Prospects for Prosperity in the Caribbean:
A vision and tool for planning and policymaking

by

Alicia Mwena Richins

supervised by

Peter Victor

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Ïëre, now called Trinidad, was so named by its First Peoples: “Land of the Hummingbird,” in reverence of the beauty and distinctiveness of the varied specimens found on the island. Above all other animals, hummingbirds were protected by the Great Spirit, since they carried the souls of those gone by—the souls of the ancestors.

In one Southern valley village they were especially numerous. After a great victory in a tribal war, the people of the village became greedy and proud; so proud were they that they forgot about Great Spirit and the departed souls carried by the hummingbirds. They began to hunt the birds for their colourful jewel-toned feathers. So hungry were the people for adornment for a victory parade that once there was a mass slaughter. The feathers adorned their spears, bows and bodies as they broke the ancient law of the Great Spirit.
Great Spirit grew angry and sought to avenge the spirits of the ancestors. Yet the pillage continued.

One day a terrible thing happened in this lush and beautiful valley: The anger of Great Spirit rose like a black cloud over the valley and the very land opened beneath the people’s feet. A thick black mass engulfed the village, swallowing up the entire tribe. It rose higher and higher still, filling the vale until there was nothing but a trim of underbrush left around it.
This lake of pitch has been there ever since, eventually becoming the source of a booming asphalt industry.

It is said that once a tree grew up from its depths, alive and reaching ten feet tall. It looked around and saw the new people brought over from Africa, working in the fields and singing sad songs. It sank back down again into the dark depths of the lake. No new life has been seen to emerge from it ever since.

Later, European settlers were warned about their own fascination with the birds. Hunted, killed and preserved, dead hummingbirds and their feathers adorned European hats, parlours and works of art. This went on until bird watchers, inspired by Great Spirit, sought to protect them.

adapted from oral retellings by Tracee Assing and Dr. Theodore Ferguson

Abstract

This Major Research paper asks the questions: What would an ecologically sustainable, system-thinking based vision for planning and development in the Caribbean look like? And how can systems dynamics modelling help to make this vision a reality?

Through the critical presentation of the current "crisis of development" that has left the Caribbean vulnerable and economically disadvantaged; the Caribbean's historical, socio-economic, environmental and planning context with respect to this crisis, and a planning framework rooted in systems theory, I conclude with a description of such a vision in Part 1.

Part 2 involves the system dynamics modelling exercise in which I examine land use changes on a Caribbean island state, while also evaluating the method as a valuable tool for planning and policymaking.

I dedicate this work to all of my past selves

who thought this feat impossible,

and to all of my futures selves,

should I ever need reminding of my resilience.

Acknowledgements

This paper would not have been possible without the instruction, guidance, mentoring and encouragement of my supervisor, Professor Peter Victor. I first met Peter as a second year undergraduate student in 2013; I was between majors, and trying to work out a curriculum for an individualized major in which I hoped to model a new (and better) economic system. I knew that it would be a big task and identified all of the fields of study I thought I'd have to read up on in order to realize this vision. The individualized program coordinator recommended Peter, and so I contacted him and he agreed to meet.

A few days later, I sat in his office as he glanced at the email I'd sent him requesting to meet.

> "So," he said hesitantly. "You want to model a new economic system, taking into account all of these...fields of study."
>
> Even more hesitantly, I nodded. "Yes. …I know it's a lot…"
>
> "A lot? Alicia, I've been working at this my entire career; it's been a few decades. You presumably are hoping to graduate in the next two years, no?"

Three years later, with a double major in economics and social science, I finally returned to the HNES building, having identified and secured Peter as my MES program advisor. The rest, as they say, is history.

As his final Master's student, I wish to express, on behalf of the countless lives he has touched throughout his career, my (our) deepest gratitude for his service and teaching, mentorship, guidance, his predilection for critical thought and analysis, and his penchant for excellence. For asking the questions I hadn't thought of asking myself, for pushing me when I needed it, and showing me compassion when I needed that more; I already knew it coming into the MES program, but I couldn't have chosen a better advisor-supervisor.

I will fondly remember our meetings over tea and biscuits as we pored over my budding STELLA model, and I look forward to more guidance and friendship in the years to come.

Thank you also to the other professors who especially guided and inspired me:

To Professor Anna Zalik, who supervised all of my individual directed study courses, (all focused on Latin America and the Caribbean), ensuring a solid historical and theoretical grounding in my regional area of focus, and many thought-provoking conversations;

To Professor Ellie Perkins, who helped me to formulate the beginnings of my research proposal, and who was an extra source of support and encouragement through the Economics for the Anthropocene program;

To Professor Jenny Foster, who consistently supported my distinct approach and focus within planning as international development, and her encouragement and excitement for my internship;

And to Punam Khosla, who taught me Planning and Politics and so much more, for great thought-provoking conversations, and for embracing my Global South focus in all assignments.

I am also grateful for the Economics for the Anthropocene (E4A) program, for creating community in an otherwise individual program, and inspiring my course of study in innumerable ways; I'd like to mention Peter Brown, Jon Erikson, and Dina Spigelski for their teaching, inspiration and support through the program; and to my fellow Cohort 3 Yorkies: Claire, Molly, Doug, Natália, Martin, David; thank you so much for walking along this journey with me, it has been an honour to share space with you and our colleagues at McGill and Vermont these past two years. This experience truly would not have been the same without you.

I would also like to thank my old colleagues in the Caribbean Country Department at the Inter-American Development Bank, for welcoming me as full member of the team; for their encouragement and support and inspiration that played a major role in the development of my final research proposal.

To my friends and family outside of school, thank you for your support, listening ears, and solid shoulders whenever I needed it. And of course I have to single out my parents, who despite not always understanding what I've been doing since I left high school, have never wavered in their support in every way imaginable, and in facilitating me making my dreams come true.

Finally, I'd like to thank my therapist, Dawn Stephenson, for her support these last few months, and guiding me to find my light whenever the storm clouds set in. I wouldn't have been able to see this through without your support, and I am eternally grateful, as you've taught me how to find my strength when fear sets in, and to keep carrying that light into all of the future chapters in my journey.

Foreword

For my MES Plan of Study, I entitled my Area of Concentration "Planning for International Development: Facilitating Alternatives," as I sought an exploration of models and systems of alternative and ecological economics, and their implications for and applications to the practice of planning for international development. With a regional focus on the Americas, I set out to examine the ways in which the hemisphere already has and still can incorporate its unique historical plurality into its planning and development, and the ways in which states and civil society can better facilitate economic alternatives to serve biospheric wellbeing.

My learning objectives were organized according to 3 components of my area of concentration: the Context of the Americas; Alternative and Ecological Economics, and International Development Planning, and consisted in an expansion of historical and theoretical knowledge in these areas, as well as technical knowledge of ecological economics methods. Through courses in both the Planning certificate and the Economics for the Anthropocene program, individual directed studies on my regional area of focus, membership in the Centre for Research in Latin America and the Caribbean, and an internship at the Inter-American Development Bank, I am confident in my fulfillment of my learning objectives.

This paper, then serves as a culmination of these efforts, as I present the knowledge and new ideas and questions sparked by my Plan of Study, and demonstrate my capacity to use the technical method of system dynamics modelling. In these pages, I propose a vision for planning and development in the Caribbean that is rooted in the principles of ecological sustainability, systems-thinking and social justice, which I hope will inspire other academics, policy-makers and citizens to work toward resilience in one of the most vulnerable regions in the world.

I have certainly been changed by this exercise and will carry with me the skills, knowledge, values, ideas and questions that both inspired and have been inspired by this Major Research Paper.

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INTRODUCTION

There is a well-established and increasingly urgent interest in the fields of international development and affairs, of attaining "sustainable development:" an advancement of the material well-being and social progress of people—especially those most impoverished and marginalized—that is environmentally responsible, and averts as much as possible further human contributions to the imminent threat of climate change. At the same time, in the field of economics over the past few decades, criticisms of the neoliberal paradigm and its teaching apparatus are also well-established and growing, with new heterodox economic thinking, writing and teaching shared every year. Of particular interest to me has been the heterogenous field of ecological economics that, simply put, seeks to reposition the economy as a subsystem of society and of the planet as a whole—the natural ecosystem that has allowed our species to thrive.

Common to both of these developments is the work of climate scientists and environmentalists: prioritization of ecological harmony in the way that we understand, manage and envision the world and our place in it. The purpose of this Major Research Paper is to merge the efforts of these two fields, in application to the Caribbean, my home, and one of the world regions most vulnerable to the negative consequences of global warming and a changing climate. Thus, I will examine the prospects for prosperity in Caribbean small-island developing states, taking into account the shift in perspectives and practices necessary to secure that prosperity and resilience in the face of current and future challenges.

My research question consists of two parts:

1. *What should the objectives and framework of planning and development in the Caribbean look like, if aimed at a vision that is that is ecologically sustainable and rooted in systems theory?*
2. *To what extent can system dynamics help to make such a vision a reality?*

In the first instance I have relied on literature reviews and critical analyses to develop an answer, enclosed in Part 1 of this paper, while Part 2 seeks to answer the second question in the application of system dynamics modelling using STELLA® software. My objectives are thus to develop a framework and vision for planning and development in the Caribbean that is ecologically sustainable and rooted in systems science, and to demonstrate the application of system dynamics as a tool to further such a framework and vision.

My sources range from the fields of ecological economics and complexity science, to critical planning and development theory, Caribbean and Latin American social theory, political economy and planning literature, my model was built using the World Bank's World Development Indicators for Caribbean small states.

As mentioned earlier, this paper consists of two parts. Part 1, consisting of three chapters which: lay out the foundation of the ecological crisis, and the attendant crises in development and economics and the need for fundamental shifts (Chapter 1); provides the history and context of the planning and development in the Caribbean, as well as the region's unique present and imminent challenges (Chapter 2); considers the application of systems science to the practice of planning and development in the Caribbean context, introducing the need for systems science-based tools in planning and policymaking (Chapter 3). After each chapter is a short case study- highlight of concepts as food for thought in application of this framework: Rights of Nature, the Blue Economy and the Circular Economy respectively.

Part 2 then presents and explains the model I built—of land use change on a Caribbean island state—along with scenarios, results, discussion, and an evaluation of system dynamics modelling as a viable and valuable policymaking tool.

