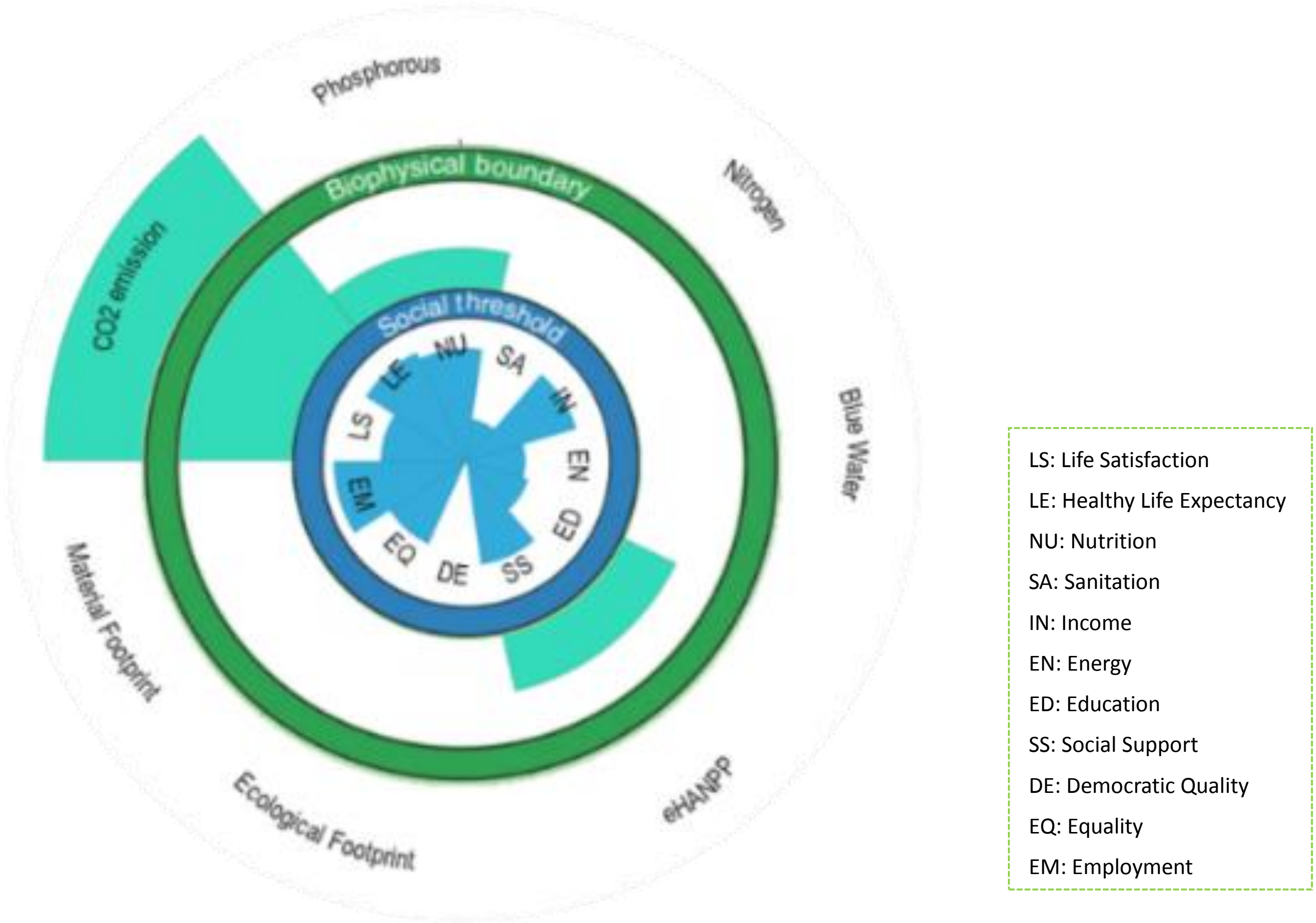
Between 1995 and 2003, the gross enrollment rate in secondary school in Jamaica is approximately 85%. The situation improved gradually until 2009 when the rate increased to 94.53%, nearly approaching the threshold value of 95%. However, it started decreasing in 2010 and in 2015, the rate dropped to 80.60%, 5% lower than the 1995 level. Between 1998 and 2007, the situation of Jamaica's labor market was improving with the employment rate increasing from 84.5% in 1998 to 90.3% in 2007. It deteriorated in 2008 and dropped to only 84.7% in 2013. Since 2014 the situation started improving and in 2017, 88.3% of the labor force were employed, still 5.7% lower than the threshold value.

In 2004, 98.3% of Jamaica's population lived on more than $ 1.90 a day. The change of its equality can be divided into two stages. The first period was between 1996 and 1999, during which social equality was increasing. Starting from 1999, it started its downward trend until 2004, when the value dropped to 0.43, 61% of the threshold value. democratic quality of Jamaica increased from 0.15 in 2006 to 0.36 in 2004, followed by a drop to 0.29 in 2015, satisfying only 36% of the threshold value. People in Jamaica were most satisfied with life in 2006 with a score of 6.2. The value drops to only 5.4 in 2011, followed by an increase to 5.7 in 2013. The score drops again to 5.3 in 2014 and gradually increased to the most recent value of 5.9 in 2017. In 2006, 90.91% of its population believed they had someone to rely on in times of difficulties. The score dropped to only 85.5% in 2011. After 2011, the score started its gradual increase until in 2014, about 91.3% of its population believed they could depend on friends or families when necessary, marginally higher than the threshold value of 90%.

4.4 Haiti

As shown in Figure 12, Haiti exceeds 1 out of 7 planetary boundaries and achieves none of the 11 social outcomes. Table 11 quantifies the level of stress on the ecosystem and the extent to which social outcomes are satisfied.

Figure 12: Haiti's position within the Safe and Just Space of the Doughnut



CO_2 emissions from burning of fossil fuels and biomass were relatively consistent between 1995 and 2001. Since 2001, the emission value increased gradually and in 2008 it exceeded the boundary level by 32%. The main source for CO_2 emissions in Haiti is burning of biomass and the amount of CO_2 emissions from burning of biomass is five times the amount from burning of fossil fuels. CO_2 emissions from the burning of biomass increased by 27% from per capita 1.4 t in 1995, to per capita 1.78 t in 2008. CO_2 emissions from the burning of fossil fuels in Haiti increased by 55% from per capita 0.22 t in 1995 to per capita 0.34 t in 2008. CO_2 emissions from the burning of fossil fuels embedded in imported goods decreased between 1995 and 2003. Starting from 2003, it started increasing until it reached its peak value in 2010. CO_2 emissions from the household burning of fossil fuels was relatively constant between 1995 and 2008. CO_2 emissions from the household burning of biomass was relatively constant between 1995 and 2004. Since 2004, it started increasing and in 2008 the CO_2 emissions from the household burning of biomass increased by 39%, compared with its 2004 value. In 2008, CO_2 emissions from the household burning of biomass was 31 times the amount of CO_2 emissions from household burning of fossil fuels.

Table 11: Environmental and Social Performances of Haiti

Environmental performances: A ratio <1 means the country functions within the boundary level; a ratio > 1 means the country exceeds the boundary level. Areas shaded in red means areas where the country exceeds the boundary level.			
	Boundary Level (per capita per year)	**Haiti Performance (per capita per year)**	**Ratio (Haiti performance/ Boundary Value)**
CO_2 Emission	1.61 t	2.13	1.32
Phosphorous Flow	0.89 kg	0.66	0.74
Nitrogen Flow	8.9 kg	4.12	0.46
Blue Water	574 m^3	195.33	0.34
eHANPP	2.62 t C	2.16	0.82
Ecological Footprint	1.71 gha	0.67	0.38
Material Footprint	7.2 t	2.90	0.38
Social Performances: A ratio < 1 means the country fails to achieve the social outcome; a ratio >1 means the country satisfies the social outcome. Areas shaded in green means areas where the country fails to satisfy the social outcomes.			
	Threshold Value	**Haiti Performance**	**Ratio (Haiti performance/ Threshold value)**
Life Satisfaction	6.5	3.824	0.59
Healthy Life Expectancy	65	53.347	0.82
Nutrition	2700	2091	0.77
Sanitation	95%	27.6%	0.49
Access to Electricity	95%	38.69%	0.29
Income	95%	46.1%	0.41
Education	95%	42.2%	0.44
Social Support	90%	64.7%	0.72
Democratic Quality	0.8	0	0
Equality	70	43.8	0.63
Employment	94%	85.9%	0.91

The biochemical flow, both the phosphorous and nitrogen flows, have been relatively constant for the past 20 years. Phosphorous flow from the application of fertilizer embedded in imported goods increased between 2007 and 2010, with the 2010 value 47 times that of 2007. Nitrogen flow from the application of fertilizer embedded in imported goods presented a similar trend to that of phosphorous flow, which increased between 2007 and 2010 and remained constant between 2010 and 2015. Haiti's material footprint between 1995 and 2000 was relatively constant until it jumped by 21% in 2001, after which it increased gradually with the average annual increase rate of 0.76%. Data related to material consumption embedded in imported goods into Haiti are not available between 1995 and 2009 at Eora MRIO. The amount embedded in imported goods in 2010 is six times that of 2011. The value embedded in imported goods between 2011 and 2015 has been relatively constant. Haiti's ecological footprint was relatively constant between 1995 and 2014 with a difference of per capita 0.67 t during the period of 19 years. Similarly, Haiti's eHANPP increases from per capita 2.32 C t in 1995 to per capita 2.68 C t in 2000. Since 2000, it started decreasing gradually until reaching the value of per capita 2.16 C t in 2007.

It is stated in the 2016 Human Development Report that the percentage of population in Haiti that lives on less than $1.90 a day (2011 PPP) is 53.9% (UNDP, 2016b). The assumption in this thesis is in 2011 around 46.1% of the population in Haiti lived on more than $1.90 a day. The healthy life expectancy in 2006 was 50, and it increased to 53 in 2017, an average annual increase rate of 0.5%. There were no data available for Haiti's gross enrolment ratio in secondary school at the World Development Indicator, for the period between 1995 and 2015. It is stated in a 2008 UNICEF report that the gross enrolment ratio in secondary school in Haiti was 20.8% in 1991 (UNICEF, 2008). This value coincides with the value of 20.2% in 1992 provided by Nations Encyclopedia (2011). Table 12 below lists the gross enrollment ratio in secondary school in Haiti between 1991 and 1996 from National Encyclopedia. It is obvious between 1991 and 1996 that the gross enrollment ratio in secondary school in Haiti increased with a relatively steady annual increase rate of 5% - 3%. Assuming annual increase rate remains constant, the gross enrollment ratio in secondary school in Haiti is estimated as 42.15% in 2011.

Table 12: Gross Enrolment Rate in Secondary School in Haiti

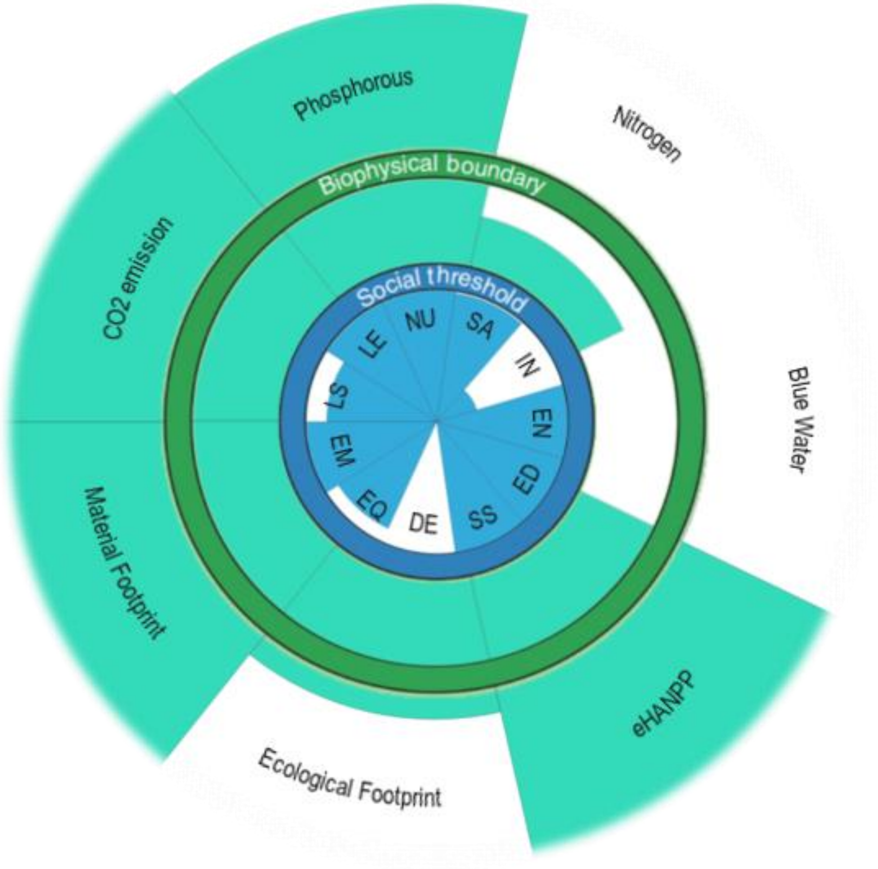
Year	Gross Enrollment Ration Secondary
1991	20.2%
1992	23.5%
1993	25.1%
1994	26.5%
1995	27.3%
1996	28.2%

Haiti's per capita calorie intake per day was only 77% of the threshold value in 2013. In 1995 only 19.2% of its population had access to improved sanitation, and 20 years later, the ratio increased to 27.6% in 2015, an annual increase rate of 2.1%. In 1995, 31.3% of its population had access to electricity, with an average annual increase rate of 1.5%, the ratio increased to 41% in 2016. The employment rate was 85.9% in 2012 but dropped by 49% to only 43.8% in 2014. Its equality value is 0.46 in 2001, 66% of the threshold value of 0.7. In 2012, it decreased to 0.42, 63% of the threshold value. In 2006, the democratic quality of Haiti was -1.053. There has been gradual increase since then and by 2017 the ratio increased to -0.735, with the threshold value being 0.8. For the two indicators that comprise the democratic quality, political stability & absence of violence and voice and accountability, both have minus values for the past 20 years. The highest social support ratio in Haiti is in 2012 when 74.9% of the population felt they had people to rely on when necessary, but it dropped to its lowest value of 55.4% in 2014. The most recent value was 64.7% in 2017, only 72% of the threshold value. People were most satisfied with life between 2011 with the score of 4.8, 74% of the threshold value. It dropped to the lowest value of 3.4 in 2016 and increased to the most recent value of 3.8 in 2017, 58% of the threshold value.

4.5 Cuba

As shown in Figure 13, Cuba exceeds 5 out of 7 planetary boundaries and achieves 7 of the 11 social outcomes. Table 13 quantifies the level of stress on the ecosystem and the extent to which social outcomes are satisfied.

Figure 13: Cuba's position within the Safe and Just Space of the Doughnut



- LS: Life Satisfaction
- LE: Healthy Life Expectancy
- NU: Nutrition
- SA: Sanitation
- IN: Income
- EN: Energy
- ED: Education
- SS: Social Support
- DE: Democratic Quality
- EQ: Equality
- EM: Employment

CO_2 emissions from the burning of both fossil fuels and biomass declined between 1995 and 2008, with periodic fluctuations. The per capita value in 2008 was 5.76 t, decreasing by 25% compared to the 1995 emission value. However, this was still 3.58 times the boundary level at per capita 1.61 t. CO_2 emissions from the burning of fossil fuels was relatively constant between 1995 and 2007. It increased by 14% from per capita 3.82 t in 2007 to 4.35 t in 2008. CO_2 emissions from the burning of biomass decreased between 1995 and 2004 with fluctuations. Since 2004, it has decreased until 2008, when the per capita is 1.41 t, a decrease of 62% compared with the 1995 value. CO_2 emissions from household activities was relatively constant between 1995 and 2008. Before 2004, the amount of CO_2 emissions from the household burning of biomass equaled the amount of emissions from the household burning of fossil fuels. Since 2004, CO_2 emissions from the household burning of fossil fuels gradually exceeded the amount from the household burning of biomass. CO_2 emissions from the burning of fossil fuels embedded in imported goods into Cuba increased until its peak value in 2008. It then decreased by 32% in 2009 and remained relatively constant until 2015.

Table 13: Environmental and Social Performances of Cuba

Environmental Performances: A ratio <1 means the country functions within the boundary level; a ratio > 1 means the country exceeds the boundary level. Areas shaded in red means areas where the country exceeds the boundary level.			
	Boundary Level (per capita per year)	**Cuba Performance (per capita per year)**	**Ratio (Cuba performance/ Boundary Value)**
CO_2 Emission	1.61 t	5.76	3.58
Phosphorous Flow	0.89 kg	1.39	1.56
Nitrogen Flow	8.9 kg	7.57	0.85
Blue Water	574 m^3	270.59	0.47
eHANPP	2.62 t C	4.52	1.73
Ecological Footprint	1.71 gha	1.91	1.19
Material Footprint	7.2 t	13.79	1.92
Social Performances: A ratio < 1 means the country fails to achieve the social outcome; a ratio >1 means the country satisfies the social outcome. Areas shaded in green means areas where the country fails to satisfy the social outcomes.			
	Threshold Value	**Cuba Performance**	**Ratio (Cuba performance/ Threshold value)**
Life Satisfaction	6.5	5.418	0.834
Healthy Life Expectancy	65	66.327	1.02
Nutrition	2700	3409	1.263
Sanitation	95%	93.2%	0.981
Access to Electricity	95%	100%	1.053
Income	95%	30%	0.316
Education	95%	100%	1.053
Social Support	90%	96.96%	1.077
Democratic Quality	0.8	0	0
Equality	70	62	0.886
Employment	94%	97.4%	1.046

Both phosphorous and nitrogen flows, from the application of synthetic fertilizer and farm animal manure, were relatively constant between 1995 and 2011. Its phosphorous flows value was 1.56 times the boundary value and its nitrogen flow was 15% lower than the boundary value. The highest material footprint of Cuba was that of the 1995value, which was 2.25 times the boundary value. It decreased by 25.8% in 2008, however, it was still 1.67 times the boundary value. Cuba's eHANPP in 2007 was per capita 4.52 C t, 1.73 times the boundary value, being the highest among all five Caribbean countries covered by this research. Ecological footprint increases from per capita 1.7 t in 1995 to 2.09 t in 2010, an increase of 22.9%. It then decreased to per capita 1.91 t in 2014, a decrease of 8% compared with the 2010 value.

From a social perspective, Cuba is dichotomous. Their stats exhibit 100% of the population having access to electricity, free medical service and a 100% gross enrolment ratio in secondary schools; however, their average monthly income is USD $32 and they have a daily ration for food supplies. No data on Cuba's poverty or income situation are available at the World Bank database. By using the 2016 Cuba average monthly salary of CUO 740, equivalent to $29.6 (Trading Economics, 2016), a daily salary of $1.35 can be calculated. Boston Consulting Group states in its research paper, Understanding the Evolving Cuban Consumer, that 75% of households in Cuba earn less than $1000 a year (BCG,2016), equivalent to per day $2.74. However, this has no indication on the size of the household and the percentage of salary spent to meet basic daily needs. The United Nations Development Programme states 5.6% of the total employment as "working poor" in Cuba are at $3.10 a day (UNDP, 2018b) in its Cuba country profile. In this thesis, it is assumed that around 30% of the Cuban population lives on more than $1.90 a day, based on data provided by Boston Consulting Group.

In terms of its equality, no value is available for Cuba for any periods between 1995 and 2015. Myra Espina, a Havana professor, is quoted to say that Cuba's Gini index of income inequality rose from 0.24 in 1986 to 0.28 in 2000 (Frank, 2008). Based on this, in this thesis an equality value of 62% is assumed for Cuba, covering 89% of the threshold value and the highest value among the five nations covered by this research. In 1995, 84.1% of its population had access to improved sanitation and after 20 years, the ratio rose to 93.2%, the highest value among the five selected Caribbean states, though still 1.8% lower than the threshold value. Cuba's health life expectancy is 66 years, the highest among the five selected nations. Both its social support and employment rate scores are the highest among the five countries, with 97% of its population feeling they had people to rely on when necessary and 97.4% of its working population being employed in 2017.

5 DISCUSSIONS

This thesis follows the rationale of vulnerability assessment preconditioning sustainable development in the sense that both environmental and social vulnerabilities challenge the dual objectives of sustainable development. In terms of vulnerability assessment, this thesis regards vulnerability as the product of interactions between multiple biophysical and human processes, acting upon the coupled socioecological systems with multiple feedbacks across scales. By using environmental and social indicators identified within the Safe and Just Space framework, this thesis adopts a place-based approach to assess the environmental and social performances of five Caribbean small island states and their contextualized and multi-dimensional interactions. In this way, this thesis reveals what might have hindered these five nations' transition to sustainability by analyzing their vulnerabilities from both environmental and social perspectives and explores what might be key element for the transition to sustainability. Table 14 presents an overall assessment of these five nations' environmental and social performances from which a positive relationship between high level of stress on the ecosystem and the achievement of most social outcomes can be can be identified.

5.1 Trinidad & Tobago

Being a high-income country by United Nations Human Development Index standards, Trinidad & Tobago fails to satisfy 6 out of 11 social outcomes and exceeds 6 out of 7 planetary boundaries. Its 2008 per capita CO_2 emission and material footprint values are more than 30 and 9 times the boundary values respectively. Assessed by the sharp contrast between the heavy stress on the ecosystem and the relative lack of social progress, Trinidad & Tobago's development process does not look promising, especially within the context of climate change and the associated global GHG emission mitigation.

It is stated in the Review of the Economy 2017 issued by the Government of Trinidad & Tobago (Government of TTD, 2017), starting from 2013, petroleum sector's contribution to its GDP decreases from 37.9% to 33.7% in 2017. The decrease of 11% coincides with the decrease of 8% of its GDP per capita from 2103 to 2017(World Bank, 2017). Despite government's efforts to boost economic diversification, petroleum sector still plays a major role in Trinidad & Tobago's economy, the stagnation of which inevitably leads to lack of economic growth with wider social and environmental implications. The heavy economic dependence on the energy sector pivots the multi-metric interactions between its environmental and social performances.

The economy of Trinidad & Tobago is featured as a "dual economy", i.e., the benefits of large investments in the energy sector do not easily distribute over to the rest of the economy (Artana, et al.,2007). This is also termed as "Dutch Disease", which in the case of Trinidad & Tobago, rather than contributing to the overall economic development, the natural resource abundance and growth of the oil and gas sector hinder economic diversification and social progress and eventually lead to the degradation of the social and biological environments. Economy that suffers from the "Dutch Disease" is characteristic of macro-economic volatility. Trinidad & Tobago's economy has a trend of extreme volatility, with its per capita real GDP in the last 50 years being one of the most volatile among a group of comparable economies (Artana, et al. 2007). Its economic cycles are also characterized by large amplitudes and long recovery periods. The prospect of its economic sector's recovery in the near future is grim because of the maturing oil fields and lower and more volatile oil prices in the future and the resulted structural declining of oil products (Jeetendra, 2016). The Central Bank of Trinidad & Tobago announces officially in 2015 the country is in economic recession and the trend continues to 2017 with the GDP annual growth rate of -2.34%(World Bank, 2017). The ecological footprint of Trinidad & Tobago decreases between 2009 and 2014, which, in association with the officially acknowledged economic recession, might be related more to the decrease in economic growth than with a more green-oriented development mode. Trinidad & Tobago's CO_2 emission and material footprint have been on steady rise between 1995 and 2008, with its 2008 value 34 and 9 times respectively the boundary values. Data related to its consumption-based CO_2 emission and material footprint after 2008 are not available at Eora MRIO when this thesis is being developed. It is worthwhile to compare the CO_2 emission and material footprint values after 2008 with values of previous years to see whether there has been any proportional decline associated with the economic depression.

Vulnerabilities associated with the volatility of the global market is coupled with the uncertainty of impacts of GHG regulations on oil demand and oil prices over the next 20 years (Sanchez-Sierra, 2005). Any international GHG emission mitigation initiatives might lead to further economic stagnation or even degeneration unless the country can effectively diversity its economy. Besides, the approaching exhaustion of the finite reserves of oil and natural gas also challenge Trinidad & Tobago's economic and social perspectives. Between 1998 and 2007, the timeline until oil exhaustion remained constant at 15 years, indicating that discoveries of new oil reserve e might match extraction during this period. However, the scenario is totally different when natural gas is concerned. In 1998 there were an estimated 65 years of production left for natural gas, but this fell to only 12 years in 2007 as natural gas production increased by 351% from 1998 to 2007 (Ram, 1012), which indicates not only the increasing dependence on natural gas but also the possible lack of efficiency and product diversification and innovation.

The overdependence of Trinidad & Tobago's economy on the energy sector has permeated into different social sectors with environmental implications, which jointly comprise its systematic vulnerability. In O'Neill et al.'s research (2018), income is assessed by the percentage of the population that lives on more than $1.90 a day. There has been no data available for Trinidad & Tobago relevant to this indicator at the World Bank database for the period between 1995 and 2017. The assumption is that since the state belongs to the high-income group, 100% of Trinidad & Tobago's population should live on more than $1.90 a day. However, Trinidad & Tobago might be regarded as a poverty-stricken country if the multi-dimensional aspects of poverty are interpreted within its social context. Poverty in Trinidad & Tobago is closely associated with its unemployment rate, which is pivoted by the volatile global oil market, and social inequality associated with the difficulty in distributing profits from the energy sector for economic diversity and social progress.

According to the Human Development Report, Trinidad & Tobago belongs to the high-income group with a GDP per capita of USD 31,577.7 in 2017 (UNDP, 2016b). However, between 1990 and 2001, approximately 12.4% of its population earns less than $1 per day and 39% on less than $ 2 per day (Cambridge, et al. 2007), which might challenge the assumption that currently 100% of its population live on more than &1.90 a day, even despite possible income increase during the past 16 years. In Trinidad & Tobago, because the revenues from the energy sector do not easily distribute to the rest of the economy, even at the height of the first oil boom between 1973 – 1982, its unemployment rate does not fall substantially below 10%. As the international oil price declines during the 1980's, Trinidad & Tobago's per capita GDP drops by 43.9% from 1982 to 1992, with the unemployment rate rising from 10% to 20% (World Bank, 1995). Poverty in 1980s in Trinidad & Tobago is characteristic of the new phenomenon of the "New Poor", the group that becomes unemployed during the mid-eighties (Cambridge, et al., 2007). Within the context of the volatile oil market,

Table 14: Overall Assessment of Environmental and Social Performances of Five Caribbean Nations

	Trinidad & Tobago	Dominican Republic	Jamaica	Haiti	Cuba
Environmental Performances: Individual Country's performance value/Boundary Value. A Ratio > 1 means the country exceeds the specific boundary					
CO_2 Emission	*32.5*	2.94	4.73	1.32	3.58
Phosphrous Flow	*2.15*	1.77	1.36	0.74	1.56
Nitrogen Flow	*1.05*	0.93	0.65	0.46	0.85
Blue Water	*0.49*	0.58	0.40	0.34	0.47
eHANPP	*1.08*	1.06	0.98	0.82	1.73
Ecological Footprint	*4.8*	0.99	1.20	0.38	1.19
Material Footprint	*9.66*	1.76	3.04	0.38	1.92
Social Performances: Individual country's performance value/threshold value. A ration < 1 means the country fails to satisfy the specific outcome					
Life Satisfaction	0.95	0.86	0.91	0.59	0.83
Healthy Life Expectancy	0.95	0.98	1.01	0.82	1.02
Nutrition	1.13	0.97	1.02	0.77	1.26
Sanitation	0.96	0.88	0.86	0.49	0.98
Access to Energy	1.05	1.05	1.03	0.29	1.05
Income	1.05	1.03	1.03	0.41	0.32
Education	0.9	0.81	0.85	0.44	1.05
Social Support	1.01	0.99	1.01	0.72	1.08
Democratic Quality	0.36	0.3	0.27	0	0
Equality	0.84	0.79	0.61	0.63	0.89
Employment	1.01	1.00	0.94	0.91	1.05

poverty in Trinidad & Tobago is closely related with unemployment. Between 1982 and 1992, the declining of the international oil price leads to rising unemployment, which in turn causes the decline in real value of social sector spending, followed by the resulted retrenchment of workers in the public and other private sectors, and ultimately contributes to the increase in poverty (World Bank, 1995). Although Trinidad & Tobago's employment rate in 2018 exceeds the threshold value of 94%, it starts decreasing since 2017, which can be related to the economic recession officially declared in 2015, considering the lag time between economic depression and its impacts on unemployment. Considering its current lack of effective economic diversification (Baldeosingh,2018), the trend of the period between 1982 and 1992 might repeat within the overall context of volatile global oil market and Greenhouse Gas mitigation initiatives.

The CIA World Factbook (2014) indicates in 2007 approximately 17% of the nation's population falls below the national poverty line. The Borgen Project, a non-profit organization that addresses poverty and issues, discusses the prevalent poverty in Trinidad & Tobago, despite its status as one of the strongest economies in the Caribbean region. The disparity between its economic status and the percentage of its population below the national poverty line reveals its lack of social equality. Its equality score has been decreasing between 2002 and 2005, with the most up to date value in 2005 84% of the threshold value. In Trinidad & Tobago, the fact that other sectors cannot benefit from the fast growth of its energy sector and the resulted income disparity among different sectors play a key role in its social inequality (Bourne, 2008). Social inequality tends to worsen the unequal distribution of natural resource rents and further deteriorate its Dutch Disease (Ali & Sami, 2016). In turn, the increasing overdependence on the energy sector in Trinidad & Tobago leads to higher-level of income disparity and eventually poverty among population who cannot benefit from the growth of the energy sector tends to grow.

Another lens through which the poverty situation of Trinidad & Tobago should be interpreted is its heavy reliance on strategic imports for its food supply. Its overdependence on the energy sector has led to the collapse of its traditional agriculture (Office of Disaster Preparedness and Management, 2014). The 2007 data indicates that Trinidad & Tobago imported 86% of its food requirements (John & Seetahal, 2008). The high reliance on foreign food supplies exposes local consumers to global market forces, with its Consumer Price Index (CPI) increasing from 3.5 in 1972 to 140.3 in 2017(World Bank, 2017). The gap between the increase of CPI and the increase of per capita income reflects the situation of poverty in Trinidad & Tobago is more complex than what can be simply measured by the percentage of population living on more than $1.90 a day.

With direct impacts on household activities, poverty and inequality can restrain overall social progress by negatively influencing the function of other social sectors. No data related to the gross enrollment rate in secondary schools are available for Trinidad & Tobago at the World Bank database for the period between 1995 and 2017. According to Artana et al. (2007), Trinidad & Tobago's gross enrollment rate increased from 68.8% at the end of the 1970s to 83.8% in 2004, which is 11.8% lower than the threshold value of 95% and only just equal to regional average within the Caribbean, despite its much higher income level within the region. It is mentioned by Artana et al. (2007) that the returns for finishing primary education, secondary education and non-university tertiary education are quite low in Trinidad & Tobago, compared with the average level in the Caribbean, which might explain its relatively low gross enrolment rate in secondary school. In contrast, there is a big gap between returns to university and returns to secondary education in Trinidad & Tobago. The authors believe within Trinidad & Tobago's economic structure, the difference in wages is likely to be more related to the differences in GDP composition or economic activities, rather than to the differences in the level of education received. Considering the relatively low gross enrollment rate in secondary school, it is reasonable to assume the percentage of people who finish higher than secondary education might not be high, which might lead to even lower enrolment rate at higher education. In 1996, the gross enrollment ratio for higher education was only 8% for males and 7% for females (Education Encyclopedia, 2018). These values may be reflective of the lacking supply and demand of a well-educated workforce.

In Trinidad & Tobago, revenues from the energy sector fail to contribute to the development of infrastructure to support more sophisticated upstream energy industries. Domestic economic activities are mainly focused on low-end commodity goods, which might not encourage a more well-educated labor force. The lack of market drive explains its unsatisfactory education performance and its high emigration rate, one of the highest emigration rates for skilled workers in the Caribbean region (Artana, et al. 2007). The less well-educated domestic workforce, together with the “brain-drain” resulted from the emigration of skilled workers, in turn weakens the production capacity and innovation, which further restricts its production to low-end commodities with no associated efficiency. The dominating role plays by the low-end production because of the lack of technology and human capital needed by energy and production efficiency can explain its high CO_2 emission and material footprint values.

Trinidad & Tobago’s overdependence on its energy sector and the social implication can also be interpreted by reviewing its per capita calorie intake per day and its expected Healthy Life Expectancy. Its per capita calorie intake per day exceeds the threshold value by 13%. On global level, it might be appropriate to use calorie intake as the nutrition indicator, however, in the case of Trinidad & Tobago, calorie intake by itself cannot present a whole picture of its average nutritional intake. According to WHO’s 2016 Diabetes Country Profile (WHO,2016a), 24.9% of the male and 39.5% of the female are obese in Trinidad & Tobago. The Ministry of Health also reports in Trinidad & Tobago, the percentage of deaths due to Chronical Non-Communicable Diseases (CNCSS), which is closely related to overweight and obesity, is 60%, the highest in the Caribbean, (Ministry of Health, 2012). This aligns with its average healthy life expectancy of 61.7, 3.7 years lower than the threshold level of 65. Obesity is a complex issue that can be interpreted from different social and cultural perspectives. However, although it is hard to prove the causal relationship between education and obesity, Devaux et al. (2011) present a broadly linear relationship between the number of years spent in full-time education and the probability of obesity, with the most educated individuals displaying lower rates of the condition. Increasing education at any point along the education spectrum might reduce obesity to a similar degree. The relatively unsatisfactory performance in Trinidad & Tobago’s education sector and its high death rate caused by CNSS provides an angle through which the social implication of its overdependence on the energy sector can be interpreted.

Trinidad & Tobago’s obesity rate also reveals another perspective through which the social implication of its reliance on the energy sector can be analyzed. Its food provision depends on strategic imports because of the declining of its traditional agriculture. Trinidad & Tobago exceeds the biochemical boundaries for both nitrogen and phosphorous flows, but all flows are amounts embedded in imported goods since no domestic contribution is recorded at Eora MRIO. Data unavailability itself indicates lack of effective management, which can be related to its overall underperformance of its agricultural sector. Trinidad & Tobago are heavily reliant on imported fruits and vegetables and consequently, they cannot ensure the availability of many foods essential for a healthy diet. The domestic food consumption consists mainly cereals and sugar crops and any price increase of fresh products tends to increase the percentage of cereals and sugar crops in the diet (Hawkes, et al. 2010). The CPI increase from 3.5 in 1972 to 140.3 in 2017 (World Bank Database, 2017) indicates price increase of imported fresh fruits and vegetables and the possible decreased percentage of fruits and vegetables in the diet structure.