PART 1

Chapter 1: Development in Crisis

Introducing the Crisis

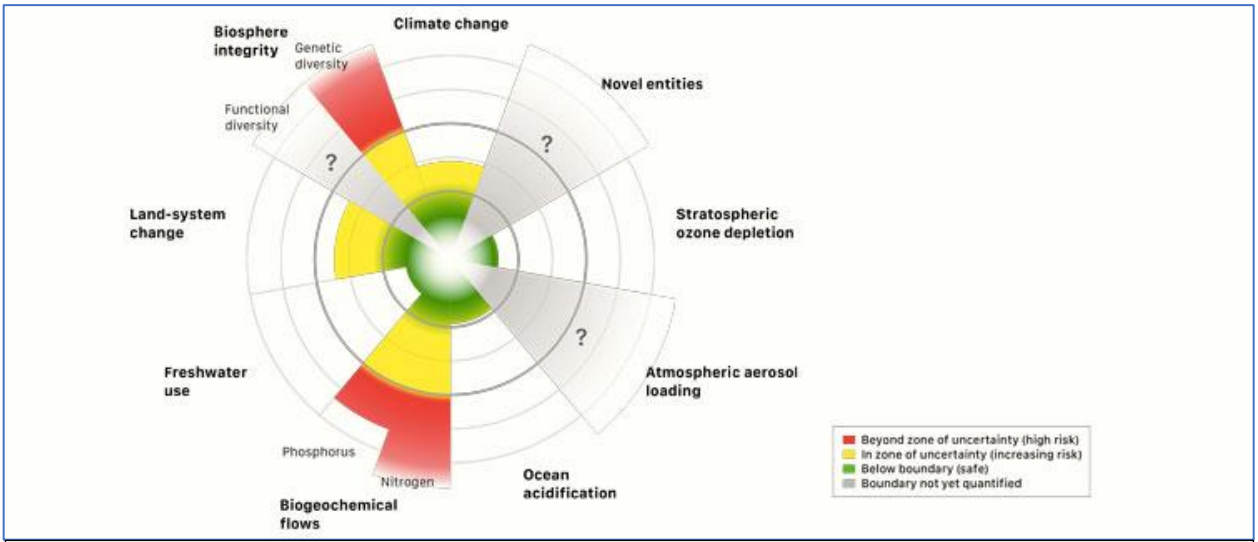
We are currently in the throes of a crisis of development that has been a long time coming. This is not news—in the Caribbean and across the planet, we face increasing climate and environmental instability: global average temperature has increased by one degree Celsius over the past hundred years, and is on track to warm by six degrees within this century. Glaciers are melting, sea levels are rising, entire species are going extinct at unprecedented rates, and the subsequent biodiversity loss is staggering. Deserts are expanding, seasons are changing, and natural disasters are becoming more frequent and damaging. It is estimated that two hundred and fifty million people will be displaced due to the effects of a changing climate by the year 2050. Our carbon dioxide emissions today exceed four hundred parts per million (one hundred ppm over sustainable levels). Through industrialization, and the expansion and increasing dependence on fossil fuels as the source of energy for our "progress," we have made a greenhouse of our atmosphere, and trapped ourselves and our planet inside in the process.

Our economic system calls for never-ending growth and expansion for survival, leading to the prevalence of a "race to the bottom" attitude, and a system of globalization that protects the interests of multinational corporations over sovereign nation-states and peoples (and ecosystems). And yet, despite all of this economic growth—this prosperity—to which we sacrifice Nature, poverty and hunger prevail, economic inequality is growing, millions of people lack access to basic services and many more live in conditions of precarity. And the god of economic growth is in decline: governments are imposing measures of increasing austerity to counteract budget deficits, while global debt accumulates in the trillions of US dollars.

We are very literally and physically coming up against (and in some cases surpassing) the planetary boundaries of this Earth system—very real limits that are starting to manifest themselves in the decline of economic growth around the world. These boundaries lie around the natural biophysical resources and processes that make it possible for human life to thrive, and which, if crossed, would lead to intractable environmental change, namely: climate change; rate of biodiversity loss (terrestrial and marine); interference with the nitrogen and phosphorus cycles; stratospheric ozone depletion; ocean acidification; global freshwater use; change in land use; chemical pollution; and atmospheric aerosol

loading.[1] These boundaries are represented in Figure 1 below, from the Stockholm Resilience Centre. The "safe operating space" is characterized by the green centre, with increasing uncertainty (and unsafety) moving outward.

Figure 1: Planetary Boundaries: A Safe Operating Space for Humanity



Stockholm Resilience Centre: http://www.stockholmresilience.org/research/planetary-boundaries/planetary-boundaries/about-the-research/the-nine-planetary-boundaries.html

The challenge we face lies in putting a halt (as much as is possible) to further environmental damage and change, but it is not an easy feat. Human-induced climate change has been recognized as a problem for decades, and we still face countless political, social and economic roadblocks to enacting effective measures to curb the changes. Geologists have recently coined the term "Anthropocene" to refer to a new era of geologic time, in which human activity is the prime driver of change in the environment. There is disagreement over when exactly this new era began, but many agree that we have officially left the Holocene—the period of stability that has allowed the human species to thrive over the last twelve thousand years—and entered into a new period of instability instigated entirely by our species.

If we are in the Anthropocene, sitting in the driver's seat of our planet's future, then how do we steer this spaceship towards sustainability and resilience? The answer is clear but not easy: we need to re-imagine our place on this planet, from the Judaeo-Christian "dominion over the earth" that still permeates

[1] Rockstrom et al. 2009. "Planetary Boundaries: Exploring the Safe Operating Space for Humanity." Ecology and Society 14(2): 32. http://www.ecologyandsociety.org/vol14/iss2/art32/

the Western psyche today, to an understanding of ourselves as emergent and embedded in Nature and neither separate from nor above it.

This aligns well with the Traditional Ecological Knowledge (TEK) of Indigenous peoples that has emerged as a distinct field of study, in recognition that "Indigenous people all over the world developed sustainable environmental knowledge and practices that can be used to address problems that face global society."[2] Native ecology is the experience and understanding of complex human relationships in complex interaction with nature. It is not a concept, not a form of discrete, separate knowledge held by people, but rather an expression of the way of life of a particular group in their particular local context. There is no separation between the people and the environment in which they live; it is understood as part of their own existence, and the knowledge generated, shared and experienced is an intrinsic facet of that life relationship. It is a spiritual and all-encompassing ontology and cosmology, and one that is fundamentally ecologic in its recognition of the human place on land/in Creation.

While this paper does not focus on the ontological and cosmological transformation required at the core of the sustained transition needed to face our current challenges—that is, I will not elaborate here on the nature of being and the origins and subsequent development of the universe—I do want to emphasize that I recognize the need for this fundamental change, and it is at the core of the proposed changes and ideas that will be explored and presented in this paper.

One of the major consequences of our historical separation from Nature and our belief in a divine right to dominate the environment to serve our will is the very idea of progress that drives our economies, governments and societies in general. To advance, to develop, to progress has meant to expand, to cross the next frontier, to stake a claim on land otherwise inhabited. Now that almost all land is accounted for in a global network of property allocation, progress simply means more wealth, more technology, higher GDPs and growth rates. Thus the project of development has been pursued, first by European competition, wars, and mercantilism, colonialism and imperialism, and now to the rest of the world, made to believe that they might find similar routes to the same prosperity. Unfortunately however, there aren't enough planet Earths to provide for such a reality—there aren't even enough Earths to provide for current levels of consumption as we reach overshoot day[3] around August of every year.

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[2] McGregor, D. (2004). Coming full circle: indigenous knowledge, environment and our future. *American Indian Quarterly*, 28(3-4), 385-410

[3] "Earth overshoot day marks the date when humanity's demand for ecological resources and services in a given year exceeds what Earth can regenerate in that year…[it] is computed by dividing the planet's biocapacity… by humanity's Ecological Footprint … and multiplying by 365, the number of days in a year." Global Footprint Network https://www.overshootday.org/about-earth-overshoot-day/ Overshoot day 2018 will occur on August 1st.

In the Caribbean and Latin America (as in other regions of the world historically exploited by colonization) there exists a rich history of critical thought, in the twentieth century especially, in opposition to the idea of progress that forms the basis of developmentalism, colonialism and neo/post-colonial processes, all fundamentally rooted in the idea of progress that has caused this crisis in development.

Caribbean and Latin American counter-narratives to developmentalism

The unique history of the Americas as the New World where "all the world" has resided for centuries, through migrations both voluntary and coerced, has created a rich tapestry of multicultural, critical, political-economic, and social thought. While the hemisphere has often been left out of global postcolonial literature many thinkers from Africa and Asia often make use of ideas that came from the Americas, and more specifically the Caribbean.[4] Ideas like counterpoint and transculturation, creolization and mestizaje, hybridity and diaspora came from thinkers such as Fanon, Césaire, Martí, Ortiz, Glissant, Lamming, Retamar, James, Hall,[5] whose ideas have such wide application in postcolonial theory due to their ability, distinct from most mainland Latin American thinkers, to theorize across the genocide of native peoples and fully contend with their multicultural diasporic realities, since no Caribbean discourse can truly claim to embody an Indigenous point of view.[6] This presents a unique ethno-cultural reality with an idiosyncratic perspective when contending with inclusion and participatory processes, which is by no means perfect in the Caribbean.

Of particular significance is the resistance in Latin American studies to identify with "postcolonial" theory which arguably renders colonialism complete and temporally limited—an issue of the past—when in fact colonialism is as much a contemporary as it is an historical experience and issue. The study of coloniality offers an alternative, here implying the challenge of thinking "across" in order to conceptualize the "overarching structure of power that has impacted all aspects of social and political experience in Latin America since the beginning of the colonial era,"[7] while also taking into account the

[4] Hulme, Peter in Moraña, M., Dussel, E., & Jáuregui, C. A. (Eds.). (2008). "Postcolonial Theory and the Representation of Culture in the Americas" in Coloniality at Large: Latin America and the Postcolonial Debate. Durham: Duke University Press Books, 388-395

[5] Caribbean social theorists of the 19th and 20th centuries, whose work can be further explored in: Bolland, Nigel O. (ed.) 2004. The Birth of Caribbean Civilization. Kingston: Ian Randle.