Another perspective from which the social implication of its dependence on the energy sector can be discussed is its democratic quality. In this thesis, democratic quality is estimated as the unweighted average of the scores of two Worldwide Governance Indicators, Voice & Accountability and Political Stability & Absence of Violence. The most recent democratic quality score for Trinidad & Tobago is 0.29, 64% lower than the threshold value of 0.8. Although the democratic quality score is the unweighted average of those two governance indicators, in Trinidad & Tobago, the performances of these two indicators vary, which can be linked to the role energy plays in its overall economy. Between 1996 and 2016, the score for Voice and Accountability ranges between 0.8 and 0.5 whilst the score for Political Stability and Absence of Violence shifts between -0.1 and 0.4. Compared with Voice and Accountability, the country obviously performs much worse when stability is concerned. Artrna et al. (2007) attribute Trinidad & Tobago's weaker institutions to "Natural Resource Curse", as part of the "dual economy" phenomenon, in which most of the government revenues come from oil and gas, not from general taxes from more diverse sectors. Democratic politics tend to work differently in a weak institutional environment because of the uncertainty associated with weak institutional power. The incentives of actors within such a context for compliance with formal rules are relatively weaker, which can somehow explain why violent crime rates in the Caribbean region is higher than in any other part of the world and why Trinidad & Tobago sees its overall crime rate escalating at a phenomenal rate within the past 10 years (Levitsky & Murillo, 2011, Sookram, et al. 2009). After empirically evaluating the effect of the criminal justice system and socio-economic conditions on serious crime in Trinidad & Tobago between 1970 and 2007, Sookram et al. (2009) suggest crime detection rate, as part of the institutional capacity, unemployment rate and tertiary education are all related to Trinidad & Tobago's current high rate of violent crime, all of which can be attributed to its overdependence on the energy sector. Its income disparity because of the resulted disillusionment within sectors that cannot benefit from the growth of energy sector and are deprived opportunities for economic mobility also contribute to its lack of social and political stability (Stiglitz, 2017). Crime and lack of stability have been identified as major challenges in Trinidad and Tobago for investment in private sectors, which deters the diversification of its economy and further deteriorates the current situation that suffers from the Dutch Disease (IDB, 2013).

As one of the strongest economies in the Caribbean region, Trinidad & Tobago fails to distribute the benefits from the energy sector for general social progress. 100% of the population in Trinidad & Tobago have access to electricity, which is not surprising considering its high CO_2 emission and heavy dependency on fossil fuel. However, the situation with regards to the percentage of population having access to improved sanitation is not equally promising. In 1995, 90.3% of the population has access to improved sanitation facilities in Trinidad & Tobago. After 19 years, the ratio increases only to 91.5%, still 3.7% lower than the threshold value. The annual growth rate of 0.19% might be related to the fact that weakened institutional capacity fails to redistribute profits from energy sector for effective improvement in people's living condition. Faced with the unpromising and volatile energy market, the approaching depletion of natural resources on which national economy solely depends on, unpredictable imported food price and the unbalanced diet, increasing unemployment and inequality, it is not surprising to witness the life satisfaction rate's decreases between

2006 and 2017. Although it is hard to quantify people's perception of life satisfaction, the decreasing score partially reflects Trinidad & Tobago people's lack of optimism when positioned within an uncertain context.

Country Summary

Within the analytical framework of Safe and Just Space, Trinidad & Tobago can be categorized as vulnerable if the level of stress on the ecosystem is associated with the achievement of social outcomes. By interpreting its environmental and social performances, it is clear within its current development process, the satisfaction of social outcomes relies on heavy stress on the ecosystem and the transgression of the environmental ceiling is closely associated with its social foundation. At the core of Trinidad & Tobago's vulnerability profile is its "dual economy" with overdependence on the energy sector that pivots its unsatisfactory social performances and the heavy stress on its ecosystem. Its CO_2 emission and material footprint have been on the rise since 1995 and in 2008 the per capita values of these two indicators are 9.1 and 5.3 times the global average respectively. In contrast, it only satisfies 5 out of 11 social outcomes. The weakened social foundation and deteriorated environment will, in turn, further victimize the economy by depriving it of the biophysical and social environments necessary for its transition to sustainability, such as the stability and infrastructure to attract investment and well-educated and healthy workforce. Dr. Roger Hosein, the economist from University of West Indi attributed Trinidad & Tobago's failure in economic diversification and overdependence on the energy sector in the period between 1999 and 2016 to lack of initiative and capacity of the state (Baldeosingh, 2018). As part of the 2020 Voluntary National Review of the High-level Political Forum on Sustainable Development Trinidad & Tobago expresses its determination to transit to a more sustainable mode (Sustainable Development Goals Forum, 2018). It requires a strong government with sufficient strategic thinking to look beyond the short-term benefits and redistribute wealth from the energy sector for the necessary economic diversification and mobility.

5.2 Dominican Republic

Dominican Republic has been enjoying steady economic progress over the past 25 years. Its average annual growth rate between 1993 and 2017 is 5.3%, which makes the country one of the top performers in the Caribbean (World Bank Group, 2018a). However, what contrasts with the economic growth is its unsatisfactory social progress and pressure on the ecosystem. It exceeds 4 out of 7 planetary boundaries, with ecological footprint and nitrogen flow only marginally within the boundaries and achieves only 3 out of 11 social outcomes. What is behind the disparity between the heavy stress on the ecosystem and lack of social progress is its failure to transform benefits from steady economic growth into an improved social infrastructure to facilitate both environmental and social progress.

Using income as an example, Dominican Republic exceeds the threshold value, with 98.1% of its population living on more than $1.90 a day. However, this only makes sense when we view this value through a lens of "absolute poverty"—which refers to poverty defined by a general definition that is valid for all economics—not necessarily when we look at "relative poverty"—when poverty is interpreted on a country, within its social context. In Dominican Republic, the moderate monetary poverty line is $4.70 per day for urban areas and $4.20 in rural areas. Taking into account these numbers, when assessed in 2011, 40.4% of the population lives below the relative poverty line (World Bank, 2014). The contrast between the average annual GDP growth of 5.3% and the percentage of more than 40% of its population living under the national poverty line reveals the dissonance between economic growth and social progress with its root cause embedded in its development model.

What underpins Dominican Republic's high economic growth is a series of key economic reforms that support generous and widespread tax incentive for the private sectors. In addition, its proximity to the US and Canadian markets helps shape FDI inflows (World Bank, 2018). Dominic Republic's beaches and easy ocean access provide it with a natural advantage for a strong touristic sector. The tourism sector accounts for 15.3% of its GDP and 14% of its employment (Fawcett, 2014). One fundamental weakness of such an economic model is the low tax collection constrains the government revenue, which in turn hinders the investment into public infrastructure, and consequently the quality of services in education, sanitation and health suffers. Economic growth promotes rapid urbanization without either sufficient institutional capacity to guide the process or social services to accommodate the associated environmental stress.

Government mandated tax incentives impose constraints on the competitiveness of the labour market and innovation that supports better-paid jobs that require a more skilled work force. The lack of opportunities in the labor market and the poor quality of public infrastructure and services, combined with its traditional closer relationship with the U. S., drive up Dominican Republic's emigration rate. Dominican Republic's emigration rate is one of the highest in the Caribbean region, with long-term economic, social and environmental implications (World Bank, 2014). In a short term, it supports economic growth and helps poverty reduction via remittance, which contributes 8% to GDP and lowers the poverty rate by 3%. It also helps increase Dominican Republic's employment rate by reducing the participation of recipients in the domestic labour market (World Bank, 2014). However, the economic and social contribution from remittance is far from being sustainable. Its contribution to GDP is vulnerable since it is totally subject to the fluctuations of the foreign markets. In the long run, remittance tends to increase income disparity and deepen social inequality. It is stated in the World Bank report (2014) that nearly 40% of the remittance accrued to the households belong to the top income bracket. Finally, remittance does not contribute to the part of national revenue that is invested in public infrastructure and services. Finally, remittance does not contribute to the part of national revenue that is invested in public infrastructure and services. The resulted disparity between increased public expenditure and less developed social infrastructure and absorbing capacity leads to heavier stress on the ecosystem. In a long run, the high emigration rate, together with the unsatisfactory performances of its education sector, also tends to worsen the overall poverty situation in Dominican Republic. In 2016, its Gross Rate of Enrollment in Secondary Schools is 77%, only 81% of the threshold value. The disparity between its steady economic growth measured by GDP-related indicators and the unsatisfactory performances of its education sector unveils the government's inability to invest effectively in public sectors. The brain-drain associated with its high emigration rate leads to an even less well-educated domestic workforce. Migrants to the U.S. are more educated than those who stay in the country, with 66% of migrants who are 25 years old or older having completed secondary education or higher, compared with only 40% of those who reside in the country (World Bank, 2014). The feedback loops between the quality of the labor force and competitiveness of the labor market work both ways. The relatively low quality of the labor force restrains the labor market to low-end and less well-paid jobs. Consequently, the lack of competitiveness of the labor market drives up emigration and consequently more brain-drain, which leads to even lower quality of the labor force and less competitive labor market.

The relationship between the employment rate and economic growth is contextual. Normally we associate high employment rate with economic growth, however, in conjunction with other social indicators, we can also relate the high employment rate to poverty since the higher employment rate indicates smaller percentage of people can afford to live without having jobs. Among the unemployed population of Dominican Republic, the percentage of people who are unemployed but available to work and active to seek for jobs is higher than those who are unemployed and available to work but are not active to find jobs (World Bank, 2018). Besides, the disparity between the employment rate of 98% and 40% of its population living under the national poverty line reveals the possible underemployment of its job market. The underemployment of Dominican Republic's job market indicates there is high percentage of population who are educated to have better-paid jobs but cannot find appropriate employment (World Bank, 2018). Underemployment tends to drive up its emigration rate, which, together with the unsatisfactory performances of its education sector, further intensifies the low quality of the domestic labor force. The lack of competitiveness of the labor market leads to the lack of economic mobility in Dominican Republic. It is stated in the World Bank's Strategic Diagnose (2018) that between 2000 and 2011, less than 2% of its population experience upward mobility[13], while 19% slide down in economic status and 79% of the population make no economic progress during the period of 11 years. The lack of economic mobility and the unbalanced distribution of remittance tend to deepen social inequality with considerable social implications.

One aspect of the social implication associated with Dominican Republic's social inequality is its unsatisfactory score for democratic quality. Between 1995 and 2016, Dominican Republic's lowest score for democratic quality, as an indicator for social stability, is 0.01 in 2010. It is most recent value for this indicator is 0.2, 25% of the threshold value. Compared with Voice and Accountability, its performance in Political Stability and Absence of Violence is worse with the relevant scores varying between -0.4 and 0.3 between 1995 and 2016. Alesina & Perotti (1993) talk about the relationship between income distribution and political instability. They conclude that income inequality tends to increase social-political instability through fueling

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[13] Upward mobility means escaping poverty to move into the vulnerable group or moving from vulnerable to middle class (World Bank, 2018).

social discontent and lessening social consolidation. The lack of social-political instability and the resulted uncertainty will eventually reduce investment and therefore hinders economic growth and mobility. Another important governance indicator, Control of Corruption, is not applied in O' Neil et al.'s research. However, it is an important indicator by which Dominican Republic's social performances are to be assessed. Dominican Republic is ranked by Transparency International as one of the most corrupt countries in 2015. Its score for control for corruption from the World Bank is -0.8 in 2016[14]. Corruption tends to intensify during modernization with the development of new sources of wealth and power and the appearance of new classes having new demands on government (Huntington, 2002). The wide-spread corruption between 1995 and 2016 in Dominican Republic can be linked to the disparity between economic growth and the weak government that lacks the capacity for effective monitoring and supervision. Using fiscal decentralization as an example, in developed countries, this approach is adopted as an effective means to better respond to local population needs and provide greater variety of public goods (Tiebout, 1956). Meriem, Hassan, Ayman (2016) insist the decentralization of expenditures has a significant reduction effect on corruption risk in emerging and developing countries. However, it is more commonly acknowledged that in emerging and developing countries, there might be increased corruption following decentralization. It might be easier for local decision makers within a country with relatively weak monitoring mechanism to establish privileged personal relationships with the local interest groups (Prud'homme, 1995; Bardhan, 2002). The availability of trained local personnel preconditions more efficient decentralized fiscal operations, which local governments of emerging and developing countries often lack (Wasylenko,1987). As part of its anti-corruption initiative that starts in 2010, the President of Dominican Republic issues a Decree to centralize the procurement of medicines in a single government entity in 2015, the operation of which is under the monitoring of a Citizen Observatory for Implementation (OCI-IPAC), comprising of 14 civil society organizations (World Bank, 2015b). The approach of "centralization" indicates the possible lack of suitable operating context required by effective decentralization of expenditure. Its score for the Control for Corruption is -0.8 in 2016 (World Bank, 2016), 6 years after the Anti-Corruption Participation Initiative launched by the President in 2010, indicates the probable failure of this initiative.

Another aspect to analyze Dominican Republic's social performance is its paradoxical national nutrition profile. On the one hand, the per capita calorie intake of Dominican Republic fails to meet the threshold value of per capita 2700 kcal per day, which indicates the possibility of the majority of its population failing to get sufficient energy intake. On the other hand, Dominican Republic has the overweight rate of 58.4% and obesity rate of 23% (WHO, 2016b). Such a paradox can be linked to its embedded social inequality and its vicinity, openness and attachment to the western, especially the U.S. market. In developed countries, overweight and obesity occur more frequently among the poor, however, the opposite happens in less developed countries where in households undergoing nutritional transition, underweight can coexist with obesity (Kain, et al. 2003). The increased "westernization" in developing countries like Dominican Republic leads to the households with increased income buying energy-intense food (Uauy, et al. 2001; Martorell, et al. 2000). Considering the ratio of 40% of its population living under the national poverty line, contrary to the trend in more developed countries, people who are overweight or obese in Dominican Republic tend to be the relatively wealthy ones who are more likely to be influenced by and have access to the U.S. life style, including energy-intensive food.

[14] It is 2.2 for both Norway and Denmark, 1.9 for the United Kingdom and 1.3 for the United States

HIV/AIDS rate is another health-related challenge on the national level, which is not applied in in O'Neill et al.'s research (2018) but is essential when assessing social performances for f the Caribbean region in general and more specifically for states such as Dominican Republic and Jamaica where HIV/AIDS rate is closely linked to its economic growth. According to a research conducted in 2011 (Padilla, et al.), currently the Caribbean region has the highest prevalence on HIV infection outside of sub-Saharan Africa. As of 2007, nearly three fourths of the region's AIDS cases occur in Dominican Republic and Haiti. In Dominican Republic, the disparity between the fast growth of its tourism sector and lack of opportunities in other sectors, especially agriculture, motivates rural population to migrate to costal tourism zones with higher exposure to HIV/AIDS risks. Padilla et al. (2011) regards tourism areas as an epicenter of demographic and social changes linked to HIV/AIDS risk, including transactional sex, elevated alcohol, substance use and internal migration. Insufficient education restricts the local labor force from taking relatively high-end jobs within the tourism sector. Instead, men and women in Dominican Republic are driven by the perception of greater potential compensation to get engaged regularly or situationally in sexual exchanges with tourists. According to Padilla et al. (2011), the fact that these people also participate in a range of other tourism jobs, including hotel work, taxi driving or tour guide services, indicates the fluidity of informal income-generation activities in tourism areas and the integration of transactional sex into the broader Dominican tourism economy. The high HIV/AIDS rate in Dominican Republic further deprives the country of the necessary social and human capital necessary for its long-term development.

From environmental perspective, the economic growth with no proportional social progress inevitably has its environmental consequences. Dominican Republic's CO_2 emission is 2.9 times the boundary value, which increases by 17% between 1995 and 2008. In 2008, the household-related CO_2 emission from burning of biomass is 2.21 times the emission from burning of fossil fuels. Dominican Republic's energy market is dominated by imported fossil fuels as both primary and secondary sources. The volatility of the oil price is one determining factor for the dominating role played by biomass as the main household energy source, despite its economic growth. For national production, CO_2 emission from burning of fossil fuels has increased by 31% during the same period, which reveals the country's increasing dependence on fossil fuels with the growth of its economy, however, with no associated energy efficiency. The increasingly important role tourism plays in the country's economy will lead to further increase of CO_2 emission and material footprint because of the construction of luxury hotels and provisions of a variety of tourism services, considering its lack of organizational capacity and technology required by energy and material efficiency (IRG, 2001).

The amount of nitrogen flow, from both synthetic fertilizer and manure, embedded in imported goods, increases from 6866 ton in 2010 and 16145 ton in 2011, an 235% increase, which indicates the its heavy dependence of strategic imports for its food supply. Despite Dominican Republic's increasing dependence on imported goods as food supply, starting from 2009, agriculture contributes 8% to total national GDP. The majority increases in its crop production are attributable to intensification of fertilizer uses (IRG, 2001). It is stated in the same report that livestock production also intensifies, which poses threats to water quality from manure and processing wastes. The phosphorous flow of Dominican Republic exceeds the threshold value whilst the nitrogen flows 93% of the boundary value. Considering the current institutional capacity and the education level of its rural labor force, the optimization of fertilizer management remains a tough challenge for the country.

Country Summary:
Dominican Republic has been undergoing steady economic growth, but with stagnant social progress and considerable stress on its environment. Its satisfaction of 3 out of 11 social outcomes while exceeding 4 out of 7 planetary boundaries reveals the vulnerability of the "invalid" economic growth with no proportional social progress at the cost of its environment. Within the coupled socio-ecological system, Dominican Republic's lack of social development not only fails to mitigate stress on the ecosystem, but also deprives the country of sufficient institutional and human capital necessary for the improvement of its environment and social performances.

One root cause for its current systematic vulnerability is its development policy of driving economic growth through tax reduction that leads to the lack of investment in public goods and social infrastructure. With tourism becoming a primary pillar for its economy, it remains a great challenge for the country whether it has the human and institutional capacity required for a more sustainable development mode. It is stated in an International Resources Group report that the international tourism is having a detrimental impact on Dominican Republic's coastal resources. With no environmentally sound urban and rural planning, the short-term profitability brought about by the growth of tourism tends to be outbalanced by further damage to its environment and ecosystem. In turn, the degraded environment will not only have direct negative impacts on life standards, but will also erode both the economic and social capitals needed for its long-term sustainability. For its transition to sustainability, Dominican Republic needs sufficient institutional capacity to distribute benefits of its economic growth to the necessary construction of social foundation.

5.3 Jamaica

The World Bank defines Jamaica as an upper middle-income country with the world's lowest annual growth rate, struggling with high public debt and external shocks (World Bank, 2018b). Earnings from remittances and tourism accounts for about 15% of its GDP and bauxite/alumina exports have declined, but still account around 5% of GDP (Index Mundi, 2018). As one pillar of its economy, Jamaica's tourism sector differs from the rest of the Caribbean in that the US market makes up more than 70% of its visitors. The heavy dependence on one sector within one market makes its economy vulnerable to any major external fluctuations related to its sole external market. The employment rate of Jamaica in 2007 was 90.3%, the highest for the period between 1995 and 2007. It started a downward trend in 2008, dropping to an ultimate low of 84.7% in 2013. The fact that the downward trend of its employment rate synchronizes with the 2008 global financial crisis in the U.S. reflects its overdependence on the U.S. market. As for remittance, this could contribute to temporary poverty reduction, but the extent to which a country can benefit from remittances is closely related to its institutional capacity and macroeconomic environment (Ratha, 2013). Bauxite might still provide a significant contribution to Jamaica's exports, but it only has a projected lifespan of 40 more years (Weis, 2004). In short, Jamaica's economy is faced with a future beyond its own control. Embedded in such a development context are Jamaica's unsatisfactory environmental and social performances, exceeding 4 out of 7 planetary boundaries and satisfying 5 out of 11 social outcomes.

Lying at the core of Jamaica's vulnerability profile is its weak institutional capacity with multi-dimensional social, economic and environmental implications, including marginalized agriculture, fast-growing mass tourism with no associated economic growth, and stagnant social progress. Jamaica has been categorized as a substantial net importer of livestock-based staples, and the monetary value of imported dairy and meat products exceeds the combined earnings from coffee, banana and sugar exports. The lack of growth of Jamaica's traditional agricultural sector in recent years can be partially attributed to its very risky natural conditions, which tend to be exacerbated by climate change (Polo et al., 2014). Besides the natural environment, the "marginalization of peasantry" and trend of "irrelevance" of agriculture as the result of the structural reform, as outlined by The World Bank and International Monetary Fund (IMF), also contribute to the lack of growth of its traditional agriculture (Thomas-Hope & Jardine-Comrie, 2007; Weis, 2004).

Despite its dwindling contribution to national GDP, agriculture is still the main livelihood in rural Jamaica (Polo, et al. 2014). Its marginalization tends to have severe impacts on its rural population, who are already victimized by unequal landownership. Jamaica's land-use matrix, as part of its colonial legacy, has hardly evolved since Emancipation in 1838. By the late 20th century, 3% of landowners controlled 62% of Jamaica's farmland and roughly 80% of all farmers possessed less than 20% (GoJ, 1992; World Bank, 1993). On top of the unequal landownership, the enforced trade liberalization, as part of the structural adjustment, further marginalized the rural population because the increased volume of cheap subsidized food imports severely constricted local farmers' access to domestic markets. The forced retreat of the state led to reductions in domestic production services where farmers could have received support (Newman & Lefranc, 1994; Anderson et al. 1994, Meikle, 1992). Exposed to both limited land ownership and challenges associated with agricultural marginalization, the impoverished peasants were driven to turn farmlands into cash crop plantations or clear off forests for the plantation of gourmet coffee or bauxite mining (Berglund & Johansson, 2004; Lundy, 1999). Such practice has become increasingly widespread because Jamaica's land policy grants landownership if the family land claim is unchallenged over a specific period. Jamaican government encourages such efforts because of the mandated export orientation required by the structural adjustment and the country's desperate need for foreign exchange (Thomas-Hope & Jardine-Comrie, 2007; Weis, 2004).

Jamaica's land-use matrix mentioned above reveals the historical lack of equality within its social system, which has been intensified by the fact that despite its declining, agriculture is still the main livelihood in rural Jamaica. As a medium high-income country by the World Bank criteria, 98% of Jamaica's population live on more than $ 1.90 a day in 2004. However, the national poverty rate of 14.5% and the fact that the majority of its population living marginally close to the national poverty line indicates its social inequality with multi-dimensional implications (Thompson, 2017). The trend of change related to social equality in Jamaica differs from that of the other four countries. Its social equality situation improves between 1996 and 1999, however, it deteriorates between 1999 and 2004 with its lowest value in 2004 when the most recent data value is available. Besides the declining of its agriculture and its land-use matrix, Jamaica's "two-layered" education system also deteriorates Jamaica's overall social equality. Jamaica is the only country among the five selected ones that experiences decrease in its Gross Enrollment Rate in Secondary School. Starting from 2009, the performance of its education sector starts deteriorating and in 2015 the Gross Enrollment Rate in Secondary Schools reaches its lowest value of 80.6%, 15.8% lower than the threshold value. Its stagnant economy during the past decade might have led to less investment, in terms of both time and money, in secondary education. Among the population that receive secondary population, its two-tier education system restricts the ability of the secondary education to prompt social mobility and reduce inequality (Handa, 1996; Levy, 2012). The secondary education in Jamaica is a highly dualistic system where most students receive only low quality technical or vocational training. The number of places that offer best quality education are limited and highly competitive. Most children that are admitted are from families that can afford "extra lessons" to increase their likelihood of admittance. The quality of secondary education in Jamaica is closely associated with family income level and further separates the wealthy from the rest of population since those who can afford quality education tend to emigrate and bring back remittance to further widen the income disparity. Rather than promoting economic mobility and improve social equality, education further widens the social and economic gap.

Accompanying its agricultural marginalization is the fast growth of its mass tourism. Jamaica's vicinity to the sea, although exposing the country to climate change-related natural disasters, also endows the country with its competitive advantages in mass tourism. The geographical advantage, combined with the government's desperate need for foreign exchange, leads to the fast development of its tourism sector. The marginalization of its agricultural sector contributes to the competitiveness of its tourism sector by providing the pool of available labour force. The poverty-stricken rural population are attracted by the perspective of improving their economic status offered by the tourism sector. Despite its fast growth, however, compared with Antigua & Barbuda, Aruba and St. Lucia, Jamaica, although being the largest and most mature and well-established destination country, has the lowest per capita net receipts (Jayawardena & Ramajeesingh, 2003). Jamaica's foreign exchange leakage from its tourism sector is 40%, in contrast to the average outflow rate of 10 to 20 percent of the most developed economies (UNEP, 2002). This level of foreign exchange leakage reveals the unsustainability of Jamaica's tourism sector in which the country fails to fully benefit from its growth of the tourism at the expense of its own environment. There are multiple factors that contribute to Jamaica's high level of foreign exchange leakage. Although the marginalisation of its agriculture provides the pool of the required free labour, the lack of quality education restricts rural labor's employment to low-end manual jobs. Because of the international competition for destination countries and the country' desperate for foreign exchange, Jamaica has already lost its status as an exclusive resort attracting a relatively smaller number of visitors. The compulsory shift to mass tourism has driven the country into a highly developed dependency relationship on external market in which the growth of its tourism sector rests with foreign agencies because of the lack of domestic human capital. A lot of promotion, recruitment, product design and marketing related to mass tourism products occur outside of the country, which leads to the outflow of revenues and ultimately the high level of foreign exchange leakage. The country's heavy dependency on imported food supply also serves as one minor but significant determining factor for its foreign exchange leakage. A substantial part of the profits generated by the tourism sector have been used to cover the costs of expensive imported food, especially meat and dairy products, considering the main composition of its tourists (Bélisle, 1984). In the case where the new opportunities provided by tourism cannot keep pace with the scale of displacement resulted from the marginalization of the agricultural sector, the social convulsions tend to be mitigated by massive emigration (Thomas-Hope & Jardine-Comrie, 2007). Within a decade, about one out of twelve Jamaicans emigrate to other countries. The resulted brain-drain has further deprived Jamaica of the qualified human capital needed by the more sophisticated part of the activities within the tourism sector and deteriorated its foreign exchange leakage.

As mentioned earlier, one aspect of Jamaica's weak institutional capacity is its inefficient land policy that leverages its poverty and social inequality. Another aspect of its weak exercise of authority is its democratic quality, the highest score of which is 0.36, 55% lower than the threshold value of 0.8. The two governance indicators that comprise of its democratic quality, its Voice and Accountability value is 0.7[15] in 2016 but the value for Political Stability and Lack of Violence is only 0.2[16]. Its weak state power allows relatively higher level of freedom of speech and accountability but leads to high level of political instability and presence of violence. Crime is regarded as the main public safety issue in Jamaica, with the homicide rates notably higher than both the regional and global averages, which poses a serious challenge to its tourism sector. The construction of all-inclusive hotels is only a short-term solution that fails to effectively deal with the root causes for crime and might eventually intensify social conflicts by excluding the already marginalized population from benefiting from its sole fast-growing industry (Boxill, 2004, Levy, 2012; Harriott & Jones, 2016).

Also associated with the marginalization of its agriculture and the weak institutional capacity is its nutrition profile. Assessed by the per capita calorie intake, Jamaica meets the threshold value of per capita 2700 kcal per day. However, as Weis (2004) points out, the dominant dietary-epidemiological problem in Jamaica might no longer be malnutrition that is usually assessed by per capita daily calorie intake, but rather a marked rise in chronic disease-related health problems. Its national overweight and obesity ratios are 58.4% and 26.8% respectively and the diabetes ratio is 11.9% (WHO, 2016c). One key contributor to this is the "meatification" of diets associated with the declining of its traditional agriculture and the rapid growth of fast food chains driven by the high volume of cheap imported goods and pervasive influence of the foreign, especially the U.S. market.

Jamaica's environmental performances collaborate its marginalizing agriculture. For example, its phosphorous flows is 1.36 times the boundary value and its nitrogen flows is 65% of the boundary value.

[15] It is 1.2 for the UK and 1.1 for the U.S.A., 1.6 for Norway

[16] It is 0.4 f or both the U. K. and the U.S.A and 1.2 for Norway

Both Biochemical Flows are amounts embedded in imported goods because, like Trinidad & Tobago, data related to Biochemical Flow from domestic production are not available at Eora MRIO. The lack of data indicates possible lack of effective management of its agricultural activities and the resulted heavy dependence on strategic imports as food supply. Its most recent eHANPP value is per capita 2.56 C t in 2007, slightly lower than the boundary value of per capita 2.62 C t. The fact it decreases from 3.12 C t in 2004 to the 2.56 C t in 2007 does not necessarily indicate progress in its performances in preserving the Net Primary Product, which is essential for the function of the ecosystem. The fluctuation of its eHANPP value is associated with the aggregated feedback of its declining traditional agriculture, the forest clearing off for cash crop plantations and mining and its heavy dependence on imported food supply. It is not possible to interpret its biomass change based on one value without discussing the interaction of multi-dimensional factors embedded in its development process. According to the research conducted by Akunne Okoli (2016) as part of his Mater thesis, fiscal and monetary economic shifts imposed by World Bank and IMF's structural adjustment program and the decrease of per person available arable land between 1961 and 2013 are possibly positively related to the biomass change in Jamaica and its deteriorating food security (Okoli, 2016; Steinberger et al., 2010).

Country Summary:
Rather than functioning in isolation, biophysical and social factors are all interconnected around a leveraging element, which in the case of Jamaica is its weak institutional capacity with the resulted faulty agricultural policy and social inequality, all of which contribute to its development profile of stagnant social progress with high pressure on its ecosystem. Instead of indicating better or worse environmental performances for individual years, its fluctuating trend of change for eHANPP, ecological footprint and material footprint all indicate the aggregated impacts of unplanned economic activities on the ecosystem. Jamaica's CO_2 emission is 4.7 times the boundary level in 2008, with the contribution from fossil fuels 5 times that from biomass. The contrast between the high CO_2 emission and stagnant social progress in most sectors reveals the lack of efficiency in its development process. Considering the fast growth of its mass tourism, it is a tough challenge for Jamaica to sustain the benefits from its tourism sectors and ensure the health of its environment. From the social perspective, the marginalization of its agricultural sector and high volume of cheap imported goods not only deteriorates poverty and inequality but also permeates into other social sector and further deprives the country of the human capital required by its transition to sustainability. Jamaica's fluctuated life satisfaction and social support values indicate people's lack of confidence when exposed to a situation of stagnant social mobility and uncertainty. What is needed is strong institutional capacity to reduce social inequity and provide quality labour force by offering more livelihood opportunities and quality education, especially for the marginalized rural population.

5.4 Haiti

Haiti presents a horrid picture of human development, judged by its social progress and the corresponding stress on the environment. Haiti is categorized as the poorest country in the west hemisphere, faced with destructive natural disasters and tumultuous political situation[17]. The 2010 devastating earthquake, with its severe socioeconomic and environment "aftershock", comes on the heels of the destructive hurricane season in 2008, only followed by the more devastating Hurricane Matthew in 2016. Hurricane Matthew is reported to have caused 585 direct deaths with 546 in Haiti, 34 in the U.S., 4 in the Dominican Republic and 1 in St. Vincent and the Grenadines (Picazo, 2017). There might be other factors associated with the different casualty rates, however, the death toll, in a way, does reflect Haiti's social fragility when faced with natural disasters.

Haiti's social fragility is also revealed by the fact that it not only fails to satisfy any of the 11 social outcomes but also as a society, it functions extraordinarily below the threshold level, despite decades of international humanitarian efforts. The trend of change related to its life satisfaction and social support values after the major earthquake in 2010 clearly indicates optimism in lieu of the large-scaled humanitarian initiatives and reconstruction efforts, immediately after the earthquake between 2010 and 2012, and the subsequent disillusionment, between 2012 and 2017, caused by lack of true social progress. In contrast to its unsatisfactory social performances, in 2008, Haiti exceeded the CO_2 emissions boundary value by 32%. The dominating role played by biomass in its energy structure is directly linked to its high rate of deforestation. Only 3.52% of its land area in 2015 was covered by forest, in comparison of the global average of around 30% (World Bank, 2015). The decrease of its eHANPP between 2000 and 2007 is not necessarily related to improvement in terms of biomass preservation. As shown by Figure 14 below, Haiti's deforestation might have led to very limited potential for further biomass consumption. Haiti's decreasing eHANPP, when interpreted together with its failure to satisfy any social outcome, indicates a lack of economic growth and social progress, rather than improved efficiency of its production and consumption.

In Haiti's case, a complex mix of both international and domestic factors and its colonial legacies, as well as its geographical location, has led to its current systematic vulnerabilities represented by its unsatisfactory position between the environmental ceiling and social foundation. Once France's most valuable colony in the 18th century, Haiti is forced to pay enormous reparation between 1825 and 1947 for diplomatic recognition and becomes a heavily indebted country. The pressure of paying back the heavy debts is directly linked to its deforestation because of the trade of mahogany and other precious hard woods used to reimburse the indemnity imposed by France (Maertens & Stork, 2017). In the 20th century the U.S. uses force and occupation to ensure Haiti sticks to its repayment schedules (Oxfam 2010). The Haitian-American project of manufacturing rubber during the Second World War not only fails to provide any economic benefits but also causes the destruction of millions of trees (Maertens & Stork, 2017). Such political and economic evasion not only erodes the country's economic foundation but also weakens its institutional capacity. The weakened institutional capacity, as part of its colonial legacy, and the resulted lack of true participation in international collaboration serve as major factors that determine its lack of social and environmental progress after

[17] Haiti made the headlines in February 2004 when its President Jean-Bertrand Aristide flew into exile and in January 2010 when a 7.3 earthquake struck its capital city, Port-au-Prince, killing hundreds of thousands and displacing millions. More recently, the international attention focused on the cholera outbreaks, the presidential election (postponed several times until early 2017), and category 5 Hurricane Matthew that devastated the south of the country in October 2016. http://www.booksandideas.net/The-Real-Story-of-Haiti-s-Forests.html

decades of aiding efforts.

As an indicator for governance, Haiti's score for democratic quality, the unweighted average of Voice & Accountability and Political Stability & Absence of Violence, is -0.735. Its endemic corruption also reflects its weak monitoring and supervision power. Haiti ranks 177 out of 180 countries surveyed in Transparency International's Corruption Perceptions Index and by Brookings Index of State Weakness, Haiti is considered the 12th weakest state in the world (Daumerie & Hardee, 2010). Another aspect of Haiti's weak governance is its lack of financial capability to promote revenue mobilization, which considerably restrains the much-needed development spending in basic infrastructure and services (World Bank, 2016 & 2017). The credit imperfections that characterize the Haitian financial market, curtail access to capital of most of Haitian poor and constrain the necessary financial capital accumulation to unleash the productive potential and promote growth.

Figure 14: Deforestation Comparison: Haiti (left) and Dominican Republic (right)

Satellite image showing deforestation in Haiti. This image depicts the border between Haiti (left) and the Dominican Republic (right). Source: NASA

Another aspect that reveals Haiti's weak institutional capacity is the urban-rural disparity embedded in its development policy. Over 80% of government revenue is drawn from direct taxation of farmers, however, Haiti's overall policies still favor urban commercial development and assembly plants, especially the area around the capital area. Haiti's urban bias leads to soil degradation and deforestation in farmers' desperate but unsupported, both politically and technically, efforts to change their living condition (World Bank, 2017). In the late 18th century, Haiti produces 40% of the sugar and 60% of the coffee consumed in Europe. By the middle of the 19th century, the over-exploitation of land with no adequate technological support fuels significant deforestation and soil degradation (Martin, et al.,2010). Jadotte (2008) states that less than 1% of the farms in Haiti use mechanical irrigation and more than 70% of them rely on rainfalls and less than 37% of farmers use fertilizers. Haiti does not exceed the boundary value for biochemical flow not because of technological innovation or fertilizer optimization but because of inability of its farmers to apply fertilizers for production growth. With no sufficient political or economic support, besides over-exploiting the soil for a bare subsidence, farmers also turn to forest-derived charcoal as their only source of cooking fuel. It is not the poverty-stricken farmers who try to make a bare living but its faulty rural policy that has directly led to Haiti's current severe soil degradation and deforestation (Martin, et al. 2010). The urban-rural disparity also fuels the massive but unplanned and unmonitored migration from rural to urban areas in the farmers' efforts to seek for security and opportunities.

It is stated in the World Bank report (2017) that around the world, urbanization is often positively related to the economic growth since the conglomeration of population could provide the required economy of scale. In the case of Haiti, rather than by production, its urbanization has been driven by the disparity between rural and urban, especially the capital area. The government lacks sufficient institutional capacity and the financial capital to effectively manage population density and provide the basic infrastructure. As a result, productivity that is usually associated with urbanization has been undermined. Instead, the lack of connectivity within the urban areas because of lack of basic infrastructure constrains the mobility of its labor market, which in turn leads to high unemployment rate and urban poverty. In 2014, 80% of Haiti's 9 million population live below the poverty line of $2 a day and 54% of this group live in abject poverty (CIA, 2014). Not only does its political bias towards urban areas fail to drive growth but also, on top of rural poverty, it also leads to urban poverty because of unplanned urbanization with basic infrastructure support.

Haiti's faulty rural policy and the resulted unplanned urbanization intensifies its social inequality. Jadotte (2008) ranks Haiti as the second highest unequal country in the world after Namibia[18]. Contrary to the conventional wisdom that high levels of inequality might be growth-enhancing because of the alleged higher propensity to save of the capital owner relative to the wage earners, Haiti's embedded inequality affects growth negatively. The high-levelled inequality has caused social tensions and political instability, as shown by its negative value for democratic quality, which the government with insufficient institutional capacities fail to bring under control. This in turn further discourages investment and constrains economic mobility. Wide-spread poverty and high income-disparity in Haiti lead to very limited access to quality education of those at the lower tail of the distribution. The resulted lack of qualified workforce can be attributed to the inflated returns to those limited number of well-educated Haitians. Instead of driving social mobility to reduce inequality, education acts a major determining factor in Haiti's worsening social inequality (Jadotte, 2008). It is not that the return of education is not high enough to attract investment of time and money. It is the wide-spread poverty and the lack of financial support that deprive the Haitian poor of the opportunity to achieve economic mobility by receiving education. The relatively better-educated Haitians tend to emigrate, and the remittance further deepens the social and economic gaps. The brain-drain further deprives the country of the human capital for a more planned and sustainable development. Like an ominous cycle, poverty deprives the Haitian poor of quality education and in return, the lack of education further denies the poor of opportunities to enhance their economic stance.

The young demographic structure of Haiti, in which the median age is 20 and nearly 70% of its population are under 30, is another indication of its wide-spread poverty (Daumerie & Hardee, 2010). One key factor to such a young demographic structure is Haiti's high fertility rate of four children per woman, which is closely related to its lack of basic infrastructure and services. Despite the high level of awareness among Haitian women of modern contraceptive methods, 57% of women never use any modern family planning methods and 38% have an unmet need for family planning (Daumerie & Hardee, 2010). Lack of access to modern contraceptive methods and misconceptions about side effects of contraceptives because of limited family planning education or health care facilities all lead to Haiti's high fertility rate. High fertility rate, combined

[18] In his study, Jadotte stated at a 95% confidence level the estimated Gini Index lies within the interval [0.6233, 0.6681]

with its low healthy life expectancy due to lack of basic social infrastructure, such as health care services and access to improved sanitation, results in Haiti's young demographic structure. The Gallop 2018 World Happiness Report records Haiti's Healthy Life Age in 2017 as 53, which, if interpreted together with the percentage of 70% of the population under 30 years old, indicates a small but long-living "elite" group in Haiti, another demonstration for its social inequality.

As stated by Daumerie & Hardee (2010), the overrepresentation of one group in a country tends to have multi-dimensional social implications. Firstly, a 30-year historical analysis (PAI, 2010) finds that countries with very young age structures—those in which 60 percent or more of the population is younger than age 30—are the most likely to face outbreaks of civil conflict and autocratic governance. Although there is no proved simple causal relationship between age structure and instability, demographics can play an essential role in mitigating or exacerbating a country's development and well-being prospects. Haiti's young age structure, to some extent, can be related to its low social stability and high level of violence. Secondly, a young population structure demands intensive investment in human capital, which conflicts with the wide-spread poverty and lack of financial support in Haiti. As a result, most of Haitian young are not equipped with the capability to improve their personal conditions or contribute positively to the country's growth (Daumerie & Hardee, 2010). Haiti's current age composition means approximately 73% of its population depends on the rest of 27% that belongs to the labor force. The high unemployment rate of 56.2% means only 15% of its population are employed, which makes its economic recovery particularly difficult. The resulted "survival economy" and little opportunity to plan for the future lead to decades of large-scaled emigration of those limited number of qualified youth (Daumerie & Hardee, 2010). Lack of access to education of the poverty-stricken population and the brain-drain caused by the exodus of relatively well-educated youth further deprive Haiti of the human capita necessary for its economic recovery and growth.

As the poorest country in the Western hemisphere exposed to severe natural disasters, Haiti has been identified as both the "Republic of NGOs" and the "graveyard of development projects" (Ramachandran 2012; Farmer 2011). Humanitarian aid is essential immediately after the disaster in the provision of rescue, food and medical services and supplies. The fact that CO_2 emissions from the burning of fossil fuels embedded in imported goods reached its peak in 2010 might mainly be related to the high volume of imported goods that flowed into the country immediately after the major earthquake. However, in the long run, humanitarian efforts without incorporating Haiti's development agenda and the Haitian government's active participation in decision-making, might erode the country of its self-reliance, from both political and economic perspectives. Amidst the inundating humanitarian efforts, what is underrepresented among the power dynamics of states and international actors is Haiti itself. After the earthquake in 2010, of the $2.29 billion of humanitarian aid from donors, 1% was distributed to the Haitian government (Quigley, 2012). For example, most of the humanitarian aids from the United States went out to international nongovernmental organizations such as the American Red Cross or private contractors outside of Haiti. Foreign firms use the funds they are originally budgeted for Haitian employment for material resources and hire less than one-fourth of the estimated Haitian workers. Contrary to the benevolence and altruism traditionally associated with humanitarian aids, the decision-making and management reflect the interests of international donors, service deliverers and certain Haitian local elites with political power, rather than the affected population of Haiti (Centre for Economic and Policy Research, 2011). The underrepresentation of Haiti's true interests within the political dynamics, minimal accountability and transparency, and little coordination between donors and implementing partners, all contribute to the fact that despite the overwhelming pledged amounts, humanitarian audits still indicate a lack of development and recovery in Haiti (Cunningham, 2012). Such failure not only has direct impacts on the satisfaction of social outcomes but also, more importantly, deprives Haiti of confidence, both internally and externally, to further invest in a more sustainable development route.

Country Summary:
As the poorest country in the west hemisphere, Haiti exceeds the planetary boundary of CO_2 emission and functions just marginally within the boundary for eHANPP. It fails to satisfy any of the social outcomes and the percentages of population that have access to electricity and improved sanitation are extraordinarily below the threshold values, despite decades of international aiding efforts. The fact that it does not exceed more planetary boundaries has much more to do with the lack of social progress than efficiency or green orientation embedded into its development process. The weakened institutional capacity, as part of its colonial legacy, intensified by both its fragility when exposed to natural disasters and the humanitarian efforts with no consideration of Haiti's development agenda, has led to the weakened rule of law and further worsened social environment for investment. The disillusion due to lack of true progress after decades of aiding efforts further deprives the country of confidence in investment and human capitals required by its sustainable development. Haiti has a long way to go for its transition to a more sustainable development mode and what is essential is a strong government that can ensure Haiti's true interests to be incorporated in any international collaborations in which Haiti is involved.

5.5 Cuba

Cuba stands out among these five Caribbean small island states in its political isolation that protects it from the subsidized cheap import goods, which is common in the rest of the Caribbean region. Such isolation results in its economic hardship but facilitates its small-scaled urban eco-agricultural initiatives and green tourism. Although the central control under one party considerably restrains people's accountability, its strong state power ensures its relatively consistent adherence to the national policy of environment protection. Its current biodiversity preservation amid the fast growth of the tourism sector reveals the relative success of its environmental protection efforts. Its 2008 CO_2 emissions and material footprint values both exceeded the boundary values, however, are 25% lower compared with the 1995 values. When interpreted in association with the fact that its GDP per capita increased by 79% from 1995 to 2008 (World Bank, 2018), the trend of change of its CO_2 emissions and material footprint reveals a relatively more sustainable development mode, compared with other nations covered by this research.

From the perspectives of social progress, Cuba presents a mystifying picture. It provides free universal education and health care, and the resulted high quality human capital contributes to the development of advanced medical services, organic agriculture, and biotechnologies (Stiftung, 2018; Sweig, & Bustamante, 2013). Despite both the political and economic hardships following the collapse of the Soviet Union and the COMECON states during the U.S. embargo, Cuba achieved 100% access to electricity in 2011, the daily calorie intake exceeded the threshold value by 24% in 2012, and the employment rate was 97.4% in 2017. However, on the flip side, it is still a nation with an average monthly salary of $32 (World Bank, 2017) and rations are applied for daily food supply. Underneath the apparent contrasts between different social aspects is the social inequality that is masked by the socialist efforts to provide equal welfare to the whole population. The lack of equality tends to deteriorate with its recent economic reform initiatives and has permeated into different aspect of its socioeconomic structure. The fact that it is not a topic for open discussion in Cuba makes it hard to tackle. Cuba's equality is estimated as 0.6, the highest among the selected five nations, but still only 86% of the threshold value. Racial inequality, as its colonial legacy, plays a major role in its overall social inequality structure. In addition, the one-party dominance tends to further intensify the social inequality because of the unbalanced power relationship between different social groups.

Racial inequality in Cuba can be traced back to the Spanish conquering and the subsequent arrivals of Africans as slaves in sugar plantations in the 19th century. After the slavery abolition, race continues to have impacts on people's legal and social rights, which has major impacts on people's economic status (de la Fuente, 1995; Helg 1995; Fernández-Robaina, 1990). Although private property is eliminated after the revolution, the deeply ingrained culture of racism has found its fertile breeding ground where race can continue to influence social relations. The capitalist-style initiatives to drive economic growth, such as opening the country up to foreign investment and mass tourism, and legitimating private enterprises and remittance, all tend to revive the racial inequality embedded within its social system and restrain the prejudiced group's opportunity for economic mobility (Hansing, 2017). It is much easier for white Cubans, as the descendants of Spanish colonists, to emigrate to the U.S. or European Countries and therefore most families that have remittance as supplementary income are white (Hansing, 2017). Due to Cuba's current imperfect credit system, remittance is nearly the only source of initial capital required by the private businesses. Consequently, remittance is not only directly related to the disparity of Cuban's consumption by providing access to expensive consumer goods but also creates the disparity in economic mobility.

Hansing (2017) states that the role played by Cuba's dual currency system in deepening its income disparity also has its racial ramification. Only certain sectors, such as tourism, private businesses, foreign joint ventures, and family remittances provide legal access to the hard currency, i.e., the Cuban Convertible Peso (CUC), about 24 times the value of the traditional Cuban Peso in which normal Cuban salaries are paid. White Cubans are not only the major group that have access to remittance but also dominate the tourism and foreign joint venture sectors where CUC is paid. By intensifying the colonial heritage of its racial prejudice, Cuba's duel currency system has further deteriorated its social inequality. Hansing (2017) believes that most of private businesses are located at private homes, which makes the location of the real estate critically important. Most successful private businesses are located at central and well-maintained neighborhood, where the owners are dominantly white. In Cuba health care and education have been free, universal rights since 1959 (Hansing, 2017). However, the income disparity with its racial implication also has negative impacts on this egalitarian aspect of its social system. Families with higher income can afford after-school private tutors for their children and the increased quality of education will in turn provide the children with more opportunities for economic or political mobility. As for health care, since physicians and doctors in Cuba are paid low state salaries in local peso, "little gifts" from the patients' families will have considerable impacts on the quality of treatment provided. Since only wealthy families, which are dominantly white, can afford the "little gifts", income disparity is transformed into disparity in health service, the originally free and equal service to all population.

Accompanying its economic initiatives, the political system of one-party dominance also has its impacts on Cuba's social inequality. The World Bank Corruption score for Cuba is between 0.3 and 0.4 during the period of 1996 – 2011. It drops to 0.2 in 2012 and remains at 0.1 until 2016. The deteriorating of its corruption situation since 2011 can also be related to the development of private businesses in which connection with the party leads to business opportunities and personal gains. There have been studies on the correlation between the one-party dominance and perceived corruption (Montinola & Jackman, 2002; Nurtegin & Czap, 2012). Although the relationship between corruption and party competition might be complex, there have been empirical evidences that in countries with limited political competition, significant corruption is likely, despite the fairness of elections. With no presence of election in Cuba, the absolute lack of political competition can lead to relatively high level of corruption, despite the party's original determination to be fair and transparent. This new type of inequality driven by the economic reform initiatives is something Cubans are not used to (Nolen, 2016). Despite its free education and medical service, the Life Satisfaction for Cuban is only 5.4, 17% lower than the threshold value of 6.5. With lack of historical data relevant to Cuban's Life satisfaction, it is not feasible to test whether people are more satisfied with life before the economic initiatives. However, it is a hypothesis that deserves research efforts whether it is the economic inequality, rather than the low income, that makes Cubans less satisfied with their lives.

Cuba's political system of socialism under one party's leadership and the resulted free education and health service provides it with a unique social profile in the Caribbean region. Firstly, its democratic quality differs from that of any other nations covered by this thesis possibly because of its central political control under one party. Cuba's score for Political Stability and Absence of Violence approaches the threshold of 0.8[19], ranging between 0.5 and 0.6 during the period of 2014 – 2016. However, its score for Voice and

[19] The threshold value for Democratic Quality is 0.8 in the Good Life for All within the Planetary Boundaries. It is the unweighted average of both Political Stability & Absence of Violence and Voice and Accountability.

Accountability is between -1.9 and -1.6 during the 10-year period between 2006 and 2016. In comparison, in Trinidad & Tobago, Dominican Republic and Jamaica, due to weaker state power, people enjoy relatively more freedom and accountability with lower level of political and social stability. The strong central control might, at least in a short term, strengthens the effectiveness of policy and legislation, however, as discussed previously, the lack of competition can be also directly related to corruption, which might constrain opportunities for a more dynamic and fair development in the long run. The second unique social aspect of Cuba is its relatively low fertility rate of the average 1.8 children per woman, the lowest among the five nations covered by this thesis. Both being low income developing states, the sheer difference between Cuba and Haiti's fertility rate indicates contextualized non-linear relationship between socioeconomic factors. Cuban's fertility rate has experienced an accelerated historic decline since the 1990s, which leads to the annual reproductive rate level falling below replacement within less than half a century (Albizu-Campos, 2014). The usual theoretical framework supports the inverse relationship between fertility rate and economic growth, i.e., the more economically developed a society is, the lower might be its fertility rate. However, Albizu-Campos (2014) relates the low fertility rate of Cuba to the decrease in living standard, assessed by the monthly real wage. Usually the high fertility rate of the economically less developed society is related to the relatively high infant mortality rate, which is not the case in Cuba because of its free health service. In Cuba, despite the economic hardship and low income level, women have access to free medical service and education, which enables Cuban women to postpone or terminate pregnancy of their own accords. Lower fertility rate contributes to lower level of stress on the ecosystem, however, the lack of replacement can put stress on the current labor force and slow down the pace of the economic development.

From the environmental perspective, Cuba also presents a unique profile among the five nations in its inverse relationship between achievement of social outcomes and stress on the ecosystem. Based on available data, Cuba exceeds 5 out of 7 planetary boundaries and satisfies only 6 out of 11 social outcomes, which does not suggest an ideal position between the environmental ceiling and social foundation. However, its environmental performances should not be interpreted in isolation without considering impacts from its colonial legacy and experiences of being one of Soviet Union's closest allies, and more importantly its recent efforts to boost economy on a more sustainable basis. As part of its colonial legacy, Cuban agriculture has been characterized by sugar monoculture since the Spanish occupation. Its dependency on the sugar industry and the resulted reliance on imported goods for its food supply are intensified by its partnership with the Soviet Union (Gonzalez, 2003). The Soviet style of high degree of mechanization, with no accompanying efficiency, leads to the large-scaled stated-owned sugar plantations, characterized of being capital-intensive, export-oriented and heavily fertilizer-dependent. The lack of product diversification of the sugar sector has deprived Cuba of its strategic edge when faced with competition from Brazil. Though declining, its sugar industry still plays a major role in its overall economy and continues to consume tremendous resources as Cuba's primary export. The lack of efficiency in the production process and the heavy fertilizer-dependency can be linked to Cuba's relatively high CO_2 emission, biochemical flow and eHANPP. It also deteriorates Cuba's food security since Cuba still imports 60% - 80% of its food and most of its population still rely on food ration for their nutritional needs (Salazar-Carrillo, 2013).

The collapse of the Soviet Union deprives Cuba of its overseas market for raw sugar and the supply of cheap machinery, oil and fertilizers, which forces the government to transform the inefficient state-owned farms into smaller agricultural cooperatives and distribute land to private producers and promote the low-input, ecologically sustainable agricultural practices. The subsequent U. S. embargo, though further deteriorates its economic situation by excluding Cuba from access to international financial aids and market, however, such economic and political isolation has also protected Cuban agriculture from the tough competition of highly subsidized agricultural producers in the U.S. and EU. Instead of following the neoliberal agricultural model that prevails in the rest of the Caribbean region, Cuba has achieved an unprecedented degree of agricultural diversifications and improved environmental stewardship by its eco-agricultural initiatives, though it takes time for such initiatives to develop and substantiate.

As part of its economic reform initiatives, Cuba government has been promoting mass tourism to increase its foreign exchange. In 2016, the total contribution of tourism to Cuba GDP is 9.6%(WTTC,2017). Consequently, the construction of hotels and provision of other tourism-related facilities have revived the production and consumption of cement, with its high contribution to CO_2 emission, and material consumption. Experts also worry the fast growth of Cuba's tourism might jeopardize its natural heritage, such as its current well-preserved coral reef and mangrove forests and cause severe environmental degradation. What is reassuring is, in Cuba, sustainable development and environmental protection have achieved constitutional status and its environmental record has been relatively promising. The rigidity associated to a strictly centralized state ensures, to some degree, tourism delivers benefits without fundamentally harming its environment (Velázquez, 2002; Wilkinson, 2008). This might explain why, by WWF criteria, Cuba is the only country that achieves both a HDI of 0.8 whilst functioning at the per capita ecological footprint of 1.8 gha per year[20].

Country Summary:
Cuba serves as an exceptional case in that its current economic status contradicts with some of its social outcomes. When assessing Cuba's development process from the perspective of interactions between biophysical and human processes, it is essential to compare the pace of social progress with the level of associated stress on the ecosystem. Despite the fast growth in its tourism sector, Cuba has maintained its biological diversity, especially its coral reef and mangrove forests. Though exceeding the planetary boundary values, the CO_2 emission and material footprint values are both 25% lower compared with the values of 1995. In her paper, Borowy (2011) analyzes the "Cuba-styled" degrowth, which is originally imposed by the economic crisis following the collapse of the Soviet Union and the U.S. embargo. The declining production and consumption rates, as the result of Cuba's adaptation to shrinking resources during the so-called Special Period, together with the protection offered by its economic and political isolation, forces it to abandon the traditional labor-intensive production models and facilitates the transition to a more environmental-friendly small-scaled eco-agriculture and ecotourism. Different from Trinidad & Tobago, Dominican Republic and Jamaica where the overdependence on one sector leads to lack of investment in social infrastructure and services, Cuba's political structure ensures benefits from its tourism sector can be distributed to support the construction of its overall social foundations. Cuba's development trend provides insights into a model of degrowth (Borowy, 2011) in which a satisfying but not excessive life can be satisfied at a proportionally decreasing rate of emission flow and resource consumption. However, it takes time for Cuba's eco-agricultural initiatives and green tourism practices to substantiate. Cuba is currently still a country that is desperately in need of foreign exchange and, due to lack of productivity and finance, has not been well-positioned to diversify its exports. With the declining of its traditional sugar exports, the real challenge is associated with its increasing dependence on its tourism sector. With the normalization of the relationship

[20] In this thesis, Cuba's latest Ecological Footprint in 2014 is per capita 1.91 gha, which is higher than 1.8 gha but still lower than that of countries with similar HDI.

between Cuba and the U.S, it remains a question whether Cuba can adhere to its principle of ecological preservation when faced with the possible capital from the international market and the associated pressure.

6. CONCLUSION

6.1 Regional Profile

The United Nation's 17 Sustainable Development Goals (SDGs) aim to improve the lives of people and increase prosperity within the earth's sustaining capacity. Given the large number of goals that cover both social and environmental performances, synergies and trade-offs between social and environmental goals are inevitable. In recent research, Scherer et al. (2018) suggest in general social goals are generally associated with higher environmental impacts. However, they also point it out that the nature of interactions differs greatly among countries and depend on specific goals. In line of this, no social or environmental factors function in isolation, instead, they interconnect with aggregated multi-metric implications within individual country's specific development context. For a country's transition to sustainability, it is essential to assess the achievement of social outcomes and the associated stress on the ecosystem within a place-based analytical framework. Only after identifying the vulnerable aspects of a nation's development process, from both environmental and social perspectives can effective strategies be made to mitigate the vulnerability for the expected transition to sustainability.

Because of their commonly acknowledged structural limitations and fragility when exposed to climate change-related natural disasters, small island states have become the focus of sustainable development since the term of Small Island Developing States (SIDS) is initiated in 1992. Vulnerability assessment of small island states has been conducted by academic institutes, international organizations and government agencies to precondition sustainable development study. However, analysis of individual country's systematic vulnerabilities by assessing the interconnections between a nation's social and environmental performances has been rare. This thesis has been one of the first efforts to interpret the vulnerability of five individual small island states in the Caribbean region by analyzing their social and environmental performances within the Safe and Just Space Framework. The research finding can contribute to sustainable development strategy on both national and regional levels by revealing the vulnerable parts of these countries' development processes, which tend to hinder these countries' transition to a more sustainable development mode.

In contrast to its commonly recognized vulnerable status, the Caribbean region, as represented by these five nations, presents a slightly more optimistic profile when compared with the global average. For 7 out of 11 social outcome indicators, the average of the 5 Caribbean states covered by this research is higher than the global average. For 5 out of 7 planetary boundary values, the average of the 5 Caribbean states is lower than that of the global average. However, based on their social and environmental performances, currently none of these five states are ideally positioned within the safe and just space between the environmental ceiling and social foundation. Except Haiti, all other nations exceed at least 4 out of 7 planetary boundaries but none of them satisfy more than half of the 11 social outcomes. Haiti, as the poorest country in the west hemisphere, exceeds one planetary boundary but fails to achieve any social outcomes. Assessed within the Safe and Just Space framework, these nations are all vulnerable but with different vulnerability profiles associated with their individual development contexts. None of the five nations reach the threshold values for life satisfaction and equality. All of them suffer from marginalization of traditional agriculture and depend on strategic imports for food provision. Urbanization in most of these five nations is not driven by production but by the urban-rural disparity and is unsupported by social infrastructure, which tends to worsen the overall social condition and environmental degradation. All five nations perform badly for democratic quality but with different profiles. Trinidad & Tobago, Dominican Republic and Jamaica perform relatively well for

Voice and Accountability but unsatisfactorily for Political Stability and Absence of Violence. Cuba performs reasonably well for Political Stability and Absence of Violence but achieves a negative value, on a scale between -2.5 and 2.5, for Voice and Accountability. Haiti's values for two indicators are both negative. From the perspective of the achievement of social outcomes and associated stress on the ecosystem, Cuba is the most promising one for the transition to a more sustainable mode. However, it is a tough challenge for a country that is desperate for foreign exchange to maintain its development mode between 1995 and 2008 when faced with its capitalization initiatives and pressure accompanying the normalization of its relationship with countries represented by the U.S.

Instead of being linear, the relationship between these Caribbean states' biosphere and human factors is multi-metric and hard to confirm because of the contextualized interactions. It is not feasible to accurately quantify individual country's vulnerability for comparison since vulnerability tends to evolve in association with other socioeconomic and environmental factors. However, despite the multi-metric interconnections, a few patterns and correlation between environment and social indicators can be observed on regional level. In general, the achievement of most social outcomes such as access to electricity, sanitation, income, nutrition, employment, education, social support and life satisfaction are positively related to emission or material consumption, such as CO_2 emission, especially from emission from fossil fuels, phosphorous flow, eHANPP, ecological footprint and material footprint. Based on performances of these five nations, the achievement of social outcomes is not closely related to blue water as one of the environmental performance indicator. There does not exist clear positive relationship between environmental indicators and social indicators such as healthy life expectancy, equality and democratic quality.

6.2 Small Island States' Vulnerability

Within the last three decades of the 20th century, there are three historical shifts related to how small island states are conceptualized. In the 1970s, the focus of the literature related is small island states' economic vulnerabilities. During the 1980s, there is a tangible shift from the structuralist critiques towards a neo-liberal ideology with its focus on small island states' export-oriented production. Since the 1992 Earth Summit in Rio de Janeiro, prompted by the global preoccupation of green agenda and the increasing attention to climate change, the focus of research on small island states shifts to both economic and environmental vulnerabilities (Campling & Rosalie, 2006). The tendency of associating small island states' vulnerability with their smallness, remoteness and the resulted lack of scale of economy and limited absorbing capacity fails to recognize the intrinsic coping capabilities and resilience embedded in their traditional disaster reduction practices that have been eroded by colonialism, neo-liberal development and globalization (Campbell, 2009). Small island states' capabilities to respond positively, collectively and responsibly to challenges that are embedded in their traditional beliefs, institutions and communities, together with their confidence in autonomy, are undermined and eroded since their initial contact with the European colonists (Baldacchino, 2005; Connell, 2007). The resulted lack of confidence and self-respect is revealed by the fact that, despite economic status and nature of political system, none of the five nations covered by this research meets the threshold value for life satisfaction.

The Caribbean region has been depicted as the crossroad of colonialism and its colonization can be traced to their first contact with the Europeans in 1492. Sugar cane plantation makes the Caribbean islands the most lucrative colonies of the European powers (Wong, 2017). As analyzed earlier, such colonial legacy can still be traced in Caribbean states' soil degradation, biomass change and the biochemical flow into the aquatic system. Bertram (2004) and McElroy (2006) correlate the economic development of small island states with their colonial ties, concluding that in comparison with sovereign states that fare poorly in the development stakes, island states, through continuing colonial-era ties to metropolitan countries, benefit from such economic and political relationships. However, such an analysis neglects the possibility that metropolitan powers might have chosen to retain the economically strong territories and give up those weak ones. Haiti's unsatisfactory social and environmental performances and Cuba's relatively high values of biomass change, CO_2 emission, biochemical flow and material footprints, despite its recent more sustainable efforts, can all be attributed to their colonial legacy and subordination to stronger powers. Small island states are not born with intrinsic vulnerability, rather, their inherent characteristics are transformed into vulnerability in their interaction with the rest of the world within the current unbalanced power system. The discourse of suggesting that smallness is synonymous with being vulnerable presents small island states as requiring help and advice from outside organizations and institutions, which all have their own political, environmental and economic agendas (Baldacchino, 2000; Scheyvens & Momsen, 2008). As discussed earlier in this thesis, external pressures from the unbalanced global power structure, such as the structural reform imposed on Jamaica by the World Bank and International Monetary Fund, tend to disrupt small island states' development process with long-term social implications and escalate their vulnerability. The creation of protected areas in small island states might undermine local well-being and impoverish population who lose entitlements to natural resources essential for their livelihoods (Stonich, 2003). As demonstrated by Cuba and Haiti's different development models, within the unbalanced global power structure, it is not the "isolation", but the interference without respect for small island states' true interests and autonomy that has transformed the small island states' structural limitations into vulnerabilities. It is then essential to dispense with the approach of regarding small island states as victims of their inherent characteristics and focus on the root causes for these countries diminishing "buoyance" (Connell, 2007) when faced with external challenges. Only after the root cause has been identified and actions taken can small island states be able to truly benefit from the international partnership and pursue self-determined sustainability.

6.3 Transition to Sustainability

Within the analytical framework of the Safe and Just Space, vulnerability reduction can be interpreted as providing a good life for everyone whilst keeping the ecosystem within biophysical limits. In a recently published paper, Fannings and O'Neil (2018) investigate the relationships between carbon-intensive consumption and two dimensions of human wellbeing, physical health and happiness for 120 countries between 2005 and 2015. They conclude that there has been no identified relationship between consumption, measured in either Gross Domestic Product or carbon footprint, and physical health. However, the research indicates countries with declining per capita consumption have significant reductions in average happiness. In contrast countries with growing per capita consumption have no significant change in happiness. In comparison, happiness is more sensitive to change to GDP than to carbon footprint. To ensure happiness within the environmental ceiling, one approach is to "decouple" carbon emission from economic growth or more importantly happiness levels must be made less sensitive to declining consumption. Such a change might require fundamental cultural shift supported by policies or initiatives to help people reevaluate quality of life. Raworth (2012) also analyzes the possibility of meeting basic human needs within the environmental ceiling within the Safe and Just Space Framework. She concludes that, in theory, it is possible to provide everyone with a satisfactory but not excessive life without pushing the ecosystem further out of the biophysical boundaries. She quantitatively demonstrates that, rather than exerting additional stress to the ecosystem, the achievement of social foundations is more related to resource redistribution and efficiency. Raworth (2012) estimates that 57% of the global income are in the hands of 10% of the population and it requires only 0.2% of global income to end income poverty for the 21% of the global population who live on less than $1.25 a day. Reducing global resource consumption and achieving global equality are key to the transition into the safe and just space. In the case of five Caribbean nations, their General National Income (GNI) is approximately $ 189 billion annually (World Bank, 2013) and the maximum amount needed to ensure 100% of its population living on more than $ 1.25 a day is around $ 6.2 billion[21], about 3% of their annual GNI. The percentage of 3% is higher than 0.2% but Raworth's (2012) estimation is on global scale and this thesis covers only 5 Caribbean small island states that include Haiti and Cuba, two nations with the lowest per capita GNI in the Caribbean region.