[6] Hulme, 2008

[7] Moraña, M., Dussel, E., & Jáuregui, C. A. (Eds.). (2008). "Colonialism and its replicants" in Coloniality at Large: Latin America and the Postcolonial Debate. Durham: Duke University Press Books, 1-20.

pre-colonial and contemporary contributions of indigenous culture, thought and practice. Then we may be able to thoroughly analyze colonialism and its many contemporary replicants—e.g. developmentalism—in the region.

Thus colonialism (and developmentalism) is recognized as a process that has continuing influence on the Latin American and Caribbean reality—and by extension, the Global South and world at large. This runs in tandem with the idea of progress that continues to permeate global development. From a human social standpoint, the road to progress for some has been unjust to many, and continues to be. As economist Ha-Joon Chang points out in his concept of kicking away the ladder, once certain groups make their way up the ladder of economic advancement (using the labour and resources of other groups, as well as protectionist policies), they then kick the ladder away in order to secure their position on top (this is done both consciously and unconsciously), touting new principles of free trade as the best practice for the management of a globalized economy.[8] Rooted in our idea of progress is that of competition; while we hear talk about steps forward for mankind, only a select few get to make the leap—the rest of us are left shuffling behind.

In the face of these unequal global power dynamics have arisen proponents of autonomous, local, context-specific development policies and processes. Norman Girvan endorses a context-specific approach to policymaking that recognizes that responses to economic policy instruments are conditioned by a wide range of local factors.[9] To this end, regionalism is positioned as a building block for a polycentric world system characterized by equitable development and respect for cultural diversity. This contribution is particularly helpful in conceiving of local, context-specific economic and policy practices that presents an increasingly compelling future for the world, and one of autonomy and equity for the Global South in particular. The discussion of "social knowledge" and the epistemic dimension of regionalism helps us to recognize the importance of local capacities and democratic decision-making.

Escobar posits that the struggles for post-development in the Third World constitute arenas for redefining and recovering terms like equality, democracy and relations of production.[10] Important in the imagining of post-development then is the generation of new ways of seeing and of renewing social and cultural self-descriptions by displacing the imposed categories of Third World groups that were constructed by dominant global forces, and social movements he argues, have the potential to be the most

[8] Chang, Ha-Joon. 2003. Kicking away the Ladder: Development Strategy in Historical Perspective. London: Anthem Press.
[9] Girvan, Norman, and UNRISD. 2005. The Search for Policy Autonomy in the South: Universalism, Social Learning and the Role of Regionalism. United Nations Research Institute for Social Development.
[10] Escobar, A. (1992). Imagining a Post-Development Era? Critical Thought, Development and Social Movements. Social Text, (31/32), 20–56. https://doi.org/10.2307/466217

effective symbols of resistance and provide some paths in the direction of this call for the re-imagining of the "Third World" and a "post-development" era. He further posits that self-organized social movements are our best hope for dismantling coloniality and hegemony in such a way as to be able to finally do away with modernity and move beyond Third World thinking.[11] This potential however, depends on the movements' ability to engage with the politics of difference, especially with political strategies that are at the same time local and transnational.

Here we have regional responses to the social and political consequences of the project of progress, modernity and development, since dominion over the earth also meant dominion of othered peoples. At this level, context-specific and people-centered and driven policies are necessary to overcome this social crisis of development.

An Ecological-Economic Lens

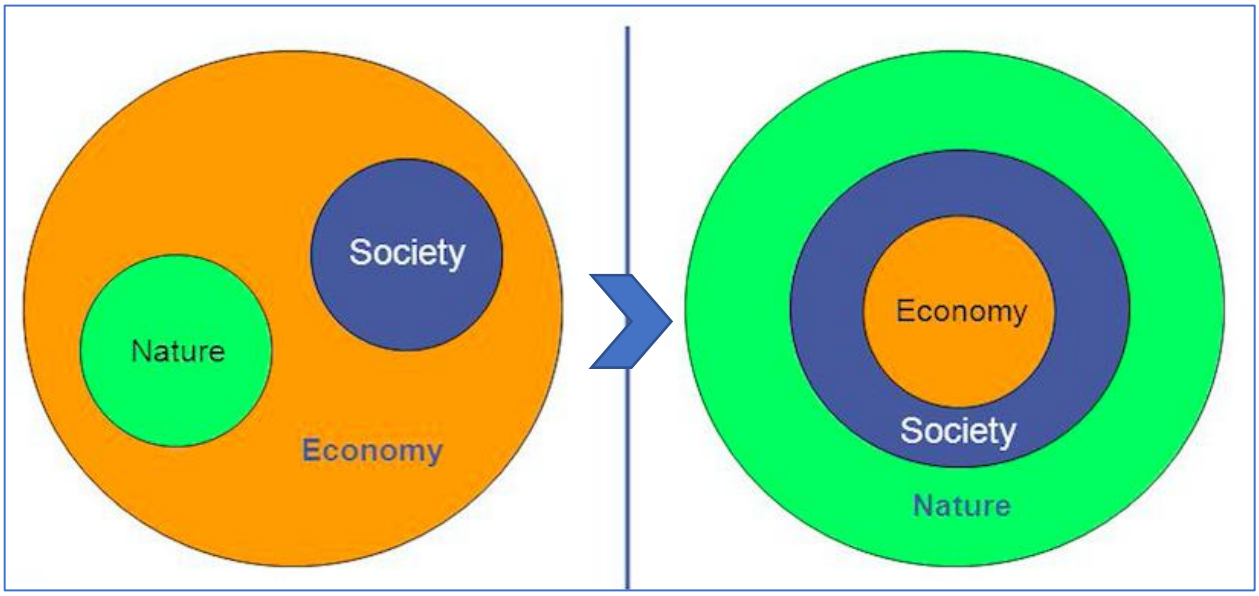
This Pan-American socio-political framework is enhanced by an environmental-ecological lens when integrated with the framework of ecological economics, which seeks to reset the position of the economy from dominator to socially-constructed subset of the Earth-system. Based on the principal and interrelated tenets of Sustainable Scale, Efficient Allocation and Just Distribution, the goal is to establish an economic paradigm that works for both people and planet, with the hope of ameliorating many of the externalities, inequities and inequalities of the current system. Thinkers like Herman Daly have been advocating for these ideas since the 1970s, also grounded in steady-state economics which challenges the growth paradigm of contemporary economic development.

Conventional neoclassical economics as practiced around the world today, has long been centred around *homo economicus*,[12] the perfectly rational individual actor seeking at all times to maximize his

[11] Escobar, A. (2004). Beyond the Third World: Imperial Globality, Global Coloniality and Anti-Globalisation Social Movements. Third World Quarterly, 25(1), 207–230.
[12] Thaler, Richard, H. 2000. "From Homo Economicus to Homo Sapiens." *Journal of Economic Perspectives*, 14 (1): 133-141.

utility above all other considerations. While homo economicus has purportedly died,[13] with the recognition of the limited scope of economic assumptions and rationale, the lack of empirical evidence, [14] and the emergence of fields like behavioural economics on the rise, many of the core principles of neoclassical economics remain very much intact: all things can be valued in monetary units; change happens marginally, and can be thoroughly analyzed in static, or fixed time-frames; evolution occurs as a process of constrained optimization; efficiency is the prime criterion for economic decision-making; and production processes are a matter of the allocation of fixed resources (e.g. the environment) according to a defined production function.[15] And the Market is always right. It is easy to find the connections to the ideas of modernity, progress and development critiqued in the previous section.

Figure 2: Conventional vs. Ecological positioning of the economy



[13] Gintis, Herbert. 2000. "Beyond Homo economicus: evidence from experimental economics." Ecological economics 35, no. 3 (2000): 311-322.
[14] Henrich, Joseph, et. al. 2001. "In search of homo economicus: behavioral experiments in 15 small-scale societies." American Economic Review 91, no. 2 (2001): 73-78.
[15] Gowdy, John and Jon Erickson. 2005. "The Approach of Ecological Economics," Cambridge Journal of Economics 2005, 29, 207–222 doi:10.1093/cje/bei033

Karl Polanyi observed in his work *The Great Transformation*, that with the historical rise of market capitalism, the markets emerged from being embedded in the social fabric of society, to being master over it. Ecological economics seeks to re-embed economics not only into the social fabric, but also into the broader ecological fabric. In contrast to the aspects of conventional economics listed above, ecological economics: recognizes the human being as a social actor involving complex, imperfect, and often unpredictable internal decision-making processes; separates value into multi-criteria assessment, in recognition of the incommensurability of value; recognizes erratic changes amid marginal ones; allows for the importance of contingency, historical accidents in evolutionary change; upholds a coevolutionary focus to decision-making, holding up criteria such as equity, stability and the resilience of social and environmental systems; and understands production as a biophysical process subject to the laws of thermodynamics.[16]

When looking at the three interrelated principles of the ecological economics approach, we find some overlap with conventional economics: Efficient allocation of limited resources is a consistent object of all schools of thought, brought about by prices determined by supply and demand in competitive markets. Neoclassical economists also concern themselves over the distribution of the final goods and services, but in contrast with the conventional principle that distribution should be determined by ability to pay, ecological economists hold that good distribution is one that is just—inequality should be constrained to an acceptable level with transfers such as taxes and welfare payments. The difference is sharpened when considering scale, the physical volume of throughput (the flow of energy and materials in and out of the environment) driven by the economy. Neo-classical economics has little regard for scale, historically disregarding the fact that Nature's resources and sinks are not infinite, and thus cannot act just like any other economic sector.[17] Ecological economics, on the other hand, recognizes good scale as one that is sustainable—that at the very least does not erode environmental carrying capacity over time, and that optimally would not lead to loss of ecosystem services.[18]

One final principle that is important to note with regard to ecological economics is the idea of limits to growth. As outlined above, at the core of this maturing school of thought is the re-positioning of the economy as a subset of society and the ecosphere of our planetary system at large. It naturally follows then, that the economy physically cannot be allowed to grow beyond the planetary bounds without

[16] For further details, and a comparative table, see Gowdy, J. and Erickson, J.D. 2005. The approach of ecological economics. Cambridge Journal of Economics, Vol. 29, No. 2.

[17] It is worth noting that the neoclassical subfields of natural resource and environmental economics do not fall into this pattern.