Raworth (2012) believes the key challenges to moving the population within the environmentally safe and socially just space remain such as how this framework could be extended to explore the fair shares of effort needed, between and within countries, to bring humanity into the safe and just space. She insists one key element to such a transition is a strong government to guide economic growth and achieve general social progress within the planetary boundaries through wealth and resource redistribution (2012 & 2014). Briguglio (2018), in his study that is focused on small island states, emphasizes the importance of institutional governance in achieving economic resilience by using Luxemburg, Estonia, Iceland, Mauritius and Malta' successes as examples. Briguglio (2018) defines economic resilience as an essential part of sustainable development, which is the policy-induced ability of a country to withstand or reduce the harm associated with external shocks. The lack of sufficient institutional capacity of the Caribbean region, as part of its colonial legacy, has been intensified by the discourse of regarding being small as being vulnerable and powerless and therefore requiring external assistance and pivots the interactions between its environmental and social performances. On country level, farmers in Jamaica cannot take advantage of the fast growth of tourism because there lacks the formal marketing system with sufficient governance and technical and financial support, which prevents Jamaican farmers from supplying high-quality, competitive priced products to hotels on a consistent basis (Rhinoy, 2011). As a region, the evolution of the Caribbean's agriculture, with long-term socioeconomic and environmental implications, reveals the region's lack of capacity to effectively guide economic growth for social progress. Despite their current diversified economic models and social structures, Dominican Republic, Jamaica and Cuba, all undergo the retreat of agriculture and transition into a service economy dominated by tourism. Trinidad & Tobago also abandons its traditional agriculture and depends solely on the energy sector. The increasingly declining role played by the agricultural sector as the primary domestic food provider can be traced back to the colonial period in which these island states are forced into a dual agricultural economy, comprising one or two export crops from large-scaled plantations and domestic food production sector dominated by small-scaled farmers (Barker, 1993). Such a development model not only leads to soil degradation, excessive biochemical flow into aquatic systems and biomass loss associated with large-scaled plantations but also results in desperate need for foreign exchange because of the heavy dependence on imported food. After gaining sovereignty, nations such as Dominican Republic and Jamaica are inundated with cheap imported food supply, which severely restricts small-scaled farmers' entry into the domestic food market. In Cuba, farmers are faced with the lack of fertilizer and energy required by its large-scaled sugar plantations, following the collapse of Soviet Union and the U.S. embargo. The government encourages small-scaled urban organic farming, which has great potential for sustainability but takes time to substantiate. Its current desperate need for foreign exchange forces the country to continue its

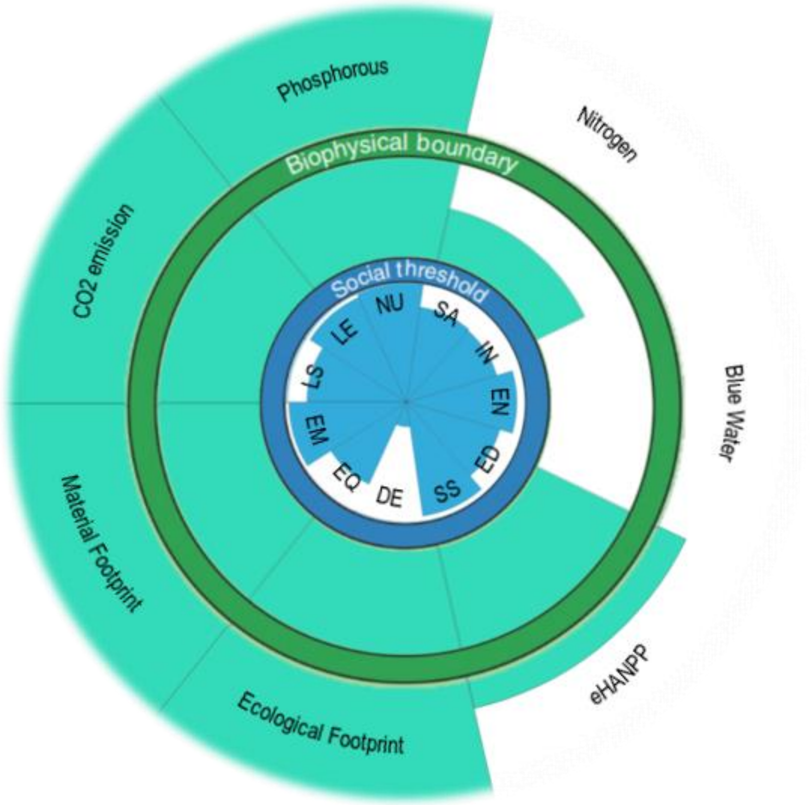
[21] Refer to Appendix G for detailed information.

dependence on its traditional sugar export, though declining when faced with international competition, with relatively high rate of emission and material consumption. In the case of these five Caribbean nations, profits from the fast growth of either tourism or energy sector are used to meet the imminent need for food provision, with no potential to redistribute profits to construct social infrastructure and encourage economic diversification. The lack of economic diversification in turn deteriorates rural poverty because agriculture is still the main livelihood in rural Caribbean, despite its declining contribution to GDP. Intensified rural poverty and the resulted urban-rural disparity, accelerate unplanned and unsupported urbanization, inequality and social instability with both environmental and social implications. Unplanned urbanization intensifies environmental pollution because of social infrastructure' limited aborting capacity and increased consumption. From social perspective, the rural-urban disparity and inequality attracts low-cost rural labor to relatively higher wage in the tourism sector. However, lack of education constrains rural labor to lower part of the tourism service chain and some of rural laborers get engaged situationally or regularly in sexual exchanges with tourists for the possibility of higher profits (McElory & de Albuquerque,1990). The high HIV/AIDS of the Caribbean region can be closely related to its fast growth of tourism sector and the lack of social infrastructure to support a higher-end labor force. Urban-rural disparity also leads to social inequality and ultimately, social instability. Lack of effective government control causes the escalation of social instability into high crime rate and the presence of violence, which inevitably will erode confidence in investment and further impede economic diversification and mobility. The widened social and economic gap drives the society into a context of excessive material consumption in which the public try to fill in the wealth gap whilst the privileged groups determine to maintain their superiority. As revealed by these five nations' development processes, no socioeconomic or environmental factors work in isolation. Instead, they are all pivoted around their lack of sufficient institutional capacity with multi-dimensional implications.

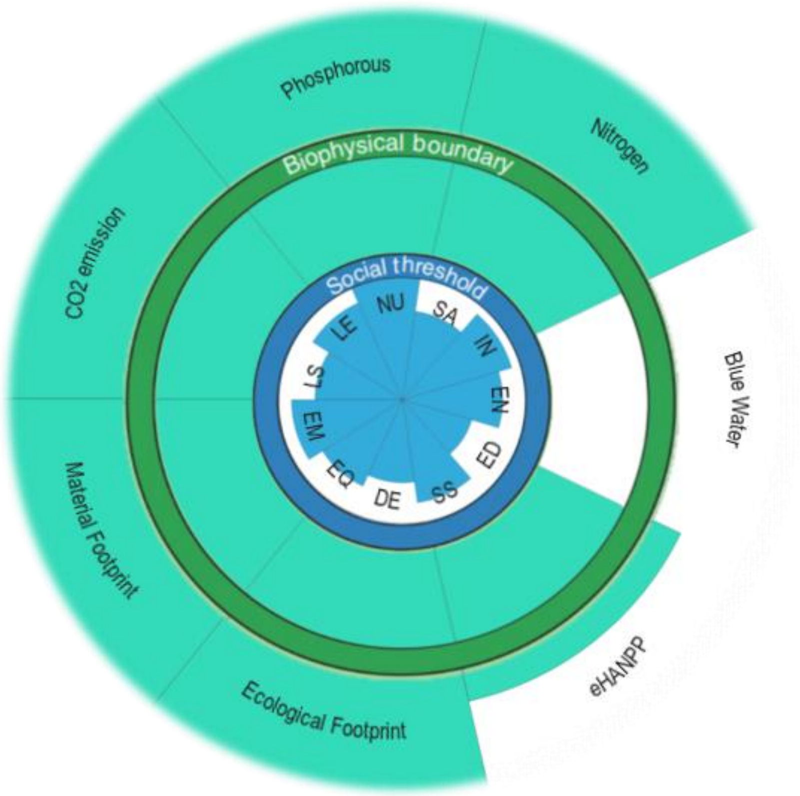
A strong government with sufficient institutional capacity can not only come up with sound policies to guide growth and achieve economic resilience and social progress but also revive the social cohesion that is embedded in small island states' community wisdom, practices and value system. Such social capital, which enables small island states to respect the force of nature but stay buoyant when faced with challenges, has been eroded in their encounters with the rest of the world. The revival of such social cohesion will unite the small island states' people together and help the small island states resume their self-respect and confidence in their autonomy. The self-confidence is essential to help the small island states respond quickly and flexibly to exogenous changes by learning from their traditional wisdom and customs.

Within the current international power structure and trend of globalization, it is not realistic to expect the small island states in the Caribbean region to build up its institutional capacity without interaction with the rest of the world. The 17th Sustainable Development Goal includes revitalizing the partnership for sustainable development. The overarching theme of the Third International Conference on Small Island Developing States held in 2014 is the sustainable development through genuine and durable partnership. Despite the high expectation for partnership in small island states' sustainable development, the current insufficient institutional capacity constrains the nations in the Caribbean region to the passive role of recipient in international collaborations. The lack of true progress in Haiti after years' aiding efforts and the worsening socioeconomic and environmental performances of Jamaica as a result of the structural reform imposed by the World Bank and IMF, as well as Cuba's high emission level as the legacy of its traditional Soviet-style sugar plantations, all indicate partnership with no small island states' true interests incorporated into the agenda not only fails to bring any long-term benefits for these states but erodes their autonomy and potential for the necessary transition. Among the five selected Caribbean nations, Cuba is the most promising one from the perspective of the social progress and associated stress on the ecosystem. In a sense Cuba's Its "degrowth" model of reduced production and consumption (Borowy, 2011) benefits from its isolation as a result of the collapse of the Soviet Union collapse and the U.S. embargo. However, the role of partnership in achieving sustainable development cannot be neglected in small island states' development process because of the urgency for the transition and the interconnectedness between countries on the global level. Based on the analysis of these five Caribbean nations' development process, we can conclude the strengthening of partnership goes beyond establishing more partnerships and requires the recognition of small island states' interests and concerns. The building-up of their institutional capacity is contingent to the international society stepping out of the mindset of regarding small island states as being inherently vulnerable and powerless, respecting their social capital embedded in traditional cultural and practices and acknowledging their interests in decision-making on global level.

Figure 15: Stress on the Ecosystem and Achievement of Social Outcomes, Regional Caribbean and Global



Regional Average



Global Average

6.4 Limitations and Future Research

The limitation associated to this study relates mostly to data constraints in terms of data availability and accuracy. To maintain consistency and comparability, this thesis uses data from the same sources as those applied in O'Neill et al.'s research (2018). However, specific data related to some of these five Caribbean small island states' social and environmental performances are not available for the period covered by this thesis. For example, income data are not available for Trinidad & Tobago, Cuba and Haiti for any year between 1995 and 2015 at the World Bank Open database. There are no data on General Enrollment Ratio in Secondary Schools for Trinidad & Tobago and Haiti at the World Bank Database for any year between 1995 and 2015[22]. Other databases, research papers and government reports are referred to, and estimations are made by following the same rationale as adopted in O'Neill's research (2018). As for environmental performances, the eHANPP data are updated to 2007, provided by Dr. Kastner. Domestic contribution to CO_2 emission and material footprints are updated to 2008 at Eora MRIO. At Water Footprint Network, the most recent data related to consumption-based blue water use is that of 2005, an average value for the 10-year period between 1996 and 2005. The 2011 consumption-based blue water value is estimated based on the 2005 value by using a factor calculated by comparing the total use of blue water in 2011 (Steffen et al. 2015) with the usage amount in 2005 (WFN, 2018). At Eora MRIO, data related to domestic contribution to Biochemical Flow is available for only 2000. Adjusting O'Neill et al.'s approach (2018), domestic contributions for each individual year between 1995 and 2015 are estimated by using a factor calculated by comparing the total use of phosphate and nitrogen fertilizers and the total amount of farm animal manure of individual year with the relevant amounts in 2000. Inaccuracy must have occurred in the process of proxy data source identification and data estimation. However, the objective of this research is not to accurately quantify individual country's vulnerability, rather, it is to analyze the relationship between an individual country's environmental and social performances over the past decade and identify the key element that might have caused its unsatisfactory position within the safe and just space. For future research, more recent data, especially consumption-based emission values, can be incorporated into the analysis to identify the interactions between these small island states' more up-to-date environmental and social performances. The result can be compared with the results covered in this research to test whether the five small island states have made measurable progress in their transition to sustainable development.

[22] For Trinidad & Tobago, data related to General Enrollment Ration in Secondary Schools is available for the year 2004 during the period between 1995 and 2015.

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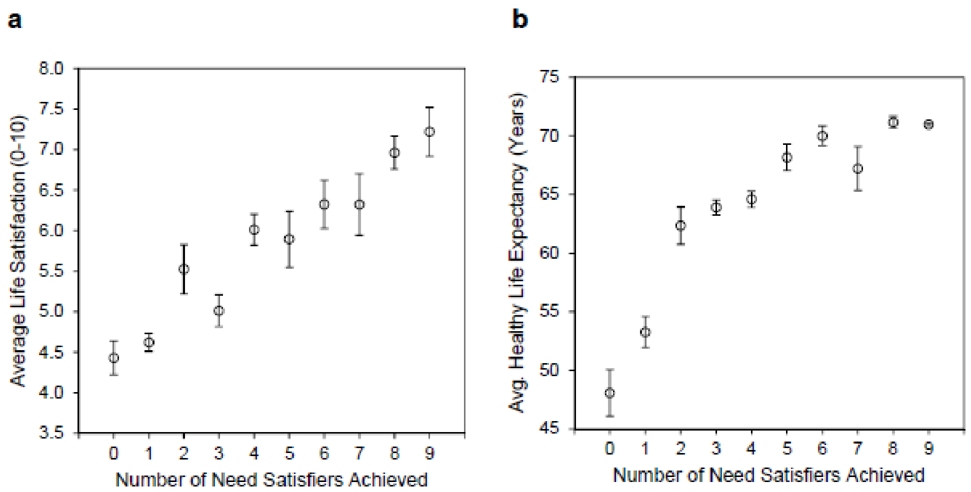
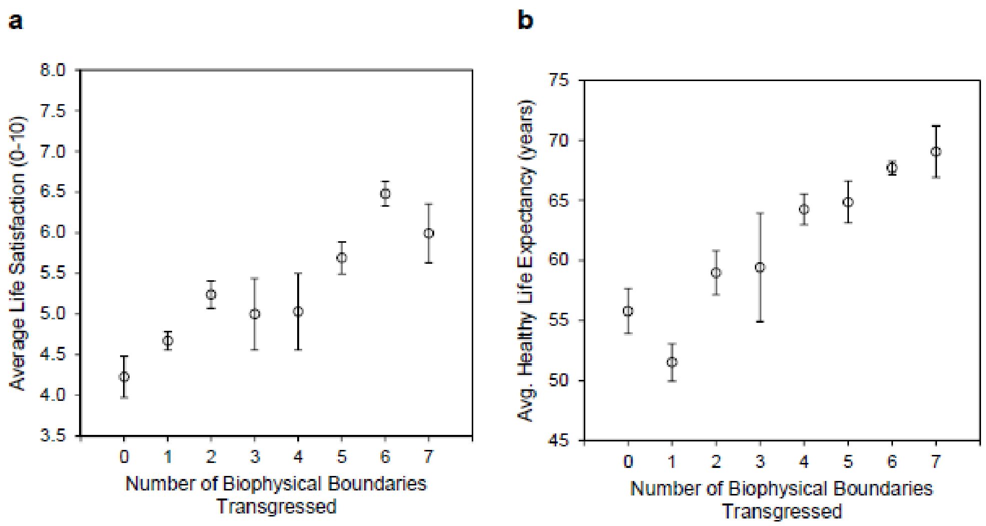
Appendices

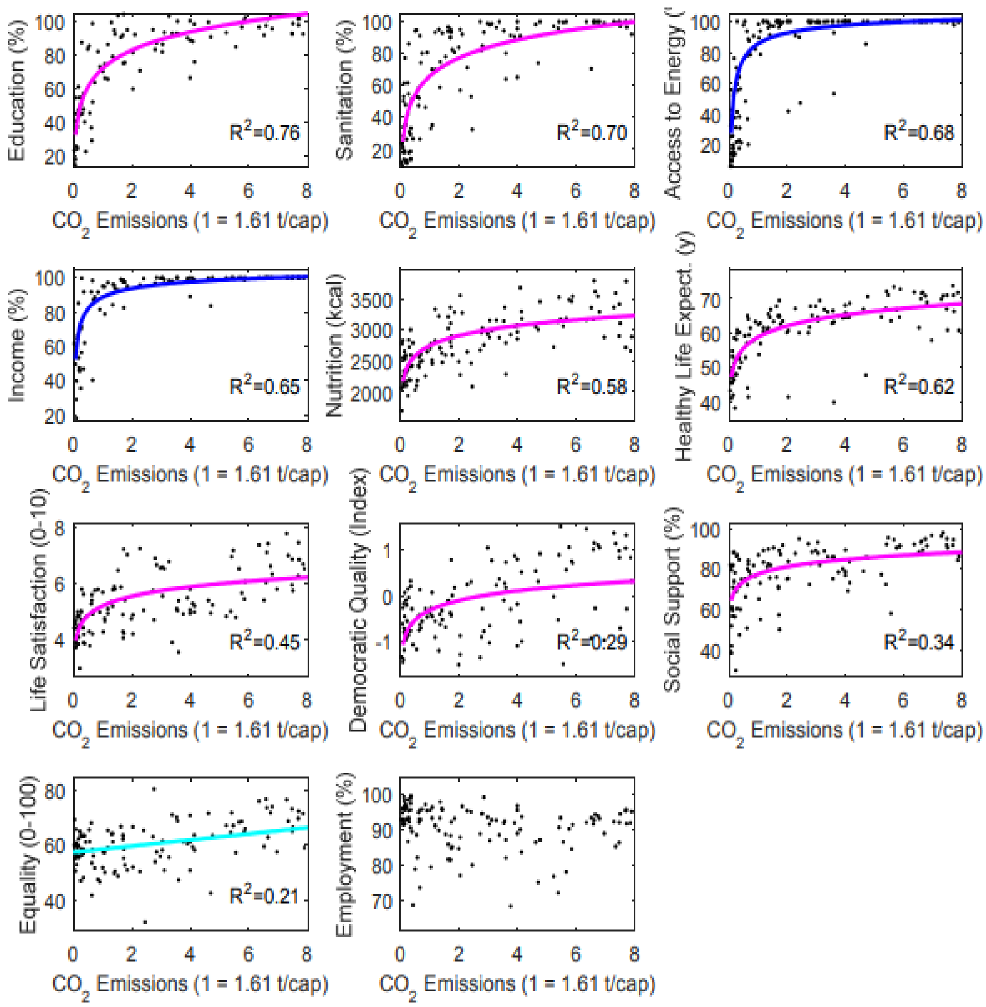
A Correlation: Biophysical and Social Performances (O'Neill, et al. 2018)



Supplementary Fig. 1. Average values of (a) life satisfaction, and (b) healthy life expectancy, for countries based on the number of needs-related social thresholds achieved. Error bars give the standard error of the mean. The countries included are the same as in Fig. 2 of the main text (*N* = 109).



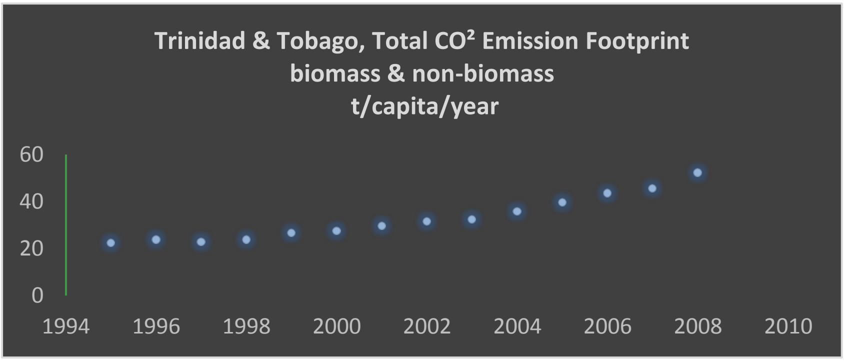
Supplementary Fig. 2. Average values of (a) life satisfaction, and (b) healthy life expectancy, for countries based on the number of biophysical thresholds transgressed. Error bars give the standard error of the mean. The countries included are the same as in Fig. 2 of the main text (*N* = 109).

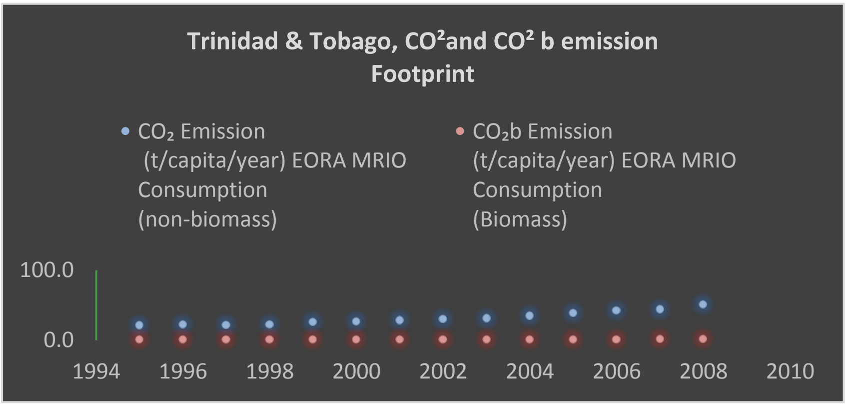


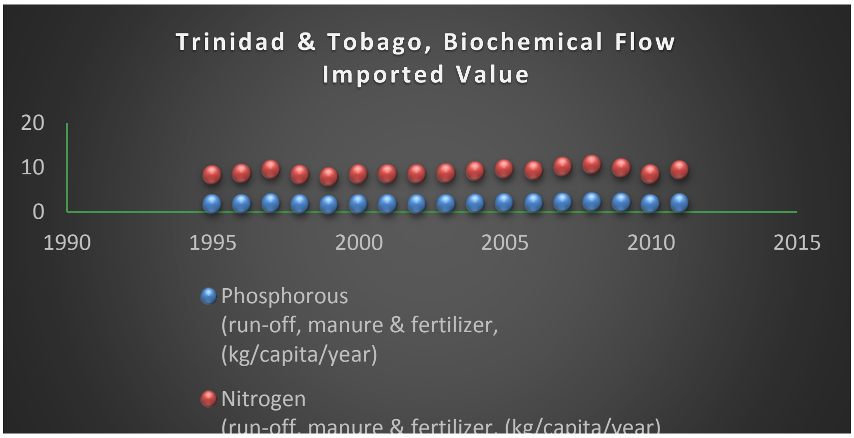
Supplementary Fig. 3. The relationship between CO2 emissions (scaled to the per capita biophysical boundary) and each of the social indicators. The best-fit curve (as determined by *AIC*), and the comparable *R2* value, are shown on each plot. Blue indicates a saturation curve, magenta indicates a linear–log curve, and cyan indicates a linear relationship. If no curve is shown, the relationship is not statistically significant.

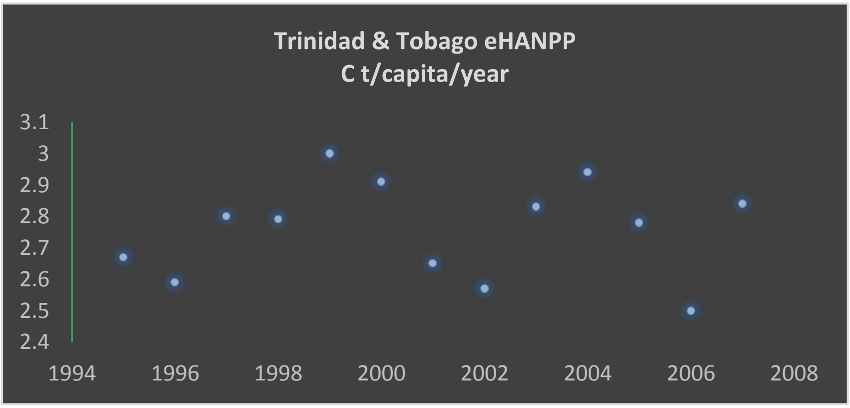
B. Trend of Change: Environmental and Social Performances of the Five Selected Caribbean Nations

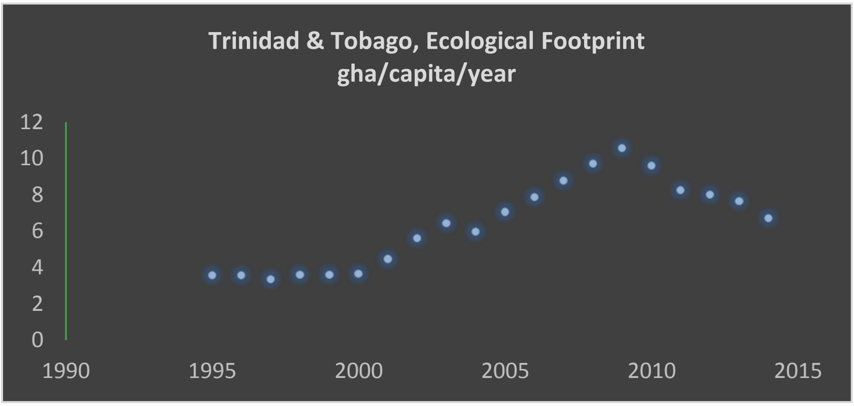
Trinidad & Tobago, Environmental Performances, Trend of Change

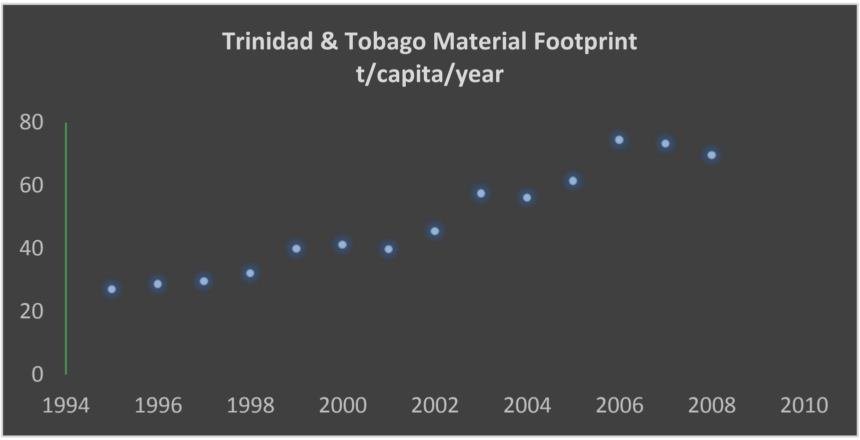




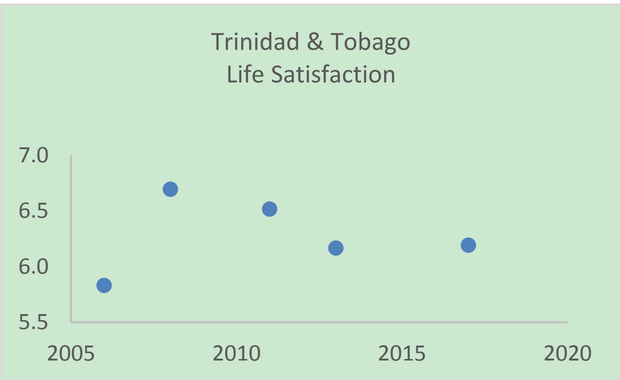


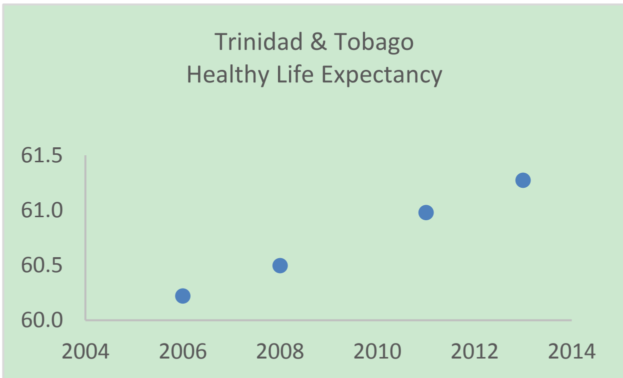


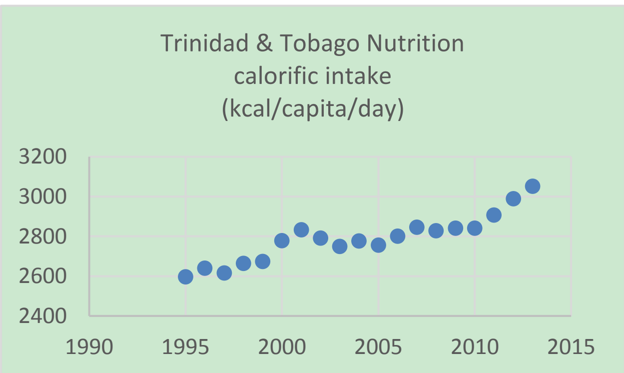


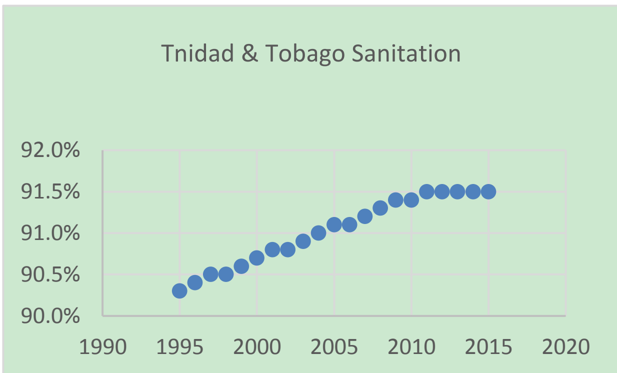


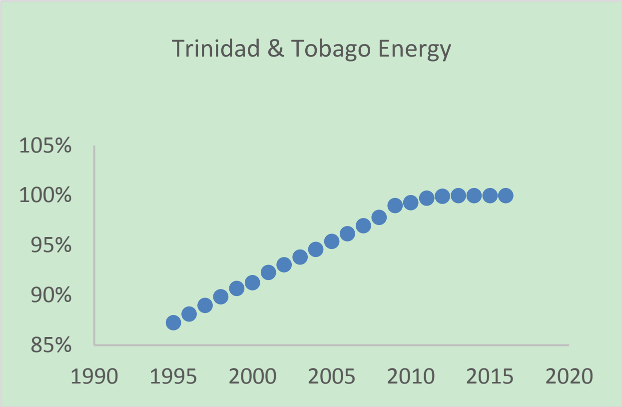
Trinidad & Tobago, Social Performances, Trend of Change

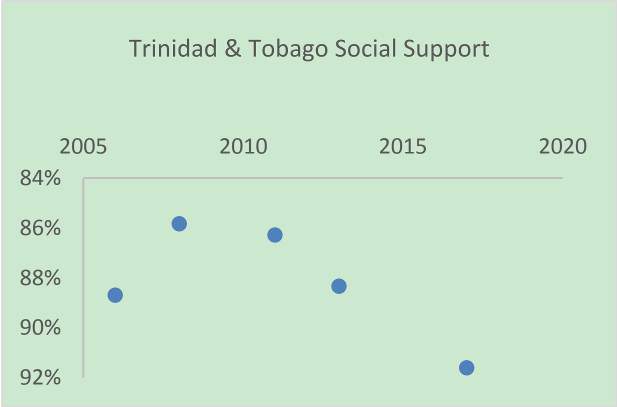


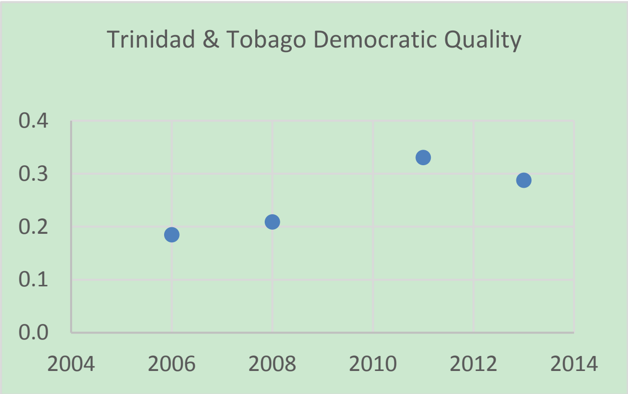


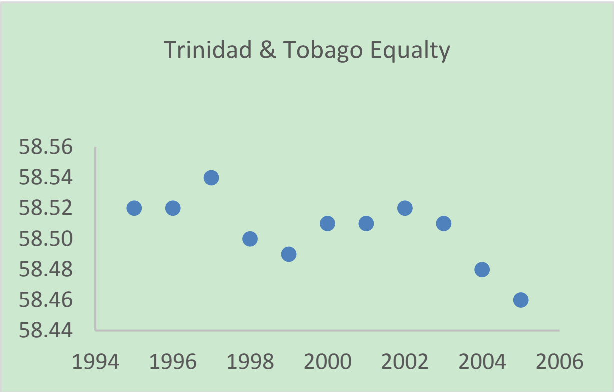


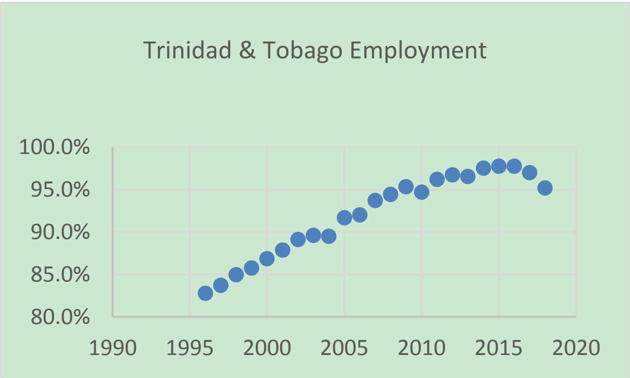




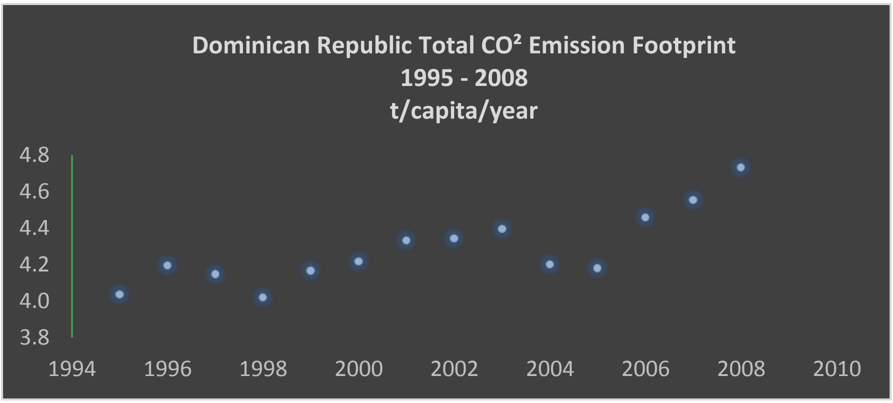


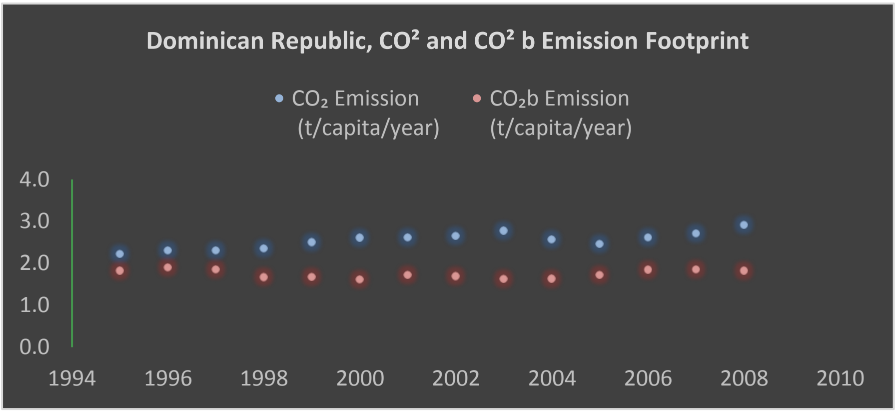


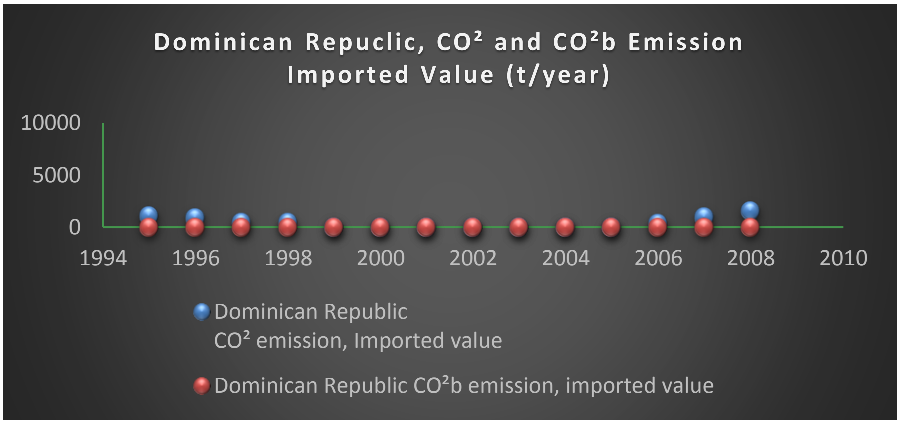


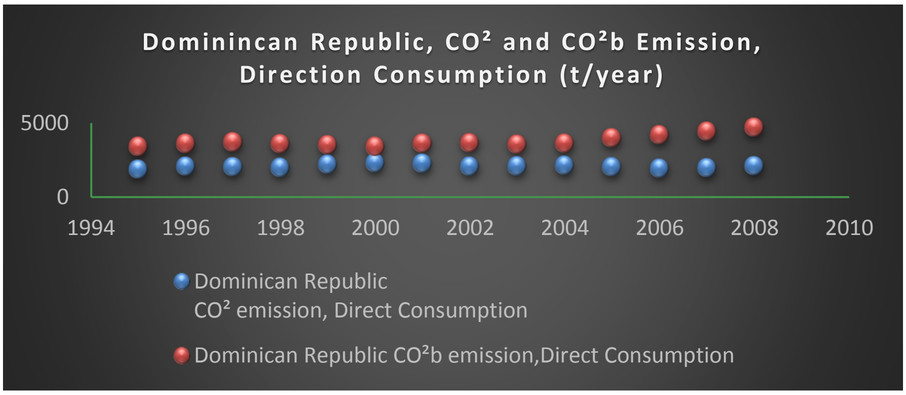


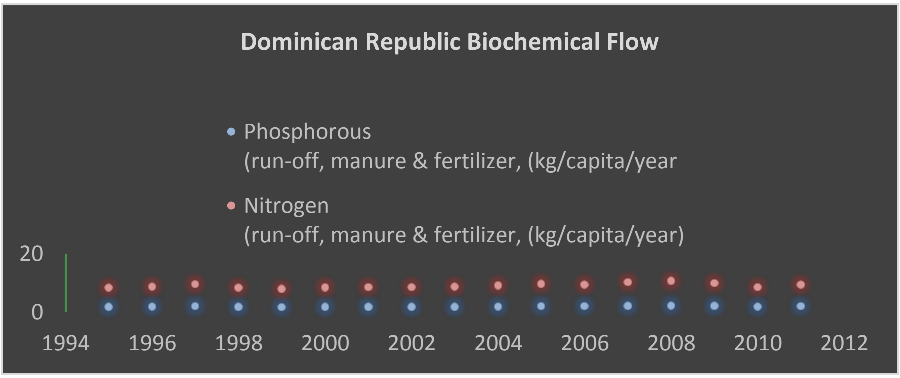
Dominican Republic, Environmental Performances, Trend of Change

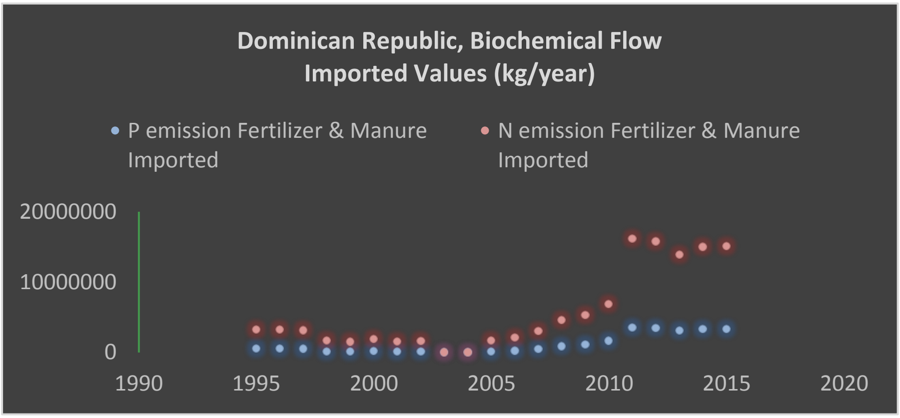


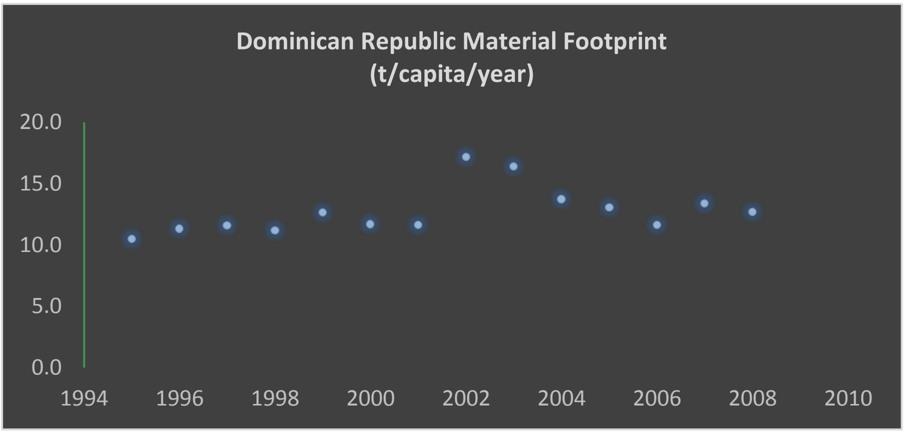

Dominican Republic, CO² and CO² b Emission Footprint
CO₂ Emission (t/capita/year)
CO₂b Emission (t/capita/year)
4.0
3.0
2.0
1.0
0.0
1994 1996 1998 2000 2002 2004 2006 2008 2010

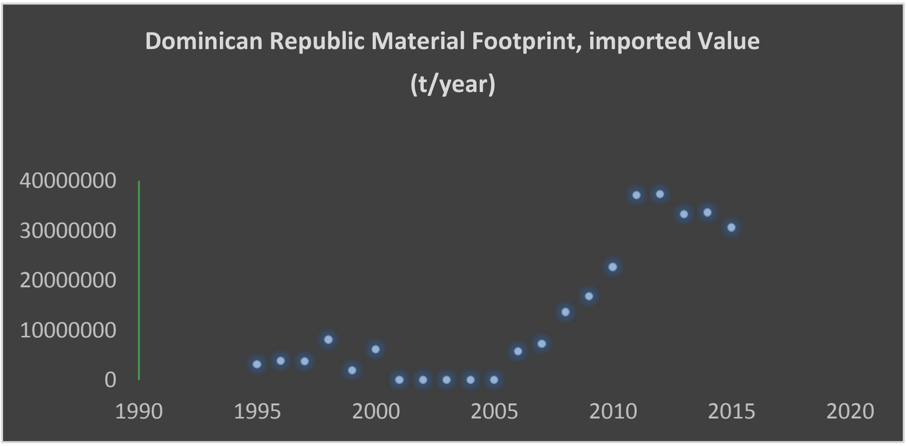

Dominican Repuclic, CO² and CO²b Emission Imported Value (t/year)
10000
5000
0
1994 1996 1998 2000 2002 2004 2006 2008 2010
Dominican Republic CO² emission, Imported value
Dominican Republic CO²b emission, imported value

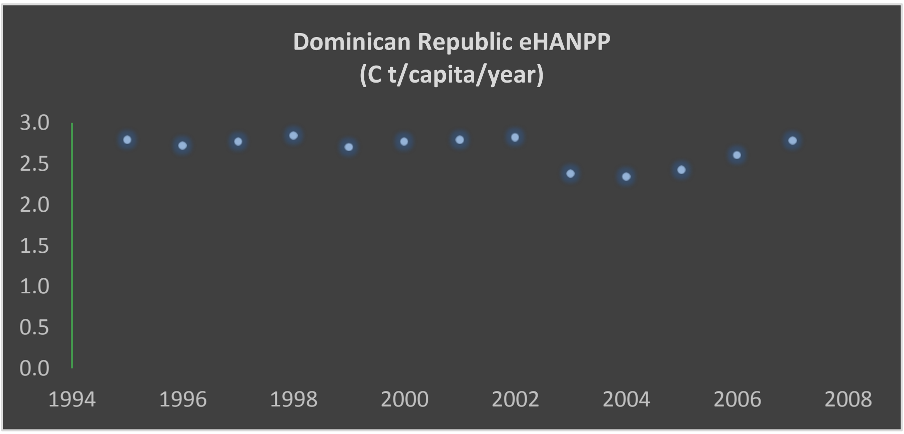

Domininçan Republic, CO² and CO²b Emission, Direction Consumption (t/year)
5000
0
1994 1996 1998 2000 2002 2004 2006 2008 2010
Dominican Republic CO² emission, Direct Consumption
Dominican Republic CO²b emission,Direct Consumption

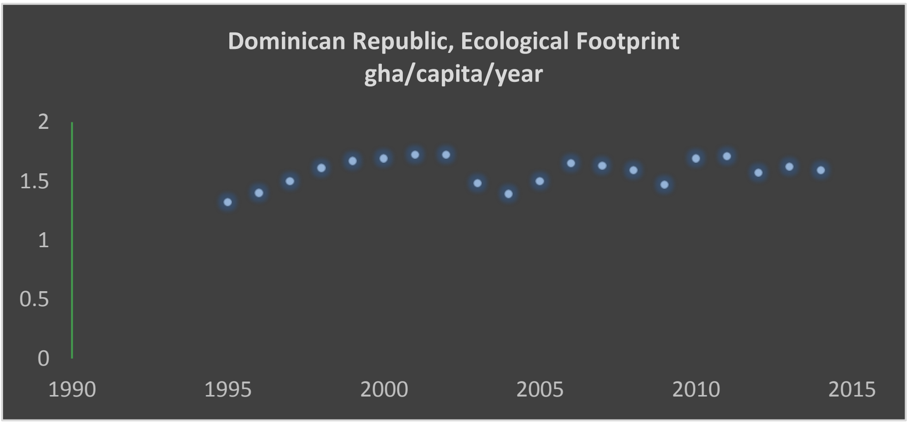

Dominican Republic Biochemical Flow
Phosphorous (run-off, manure & fertilizer, (kg/capita/year
Nitrogen (run-off, manure & fertilizer, (kg/capita/year)
20
0
1994 1996 1998 2000 2002 2004 2006 2008 2010 2012


Dominican Republic, Biochemical Flow
Imported Values (kg/year)
P emission Fertilizer & Manure Imported
N emission Fertilizer & Manure Imported
20000000
10000000
0
1990
1995
2000
2005
2010
2015
2020

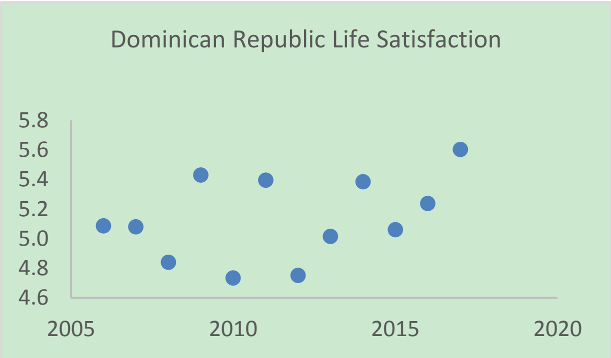

Dominican Republic Material Footprint
(t/capita/year)
20.0
15.0
10.0
5.0
0.0
1994
1996
1998
2000
2002
2004
2006
2008
2010

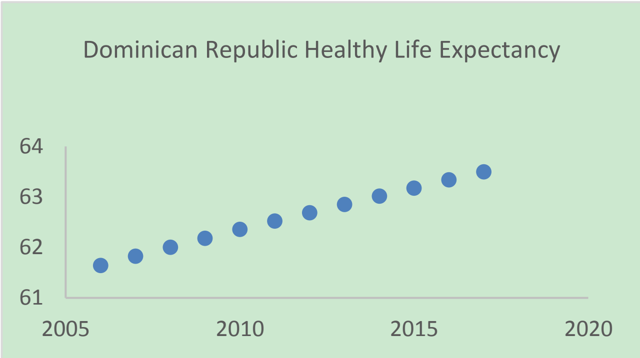

Dominican Republic Material Footprint, imported Value
(t/year)
40000000
30000000
20000000
10000000
0
1990
1995
2000
2005
2010
2015
2020

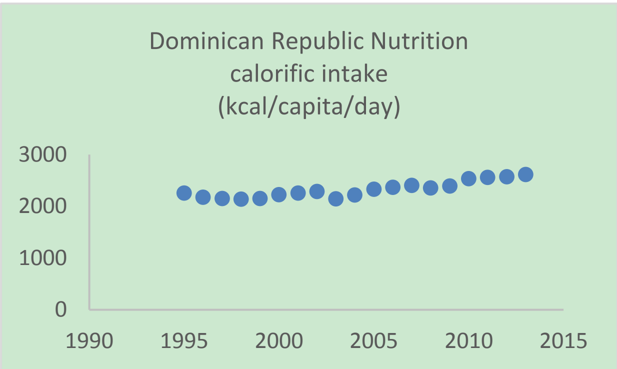

Dominican Republic eHANPP
(C t/capita/year)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1994
1996
1998
2000
2002
2004
2006
2008

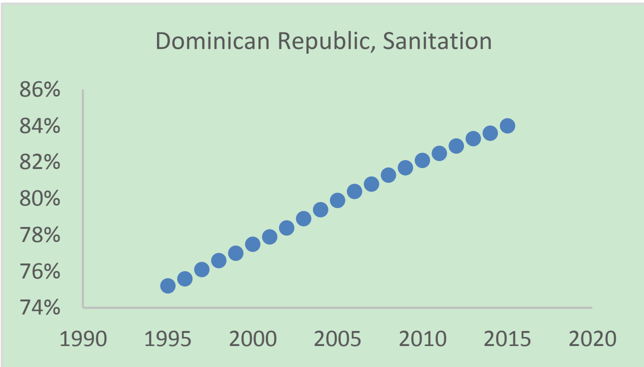


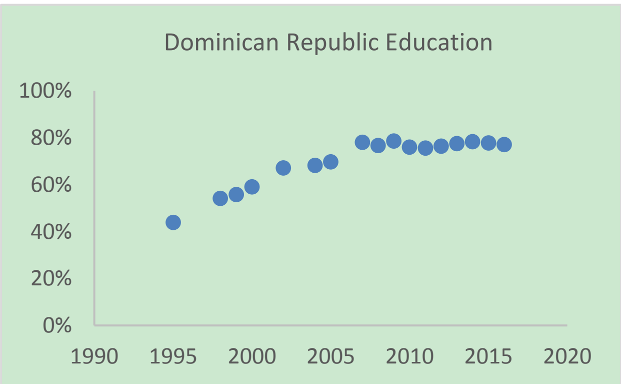
Dominican Republic, Social Performances, Trend of Change

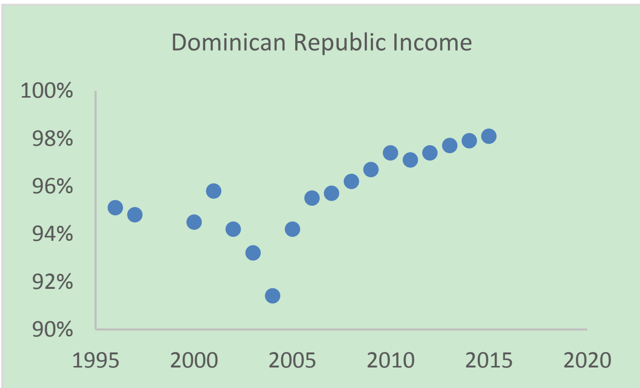


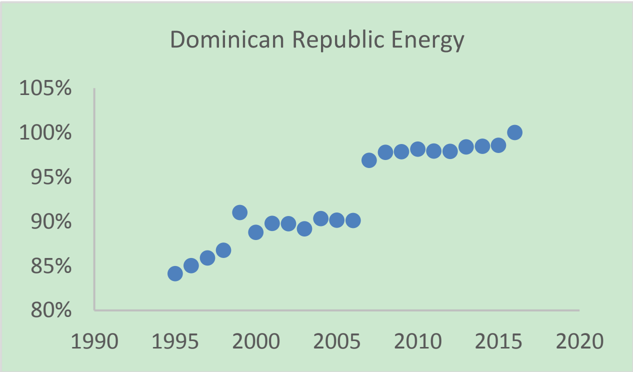


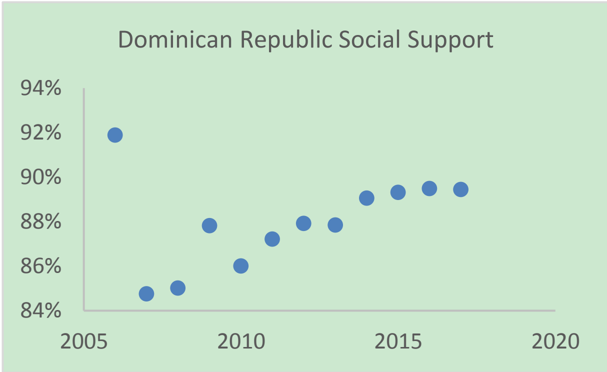


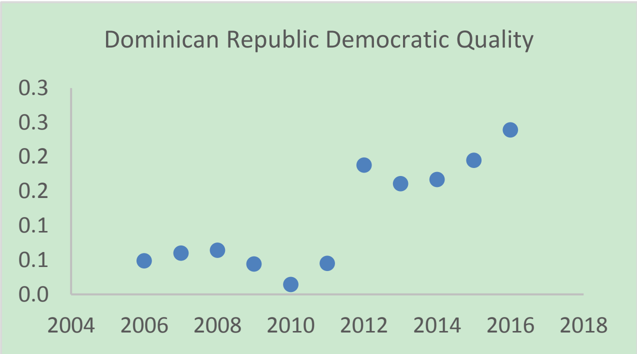


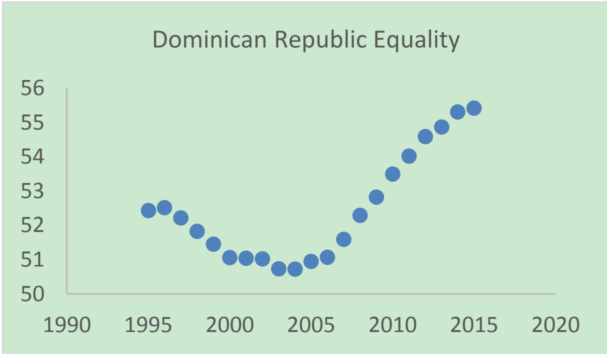


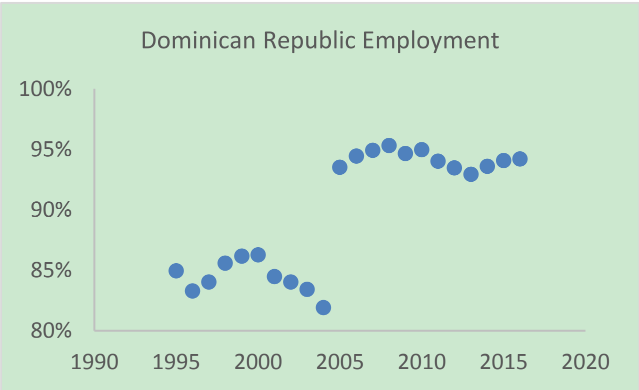




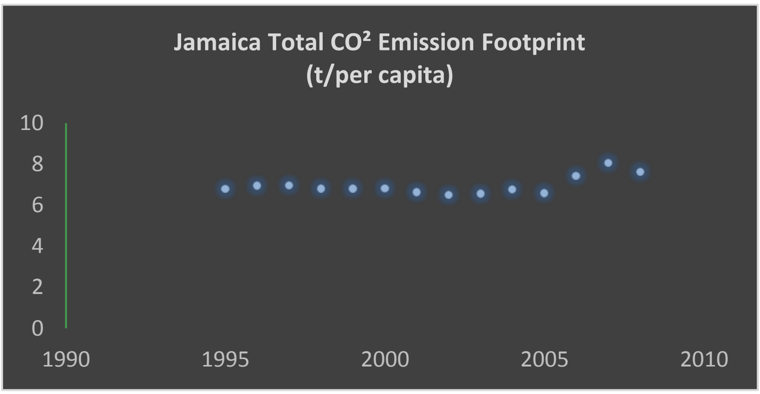


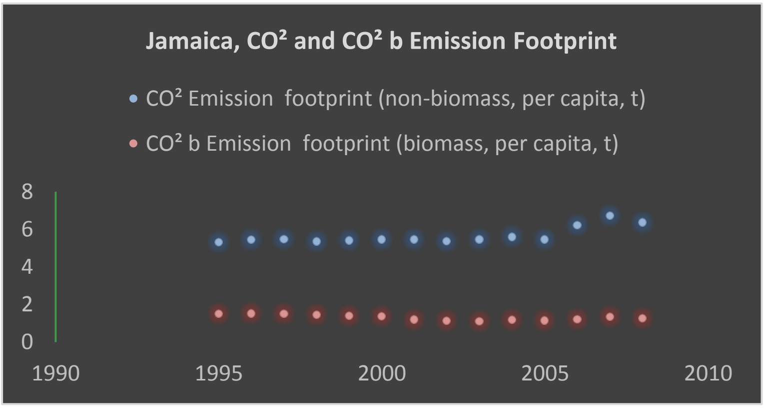


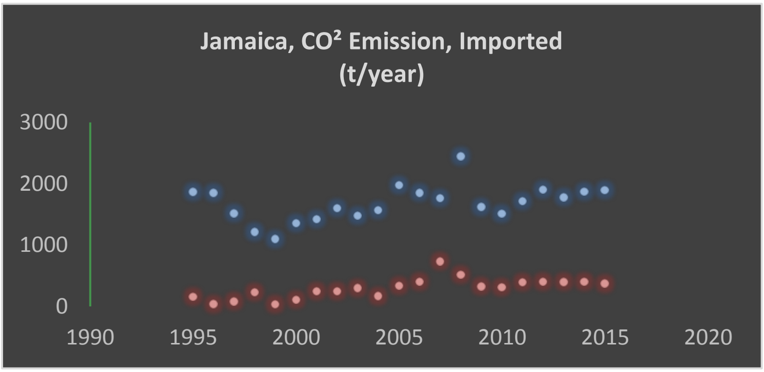


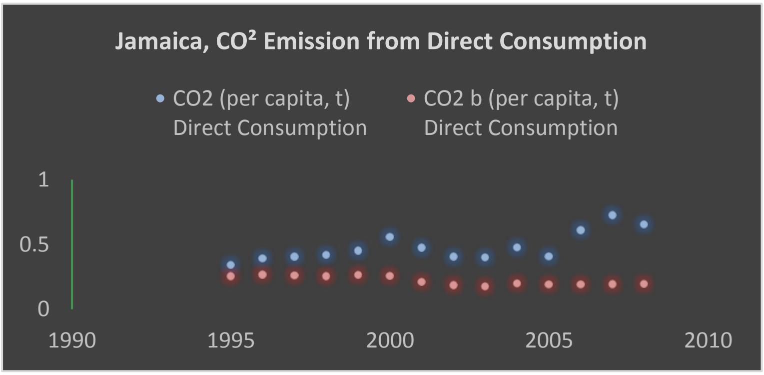


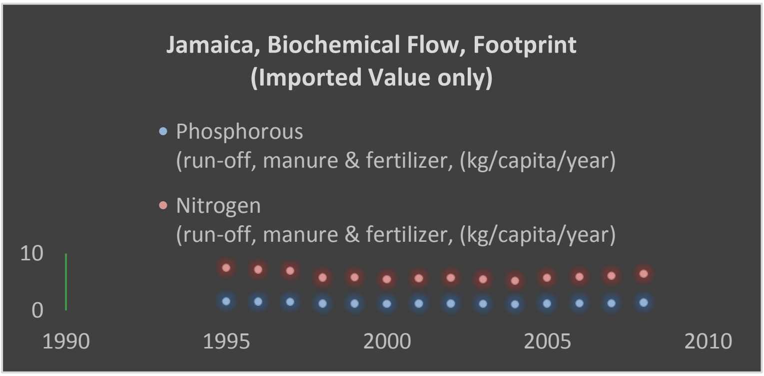
Jamaica, Environmental Performances, Trend of Change

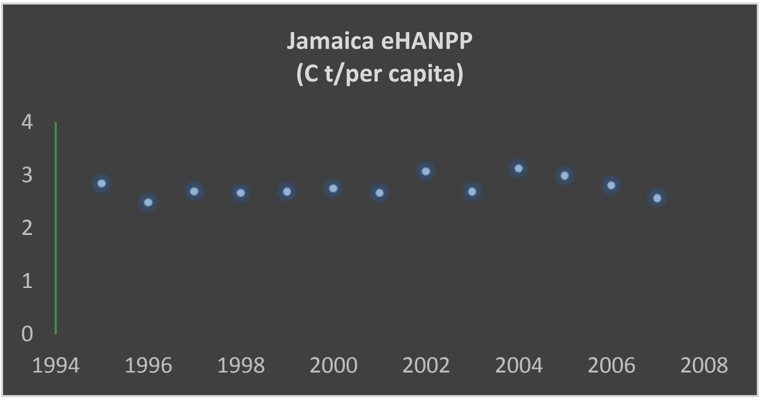


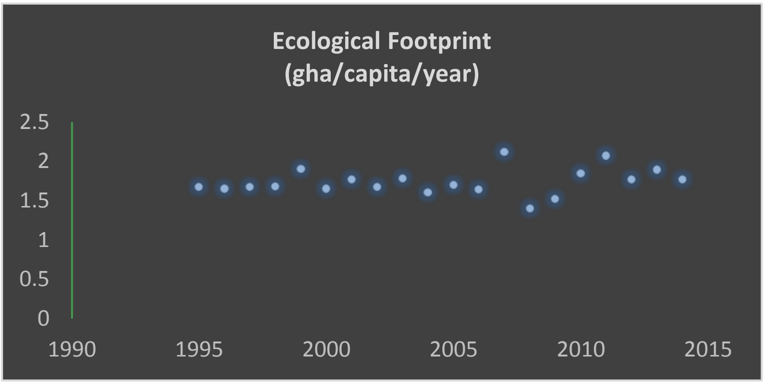

Jamaica, CO² and CO² b Emission Footprint
CO² Emission footprint (non-biomass, per capita, t)
CO² b Emission footprint (biomass, per capita, t)
8
6
4
2
0
1990
1995
2000
2005
2010

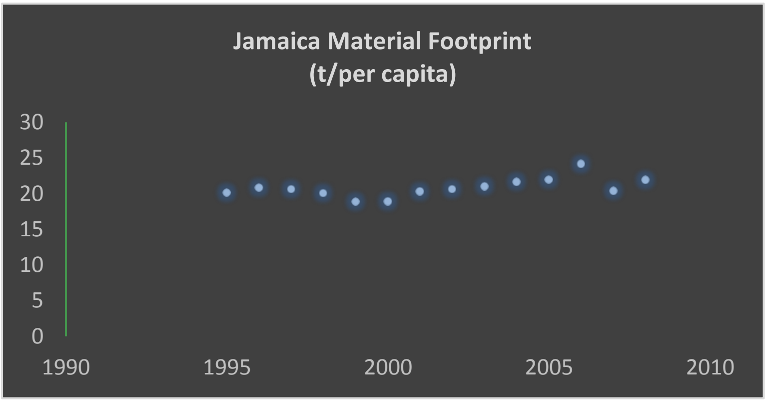

Jamaica, CO² Emission, Imported (t/year)
3000
2000
1000
0
1990
1995
2000
2005
2010
2015
2020


Jamaica, CO² Emission from Direct Consumption
CO2 (per capita, t) Direct Consumption
CO2 b (per capita, t) Direct Consumption
1
0.5
0
1990
1995
2000
2005
2010

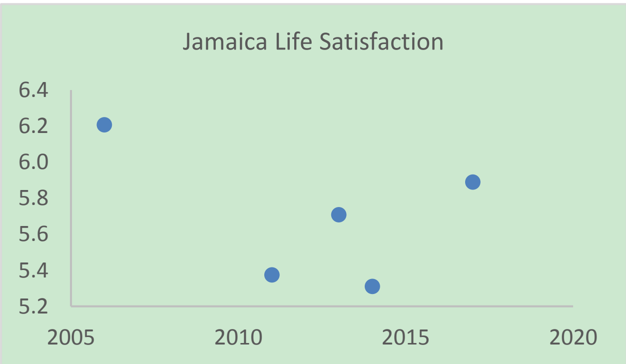

Jamaica, Biochemical Flow, Footprint (Imported Value only)
Phosphorous (run-off, manure & fertilizer, (kg/capita/year)
Nitrogen (run-off, manure & fertilizer, (kg/capita/year)
10
0
1990
1995
2000
2005
2010

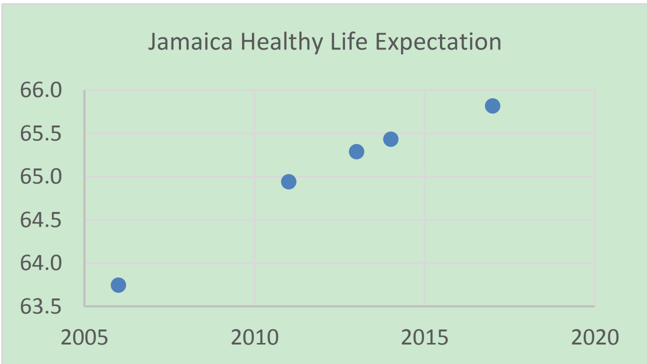


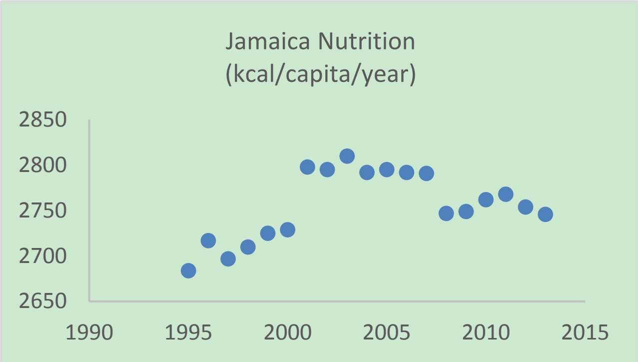


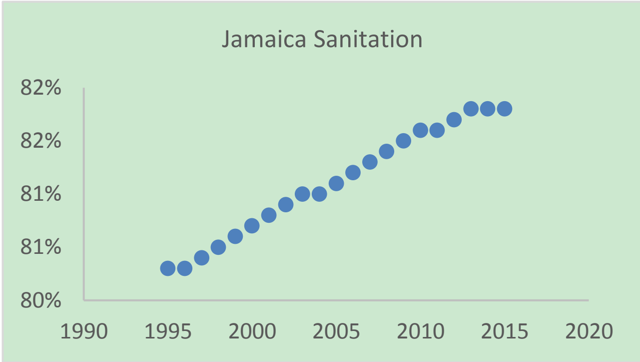


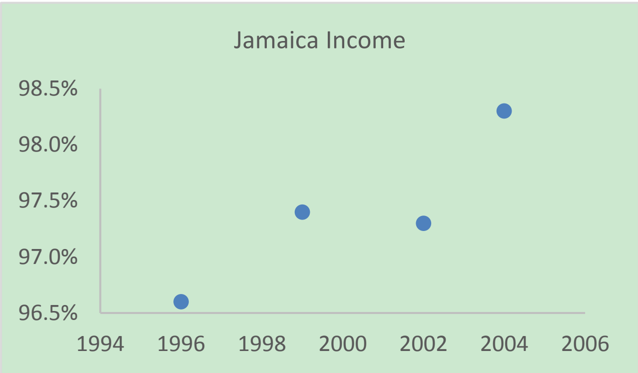
Jamaica, Social Performances, Trend of Change

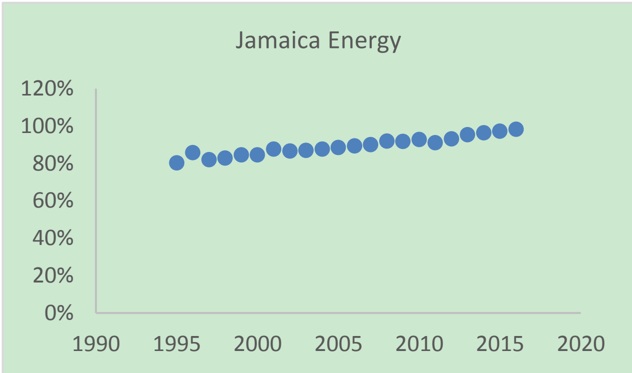


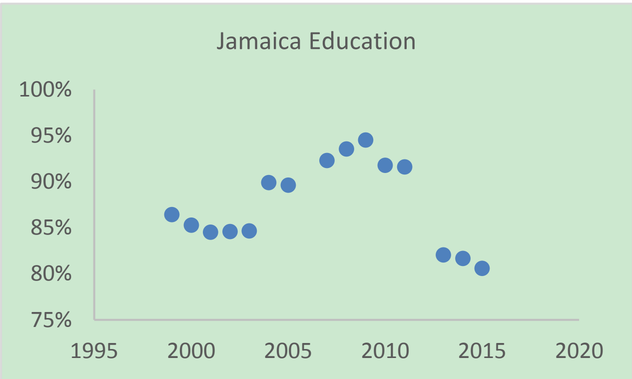


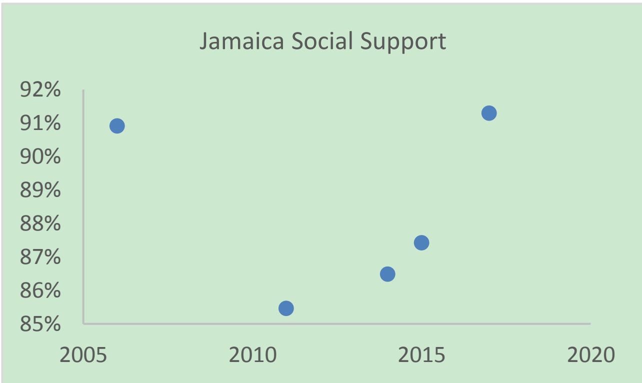

Jamaica Nutrition
(kcal/capita/year)
2850
2800
2750
2700
2650
1990
1995
2000
2005
2010
2015