[18] Daly, H.E., 1992. Allocation. distribution and scale: towards an economics that is efficient, just. and sustainable. Ecol. Econ., 6: 185-193.

wreaking havoc on the stable systems on which our species (and so many others) depend for life. Exceeding these limits as identified in the first section of this chapter could destabilize the systems, changing them irreparably so that we no longer have a stable climate, clean air to breathe, sufficient freshwater resources, safe oceans, successful nitrogen and phosphorous cycles (i.e. food), ozone protection from harmful sun rays. And perhaps more quickly perceptibly, it will force our economies to contract, causing economic, social and environmental disaster.

In his book *Managing Without Growth*, Peter Victor outlines these real limits to growth and explores some possibilities to advance human wellbeing without increasing economic growth, encouraging us to find a way to slow down "by design, not disaster."[19] Finally, an interesting point to note about Victor's book, is that his appeal is directed toward the Global North—as have been most if not all historic appeals to limit economic growth—in recognition of the unequal processes that have led to unequal socio-economic outcomes across the world, and the responsibility that the North has to slow down and allow others to at least try to catch up in terms of socioeconomic development.

Protecting a Southern Right to Development

The appeal mentioned by Victor in his prologue[20] is part of a decades-long debate in the Northern developed world over the limits to growth and how it might be managed, as nature's capacities to contain our physical and ethical wastes and sustain our untenable consumption of natural resources are persistently overshot. The argument has been that this self-constraint in the North is particularly needed to leave room for those countries systematically left behind in the quest for progress and development, to be able to grow and provide for the material well-being of their societies (i.e. catching up) before they too must more seriously contend with the global situation of limits to growth. Increasingly now, however, we must face the discomforting fact that the space for leaving room has already been taken up in our failure as a global community to face the reality of a changing climate. Now the developing world must find a way to "develop"—to pull people out of poverty, to provide for the material wellbeing of people, (not to mention their happiness and fulfillment), outside of the traditional development paths, and without the catalyst of growth that the North has had at their disposal since the Industrial Revolution.

It is helpful in the first instance to truly consider the idea of the right to development despite climate constraints. For while we must concede the need for a new development paradigm that seeks

[19] Victor, P. 2008 Managing without Growth
[20] Victor, P. 2008 Managing without Growth

ecological balance and "sustainability," it is important to give thought to the "right to development" of the Global South on moral and other grounds. Taking account of the Greenhouse Development Rights framework,[21] we are charged with the moral imperative of development in those regions of the world of previous (and continued) colonization. The present levels of poverty, hunger, disease, and lack of access to the material requirements for a "good" life are unjust in their own right, but even more so given the historical and continued contributions of the South to the progress and development of the North, who have been the biggest contributors to our climate problem in the first place. Development in this context, cannot be conceived of in the conventional fashion, for the reasons described earlier, in addition to the lack of "leaving room" left for developing countries to continue along the traditional path. While respecting the right to improved socio-economic conditions, the status of "developed" has to be more contextually, sustainably and broadly defined.

The GDR framework provides a means to calculate the responsibility and capacity for all countries, using an indicator—the Responsibility Capacity Index (RCI)— to quantify their various national climate obligations. Approaches such as global cap and trade, auction- and fund-based systems are identified as means to operationalize this framework, but of particular interest to the authors is the idea of a system of internationally harmonized taxes.[22] This progressive capacity and responsibility based "climate tax" could be expressed in terms of individual capacity and responsibility, passed down to taxpayers according to their own personal RCIs, "thus ensuring that effort sharing within nations exactly parallels effort sharing among nations."[23] Intended as more of a thought experiment than a defined objective, this climate tax would thus cap and allocate payments for over-emission while ensuring that those below the "development threshold" and who contribute nothing to their nation's obligation, would similarly pay nothing toward fulfilling it; "in effect, their climate tax would be zero"[24] which would be the case for the majority of the world's population.

Most importantly, this framework requires the building of trust between North and South and action in good faith to secure climate protection, as well as the wellbeing and right to development of all, as advocated for by the United Nations' Declaration of the Right to Development (UNGA 1986 A/RES/41/128).

[21] Kartha et. al 2010. "The Right to Development in a Climate Constrained World: The Greenhouse Development Rights Framework." In Der Klimawandel, 205–226. Springer. http://link.springer.com/chapter/10.1007/978-3-531-92258-4_12

[22] Kartha et. al., 2010

[23] Ibid.

[24] Ibid.

A Note on Northern Responsibilities to the South

Key to securing this right to development in the Global South is support, in cash and in kind, from those who have overwhelmingly benefitted from the development project of the past few centuries. By cash and kind, I refer to cash transfers, loan instruments, debt forgiveness, technological transfers, technical cooperation agreements and capacity building. Much of this already occurs in the field of international trade, aid and development, however much more is required, and not merely for the purpose of charitable donations to our less fortunate global members. These transfers should not be considered as aid or altruistic assistance, but as a very real debt that the North owes to the South.

Consider climate debt: Imagine the climate as a resource that all nations, people, species share, and into which some of the human species have released toxic greenhouse gas emissions among other transgressions. The atmosphere can hold only so much of these emissions before our global average temperatures (i.e. climate) change so much as to threaten the conditions for life that we require. So there is a limited amount of emissions that we can allow to be released into the atmosphere before we begin to seriously endanger our own lives. This limit, also called a carbon budget, has been set by the global community to the amount of emissions that would cause the global average temperature to rise to 2 degrees Celsius above pre-industrial levels. It is estimated to be around one trillion tonnes of carbon, or 1000 PgC.; at current rates, we will exceed this budget by the end of year 2045.[25]

According to climate science, if we pass that 2-degree mark, we will face "untold calamity" with regards to the stability of the climate and our conditions for life. This calamity extends from increased risk of sea level rise, forest fires, water shortages that we will surely face at this point, even if we do remain within budget. If we exceed this budget, and pass the 2 degree mark, these risks are significantly increased with every degree of warming beyond 2 degrees: global sea levels could rise by 1 meter in 2100; the intensity and frequency of wildfires will increase; heavy precipitation will increase over some land areas; the duration and intensity of droughts will also increase in many regions.[26] Heat waves will last longer, crop yields will fall, and coral bleaching will put virtually all reefs at risk.[27] These biophysical dangers will then have extensive impacts on our socio-economic systems, as food and water become increasingly insecure, climate migration intensifies, and economic constraints will tighten.

The argument continues on the premise that these limited emissions, or carbon budget, is a resource pool that everyone should have equal access to, so there's only so much emissions that we're

[25] World Resources Institute, IPCC infographics http://www.wri.org/ipcc-infographics
[26] Ibid.
[27] Carbon Brief, https://www.carbonbrief.org/scientists-compare-climate-change-impacts-at-1-5c-and-2c

each allowed.[28] And based on population size, there's only so much emissions that each country is allowed. What has happened so far is that some countries have already used up their fair allotment of these emissions. If we imagined this shared pool as a budget then, the countries who have used up more than their fair share owe their over-emissions to those who haven't. [Remember, we can't allow the global average temperature to pass that 2-degree mark.] Thus, we have debtors (overwhelmingly Northern) who owe their extra use—their debt—to the creditors (overwhelmingly Southern) who, due to a combination of choice and structural exploitation, have not used up their fair share. And now they will not be able to so without compromising our 2-degree target.

Hence the argument is that we have climate debtors and we have climate creditors, and the debtors have to find a way to pay their debt to the creditors. From this premise, the creditors in the South have a right to emissions, a right which has been impinged upon by the over-emission in the North. In the regions of the world with the greatest poverty, hunger, instability and vulnerability, we must acknowledge a right to development in order to provide for the material needs of those excluded from globalized "progress." In many ways, this right to development means a right to continued emissions, so added to the context of climate debt, where only a limited amount of global emissions can be allowed, the urgency and imperative for this debt to be paid only increases as our global average temperature increases.

According to the work undertaken by Damon Matthews on Climate Debt calculations,[29] the United States alone owes the world USD $4 trillion dollars in climate debt. Defining climate debts as the amount by which national climate contributions have exceeded a hypothetical equal per-capita share over time, Matthews' calculations are based on supply-side (i.e. production-based) accounting of emissions, calculating the accumulation of 'carbon debts' for each country since 1960, using historical estimates of national fossil fuel CO_2 emissions and population.[30] Counting from 1990, since this was when we first found a verifiable link between carbon emissions and climate change,[31] and is thus the least contestable measure of the debt, US has taken up 32% of the cumulative global climate debt from 1990-2010. Canada is also a significant debtor country at 3.9% of the world climate debt, meaning that Canada owes the world USD $500 billion—no small debt by any means. Compare that number to the combined external debt stock of "low and middle income" countries as of 2015 according to the World Bank: USD $6.669

[28] This is based on the first Rawlsian principle of distributive justice, where basic liberties are to be enjoyed by each citizen to an equal extent. [Rawls, J. (2009). A theory of justice. Harvard university press; Rawls, J. (1985). Justice as fairness: Political not metaphysical. Philosophy & Public Affairs, 223-251.]
[29] Brian Merchant, "The U.S. Owes the World $4 Trillion for Trashing the Climate," Vice News, September 15, 2015. https://motherboard.vice.com/en_us/article/bmj97q/the-us-owes-the-world-4-trillion-for-trashing-the-climate
[30] Matthews, H. D. (2016). Quantifying historical carbon and climate debts among nations. Nature climate change, 6(1), 60.
[31] Ibid.

trillion,[32] and isn't hard to see who the true global debtors and creditors are (not to mention other historical debts like slavery, biopiracy, resource exploitation, ecosystem degradation and pollution).

Furthermore, the average citizen in Toronto or Texas has not derived significant personal financial gain from the activities that are overwhelmingly the cause of the problem—while Northern consumers have benefitted from their governments' climate credit—it is the petrochemical industries more than citizen-taxpayers who ought to be called upon to settle their debts. After all, in the North, many communities—Native ones in particular—suffer from local "externalities" of extraction such as oil spills, air pollution, and their many negative environmental and human health effects.

What is needed is an autonomous, ecologically sound vision of development determined by local communities, and aided by international debt payments.