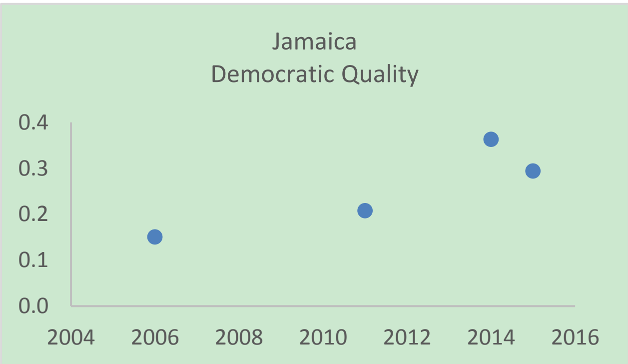

Jamaica Sanitation
82%
82%
81%
81%
80%
1990
1995
2000
2005
2010
2015
2020

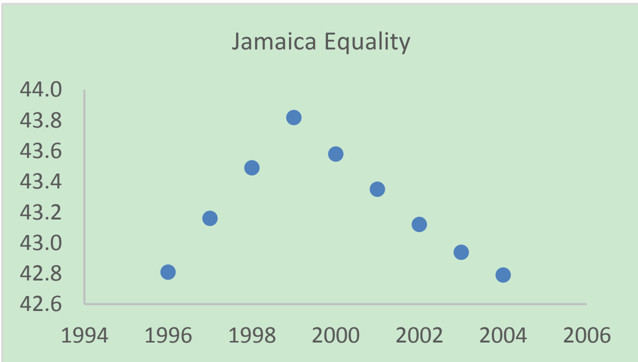

Jamaica Income
98.5%
98.0%
97.5%
97.0%
96.5%
1994
1996
1998
2000
2002
2004
2006

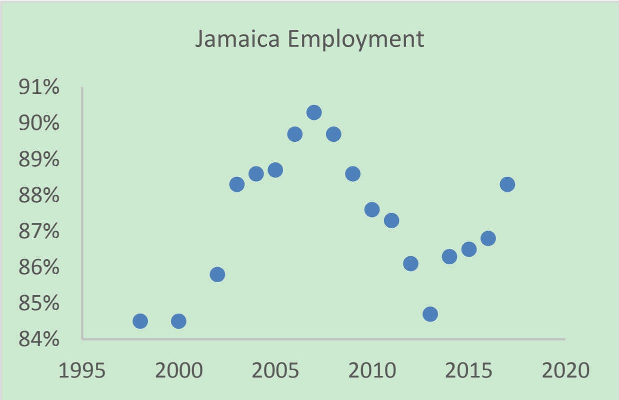

Jamaica Energy
120%
100%
80%
60%
40%
20%
0%
1990
1995
2000
2005
2010
2015
2020


Jamaica Education
100%
95%
90%
85%
80%
75%
1995
2000
2005
2010
2015
2020

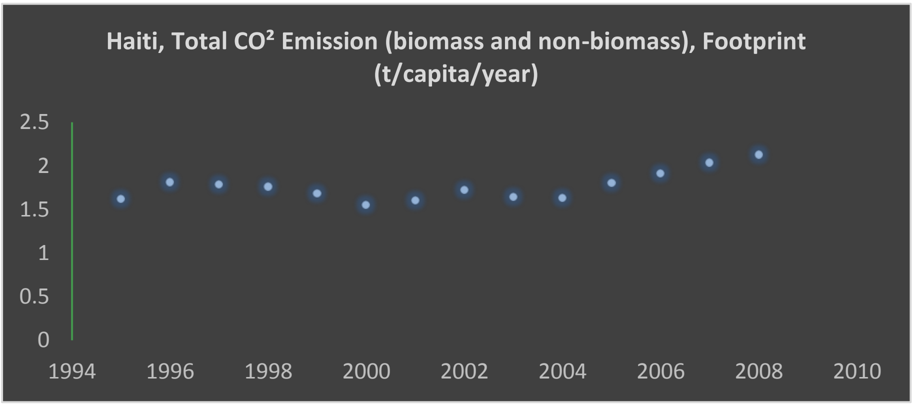

Jamaica Social Support
92%
91%
90%
89%
88%
87%
86%
85%
2005
2010
2015
2020

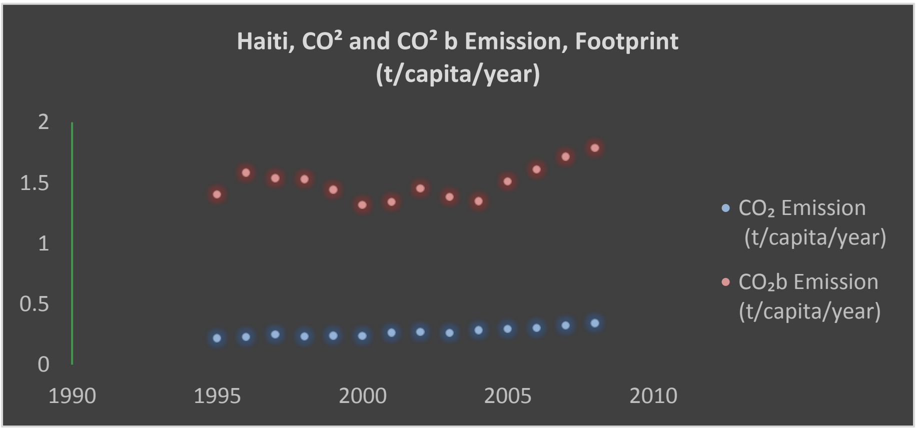

Jamaica
Democratic Quality
0.4
0.3
0.2
0.1
0.0
2004
2006
2008
2010
2012
2014
2016

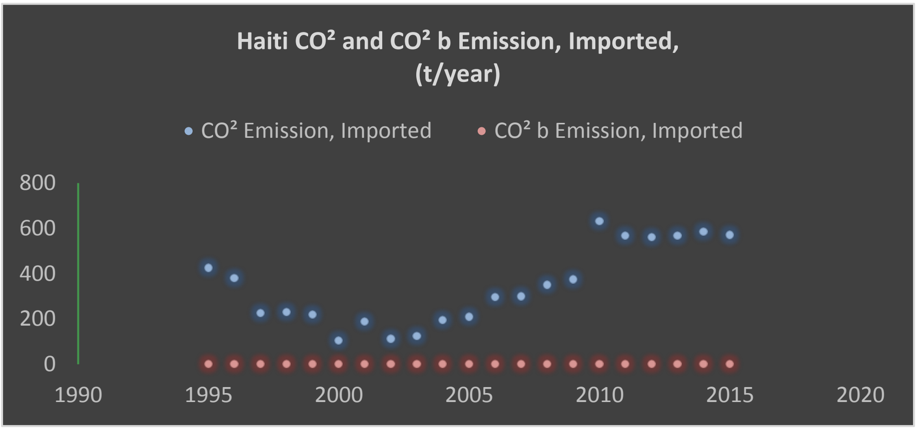

Jamaica Equality
44.0
43.8
43.6
43.4
43.2
43.0
42.8
42.6
1994
1996
1998
2000
2002
2004
2006

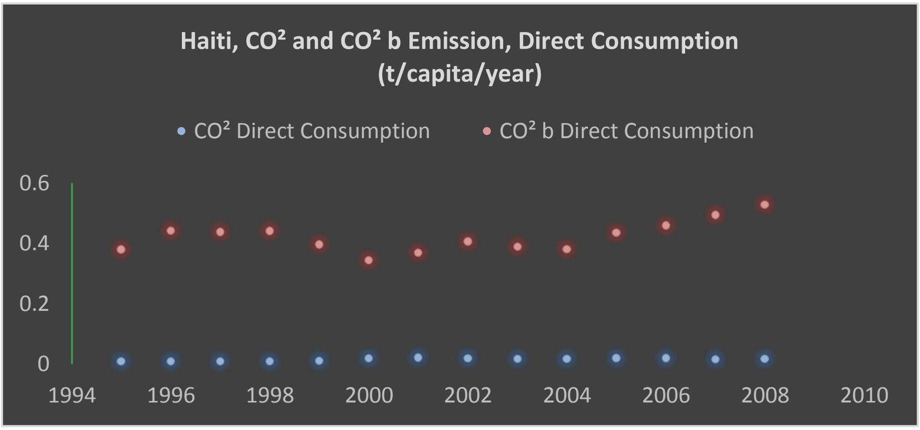


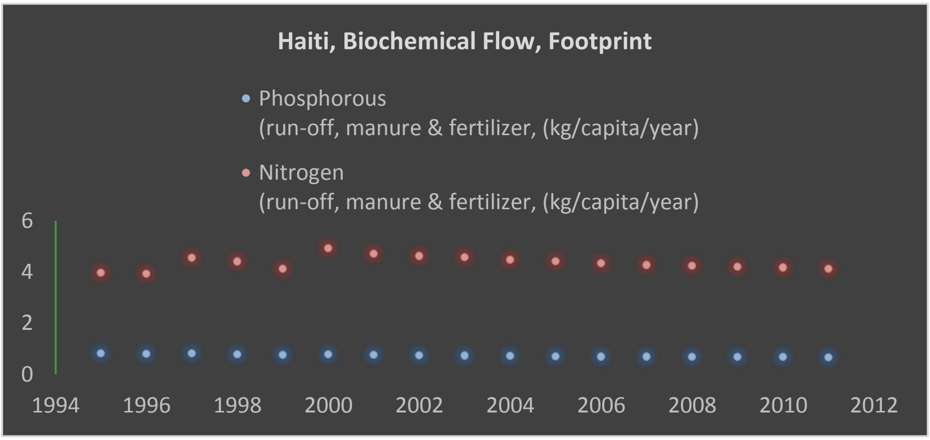
Haiti, Environmental Performances, Trend of Change

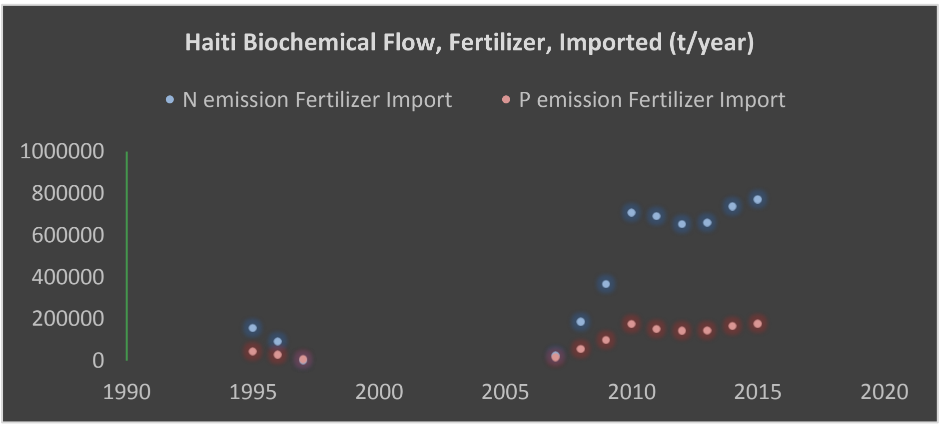


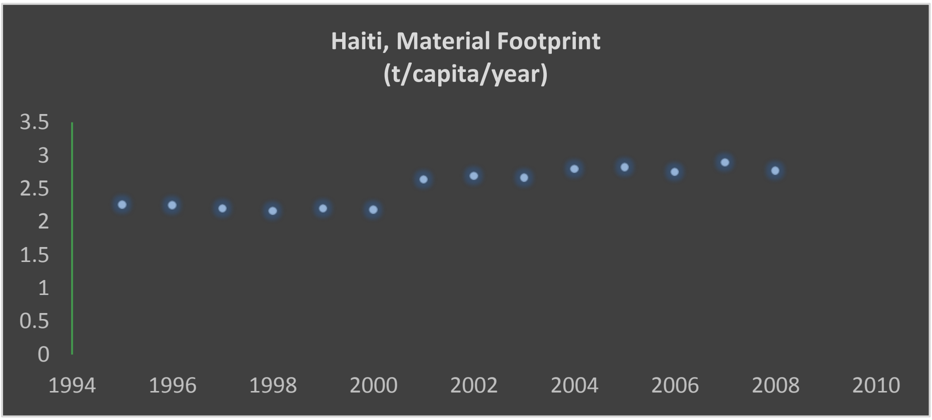


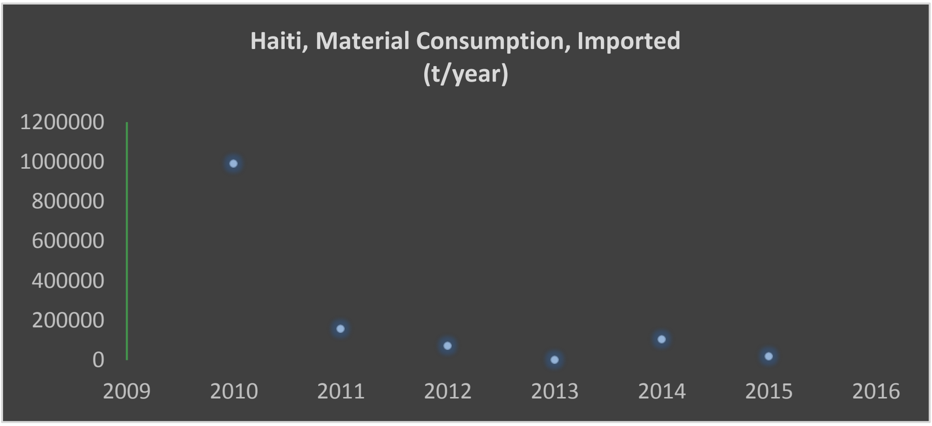

Haiti CO² and CO² b Emission, Imported, (t/year)
CO² Emission, Imported
CO² b Emission, Imported
800
600
400
200
0
1990
1995
2000
2005
2010
2015
2020

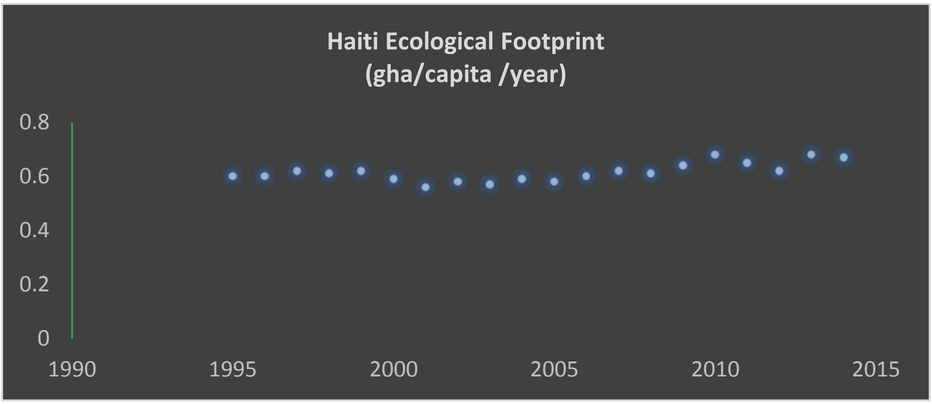

Haiti, CO² and CO² b Emission, Direct Consumption (t/capita/year)
CO² Direct Consumption
CO² b Direct Consumption
0.6
0.4
0.2
0
1994
1996
1998
2000
2002
2004
2006
2008
2010

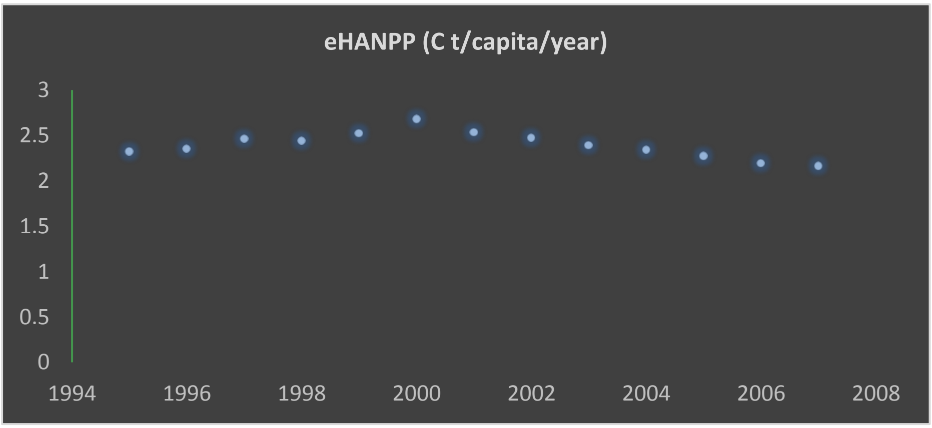

Haiti, Biochemical Flow, Footprint
Phosphorous
(run-off, manure & fertilizer, (kg/capita/year)
Nitrogen
(run-off, manure & fertilizer, (kg/capita/year)
6
4
2
0
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012


Haiti Biochemical Flow, Fertilizer, Imported (t/year)
N emission Fertilizer Import
P emission Fertilizer Import
1000000
800000
600000
400000
200000
0
1990
1995
2000
2005
2010
2015
2020

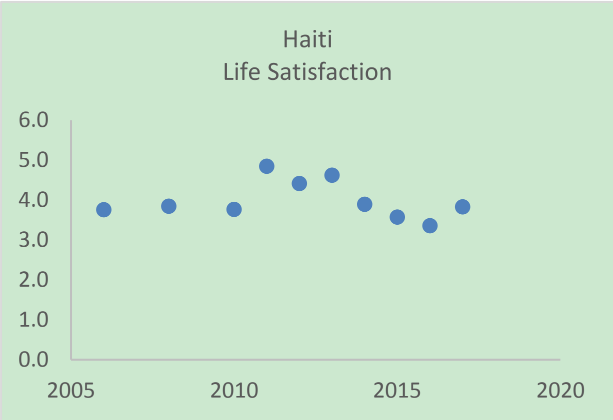

Haiti, Material Footprint
(t/capita/year)
3.5
3
2.5
2
1.5
1
0.5
0
1994
1996
1998
2000
2002
2004
2006
2008
2010

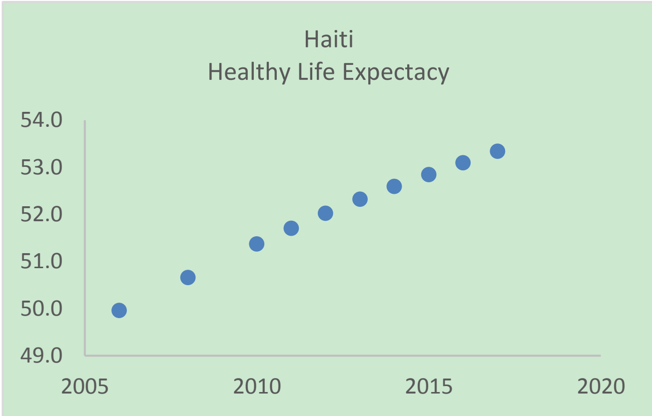

Haiti, Material Consumption, Imported
(t/year)
1200000
1000000
800000
600000
400000
200000
0
2009
2010
2011
2012
2013
2014
2015
2016

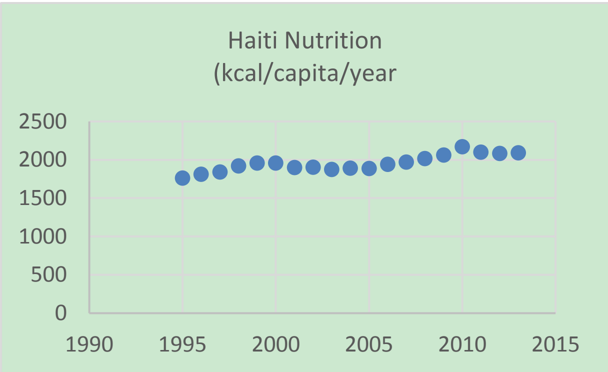

Haiti Ecological Footprint
(gha/capita /year)
0.8
0.6
0.4
0.2
0
1990
1995
2000
2005
2010
2015

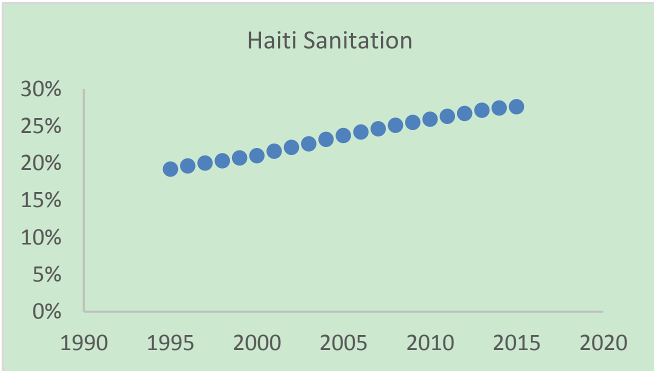

eHANPP (C t/capita/year)
3
2.5
2
1.5
1
0.5
0
1994
1996
1998
2000
2002
2004
2006
2008

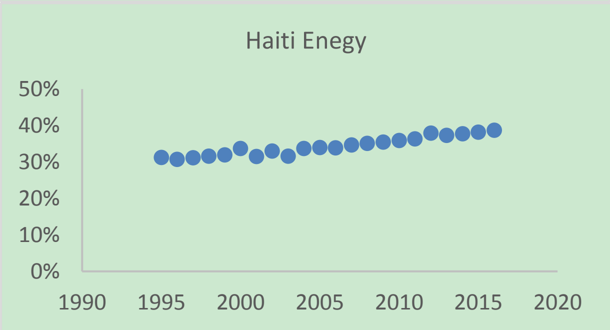
Haiti, Social Performances, Trend of Change

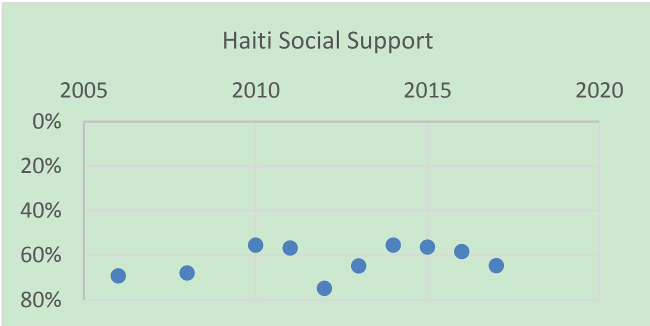


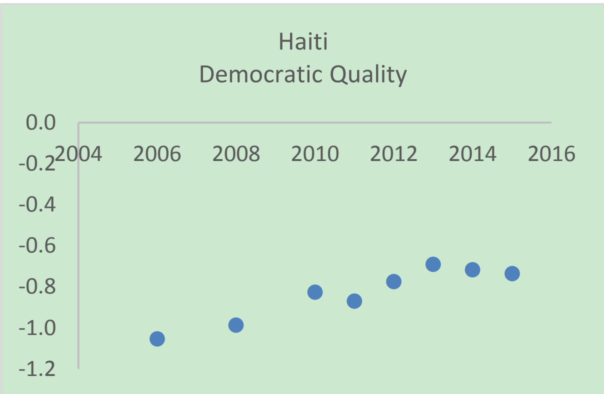


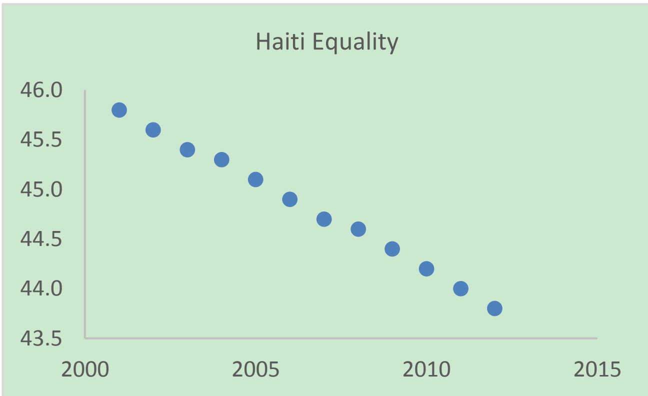


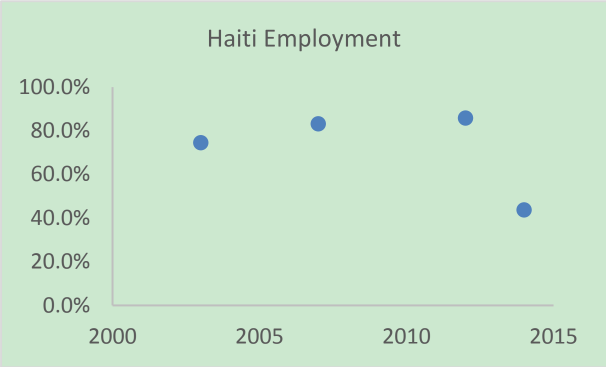




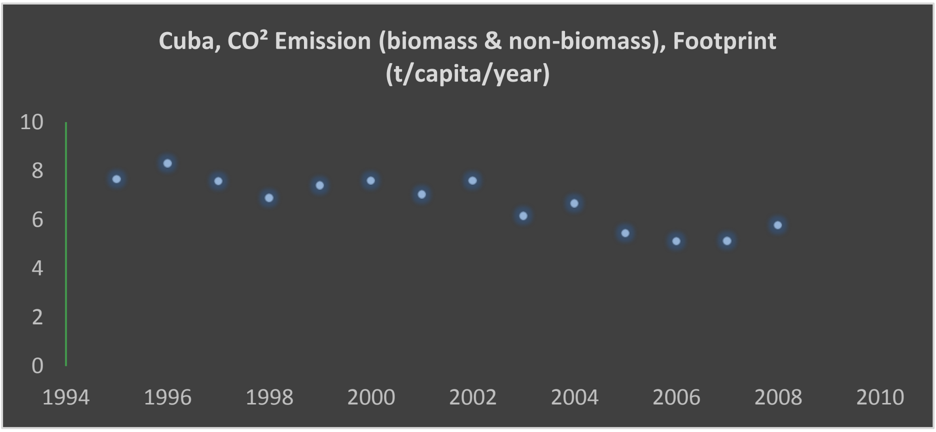


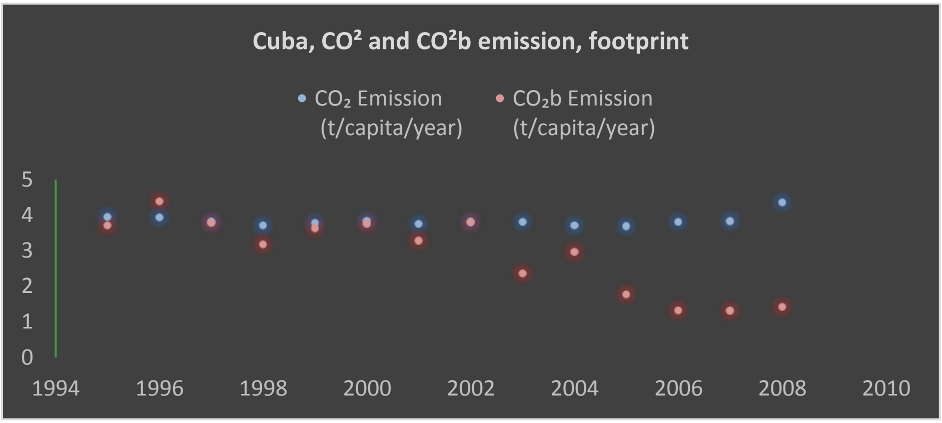


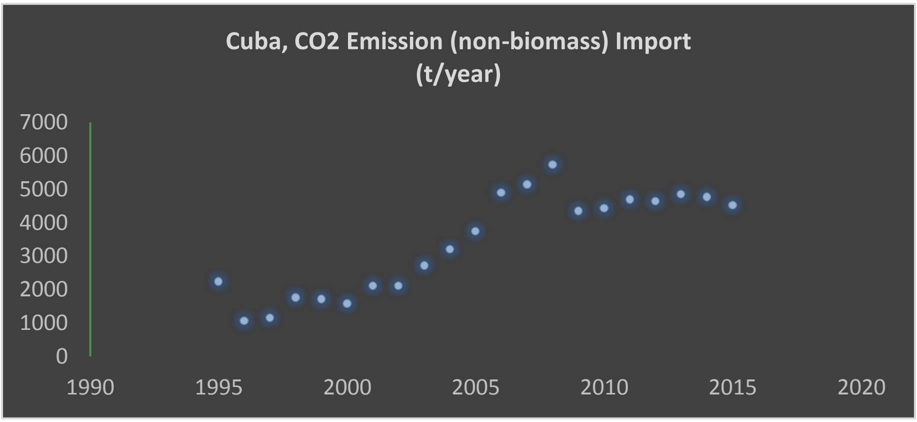


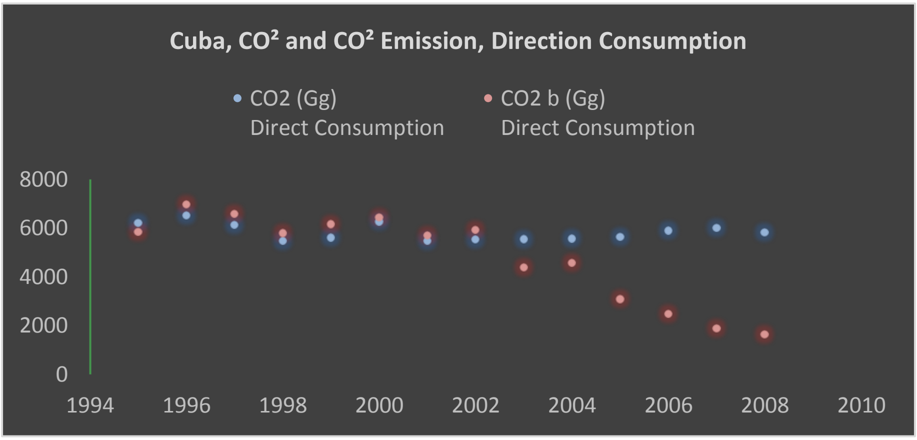


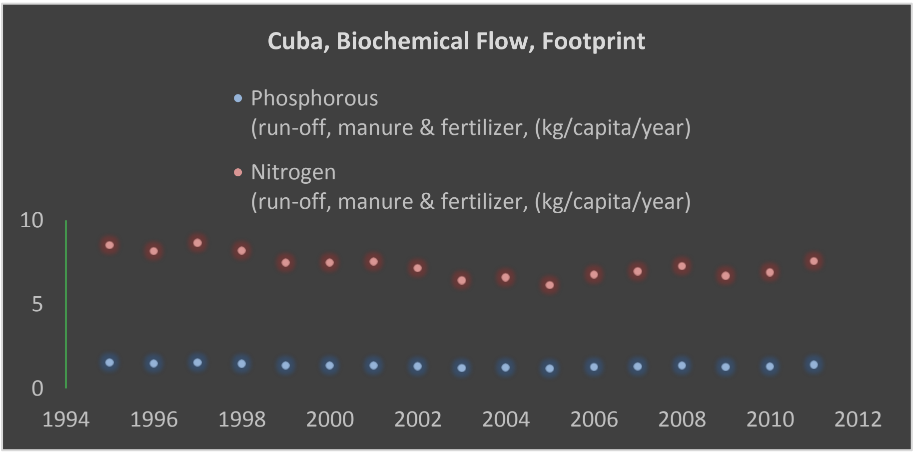
Cuba, Environmental Performances, Trend of Change

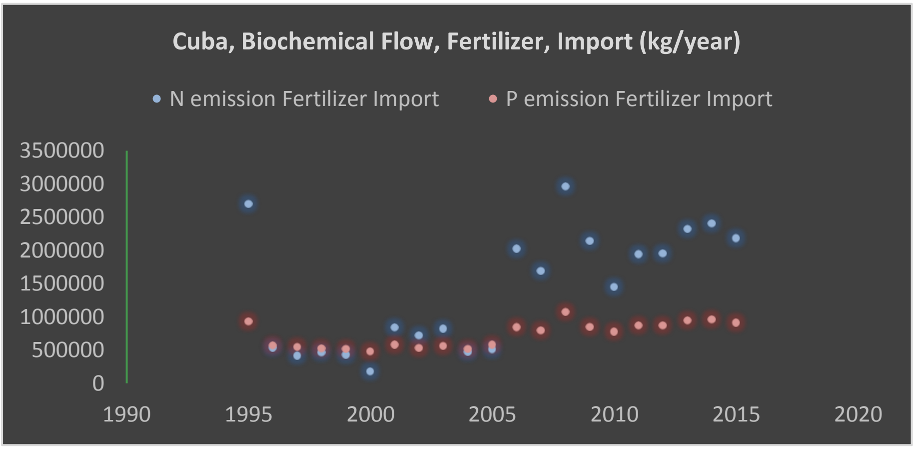


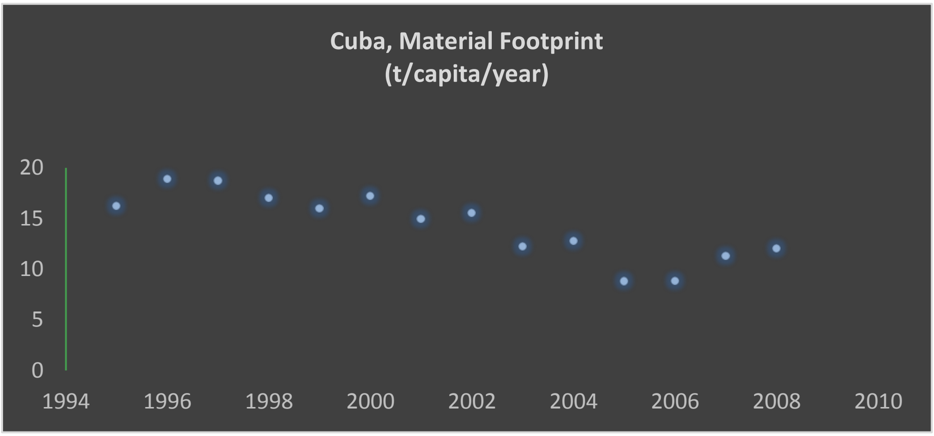


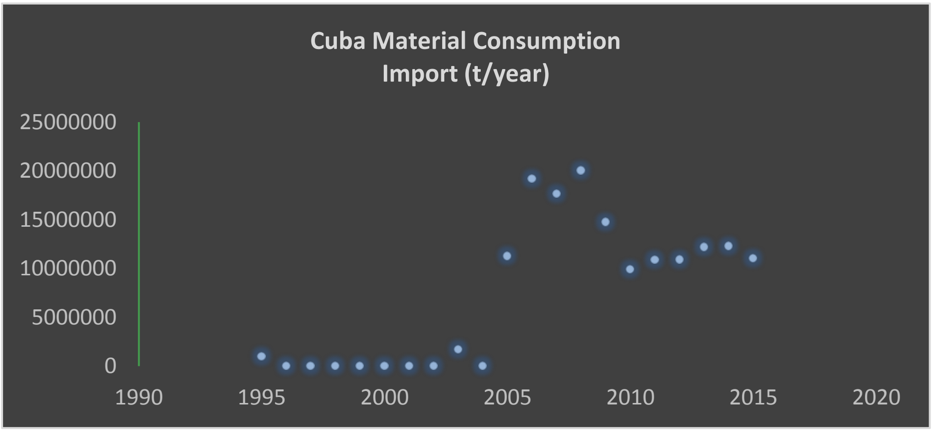

Cuba, CO2 Emission (non-biomass) Import (t/year)
7000
6000
5000
4000
3000
2000
1000
0
1990
1995
2000
2005
2010
2015
2020