[32] World Bank Data Portal, http://data.worldbank.org/topic/external-debt?locations=XO&view=chart, accessed June 2017

The Rights of Nature

In September 2008, Ecuador became the first country in the world to constitutionally (and legally) recognize the "Rights of Nature" in the ratification by referendum of its newest constitution. In April 2010, the World People's Conference on Climate Change and the Rights of Mother Earth held in Bolivia resulted in the Universal Declaration of the Rights of Mother Earth. Later that year, Bolivia's Legislative Assembly passed the Law of the Rights of Mother Earth; these rights were further recognized in statutory law the following year. In 2014, the government of New Zealand passed the Te Urewera Act, legally recognizing the former national park in its own right; and in 2017, finalized the Te Awa Tupua Act, which grants the Whanganui River legal status as an ecosystem.[33]

These developments and others around the world have been ignited and carried to fruition through the collective action of Indigenous and other local peoples, brokering with their governments on behalf of Nature to secure rights to the ecosystem that has made the flourishing of our species possible.

Article 10 of the Ecuadorian Constitution now extends the rights entitlements normally held exclusively by people to Nature, and its seventh chapter is dedicated to the Rights of Nature. Article 71 declares that: "*Nature, or Pachamama, where life is reproduced and exists, has the right to exist, persist, maintain and regenerate its vital cycles, structure, functions and its processes in evolution*."[34] The Chapter further ensures the right of nature to restoration, protection, and of the ability of people and communities to defend these rights.
The first lawsuit filed under these constitutional provisions took place in 2011, with the Vilcabamba River as plaintiff, defending its right to exist and maintain itself in the face of a highway construction project that was disturbing the natural flow and health of the river. The Provincial Court of Justice ruled in the river's favour, ordering that the project be stopped.[35]

The Bolivian Law of the Rights of Mother Earth entitles nature to the rights: to life, to the diversity of live, to water, to clean air, to equilibrium, to restoration, and to freedom from contamination.[36] The law further outlines the duties and obligations of the state and of society to ensure these rights.

Much of this Rights of Nature rhetoric has been inspired by the Buen Vivir (also Vivir Bien/Sumak Kawsay/Suma Qamaña) or Living Well philosophy of wellbeing which is based on the Indigenous worldview which holds that nature, community and individual are intrinsically interconnected and made up of the same material and spiritual matter. Particular to the Indigenous communities of Ecuador and Bolivia, the institutionalization of Buen Vivir and the Rights of Nature present an excellent examples of state institutionalization of an alternative "development" discourse that aims to repair and reorient the human relationship with each other and with Nature. While inspirational, these initiatives are not immune from limitations and challenges in implementation in an increasingly globalized world. Still, they offer points for consideration and frameworks for application in the Caribbean and around the world.

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[33] Global Alliance for the Rights of Nature. "Timeline." http://therightsofnature.org/timeline/ accessed 28.07.2018
[34] Ibid. "The Rights of Nature articles in Ecuador's Constitution." https://therightsofnature.org/wp-content/uploads/pdfs/Rights-for-Nature-Articles-in-Ecuadors-Constitution.pdf accessed 28.07.2018
[35] Ibid. ("Timeline.")
[36] World Future Fund. "Law of Mother Earth: A Vision from Bolivia." http://www.worldfuturefund.org/Projects/Indicators/motherearthbolivia.html

Chapter 2: Contextualizing the Caribbean

HISTORICAL CONTEXT

The Caribbean is a region unique to the world and difficult to define. The first stops of the European ships headed for the New World, the Caribbean played a role of strategic importance during colonial struggles. From the Spanish enslavement, exploitation and massacre of Indigenous peoples across the region in the hunt for gold and other resources; to the enslavement and importation of African people to continue mining labour; to the European imperial rivalries played out in the capture of Caribbean gateway territories, to the establishment of plantation economies for the production of sugar, cocoa and coffee; and the continued capture and importation of millions of enslaved Africans. After emancipation, facing huge labour shortages on the plantations, indentureship agreements brought people from India, China, Indonesia to counter the economic losses of emancipation. Throughout this period many other people seeking better opportunities also emigrated to the region from parts of Europe and the Middle East, adding even more to the mix of peoples.[37, 38, 39]

There are two major consequences of this history that are important to understand if one hopes to contextualize the contemporary state of affairs:

Firstly, this distinctive past has resulted in the Caribbean as "all the world in one place;" a small region hosting a diverse plurality of language and ethnicity, religion and culture, long before the word "multiculturalism" entered the Western lexicon in the twentieth century. Due to its history of colonization, shared in part with the wider Latin American and Caribbean region and the Americas as a whole, this region presents "a case unique to the entire planet: a vast zone for which mestizaje is not an accident but rather the essence, the central line."[40] From the Spanish, mestizaje, to the French creolité, to the anglicized idea of creoleness, this (forced) diasporic condition is not a mere detail of the contemporary social fabric, but a central defining characteristic of the Caribbean and out of which Caribbean social thought emerged.[41] Different peoples torn from their native lands (and encountering few

[37] Williams, Eric. 1971. *From Columbus to Castro: The History of the Caribbean 1492–1969*. New York: Random House

[38] Martin, Tony. 2012. *Caribbean History: From Pre-colonial Origins to the Present*. Taylor & Francis: NYC, NY.

[39] King, Russell (2010). *People on the Move: An Atlas of Migration*. Berkeley, Los Angeles: University of California Press.

[40] Retamar, Roberto Fernandez. 1971. "Caliban: Notes Toward a Discussion of Culture in Our America. In "Roberto Fernandez Retamar," The Birth of Caribbean Civilization. Ed. O. Nigel Bolland. Kingston: Ian Randle, 2004. 122-134.

[41] Reddock, Rhoda. 2014. "Radical Caribbean Social Thought: Race, Class Identity and the Postcolonial Nation." Current Sociology, 62.4 (2014): 493-511.

if any native peoples upon their arrival) had to face, over centuries, the challenge of "disadjustment and readjustment, of deculturation and acculturation—in a word, of transculturation."[42] And thus we have this continuous process of creolization, where the outcome of the combination of cultures is like offspring, having always something from both parents, but also always being different from each of them. There is no unified ideology of creolity[43] or of self, nor any truly native Caribbean point of view, but rather a heterogenous mosaic of ideas of how to move forward into the future together.

Secondly, the development of the colonial Caribbean as peripheral plantation economies with the sole purpose of providing raw materials for export to the colonial bases has consequences for the contemporary management of the economy and society. The colonial powers saw no benefit in developing local economies; the colony's purpose was to produce and export the raw material that would then be manufactured into final goods in Europe; any required resources for the maintenance of society would be imported, leaving a lasting trend in Caribbean economies. Socio-politically as well as economically, the region was designed to be externally driven;

> "The Plantations, entities turned in upon themselves, paradoxically, have all the symptoms of extroversion. They are dependent, by nature, on someplace elsewhere. In their practice of importing and exporting, the established politics is not decided from within."[44]

And so we have the peculiar context of a region that is extremely vulnerable due to history and geography, to external shocks, events, policies and economic demand, and that was structured to serve a foreign center, the effects of which remain in the outward-looking application of foreign systems and solutions to local problems, all despite possessing a unique social reality rich in plurality and heterogeneity that demands—like all other places—the development of locally-driven and designed context-specific solutions and ideas for "development."

Defining, or rather delineating the Caribbean poses the challenge of multiple definitions that include and exclude various territories.

Geologically speaking, the Caribbean is the area that rests upon the relatively small Caribbean tectonic plate, bordered by the North American, South American, Nazco and Coco plates. This area expresses similar tectonic, seismic and volcanic features and processes: it is a known earthquake zone that shares an annual hurricane season from June to November, and is rife with volcanic activity in the Lesser

[42] Ortiz, Fernando. 1947. "Cuban Counterpoint: Tobacco and Sugar (excerpts)" in "Fernando Ortiz" The Birth of Caribbean Civilization. Ed. O. Nigel Bolland. Kingston: Ian Randle, 2004. 36-60.
[43] Benitez-Rojo, Antonio. 1989. "Three Words Toward Creolization." In "Antonio Benitez Rojo." The Birth of Caribbean Civilizatoin. Ed. O. Nigel Bolland. Kingston: Ian Randle, 2004. 160-169.
[44] Glissant, Edouard. 1997. "Closed Place, Open Word." In "Edouard Glissant." The Birth of Caribbean Civilization. Ed. O. Nigel Bolland. Kingston: Ian Randle, 2004. 267-279.

Antilles in particular. This delineation implies that the Caribbean extends from Hispaniola in the North, to parts of Trinidad and Tobago, Venezuela and Colombia in the South, and from Central America in the West to just East of the Lesser Antilles in the East. Geographically, the Caribbean is defined as the area surrounding the Caribbean Sea, known as the Caribbean Basin area. This area would include all parts of the geologic Caribbean, plus Cuba, and parts of Mexico.

Historical definitions of the Caribbean would group the territories according to shared colonial experiences, and this often also refers to shared official languages. We would also then include Guyana and Suriname in this definition, and group the territories as being either former British, Spanish, French or Dutch colonies. It is important to note, however that various territories experienced multiple European powers in control during the colonial period, which has consequences for local culture and language. For instance, in Curacao, while the official language is Dutch, many people also speak Papamiento, English and Spanish; in Trinidad while the official language is English, the local creole is originally French-rooted; and on the Caribbean coasts of Nicaragua, Honduras, Belize and Guatemala, the Garifuna[45] people speak an indigenous-based language influenced by Spanish, English and French.

Political delineations would categorize Caribbean territories as either: (1) Independent States, which are now self-governing, though not all independent states are republics, leaving the Queen of England as de-facto head of state in a number of previously British territories; (2) Associated States, which are not independent, but enjoy all of the rights and privileges of the country governing it (e.g. Puerto Rico); and (3) Colonial Dependencies, which are those directly governed by another country and do not enjoy all the rights and privileged enjoyed by those living in the governing country (e.g. Martinique, Guadeloupe, French Guyana (France); Cayman Islands, Turks and Caicos, Bermuda, British Virgin Islands (UK)).

Politically, the Caribbean can also be defined according to various supranational organizations, further exhibiting the complexity of defining the Caribbean, such as: CARICOM (Caribbean Community) whose objective is to promote economic integration and co-operation, and which includes all prior and current British colonies in the Caribbean, as well as Haiti, Suriname, and a number of Observer members with Spanish and Dutch histories of colonization (15 full members, 5 associate, 8 observers). The Association of Caribbean States (ACS) has the purpose of developing greater trade, transportation, tourism, and disaster response among members. It includes all territories of the Caribbean Basin, that is, CARICOM plus the Central and South American states that have Caribbean coastlines (25 full, 7 associate members). The Organization of Eastern Caribbean States is associated with CARICOM, and

[45] Also referred to by colonial masters as Black Caribs, the Garifuna are a people of mixed indigenous and African ancestry who were exiled from the islands of the Lesser Antilles for revolting, and who settled along the coast of Central America.

includes ten Eastern Caribbean territories that form almost a continuous archipelago across the Leeward and Windward Islands. Many Caribbean states are also members of CELAC, the Community of Latin American and Caribbean States, created to counter the US hegemony in the Organization of American States (yet another regional association including Caribbean states).