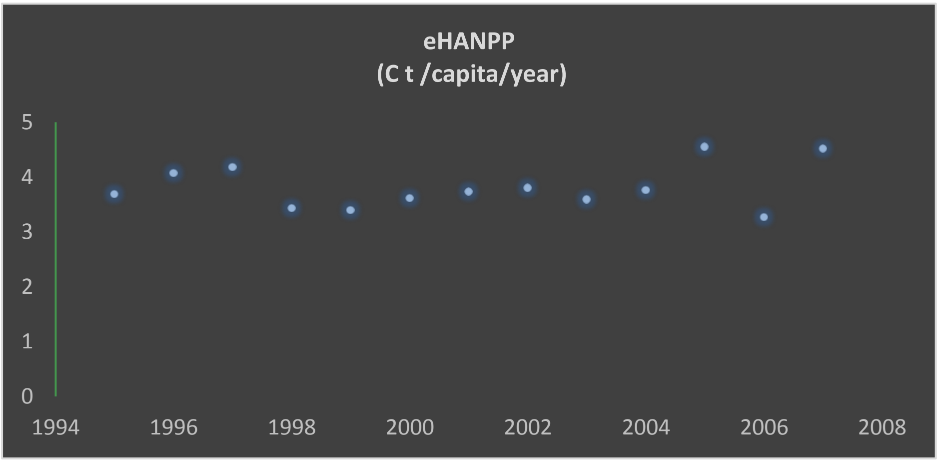

Cuba, CO² and CO² Emission, Direction Consumption
CO2 (Gg) Direct Consumption
CO2 b (Gg) Direct Consumption
8000
6000
4000
2000
0
1994
1996
1998
2000
2002
2004
2006
2008
2010

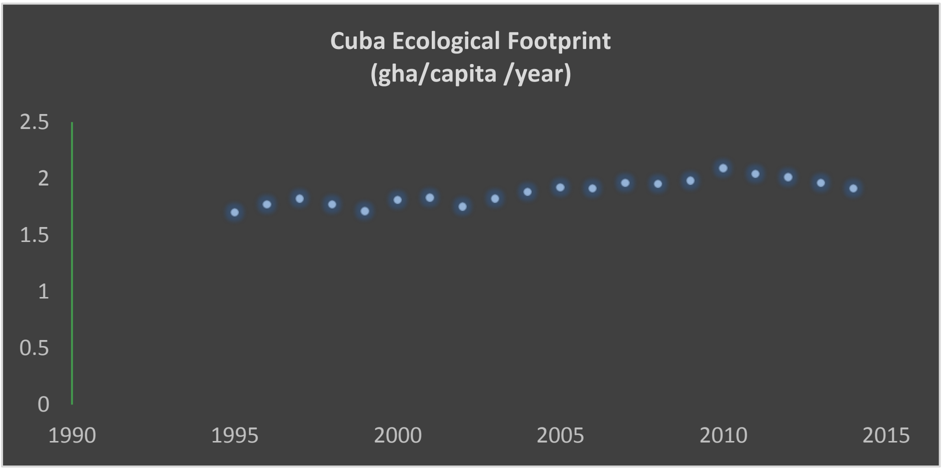

Cuba, Biochemical Flow, Footprint
Phosphorous (run-off, manure & fertilizer, (kg/capita/year)
Nitrogen (run-off, manure & fertilizer, (kg/capita/year)
10
5
0
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012


Cuba, Biochemical Flow, Fertilizer, Import (kg/year)
N emission Fertilizer Import
P emission Fertilizer Import
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
1990
1995
2000
2005
2010
2015
2020

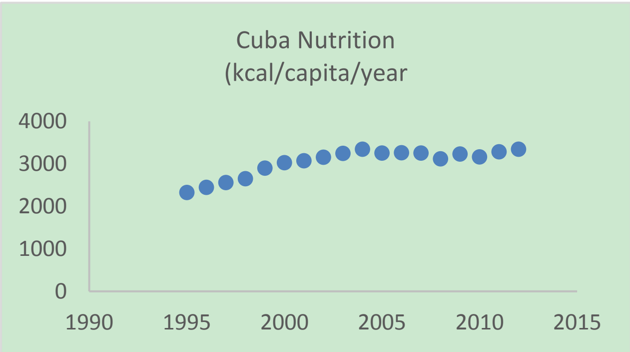

Cuba, Material Footprint
(t/capita/year)
20
15
10
5
0
1994
1996
1998
2000
2002
2004
2006
2008
2010

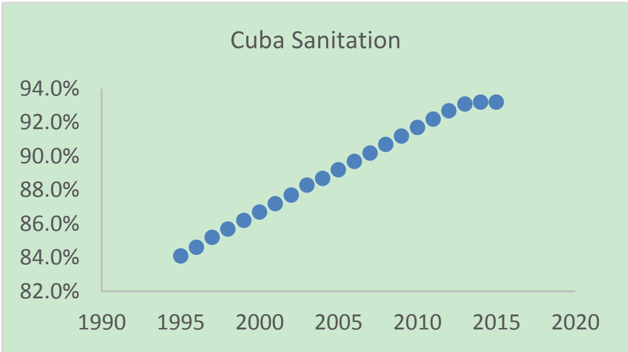

Cuba Material Consumption
Import (t/year)
25000000
20000000
15000000
10000000
5000000
0
1990
1995
2000
2005
2010
2015
2020

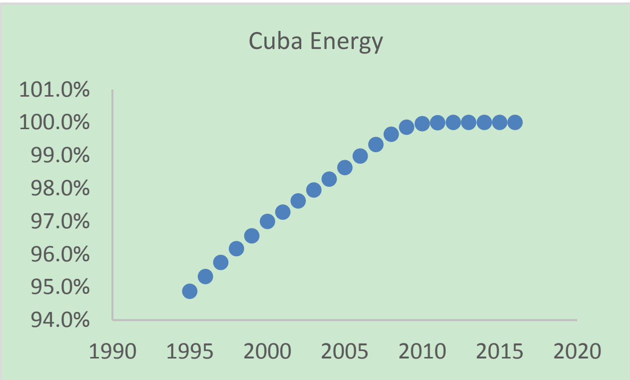

eHANPP
(C t /capita/year)
5
4
3
2
1
0
1994
1996
1998
2000
2002
2004
2006
2008

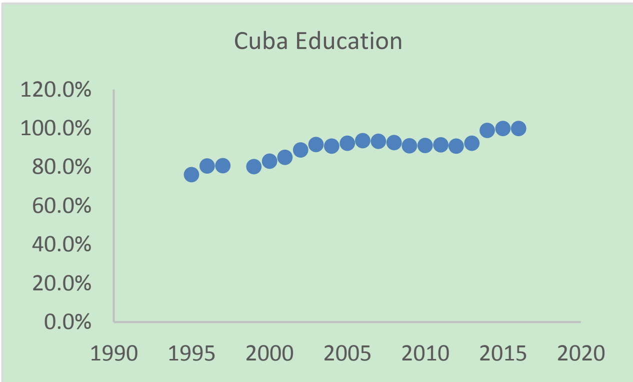


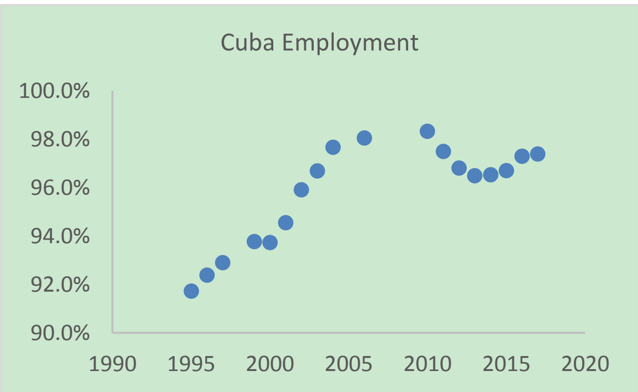
Cuba, Social Performances, Trend of Change



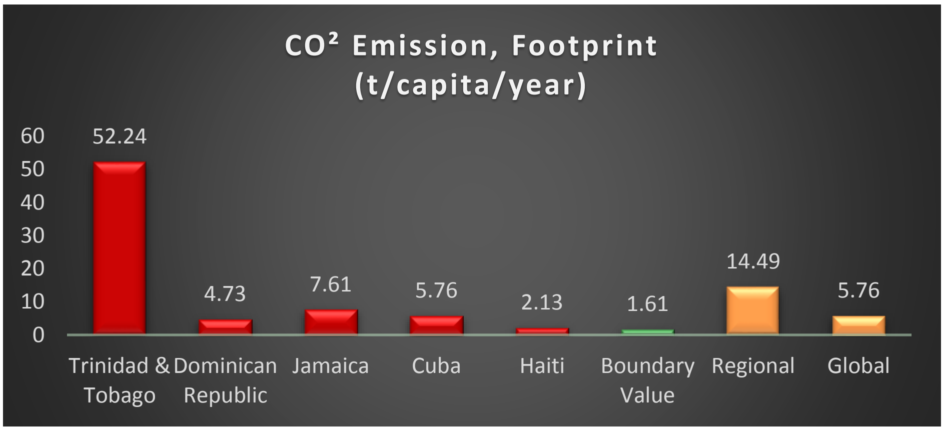


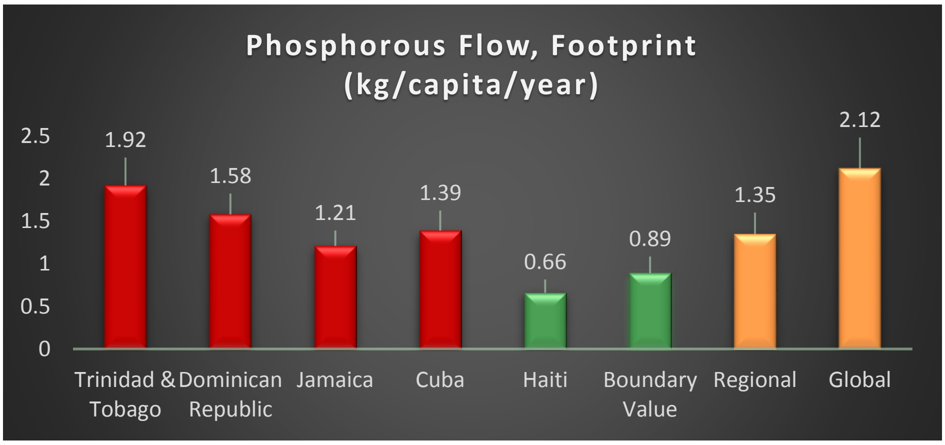


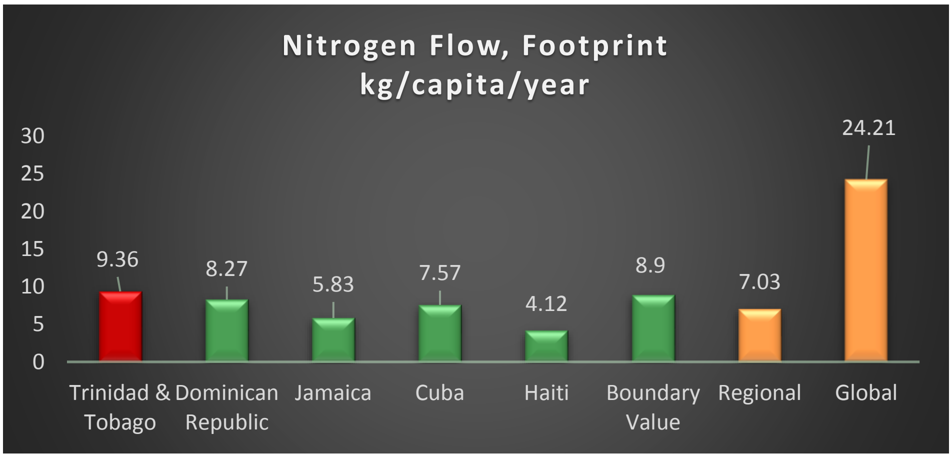


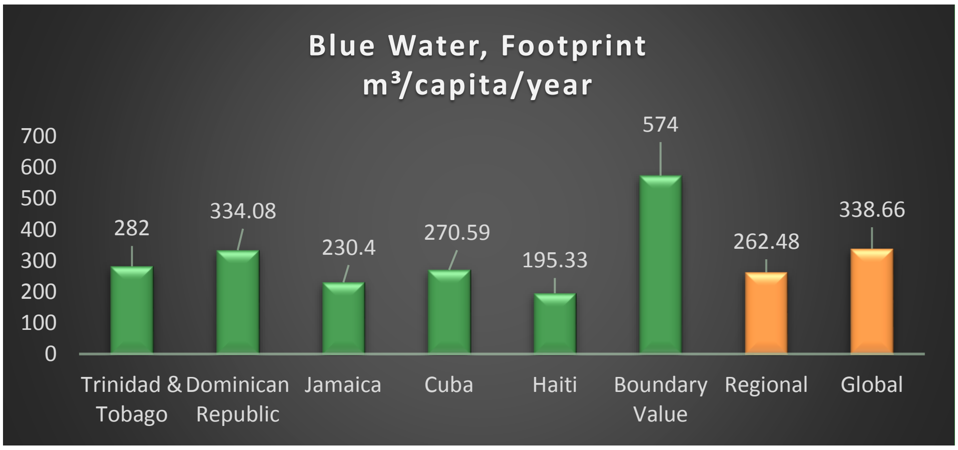


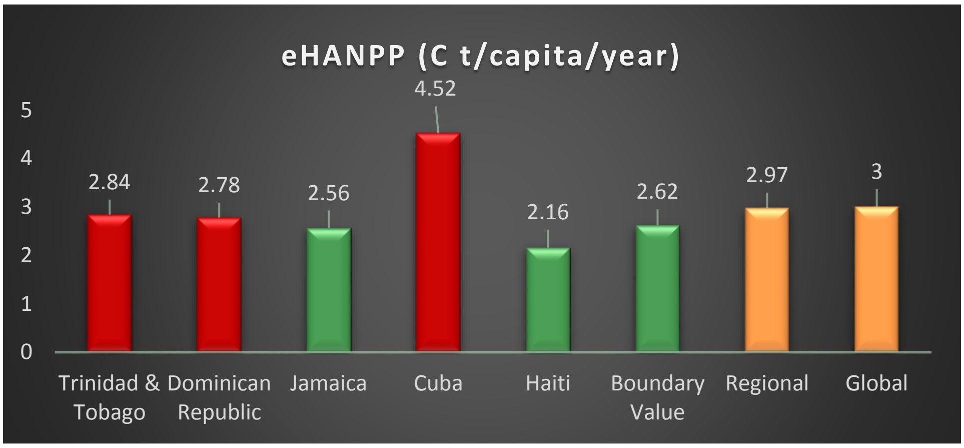
C. Environmental Performances, National, Regional and Global Comparison

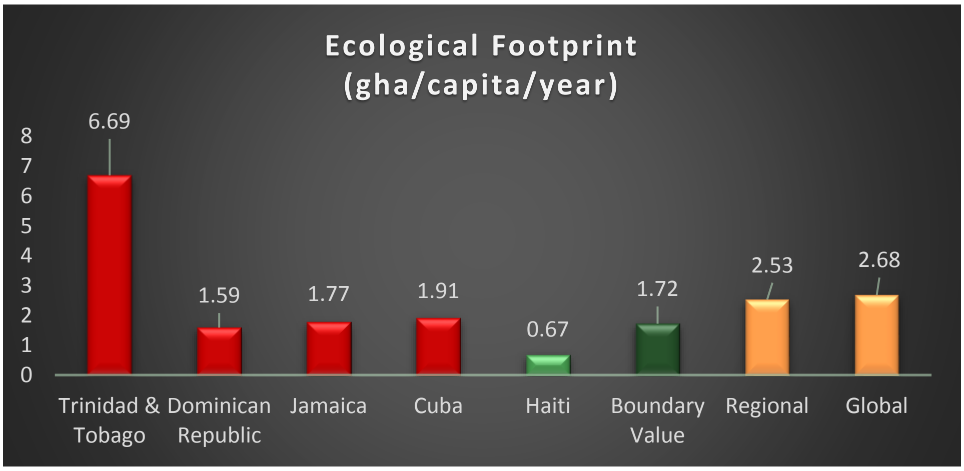


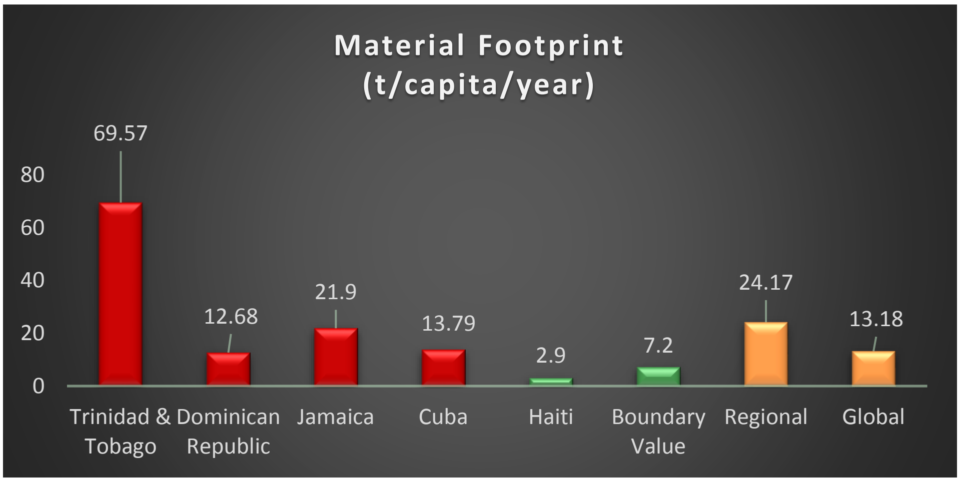




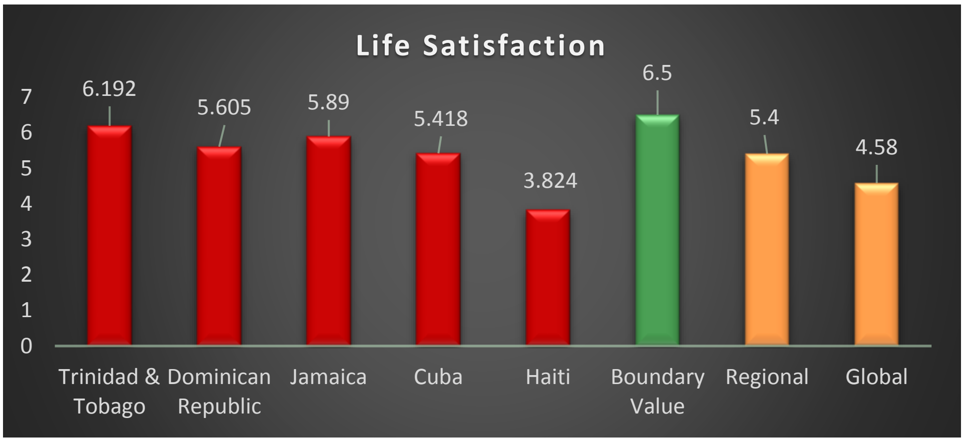

Blue Water, Footprint
m³/capita/year
700
600
500
400
300
200
100
0
282
334.08
230.4
270.59
195.33
574
262.48
338.66
Trinidad & Tobago
Dominican Republic
Jamaica
Cuba
Haiti
Boundary Value
Regional
Global

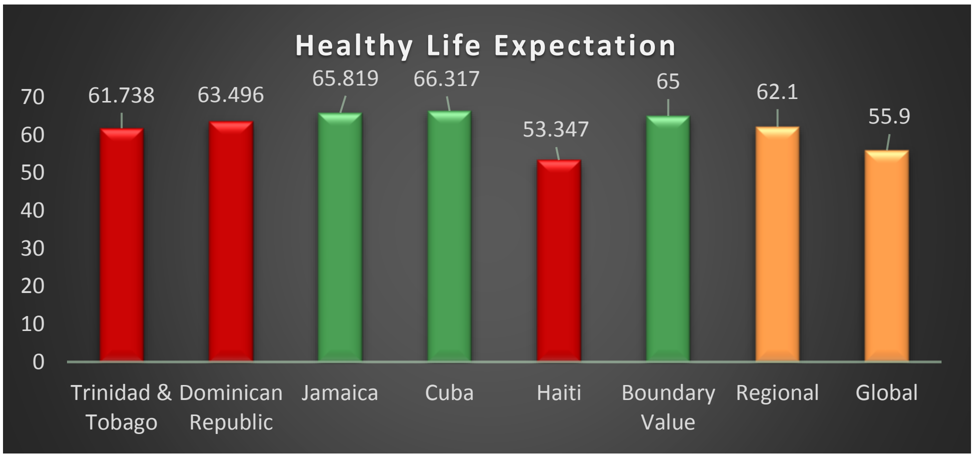

eHANPP (C t/capita/year)
5
4
3
2
1
0
2.84
2.78
2.56
4.52
2.16
2.62
2.97
3
Trinidad & Tobago
Dominican Republic
Jamaica
Cuba
Haiti
Boundary Value
Regional
Global

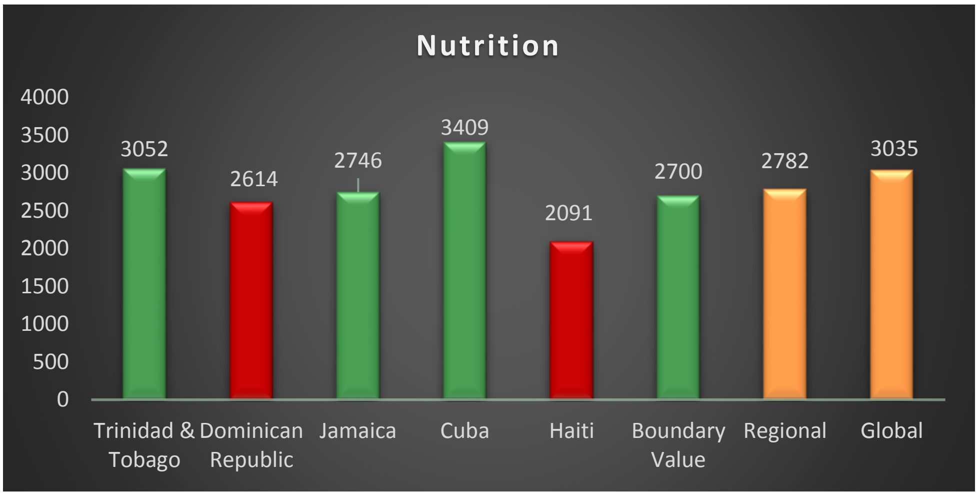

Ecological Footprint
(gha/capita/year)
8
7
6
5
4
3
2
1
0
6.69
1.59
1.77
1.91
0.67
1.72
2.53
2.68
Trinidad & Tobago
Dominican Republic
Jamaica
Cuba
Haiti
Boundary Value
Regional
Global

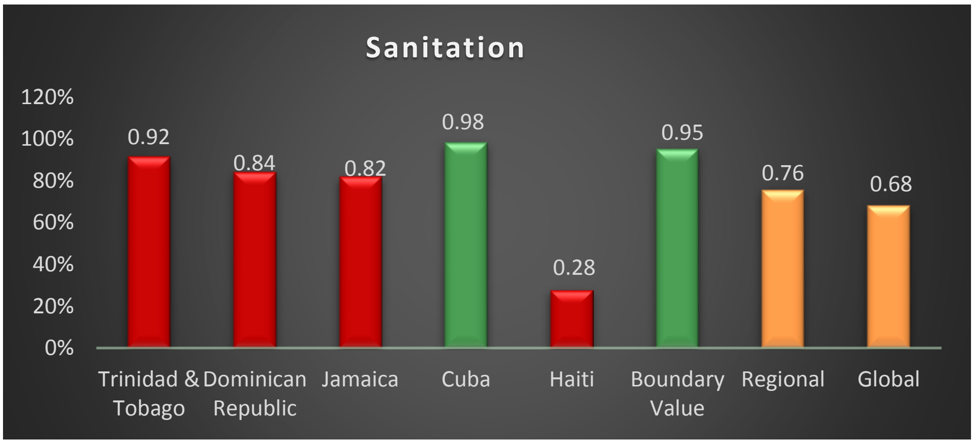


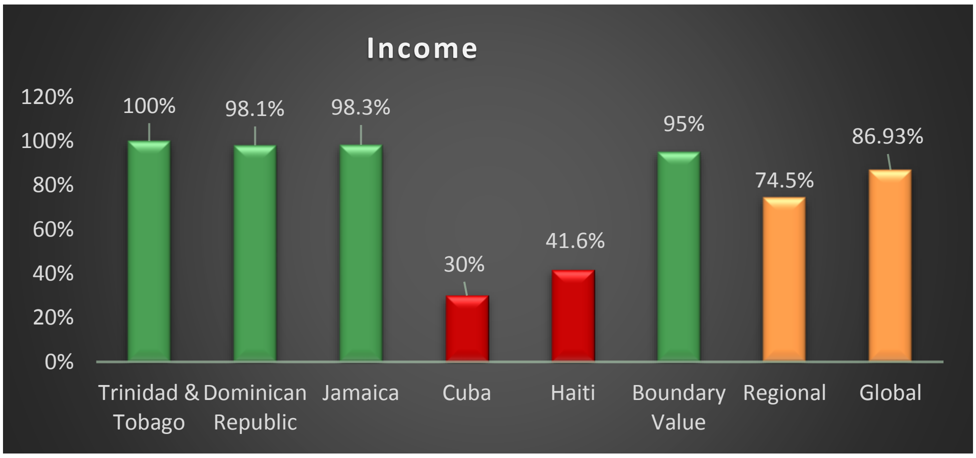
D. Social Performances, National, Regional (Caribbean) and Global Comparison

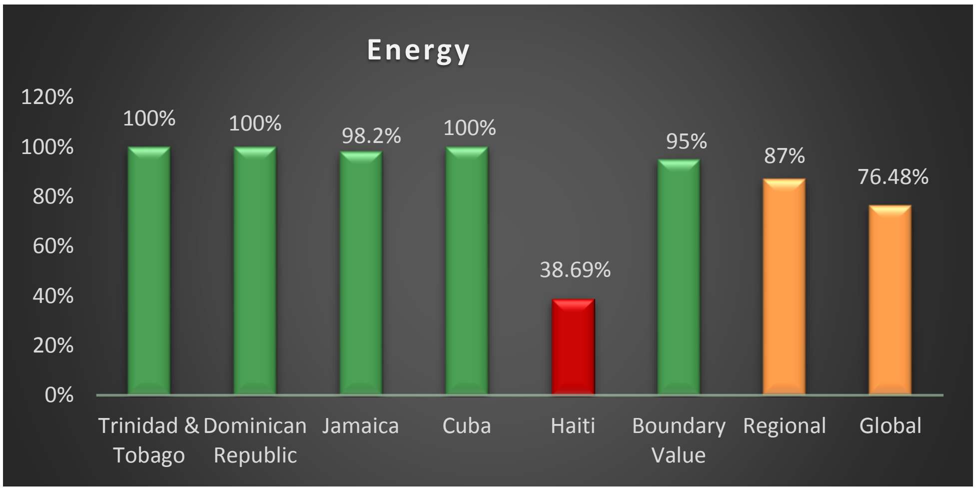


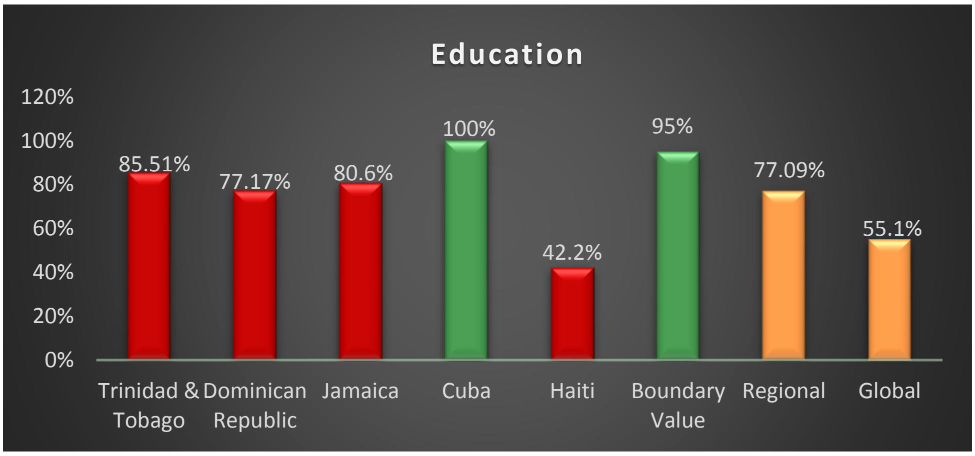


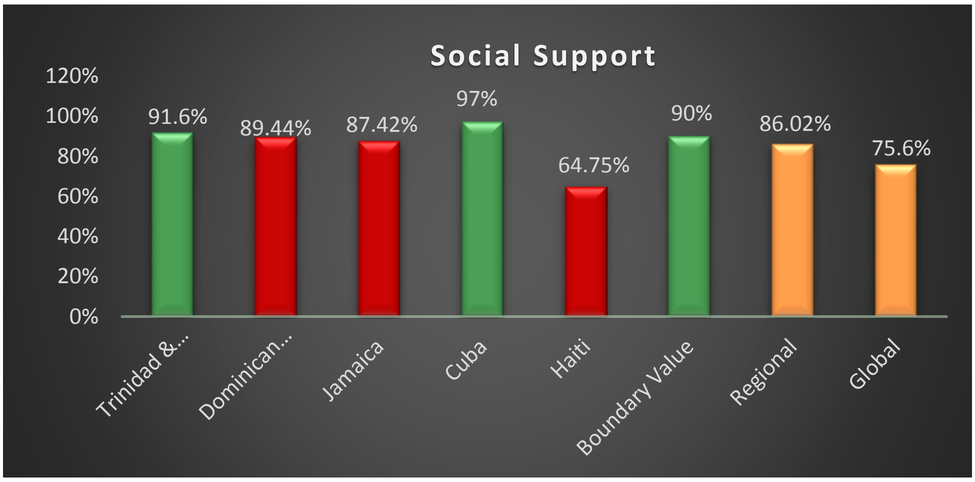

Nutrition
4000
3500
3000
2500
2000
1500
1000
500
0
3052
2614
2746
3409
2091
2700
2782
3035
Trinidad & Tobago
Dominican Republic
Jamaica
Cuba
Haiti
Boundary Value
Regional
Global

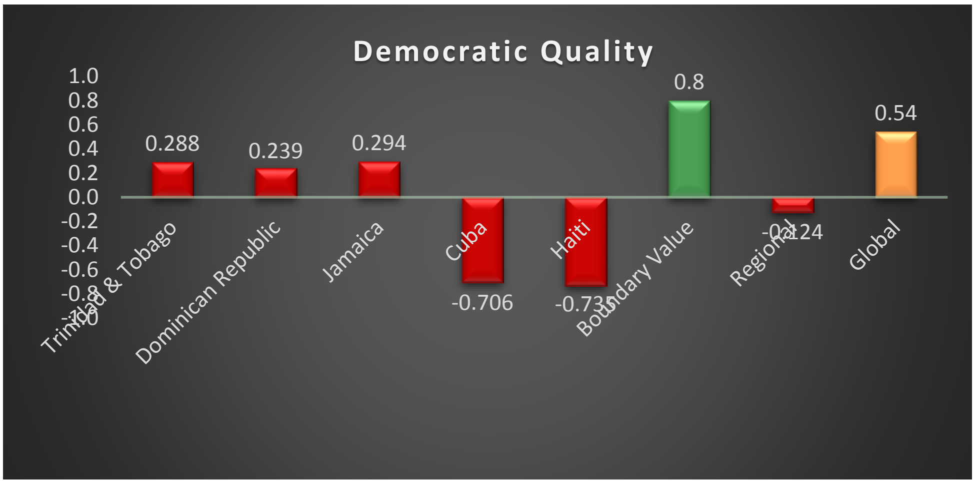

Sanitation
120%
100%
80%
60%
40%
20%
0%
0.92
0.84
0.82
0.98
0.28
0.95
0.76
0.68
Trinidad & Tobago
Dominican Republic
Jamaica
Cuba
Haiti
Boundary Value
Regional
Global

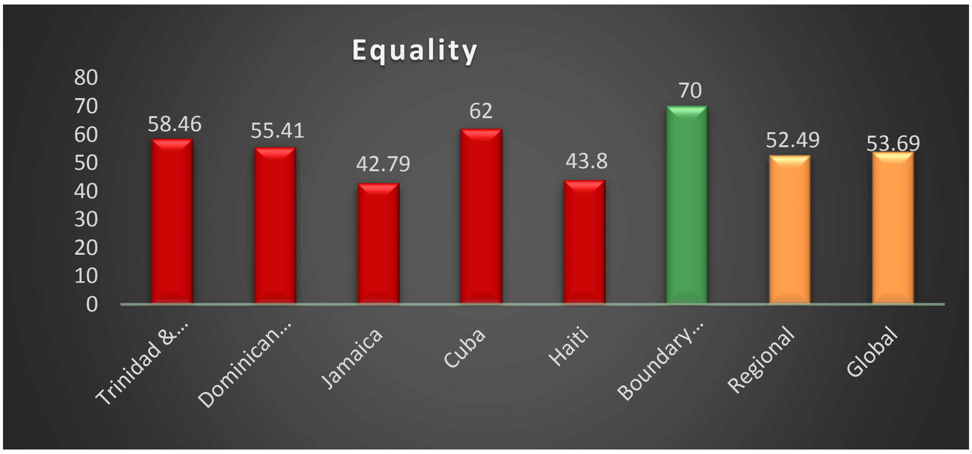

Income
120%
100%
80%
60%
40%
20%
0%
100%
98.1%
98.3%
30%
41.6%
95%
74.5%
86.93%
Trinidad & Tobago
Dominican Republic
Jamaica
Cuba
Haiti
Boundary Value
Regional
Global

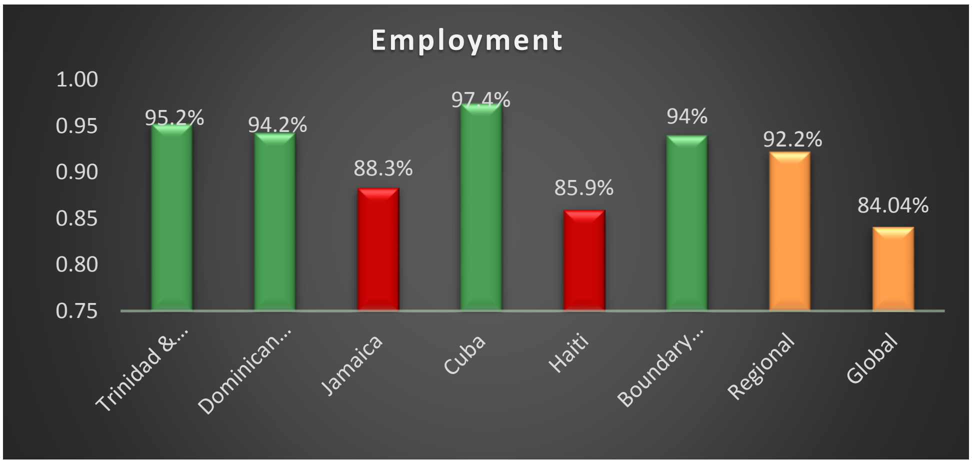

Energy
120%
100%
80%
60%
40%
20%
0%
100%
100%
98.2%
100%
38.69%
95%
87%
76.48%
Trinidad & Tobago
Dominican Republic
Jamaica
Cuba
Haiti
Boundary Value
Regional
Global