While holding a broader view of the Caribbean, I will tend in this paper to focus on those full members of CARICOM as the most established "Caribbean" association, and those territories that are overwhelmingly implied in political narratives of the Caribbean as a region.

SOCIO-ECONOMIC OVERVIEW

The most pressing contemporary development challenges for small-island developing states stem for the most part from their particular vulnerabilities such as: remoteness, small size, limited resources and narrow export bases, and significant exposure to external economic shocks and global environmental challenges, which include a large range of climate change impacts and increasingly frequent and intense natural disasters.[46] Sea level rise poses the challenge of territory loss, especially for smaller low-lying islands. Poverty reduction and debt sustainability continue to be major economic challenges, with few advances in the last twenty years. Social progress in areas such as gender, health and education have been achieved, but more work is needed. Though trends vary considerably across the Caribbean, most states continue to struggle with poor economic growth and fiscal management, high and increasing debt, and a lack of economic diversification. While the performance of tourism-dependent states has improved somewhat, that of those that are resource dependent remains tenuous.[47]

Socially, there has been significant progress in the Caribbean with regard to access to basic social services, especially education and water and sanitation. Near universal access to primary education has been achieved in most countries, with net enrolment ratios of over 90%, with similar results for access to water and sanitation facilities in both urban and rural areas in the region.[48] Despite these advances, however there remains much to be done to achieve and sustain the quality of life to which the region aspires. Unemployment for instance remains quite high, amidst persistent high rates of poverty and unemployment.

Economic performance over the last twenty years has been sluggish due to the Great Recession of 2008, an increasing number and severity of natural disasters, and high levels of indebtedness. While the economic growth forecasted for the world economy for 2018 is looking up at 3.9%, and 2% in the Latin American and Caribbean region, the Caribbean is looking at an improved though still low 1.8% growth amid continuing vulnerability.[49] This level of growth lags behind that of other small-island developing states (SIDS), who saw 4.8% growth in 2017.[50] The average growth rate per capita in the Caribbean, a

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[46] United Nations. (2012). *The Future We Want.* Outcome document of the UN Conference on Sustainable Development, Rio+20 https://sustainabledevelopment.un.org/content/documents/733FutureWeWant.pdf

[47] Donovan, Michael and Michelle Mycoo. (2017) *A Blue Urban Agenda: Adapting to Climate Change in the Coastal Cities of Caribbean and Pacific Small Island Developing States.* Washington, D.C.: Inter-American Development Bank.

[48] Caribbean Development Bank. 2017. Development Effectiveness Review. Bridgetown, Barbados.

[49] Caribbean Country Department. 2018. Caribbean Region Quarterly Bulletin. Inter-American Development Bank. Washington, D.C., June.

[50] Caribbean Development Bank, 2017

measure of economic prosperity, is equally low at 1.7% at the end of 2017. The level required to achieve the eighth Sustainable Development Goal (SDG #8)—"to promote sustained, inclusive & sustainable economic growth, full & productive employment, decent work for all"—is 7% per year by 2030 for least developed countries.

The Caribbean is one of the most indebted regions in the world, with the gross public debt as a percentage of GDP currently at 74.8% in 2017, down from 78% in 2016. This affects the economies' ability to buffer against external shocks, while the impact of climate change and natural disasters continues to magnify the macroeconomic problems in the region. Tourism-dependent territories are seeing general improvements as the US, Canadian and British economies pick up, while also benefitting from the low prices of crude oil and increased remittances from abroad. Resource-dependent countries on the other hand, are suffering from the fall in commodity prices as we come to the end of the global commodity cycle.[51]

While the outlook is beginning to improve for commodity exporters and further improvements are expected, fiscal challenges remain significant. Pronounced gaps remain in data quality and availability which limits the prospects for meaningful analysis and dialogue, and evidence-based decision-making, though overall macroeconomic data is relatively robust. The business environment is currently stymied by high transaction costs, lengthy processing times, burdensome procedures with respect to opening new businesses, and high electricity costs.[52] A concerted effort is required in order to improve the business environment through the removal of barriers to trade and investment. According to the Caribbean and Inter-American Development Banks, this will need to be accompanied by the appropriate regulatory and policy frameworks, and rooted in the improved efficiency of public sector institutions that are aimed at creating an enabling environment for business development. The dilemmas to target, according to the regional development banks involved, are those of high debt, low growth and climate change, which are encompassed in a balance between economic prosperity and ecological sustainability.

To secure these more effective measures, a visioning process that is at least partly shared across the public, private and NGO sectors is imperative, with public participation the likes of which has yet to be seen in the region embraced. While aiming at these 'global standard' targets for economic development, the socio-cultural context of the region needs to be engaged, towards a context-specific, home-grown vision for the future, in addition to a fundamental acknowledgement of the need to do away with the primacy of economic growth. Greater public service efficiency and streamlining and improved

[51] Inter-American Development Bank, June 2018
[52] Caribbean Development Bank, 2017

data collection must be part of a larger Caribbean-specific framework for development: prosperity and resilience.

ENVIRONMENTAL CHALLENGES

Focusing on the small-island developing states in the region, ecologically the Caribbean lies within a tropical hurricane belt, covers nearly two million square kilometers, averages 2,200 metres in depth (and plunging to 7,100 metres in the Cayman trench), receives run-off from eight major river systems, contains well developed seasonally stratified marine waters, and at least one dead zone. The islands themselves vary in size from 91 square kilometers in Anguilla to Cuba's 110,860 square kilometers, with highly varied topographies and geology, including low-lying limestone and coral reef atolls, volcanic outcrops and diverse local flora and fauna. Their coastal ecosystems are a mixture of mangrove, sea-grasses and coral reefs while the terrestrial ecosystems are made up of thirty-four ecoregions all with high levels of endemism—species unique to these islands. The freshwater supply is highly varied, from Jamaica ranked as the SIDS with the most abundant freshwater supply, to Barbados being one of the world's most arid countries.[53]

The experience of environmental change and challenges is more pronounced in SIDS compared to the rest of the world due to their small physical scale, geographic isolation, unique biodiversity, exposure to natural hazards and disasters, high population growth coupled with out- migration and significant seasonal in-migration from tourism, limited resource base, remoteness from global markets and small economies of scale.[54] In addition to global economic stagnation and population growth, there are various other drivers and pressures affecting SIDS' outlook: "vulnerability to climate change, local access to water, nutrition and food security, energy and transport demand, exploitation of natural resources, local sectoral development, poor management of waste and pollution, coastal squeeze and loss of ecological resilience and a range of emerging issues, such as social disintegration, and in some instances the disappearance of their national territory.[55]

While it is a region that produces marginal emissions relative to the rest of the world (less than one percent of global greenhouse gas emissions), it faces a disproportionate brunt of the effects of global warming and climate change. These threats include sea level rise, extreme storm events and droughts,

[53] UNEP 2014. GEO Small Island Developing States Outlook. United Nations Environment Programme, Nairobi, Kenya.
[54] Ibid.
[55] Ibid.

coastal erosion, inundation, saltwater intrusion into groundwater systems, coral bleaching, ecosystem destruction, ocean acidification, adverse effects on crops and fisheries and increases in vector-borne diseases,[56] all of which affect Caribbean SIDS to varying degrees.

To address these issues, and the socio-economic challenges related to them, SIDS need to act quickly and cooperatively, in partnership with each other and the global community, to reduce the impacts of environmental change and to build resilience in the face of all of their unique challenges. Needed action spans from the explicitly environmental, to the economic, social, spheres, addressing governance and policy limitations and the need for financing and investment in renewables, infrastructure, and social needs. In fact, the unique situation of the Caribbean and other SIDS presents a great opportunity for innovation labs, to first address urgent local needs, and which can then be transplanted to address challenges around the world.

LAND-USE PLANNING AND CHANGE IN THE CARIBBEAN

Like much else in the region, planning in the Caribbean has a consistent history of foreign-imported policies and practices, from colonial transplantation under British rule, to externally determined policies post-independence, finally to a newly emerging era of locally designed frameworks based on a home context. The former Spanish colonies (Cuba, Dominican Republic, Puerto Rico) had different and earlier experiences of independence, allowing for a longer history of self-determined planning, while many of the French and Dutch colonies still remain under colonial mandate today, with the exception of Suriname, whose trajectory more closely resembles that of the former British colonies, and Haiti with its own long, rich and well-known history.

Focusing on the anglophone Caribbean islands, also known as the West Indies, this sub-region shares legacies of British colonization that have influenced national planning processes, frameworks and institutions into the present day: From a lack of any planning following emancipation in the 1840s—to the adoption of the English 1932 Town and Country Act in the late 1930s as means of expediency in response to unrest over poor housing and infrastructure, and the need to maintain colony loyalty during WWII[57]—to the pressures of newly independent states seeking legitimacy and economic stability, merely copying systems from other places and contexts; the challenge of planning in the Caribbean is by no

[56] Ibid.

[57] Home, Robert. 1993. "Transferring British Planning Law to the Colonies: The Case of the 1938 Trinidad Town and Regional Planning Ordinance." Third World Planning Review; Liverpool 15 (4):397–410.

means a new issue. Following the demise of the Washington Consensus and the evidence of largely ineffective aspirational declarations rather than context-specific plans with real means of implementation, Caribbean governments now find themselves in need of new planning mechanisms, practices, policies and visions.

Current planning challenges in the region include: rapid urbanization, urban sprawl, urban informality, environmental degradation, inefficient infrastructure, and poor access to basic services.[58] Furthermore, less than ten percent of the urban landscape is in compliance with zoning regulations and building standards. Many of these regulations face strong public criticism for their rigidity and exorbitance, based on outmoded and irrelevant planning legislation and codes all too reminiscent of colonial times. Ever since those first planning acts were passed under British rule, local elites have continued to re-appropriate, adapt and mediate Western planning processes, in many cases to secure and expand their own power at the expense of local planning expertise, which has thus been marginalized.