Education
120%
100%
80%
60%
40%
20%
0%
85.51%
77.17%
80.6%
100%
42.2%
95%
77.09%
55.1%
Trinidad & Tobago
Dominican Republic
Jamaica
Cuba
Haiti
Boundary Value
Regional
Global


Social Support
120%
100%
80%
60%
40%
20%
0%
91.6%
89.44%
87.42%
97%
64.75%
90%
86.02%
75.6%
Trinidad &...
Dominican...
Jamaica
Cuba
Haiti
Boundary Value
Regional
Global


Democratic Quality
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0.288
0.239
0.294
-0.706
-0.735
0.8
-0.124
0.54
Trinidad & Tobago
Dominican Republic
Jamaica
Cuba
Haiti
Boundary Value
Regional
Global


Equality
80
70
60
50
40
30
20
10
0
58.46
55.41
42.79
62
43.8
70
52.49
53.69
Trinidad &...
Dominican...
Jamaica
Cuba
Haiti
Boundary...
Regional
Global


Employment
1.00
0.95
0.90
0.85
0.80
0.75
95.2%
94.2%
88.3%
97.4%
85.9%
94%
92.2%
84.04%
Trinidad &...
Dominican...
Jamaica
Cuba
Haiti
Boundary...
Regional
Global

E. Data, Environmental Performances

Trinidad & Tobago

Year	CO_2 Emission (t/capita/year)	CO_2b Emission (t/capita/year)	Total CO^2 Emission (t/capita/year)	Phosphorous (run-off,fertilizer) (kg/capita/year)	Phosphorous (run-off from manure) (kg/capita/year)	Phosphorous (run-off, manure & fertilizer, (kg/capita/year	Nitrogen (run-off, fertilizer) (kg/capita/year)	Nitrogen (run-off, manure, kg/capita/year)	Nitrogen (run-off, manure & fertilizer, (kg/capita/year)	Blue Water (m^3/capita/year)	eHANPP	Ecological Footprint (gha/capita /year)
	EORA MRIO Consumption (non-biomass)	EORA MRIO Consumption (Biomass)	EORA MRIO Consumption (non-biomass & Biomass)	Eora MRIO	Eora MIRO	Eora MIRO	Eora MRIO	Eora MRIO		WFP	Kastner et al	GFN
1995	21.31	1.11	22.42	0.76	0.92	1.68	3.21	5.04	8.25		2.67	3.55
1996	22.67	1.08	23.75	0.79	0.96	1.75	3.34	5.25	8.59		2.59	3.56
1997	21.53	1.22	22.75	0.86	1.07	1.93	3.69	5.81	9.50		2.80	3.34
1998	22.69	1.05	23.74	0.73	0.94	1.67	3.14	5.13	8.28		2.79	3.59
1999	25.57	1.04	26.61	0.68	0.89	1.57	2.94	4.85	7.79		3.00	3.59
2000	26.43	0.98	27.41	0.75	0.95	1.70	3.24	5.18	8.41		2.91	3.64
2001	28.60	0.99	29.59	0.74	0.97	1.71	3.22	5.27	8.48		2.65	4.45
2002	30.44	0.98	31.42	0.73	0.98	1.71	3.17	5.31	8.48		2.57	5.59
2003	31.23	1.03	32.26	0.75	0.99	1.74	3.23	5.40	8.63		2.83	6.42
2004	34.70	0.95	35.65	0.79	1.04	1.83	3.47	5.62	9.08		2.94	5.95
2005	38.47	1.05	39.52	0.85	1.09	1.94	3.65	5.92	9.58	110	2.78	7.04
2006	42.39	1.11	43.50	0.84	1.06	1.89	3.60	5.74	9.33		2.50	7.85
2007	44.00	1.57	45.57	0.93	1.13	2.06	3.97	6.16	10.13		2.84	8.78
2008	50.97	1.27	52.24	1.08	1.10	2.18	4.60	5.99	10.59			9.70
2009	52.74	1.14		1.01	1.01	2.02	4.26	5.53	9.78			10.55
2010	54.57	1.05		0.87	0.88	1.75	3.69	4.79	8.48			9.58
2011	56.46	1.10		0.94	0.98	1.92	4.05	5.31	9.36	282		8.25
2012	58.42	1.15		1.00	1.03	2.03	4.28	5.62	9.90			7.99
2013	60.45	1.19		1.00	1.04	2.04	4.32	5.67	9.98			7.64
2014	62.55	1.19		1.02	1.05	2.07	4.37	5.73	10.10			6.69
2015	64.72	1.13		1.04	1.05	2.09	4.42	5.75	10.17			
Boundary	1.61			0.89			8.90			574	2.62	1.72
2007/Boundary											1.08	
2008/Boundary	31.66	0.70	32.45									
2011/Boundary				1.06	1.18	2.15	0.45	0.65	1.05	0.49		4.80

Dominican Republic

Year	CO_2 Emission (t/capita/year)	CO_2b Emission (t/capita/year)	Total CO^2 Emission (t/capita/year)	Phosphorous (run-off,fertilizer) (kg/capita)	Phosphorous (run-off, manure) (kg/capita)	Phosphorous (run-off, manure & fertilizer, (kg/capita/year	Nitrogen (run-off, fertilizer) (kg/capita)	Nitrogen (run-off, manure) (kg/capita)	Nitrogen (run-off, manure & fertilizer, (kg/capita/year)	Blue Water (m³/person/year)	eHANPP	Ecological Footprint (gha/capita /year)	Material Footprint (t/year)
	EORA MRIO Consumption (non-biomass)	EORA MRIO Consumption (Biomass)	Eora MRIO	Eora MRIO	Eora MIRO	EORA MRIO	Eora MRIO	Eora MRIO	EORA MRIO	WFP	Kastner et al	GFN	Eora MRIO
1995	2.22	1.82	4.04	0.47	0.79	1.25	1.81	4.72	6.53		2.79	1.32	10.48
1996	2.30	1.89	4.19	0.46	0.82	1.28	1.77	4.91	6.68		2.72	1.40	11.31
1997	2.30	1.85	4.15	0.49	0.81	1.30	1.88	4.88	6.76		2.77	1.50	11.57
1998	2.35	1.67	4.02	0.40	0.80	1.20	1.56	4.78	6.34		2.84	1.61	11.15
1999	2.50	1.67	4.17	0.40	0.69	1.09	1.56	4.15	5.71		2.70	1.67	12.64
2000	2.61	1.61	4.22	0.37	0.66	1.04	1.47	3.98	5.45		2.77	1.69	11.67
2001	2.61	1.72	4.33	0.44	0.68	1.12	1.70	4.07	5.76		2.79	1.72	11.61
2002	2.65	1.69	4.34	0.38	0.83	1.21	1.46	4.98	6.44		2.82	1.72	17.15
2003	2.77	1.62	4.39	0.28	0.79	1.08	1.00	4.76	5.76		2.38	1.48	16.39
2004	2.57	1.63	4.20	0.29	0.87	1.16	1.01	5.22	6.23		2.34	1.39	13.71
2005	2.46	1.72	4.18	0.26	0.87	1.14	1.06	5.25	6.31	130.5	2.42	1.50	13.05
2006	2.61	1.84	4.46	0.35	0.90	1.25	1.38	5.39	6.77		2.60	1.65	11.62
2007	2.71	1.85	4.55	0.34	0.97	1.31	1.35	5.81	7.17		2.78	1.63	13.39
2008	2.91	1.82	4.73	0.37	0.94	1.31	1.46	5.64	7.11			1.59	12.68
2009	2.94	1.82		0.40	0.95	1.35	1.58	5.68	7.25			1.47	13.15
2010	3.07	1.82		0.48	0.98	1.46	1.88	5.73	7.61			1.69	13.90
2011	3.30	1.86		0.51	1.07	1.58	2.07	6.20	8.27	334.08		1.71	15.48
2012	3.32	1.86		0.43	1.05	1.48	1.78	6.11	7.88			1.57	15.63
2013	3.29	1.85		0.43	1.02	1.44	1.75	5.93	7.68			1.62	15.38
2014	3.31	1.84		0.47	1.01	1.49	1.92	5.90	7.82			1.59	15.55
2015	3.32	1.83		0.51	1.00	1.51	2.03	5.83	7.86				15.41
Boundary	1.61			0.89			8.90			574	2.62	1.72	7.20
2007/Boundary											1.06		
2008/Boundary	1.81	1.14	2.94										1.76
2011/Boundary				0.58	1.12	1.77	0.23	0.66	0.93	0.58		0.99	

Jamaica

Year	CO_2 Emission (t/capita/year)	CO_2b Emission (t/capita/year)	Total CO^2 Emission (t/capita/year)	Phosphorous (run-off,fertilizer)	Phosphorous (run-off, manure)	Phosphorous (run-off, manure & fertilizer, (kg/capita/year)	Nitrogen (run-off, fertilizer)	Nitrogen (run-off, manure)	Nitrogen (run-off, manure & fertilizer, (kg/capita/year)	Blue Water (m^3/person/year)	eHANPP	Ecological Footprint (gha/capita /year)	Material Footprint (t/year)
	EORA MRIO Consumption (non-biomass)	EORA MRIO Consumption (Biomass)	EORA MRIO	Eora MRIO	Eora MRIO	EORA MRIO	Eora MRIO	Eora MRIO	EORA MRIO	WFP	Kastner et al	GFN	Eora MRIO
1995	5.29	1.49	6.78	0.77	0.79	1.55	3.12	4.36	7.48		2.84	1.67	20.08
1996	5.43	1.51	6.94	0.74	0.77	1.52	2.86	4.29	7.15		2.48	1.65	20.79
1997	5.46	1.50	6.96	0.69	0.74	1.43	2.84	4.09	6.93		2.69	1.67	20.60
1998	5.34	1.45	6.79	0.55	0.62	1.18	2.29	3.44	5.74		2.66	1.68	20.05
1999	5.39	1.40	6.79	0.56	0.63	1.19	2.32	3.48	5.80		2.68	1.90	18.82
2000	5.45	1.36	6.81	0.52	0.60	1.12	2.17	3.30	5.47		2.74	1.65	18.86
2001	5.44	1.19	6.63	0.54	0.61	1.15	2.22	3.39	5.60		2.66	1.77	20.26
2002	5.36	1.12	6.48	0.54	0.62	1.17	2.24	3.45	5.69		3.06	1.67	20.59
2003	5.45	1.10	6.55	0.52	0.60	1.12	2.14	3.30	5.44		2.68	1.78	20.99
2004	5.58	1.17	6.75	0.50	0.56	1.06	2.07	3.11	5.19		3.12	1.60	21.60
2005	5.44	1.14	6.58	0.55	0.62	1.17	2.25	3.42	5.67	90	2.98	1.70	21.91
2006	6.22	1.20	7.42	0.57	0.64	1.20	2.33	3.51	5.84		2.80	1.64	24.13
2007	6.70	1.34	8.04	0.60	0.65	1.25	2.45	3.60	6.04		2.56	2.12	20.38
2008	6.35	1.26	7.61	0.70	0.64	1.34	2.86	3.54	6.40			1.40	21.90
2009	6.09	1.17		0.62	0.56	1.18	2.52	3.12	5.64			1.52	22.03
2010	6.08	1.15		0.57	0.52	1.10	2.34	2.90	5.24			1.84	22.16
2011	6.18	1.16		0.63	0.58	1.21	2.58	3.24	5.83	230.40		2.07	22.29
2012	6.28	1.14		0.62	0.58		2.57	3.23				1.77	22.42
2013	6.26	1.12		0.60	0.56		2.47	3.11				1.89	22.55
2014	6.32	1.10		0.61	0.57		2.53	3.18				1.77	22.69
2015	6.36	1.07		0.62	0.57		2.55	3.19					22.82
Boundary	1.61			0.89			8.90			574.00	2.62	1.72	7.20
2007/Boundary											0.98		
2008/Boundary	3.94	0.67											3.04
2011/Boundary				0.70	0.64		0.29	0.36		0.40		1.20	

Haiti

Year	CO_2 Emission (t/capita/year)	CO_2b Emission (t/capita/year)	Total CO^2 Emission (t/capita/year)	Phosphorous (run-off,fertilizer)	Phosphorous (run-off, manure)	Phosphorous (run-off, manure & fertilizer, (kg/capita/year)	Nitrogen (run-off, fertilizer)	Nitrogen (run-off, manure)	Nitrogen (run-off, manure & fertilizer, (kg/capita/year)	Blue Water (m^3/person/year)	eHANPP	Ecological Footprint (gha/capita /year)	Material Footprint (t/year)
	EORA MRIO Consumption (non-biomass)	EORA MRIO Consumption (Biomass)	EORA MRIO	EORA MRIO	EORA MRIO	EORA MRIO	EORA MRIO	EORA MRIO	EORA MRIO	WFP	Kastner et al	GFN	Eora MRIO
1995	0.22	1.40	1.62	0.06	0.75	0.81	0.85	3.12	3.97		2.32	0.60	2.26
1996	0.23	1.58	1.81	0.06	0.74	0.80	0.76	3.16	3.92		2.35	0.60	2.25
1997	0.25	1.54	1.78	0.09	0.72	0.81	1.27	3.28	4.56		2.46	0.62	2.20
1998	0.23	1.53	1.76	0.07	0.71	0.78	0.99	3.42	4.40		2.44	0.61	2.16
1999	0.24	1.44	1.68	0.05	0.70	0.75	0.75	3.36	4.11		2.52	0.62	2.20
2000	0.23	1.32	1.55	0.09	0.69	0.78	1.25	3.67	4.92		2.68	0.59	2.18
2001	0.26	1.34	1.60	0.07	0.67	0.74	1.07	3.63	4.70		2.53	0.56	2.64
2002	0.27	1.45	1.72	0.07	0.66	0.73	1.04	3.58	4.62		2.47	0.58	2.69
2003	0.26	1.38	1.64	0.07	0.65	0.72	1.03	3.54	4.57		2.39	0.57	2.66
2004	0.28	1.35	1.63	0.07	0.64	0.71	1.01	3.45	4.47		2.34	0.59	2.80
2005	0.29	1.51	1.80	0.07	0.63	0.70	1.00	3.42	4.41	76.3	2.27	0.58	2.82
2006	0.30	1.61	1.91	0.07	0.62	0.69	0.98	3.35	4.33		2.19	0.60	2.75
2007	0.32	1.71	2.04	0.07	0.61	0.68	0.97	3.30	4.27		2.16	0.62	2.89
2008	0.34	1.79	2.13	0.07	0.60	0.67	0.98	3.26	4.23			0.61	2.77
2009	0.35	1.79		0.08	0.60	0.68	0.98	3.21	4.19			0.64	2.81
2010	0.38	1.80		0.08	0.59	0.67	1.00	3.16	4.17			0.68	2.95
2011	0.38	1.81		0.08	0.58	0.66	0.99	3.13	4.12	195.33		0.65	2.90
2012	0.39	1.82		0.08	0.57		0.97	3.11				0.62	2.94
2013	0.39	1.83		0.08	0.56		0.96	3.07				0.68	2.97
2014	0.40	1.83		0.08	0.55		0.96	3.03				0.67	3.02
2015	0.41	1.84		0.08	0.55		0.95	3.01					3.06
Boundary	1.61			0.89			8.90			574	2.62	1.72	7.20
2007/Boundary											0.82		
2008/Boundary	0.21	1.14											0.38
2011/Boundary				0.09	0.62		0.11	0.34		0.34		0.38	

Cuba

Year	CO_2 Emission (t/capita/year)	CO_2b Emission (t/capita/year)	Total CO^2 Emission (t/capita/year)	Phosphorous (run-off,fertilizer, kg/capita)	Phosphorous (run-off, manure kg/capita)	Phosphorous (run-off, manure & fertilizer, (kg/capita/year)	Nitrogen (run-off, fertilizer kg/capita)	Nitrogen (run-off manure kg/capita)	Nitrogen (run-off, manure & fertilizer, (kg/capita/year)	Blue Water (m³/person/year)	eHANPP	Ecological Footprint (gha/capita /year)	Material Footprint (t/year)
	EORA MRIO Consumption (non-biomass)	EORA MRIO Consumption (Biomass)	EORA MRIO	Eora MRIO	Eora MRIO	EORA MRIO	EORA MRIO	Eora MRIO	EORA MRIO	WFP	Kastner et al	GFN	Eora MRIO
1995	3.95	3.71	7.65	0.36	1.17	1.53	2.28	6.24	8.52		3.68	1.70	16.31
1996	3.93	4.38	8.31	0.33	1.14	1.46	2.07	6.09	8.16		4.07	1.77	18.88
1997	3.81	3.77	7.58	0.41	1.11	1.52	2.71	5.93	8.65		4.18	1.82	18.73
1998	3.71	3.17	6.88	0.34	1.12	1.46	2.19	6.00	8.19		3.43	1.77	17.01
1999	3.77	3.63	7.40	0.24	1.12	1.36	1.48	5.99	7.47		3.39	1.71	15.98
2000	3.84	3.75	7.59	0.25	1.10	1.35	1.57	5.89	7.46		3.61	1.81	17.22
2001	3.74	3.28	7.02	0.26	1.10	1.36	1.63	5.89	7.52		3.73	1.83	14.91
2002	3.81	3.79	7.60	0.23	1.07	1.30	1.39	5.75	7.14		3.80	1.75	15.53
2003	3.80	2.35	6.15	0.12	1.09	1.21	0.56	5.85	6.41		3.59	1.82	12.37
2004	3.71	2.96	6.66	0.16	1.07	1.22	0.86	5.72	6.58		3.76	1.88	12.78
2005	3.68	1.76	5.44	0.13	1.02	1.16	0.65	5.48	6.13	105.7	4.55	1.92	9.79
2006	3.80	1.31	5.11	0.19	1.07	1.26	1.03	5.73	6.76		3.27	1.91	10.51
2007	3.82	1.30	5.12	0.21	1.08	1.29	1.16	5.78	6.95		4.52	1.96	12.84
2008	4.35	1.41	5.76	0.25	1.09	1.34	1.40	5.85	7.25			1.95	13.79
2009	4.21	1.36		0.16	1.10	1.26	0.79	5.90	6.69			1.98	13.00
2010	4.21	1.31		0.19	1.09	1.29	1.03	5.86	6.89			2.09	12.26
2011	4.22	1.26		0.27	1.12	1.39	1.58	5.99	7.57	270.59		2.04	12.04
2012	4.20	1.21		0.25	1.08		1.46	5.78				2.01	11.75
2013	4.21	1.16		0.29	1.09		1.71	5.82				1.96	11.57
2014	4.19	1.12		0.34	1.11		2.12	5.93				1.91	11.29
2015	4.15	1.08		0.31	1.10		1.86	5.91					10.91
Boundary	1.61			0.89			8.90			574	2.62	1.72	7.20
2007/Boundary											1.73		
2008/Boundary	2.70	0.67											1.92
2011/Boundary				0.30	1.24		0.18	0.66		0.47		1.19	

F Data, Social Performances

Trinidad & Tobago

Year	Life Satisfaction Response Cantril life ladder (0–10 scale).	Healthy Life Expectancy No. of years in good health	Nutrition calorific intake (kcal/capita/day)	Sanitation Percentage improved sanitation	Income Percentage > $1.90/day	Access to Energy Percentage access to electricity	Education Gross Enrollmentn ratio, Secondary School	Social Support 90% with friends/family to depend on	Democratic Quality Average of voice and accountability & political stability	Equalty (1-Gini coefficient of household disposable income) * 100	Employment Percentage of employed labor force
	Gullup World Happiness Report	Gullup World Happiness Report	FAOSTAT	World Bank	World Bank	World Bank	World Bank	Gullup World Happiness Report	Gullup World Happiness Report	Standardized World Income Inequality Databas	World Bank
1995			2596	90.3%		87.26%				58.52	82.78%
1996			2640	90.4%		88.15%				58.52	83.75%
1997			2616	90.5%		89.02%				58.54	84.99%
1998			2664	90.5%		89.87%				58.50	85.79%
1999			2674	90.6%		91%				58.49	86.88%
2000			2777	90.7%		91.29%				58.51	87.9%
2001			2832	90.8%		92%				58.51	89.12%
2002			2790	90.8%		93.08%				58.52	89.61%
2003			2749	90.9%		93.85%				58.51	89.5%
2004			2776	91.0%		94.62%	85.51%			58.48	91.7%
2005			2756	91.1%		95.40%				58.46	92%
2006	5.832	60.222	2801	91.1%		96.19%		88.68%	0.185		93.7%
2007			2845	91.2%		97%					94.5%
2008	6.696	60.498	2828	91.3%		97.83%		85.83%	0.209		95.4%
2009			2841	91.4%		99%					94.7%
2010			2841	91.4%		99.30%					96.2%
2011	6.519	60.980	2906	91.5%		99.74%		86.28%	0.331		96.8%
2012			2989	91.5%		99.94%					97%
2013	6.168	61.274	3052	91.5%		99.99%		88.32%	0.288		97.5%
2014				91.5%		100%					97.8%
2015				91.5%		100%					97.8%
2016						100%					97.0%
2017	6.192	61.738						91.60%			95.2%
Boundary	6.5	65	2700	95%	95%	95%	95%	90%	0.80	70	94%
2011/Boundary	1.003	0.938	1.076	0.963	1.053	1.050	0.9	0.959	0.414	0.835	1.029
2013/Boundary	0.949	0.943	1.130	0.963		1.053		0.981	0.360		1.038
2014/Boundary				0.963		1.053					1.040
2015/Boundary				0.963		1.053					1.040
2016/Boundary						1.053					1.032
2017/Boundary	0.953	0.950						1.018			1.013

Dominican Republic

Year	Life Satisfaction Response Cantril life ladder (0–10 scale).	Healthy Life Expectancy No. of years in good health	Nutrition calorific intake (kcal/capita/day)	Sanitation Percentage improved sanitation	Income Percentage > $1.90/day	Access to Energy Percentage access to electricity	Education Gross Enrollmentn ratio, Secondary School	Social Support 90% with friends/family to depend on	Democratic Quality Average of voice and accountability & political stability	Equalty (1-Gini coefficient of household disposable income) * 100	Employment Percentage of employed labor force
	Gullup World Happiness Report	Gullup World Happiness Report	FAOSTAT	World Bank	World Bank	World Bank	World Bank	Gullup World Happiness Report	Gullup World Happiness Report	Standardized World Income Inequality Databas	World Bank
1995			2256	75.2%		84.14%	44%			52.43	84.97%
1996			2175	75.6%	95.1%	85.03%				52.51	83.31%
1997			2153	76.1%	94.8%	85.9%				52.21	84.04%
1998			2141	76.6%		86.75%	54.17%			51.82	85.60%
1999			2149	77%		91%	55.79%			51.45	86.18%
2000			2224	77.5%	94.5%	88.77%	59.04%			51.06	86.29%
2001			2258	77.9%	95.8%	89.79%				51.04	84.48%
2002			2285	78.4%	94.2%	89.75%	67.2%			51.02	84.05%
2003			2143	78.9%	93.2%	89.17%				50.73	83.44%
2004			2216	79.4%	91.4%	90.32%	68.2%			50.72	81.93%
2005			2328	79.9%	94.2%	90.14%	69.75%			50.95	93.52%
2006	5.088	61.642	2367	80.4%	95.5%	90.12%		91.89%	0.049	51.07	94.44%
2007	5.081	61.825	2403	80.8%	95.7%	96.88%	78.08%	84.75%	0.06	51.59	94.93%
2008	4.842	62.004	2352	81.3%	96.2%	97.76%	76.75%	85.01%	0.064	52.29	95.33%
2009	5.431	62.181	2392	81.7%	96.7%	97.86%	78.58%	87.82%	0.044	52.82	94.66%
2010	4.735	62.353	2532	82.1%	97.4%	98.15%	76.02%	86.00%	0.014	53.49	94.98%
2011	5.397	62.521	2562	82.5%	97.1%	97.9%	75.63%	87.21%	0.045	54.01	94.03%
2012	4.753	62.687	2573	82.9%	97.4%	97.87%	76.39%	87.92%	0.188	54.58	93.48%
2013	5.016	62.852	2614	83.3%	97.7%	98.39%	77.60%	87.84%	0.161	54.86	92.93%
2014	5.387	63.014		83.6%	97.9%	98.47%	78.36%	89.06%	0.167	55.30	93.60%
2015	5.062	63.175		84%	98.1%	98.56%	77.82%	89.32%	0.195	55.41	94.08%
2016	5.239	63.335				100%	77.17%	89.48%	0.239		94.22%
2017	5.605	63.496						89.44%			
Boundary	6.5	65	2700	95%	95%	95%	95%	90%	0.80	70	94%
2011/Boundary	0.830	0.962	0.949	0.868	1.022	1.031	0.796	0.969	0.056	0.772	1.000
2013/Boundary	0.772	0.967	0.968	0.877	1.028	1.036	0.817	0.976	0.201	0.784	0.989
2014/Boundary	0.829	0.969		0.880	1.031	1.037	0.825	0.990	0.209	0.790	0.996
2015/Boundary	0.779	0.972		0.884	1.033	1.037	0.819	0.992	0.244	0.792	1.001
2016/Boundary	0.806	0.974				1.053	0.812	0.994	0.299		1.002
2017/Boundary	0.862	0.977						0.994			

Jamaica

Year	Life Satisfaction Response Cantril life ladder (0–10 scale).	Healthy Life Expectancy No. of years in good health	Nutrition calorific intake (kcal/capita/day)	Sanitation Percentage improved sanitation	Income Percentage > $1.90/day	Access to Energy Percentage access to electricity	Education Gross Enrollmentn ratio, Secondary School	Social Support 90% with friends/family to depend on	Democratic Quality Average of voice and accountability & political stability	Equalty (1-Gini coefficient of household disposable income) * 100	Employment Percentage of employed labor force
	Gullup World Happiness Report	Gullup World Happiness Report	FAOSTAT	World Bank	World Bank	World Bank	World Bank	Gullup World Happiness Report	Gullup World Happiness Report	Standardized World Income Inequality Databas	World Bank
1995			2684	80.3%		80.26%					
1996			2717	80.3%	96.6%	85.71%				42.81	
1997			2697	80.4%		82.04%				43.16	
1998			2710	80.5%		82.91%				43.49	84.5%
1999			2725	80.6%	97.4%	84.55%	86.43%			43.82	
2000			2729	80.7%		84.57%	85.29%			43.58	84.5%
2001			2798	80.8%		87.71%	84.53%			43.35	
2002			2795	80.9%	97.3%	86.68%	84.59%			43.12	85.8%
2003			2810	81.0%		86.94%	84.68%			42.94	88.3%
2004			2792	81.0%	98.3%	87.73%	89.93%			42.79	88.6%
2005			2795	81.1%		88.51%	89.65%				88.7%
2006	6.208	63.745	2792	81.2%		89.31%		90.91%	0.151		89.7%
2007			2791	81.3%		90.13%	92.31%				90.3%
2008			2747	81.4%		92.00%	93.56%				89.7%
2009			2749	81.5%		91.84%	94.53%				88.6%
2010			2762	81.6%		92.72%	91.78%				87.6%
2011	5.374	64.939	2768	81.6%		91.10%	91.62%	85.46%	0.208		87.3%
2012			2754	81.7%		93.10%					86.1%
2013	5.709	65.289	2746	81.8%		95.43%	82.08%	86.49%	0.363		84.7%
2014	5.311	65.434		81.8%		96.35%	81.67%	87.42%	0.294		86.3%
2015				81.8%		97.28%	80.60%				86.5%
2016						98.20%					86.8%
2017	5.890	65.819						91.30%			88.3%
Boundary	6.5	65	2700	95%	95%	95%	95%	90%	0.80	70	94%
2011/Boundary	0.827	0.999	1.025	0.859	1.035	0.959	0.964	0.950	0.260	0.611	0.929
2013/Boundary	0.878	1.004	1.017	0.861		1.005	0.864	0.961	0.454		0.901
2014/Boundary	0.817	1.007		0.861		1.014	0.860	0.971	0.368		0.918
2015/Boundary				0.861		1.024	0.848				0.920
2016/Boundary						1.034					0.923
2017/Boundary	0.906	1.013						1.014			0.939

Haiti

Year	Life Satisfaction Response Cantril life ladder (0–10 scale).	Healthy Life Expectancy No. of years in good health	Nutrition calorific intake (kcal/capita/day)	Sanitation Percentage improved sanitation	Income Percentage > $1.90/day	Access to Energy Percentage access to electricity	Education Gross Enrollmentn ratio, Secondary School	Social Support 90% with friends/family to depend on	Democratic Quality Average of voice and accountability & political stability	Equalty (1-Gini coefficient of household disposable income) * 100	Employment Percentage of employed labor force
	Gullup World Happiness Report	Gullup World Happiness Report	FAOSTAT	World Bank	World Bank	World Bank	World Bank	Gullup World Happiness Report	Gullup World Happiness Report	Standardized World Income Inequality Databas	World Bank
1995			1761	19.2%		31.3%					
1996			1809	19.6%		30.77%					
1997			1839	20%		31.2%					
1998			1920	20.3%		31.61%					
1999			1956	20.7%		31.99%					
2000			1958	21%		33.7%					
2001			1897	21.6%		31.54%				45.8	
2002			1902	22.1%		33.04%				45.6	
2003			1872	22.6%		31.6%				45.4	74.59%
2004			1889	23.2%		33.69%				45.3	
2005			1884	23.7%		34.02%				45.1	
2006	3.754	49.962	1942	24.2%		33.9%	42.2%	69.3%	-1.053	44.9	
2007			1970	24.6%		34.73%				44.7	83.2%
2008	3.846	50.664	2014	25.1%		35.11%		67.9%	-0.986	44.6	
2009			2060	25.5%		35.52%				44.4	
2010	3.766	51.374	2169	25.9%		35.94%		55.4%	-0.826	44.2	
2011	4.845	51.711	2097	26.3%		36.38%		56.7%	-0.870	44.0	
2012	4.413	52.029	2084	26.7%	46.1%	37.9%		74.9%	-0.775	43.8	85.9%
2013	4.622	52.325	2091	27.1%		37.29%		64.8%	-0.690		
2014	3.889	52.598		27.4%		37.75%		55.4%	-0.717		
2015	3.570	52.848		27.6%		38.22%		56.4%	-0.735		
2016	3.352	53.097				38.69%		58.4%			
2017	3.824	53.347						64.7%			
Boundary	6.5	65	2700	95%	95%	95%	95%	90%	0.80	70	94%
2011/Boundary	0.745	0.796	0.777	0.277	0.485	0.383	0.444	0.630	0	0.629	0.914
2013/Boundary	0.711	0.805	0.774	0.285		0.392		0.720	0		
2014/Boundary	0.598	0.809		0.288		0.397		0.616	0		
2015/Boundary	0.549	0.813		0.291		0.402		0.627	0		
2016/Boundary	0.516	0.817				0.407		0.649			
2017/Boundary	0.588	0.821						0.719			

Cuba

Year	Life Satisfaction Response Cantril life ladder (0–10 scale).	Healthy Life Expectancy No. of years in good health	Nutrition calorific intake (kcal/capita/day)	Sanitation Percentage improved sanitation	Income Percentage > $1.90/day	Access to Energy Percentage access to electricity	Education Gross Enrollmentn ratio, Secondary School	Social Support 90% with friends/family to depend on	Average of voice and accountability & political stability	Equalty (1-Gini coefficient of household disposable income) * 100	Employment Percentage of employed labor force
	Gullup World Happiness Report	Gullup World Happiness Report	FAOSTAT	World Bank	World Bank	World Bank	World Bank	Gullup World Happiness Report	Gullup World Happiness Report	Standardized World Income Inequality Databas	World Bank
1995			2325	84.1%		94.88%	76.13%				91.73%
1996			2447	84.6%		95.33%	80.55%				92.39%
1997			2563	85.2%		95.76%	80.73%				92.90%
1998			2651	85.7%		96.17%					93.77%
1999			2898	86.2%		96.56%	80.27%				93.74%
2000			3031	86.7%		97.00%	83.13%			62	94.55%
2001			3076	87.2%		97.28%	85.04%				95.92%
2002			3154	87.7%		97.62%	88.80%				96.69%
2003			3246	88.3%		97.95%	91.68%				97.67%
2004			3346	88.7%		98.29%	90.86%				
2005			3254	89.2%		98.63%	92.30%				98.05%
2006	5.418	66.327	3260	89.7%		98.98%	93.66%	96.96%	-0.706		
2007			3251	90.2%		99.33%	93.38%				
2008			3120	90.7%		99.64%	92.72%				
2009			3233	91.2%		99.86%	90.94%				98.33%
2010			3160	91.7%		99.96%	91.13%				97.50%
2011			3285	92.2%		100%	91.47%				96.82%
2012			3346	92.7%		100%	90.83%				96.50%
2013			3409	93.1%		100%	92.29%				96.54%
2014				93.2%	30%	100%	98.99%				96.71%
2015				93.2%		100%	100%				97.30%
2016						100%					97.40%
2017											
Boundary	6.5	65	2700	95%	95%	95%	95%	90%	0.80	70	94%
2011/Boundary	0.834	1.020	1.217	0.971	0.316	1.053	0.963	1.077	0.000	0.886	1.030
2013/Boundary			1.263	0.980		1.053	0.971				1.027
2014/Boundary				0.981		1.053	1.042				1.029
2015/Boundary						1.053	1.053				1.035
2016/Boundary						1.053					1.036
2017/Boundary											

G: 100% of the Five Countries' Population Living on more than $ 1.90 a day

	Trinidad & Tobago	Dominican Republic	Jamaica	Haiti	Cuba
Population	1,369,130	10,528,394	2,728,777	10,145,054	11,475,982
Percentage of living on less than $ 1.25 a day	0	1.9%	1.7%	53.9%	70%
Amount needed to fill in the gap[23]	0	$250,049/day	$57,986/day	$6,835,230	$10,041,484
Total	$17,184,749/day Annual Amount: $17,184,749* 365= 6.2 billion				

[23] There is no information related to the exact amount of daily expenditure of those who are reported to live on less than $ 1.25a day. The assumption is they do not have any income at all.