Since then, many physical plans and other planning documents, in addition to projects for multilateral financing, were created by foreign consultants despite advancements in local human resource capacity building. These plans were generally accepted by political administrators without reservation, and without sufficient review, and were rarely implemented due to little grasp of the sociopolitical culture. More recently, however, local elites across the region have begun to embrace the popular appeal to context-specific local solutions to local problems, though an agreed national framework for development is still overwhelmingly lacking in the physical planning systems, thereby limiting their capacity to effectively respond to external policies for gaining loan financing, and maintaining ambiguities that allow politicians to make decisions to attract foreign investments at any and all costs.

Administrative deficiencies, changing economic trends and political expediency have undermined spatial planning. In most territories, as noted by Mycoo (2017), political interference from the office of the Prime Minister can halt and spur on planning making and enforcement, while most Ministers of Planning cannot be held accountable for planning decisions. Within development control, approval processes are tedious, encouraging bribery and corruption, and enforcement is problematic and suffers from limited capacities.

A technical, top-down and expert-driven approach still very much characterizes the practice of land-use planning, relying on the old "neutralist" ideology that planning is purely a technical exercise, while the customary form of master planning—largely ineffective aspirational declarations—has yet to

[58] Mycoo, Michelle. 2017. "Reforming spatial planning in anglophone Caribbean countries," Planning Theory & Practice, 18:1, 89-108, DOI: 10.1080/14649357.2016.1241423

catch up to current trends that emphasize governance, decentralization and democratization. It is evident in any reading of strategic Plans in the region—from CARICOM at the regional level, to national development plans—that for the most part they embody a "regime analysis"[59] whereby effective governance depends upon the cooperation of nongovernmental actors, and on the combination of state capacity with nongovernmental resources. Here state, private sector, non-governmental organizations and other social institutions and leaders operate as a regime that co-operates and leads the development of the city/nation.

Policy preferences are recognized as being relatively fluid, requiring public consultation and participation in the initial stages of identifying the most pressing needs of the community, and they do seem to be influenced by perceived feasibility, as resource constraints are frequently referred to in the challenges to achieving the stated objectives. Just as the literature of the urban regime analysis theory, points out, limitations abound in the political economy focus that sidelines the agency of the social sphere in society, and in the need for alternatives to corporate-centered development strategies.[60]

The degree to which participation is engendered varies, with Barbados' "people-centred development" pointing to a potential evolution from regime analysis to the right to the city (nation), where political, social and class struggles are recognized as inherent in the processes of the state. [61] For now, there is increasing recognition that the success of planning depends on public buy-in, requiring deeper public participation in order to avoid the present state of public resistance to plans and lack of trust in the planning process.

Many of the strategies and objectives identified align with Mycoo's assertion of the need for the use of market incentives, the reform of outdated legal regimes and traditional bureaucratic cultures, and the strengthening of government commitment. Still missing however, is a devolution of planning functions and better coordination across functions, sectors and scales. Furthermore, the mainstreaming of environmental and resilience efforts into national planning and development policies is yet to be fully realized,[62] in order to truly integrate climate action with development goals.[63]

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[59] Stone, Clarence. 1993. "Urban Regimes and the Capacity to Govern: A Political Economy Approach" Journal of Urban Affairs 15.1. E-Resources.
[60] Ibid.
[61] Harvey, David. 2012. Rebel cities: from the right to the city to the urban revolution. Verso Books. Section One "The Right to the City": 3-66.
[62] Pelling, Mark, and Juha I. Uitto. 2001. "Small Island Developing States: Natural Disaster Vulnerability and Global Change." Environmental Hazards 3 (2):49–62.
[63] Janetos, Anthony C., et. al. 2012. "Linking Climate Change and Development Goals: Framing, Integrating, and Measuring." Climate and Development 4 (2):141–56. https://doi.org/10.1080/17565529.2012.726195.

The Caribbean's unique history and biophysical reality, in addition to the challenging economic situation, require innovative action, coordination and investment in order to secure prosperity today and resilience in the face of tomorrow's trials. Planning practice and governance need to evolve to serve these needs in a region that is ready to through off the yoke of colonial and other foreign structures and determine for itself how to develop processes and solutions to local problems. With the continuing expansion and improvement of education across the region, there is growing cadre of capable human resources who need to be consulted, included participants of the planning process in order to navigate through the challenges of the twenty-first century.

The Blue Economy

Covering 71% of the Earth's surface, containing 97% of the planet's water and 99% of its living space,[64] the world's oceans are critical to most if not all forms of life on this Blue Planet. Over 3.1 billion people live within 100 km of the ocean or sea in about 150 coastal and island nations;[65] fish provide 4.3 billion people with about 15 percent of their intake of animal protein;[66] and around 880 million people depend on the fisheries and aquaculture sector for their livelihoods.[67] Oceans and seas are the waterways for our global trade system, with more than 90 percent of global trade carried by sea,[68] and global ocean economic activity is estimated to be between 3 and 5 trillion US dollars.[69] Furthermore, our oceans provide vital ecosystem services, serve as a growing source of renewable energy, and make crucial contributions to global food production and food security through the provision of food, minerals and nutrients.[70]

Thus it comes as no surprise that for small island and coastal developing states, the ocean's role as a critical provider of nourishment and income is even more magnified, as the areas in the world most reliant on coastal and maritime economies for livelihoods, income and employment, and having jurisdiction over marine space typically far exceeding their equivalent land mass.[71] Therefore there is a great opportunity in this area for SIDS to utilize marine resources in the transformation of their productive bases, to secure livelihoods, eradicate insecurities of poverty, food and energy, and to achieve long-term sustainable development goals.

The blue economy concept provides a framework to achieve sustainable development objectives through the sustainable use of ocean, sea and coastal resources. Arising from the Rio +20 2012 UN Conference on Sustainable Development, the blue economy offers new avenues for sustainable development, adapting features of the green economy (environmental sustainability, fairness in the use of resources), applied in the context of ocean and maritime resources. The framework was further enshrined in the UN Sustainable Development Goals through SDG #14: "Conserve and sustainably use the oceans, seas and marine resources for sustainable development."[72] The blue economy concept consists of four main themes:

1. Sustainable and inclusive growth and development;
2. Reducing the risk of over exploitation and risky methods of extraction/usage of the ocean's resources;
3. Enhancing the welfare of coastline communities in terms of economic opportunities and social protection;
4. Ensuring resilience of countries to natural disasters and the impact of climate change.[73]

In the Caribbean, Grenada is at the forefront of the blue economy economic transformation, with a Blue Growth Coastal Master Plan that identifies opportunities for blue growth development in fisheries and agriculture, blue biotechnology, renewable energy, research and innovation. It proposes a 'Blue Innovation Institute' to act as a research think tank, and seeks to develop innovative blue financing instruments such as debt-for-nature swaps, blue bonds, blue insurance and blue impact investment schemes.[74] Thus the "Spice Isle" is positioning itself as the pioneer of a new blue growth model, leading the way for its neighbours and the world at large.

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[64] Oceanic Institute. 2016. "Aqua Facts." www.oceanicinstitute.org/aboutoceans/aquafacts.html

[65] Food and Agriculture Organization. 2014. Global Blue Growth Initiative and Small Island Developing States. https://sustainabledevelopment.un.org/content/documents/2236Global%20Blue%20Growth%20Initiative.pdf

[66] Ibid.

[67] International Maritime Organization. 2012. "International Shipping Facts and Figures — Information Resources on Trade, Safety, Security, Environment." June 26. www.imo.org/en/KnowledgeCentre/ShipsAndShippingFactsAndFigures/Documents/International%20Shipping%20-%20Facts%20and%20Figures.pdf

[68] Ibid.

[69] FAO 2014

[70] Rustomjee, Cyrus. 2016. "Developing the Blue Economy in the Caribbean and other Small States." Centre for International Governance Innovation, Policy Brief No. 75. March 2016.

[71] Ibid.

[72] UN Department of Economic and Social Affairs. 2015. "#Envision2030 Goal 14: Life Below Water." https://www.un.org/development/desa/disabilities/envision2030-goal14.html

[73] Caribbean Development Bank. 2018. "Financing the Blue Economy: A Caribbean Development Opportunity." May 31st. http://www.caribank.org/publications/featured-publications/financing-the-blue-economy-a-caribbean-development-opportunity

[74] Hurley, Gail. 2017. "From 'Spice Isle' to 'Blue Innovation' Hub: Grenada's Vision for the Future." Our Perspectives, United Nations Development Programme, 1st March.

Chapter 3: Planning and Development for Complex Systems

As was aptly stated by the United Nations Environment Programme, in reference to small-island developing states: "Each island is part of a complex, integrated system binding human society with nature and the economy."[75] In this chapter, we will review the central tenets of systems thinking as outlined by Capra and Luisi in *The Systems View of Life*[76] and the applications of this perspective to planning for development in Caribbean SIDS. Systems thinking is central to the shift in perspective of our place in the Earth system, and of our understanding the myriad processes around us, so that our solutions may be more comprehensive and contextual, given a more comprehensive and contextual understanding of our problems and challenges.

THINKING IN SYSTEMS

The most general characteristic of systems-thinking is the shift in perspective from the parts to the whole. Organic systems are unified wholes whose properties cannot be reduced to those of its smaller parts. Firstly, the essential properties of the system as a whole do not lie in its parts; rather, they arise from the patterns of organization—the structure of the systems as a whole.[77] Second is the inherent multidisciplinarity of systems-thinking; all living systems share a set of common attributes and principles of organization, meaning that this perspective can be applied to discover similarities between phenomena, and to integrate distinct academic disciplines.[78] Thirdly is the shift from focus on objects or parts to relationships: objects are themselves networks of relationships embedded in ever-larger networks of relationships. Instead of the primacy of parts, systems-thinking moves the primacy to the relationships between components.[79]

Fourth is the shift from measuring to mapping; relationships cannot be measured like objects, instead they must be mapped. Thus this change is an inherent result of the shift from the primacy of objects to relationships, requiring also a change in methodology. As relationships are mapped, patterns can be detected, such as the networks, cycles and boundaries at the centre of attention in systems

[75] United Nations Environment Program. 2014. Global Environment Outlook for Small Island Developing States. Nairobi, Kenya.
[76] Capra, Fritjof and Pier Luigi Luisi. 2014. The Systems View of Life: A Unifying Vision. Cambridge University Press. Cambridge, U.K.
[77] Ibid.
[78] Ibid.
[79] Ibid.

science.[80] Fifth is the further requisite shift from quantities to qualities as mapping relationships and studying patterns is qualitative rather than quantitative.[81] Sixth, we find the shift from structures to processes. Whereas conventional Cartesian science recognizes fundamental structures that then give rise to processes, in systems science, every structure is but a manifestation of some underlying processes. Living systems contain continuous flows of matter that simultaneously maintain their structures, thus the processes of these flows are more decisive than their structures.[82]

Science itself then shifts from an objective to epistemic enterprise since epistemology (the understanding of the process of knowing) must be explicitly included in the description of phenomena. No human undertaking, including science, can be independent of the human observer and the human process of knowing—a subjective dimension is always involved. Finally, is the shift from certainty to approximation. If everything is connected to everything else then it would be incredibly difficult to fully, comprehensively understand anything with absolute certainty—one would have to understand literally everything first; we are always dealing with limited and approximate knowledge.[83]

What is most important to understand from this rubric, is that like Nature, our major problems are also systemic; everything is not isolated but is interconnected and interdependent—the universe, life itself, as well as our major problems, and their solutions, are complex systems. Reducing these systems to their parts, while helping us to understand how they work, will not bring about systemic and sustainable solutions on their own. Everything we are dealing with is relational and qualitative, and our understanding of them is inherently epistemic and approximate. The process of development is thus not merely economic but also social, ecological, cultural, ethical, even spiritual. It is multidimensional and qualitative. Thus part of our problem is a crisis in perception of the world around us, in which we were are materially embedded. It then follows that our solutions must be systemic if they are to be viable and successful.

Changing the paradigm will involve many contemporary and yet-to-come advances such as the redesign of the corporation and globalization itself, advancing awareness of climate change, weaning ourselves off of fossil fuels and redesigning energy and energy-dependent human systems (e.g. transportation), developing agroecology, and other eco-design technologies and initiatives.[84] There is an current surge in these schemes, but their ultimate success in comprehensively addressing our issues in the

[80] Capra & Luisi, 2014.
[81] Ibid.
[82] Ibid.
[83] Ibid.
[84] Capra & Luisi, 2014.

long run will depend on the systemic nature of their design and implementation, not to mention being grounded in the principles of ecological sustainability.

PLANNING FOR COMPLEX SYSTEMS

In understanding the world around us as complex and systemic, it naturally follows that cities, regions and nation-states are also complex, adaptive, self-organizing systems—especially since they are in fact, the product of human activity. Through our individual behaviour and decisions, and the collective decision-making of communities, developers, governments, and planning and other authorities, we alter and expand our cities, regions and nation-states to satisfy our range of needs and wants. Each individual decision is made in its own context of constraints and prior decisions, but in the end, the overall structure of the built environment as a whole emerges out of the aggregate of all of these decisions without anyone specifically deciding the entire structure. It is in this way that it is self-organizing; "the city creates itself."[85]

The role of planning then, is not to prescribe the structure of our physical environment, but rather, in understanding its complex, self-organizing nature, to guide the process of development towards desired societal outcomes. The practice of planning varies from place to place, and in many locales, land use planning can be absent or ineffective, as is evident in the Caribbean where only a small fraction of development actually conforms to code.[86] To improve these outcomes, spatial planning needs to be based on a realistic understanding of the spatial dynamic of urban and regional development. Then planning efforts would be able to guide the development process in directions that are feasible, desirable and adaptive.

Key to this is the use of models that embody complex systems scenarios—complex systems models that can enrich our understanding of the built environment while also broadening our awareness of the possibilities and limitations of the models themselves. As the modelling process is repeated, modified, expanded, our confidence in their viability improves, as does our understanding of the phenomena being modelled.

[85] White et. al. 2015. Modelling Cities and Regions as Complex Systems: from theory to planning applications. Massachusetts Institute of Technology. Cambridge, Massachusetts.
[86] Mycoo, 2017.

Modelling techniques and software like the one used in Part 2 of this paper[87] are able to pair the empirical with the subjective, as feedback between the model and the modeller (the modeller's perceptions shape the model's design, which generates certain outcomes, which then further affects the modeller's perceptions, and round again) and other users generate improved understanding of the phenomena under study, affecting academic, professional and public discourse about the issues highlighted. Complex systems models make it possible to explore alternatives and different potential futures, which can prove to be indispensable to planners, policymakers and even communities to assess decision options up for debate. Software like the one used in Part 2 of this paper is particularly applicable in a broad/public sense, as its algorithm generates the equations that make the model design possible, thus not requiring any extensive mathematical or statistical—or technical—knowledge for use. In this way, community-based, participatory planning processes and systems (like the one covered in the next section) are enhanced and strengthened.

As we are better able to understand and envision the systems in motion around us, our planning efforts become increasingly more effective and successful.

[87] The process and software for systems dynamics modelling used is further explained in Part 2 of this research project.

PARTICIPATION AND MODEL MEDIATION

The other important element in the modelling-planning process is the degree of participation of the stakeholders involved in the system or process under analysis. Without deep stakeholder participation, planning is left as an expert-driven technocratic exercise with the problems of lack of public buy-in and ultimately, limited or failed implementation. Participation exists on a spectrum of involvement. In a modelling process this can range from individual stakeholder consultation in the modelling process, to an interactive team learning experience where a group of stakeholders has complete control over the type of modelling undertaken and its content. It is at this high end of the participation spectrum that we locate mediated modelling, where the model is a by-product of team learning.[88]

There is another spectrum of participation in the modelling process, from involvement that is invited relatively late in the process, leaving little room for change by stakeholders, to a process in which participation shapes the modelling process from its inception. Mediated modelling then can range from relating and integrating existing information in the first instance, to providing support in exploring a range of innovative solutions while the group chooses the form and content of the model.

This mediated modelling aims for collaborative team learning in the modelling process to improve the shared understanding of a community and to foster better consensus over planning goals and decisions. This is typically facilitated using computer software, such as STELLA® (used for the model developed in Part 2) to aid in the visualization of changes over time, aiding in participants' understanding of the problem of goals being addressed, and the effects of suggested interventions and policies. Modelling software also enables a diverse range of stakeholders to better interactively and collaboratively design, construct and analyze a model of a complex system. The process of mediated modelling helps to structure a group's thinking, discussions and stimulates joint learning in diverse groups. It is rooted in ecological economics, system dynamics thinking, organizational learning, social psychology, and other tools and concepts.[89]

The process consists of preparation, workshops and follow-up coordinated by the modeller who acts as facilitator, mediator and modeller. The expected results include: team building and learning, (strong) consensus, a communication tool, decision support for policy and management, and adaptive management. While mediated modelling and other forms of high participation can make the modelling

[88] Van den Belt, Marjan. (2004). Mediated Modeling: a system dynamics approach to environmental consensus building. Island Press. Washington, D.C.
[89] Ibid.

process more time consuming and expensive, savings are made in the higher level of consensus, and thus better implementation of the policy decisions generated.

Policies are thus treated as experiments that will require revisions and sometimes even retractions, but which allow for the flexibility required in responding to the dynamics of the complex systems in which we find ourselves.

The benefits of systems-thinking and modelling in planning and development should now be clear, and the possibilities for application in the Caribbean context elucidated. Many of the challenges in the planning process, and in response to the vulnerability and instability generated by our ecological-economic-social problems would be greatly aided by a fundamental shift to systems thinking, further facilitated by modelling tools and deep participation.

While a mediated modelling process is out of the scope of this undertaking, the next major part of this paper will illustrate a systems dynamic model of land-use change on a Caribbean island state in order to demonstrate and evaluate modelling as a tool for policymaking.

Conclusion: A Normative Vision For Planning And Development In The Caribbean

The vision should be clear without being static. Our understanding of the challenges we face should be rooted in systems-thinking in order to address them successfully and sustainably in securing a future of prosperity for people and planet. In the Caribbean, this means throwing off the yoke of history and embracing our unique place in the world in order to develop innovative, contextual and adaptive strategies and solutions that generate resilience and set examples for the rest of the world as we face shared systemic issues.

Our inherent social plurality should be a point of inspiration for a plurality of ideas and design that reach across barriers to centre public participation and to treat policy as contextual, dynamic and ever-evolving. As much as we need broader ecological literacy, we also need to centre the people who bear witness to the effects of a changing climate and failing economic system in their everyday lives. Imparting rights to Nature and exploring application possibilities for strategies such as the blue-green and circular economies provide interesting points of departure for a new era in Caribbean planning and development. An expansion in the use of tools such a system dynamics modelling, geographic information systems, statistical models and role play games and exercise would greatly aid this effort.

We should focus less on a defined destination, and more on a process-journey that embodies the principles of justice, ecological sustainability and social inclusion to provide for prosperity in the broadest and deepest sense, for ourselves, and the living systems in which we are inextricably embedded.

In the words of Fernando Coronil:

> "Although the future isn't open, it offers openings. And although the final destination may not be clear, the sense of direction is: toward justice, equality, freedom, diversity, and social and ecological harmony. [We] have no map, but [we have] a compass."[90]

The future is uncertain, but with the right directional push, together we may arrive at the new world of our imaginings.

[90] Coronil, Fernando. 2011. "The Future in Question: History and Utopia in Latin America (1989-2010)." In Craig Calhoun and Georgi Derluguian (eds) *Business as Usual: The Roots of the Global Financial Meltdown*. New York University Press, N.Y.C: 231–292.

The Circular Economy

To a large extent, the world in which we operate today follows a linear model: we extract raw materials, process them into final products, sell them, use them, and then throw them away when they either break, get old/worn out, or no longer serve our needs and wants.[91] At the point of disposal, all of the energy and resources used in production are lost, not to mention the ever-expanding stockpiles of waste in landfills and oceans today.

In contrast, a circular economy is one where the resources coming into the economy are not allowed to become waste or lose their value—to the fullest extent feasible. Instead, this economy would recover those resources and keep them in productive use for as long as possible.[92] Understanding the economy (and the society and environment within which it is embedded) as a complex, dynamic, adaptive system, that is "much more a metabolism than a machine,"[93] the circular economy has emerged, inspired by key texts such as *Reinventing Fire* (Amory Lovins), *Natural Capitalism* (Lovins, et. al), and *Cradle to Cradle* (McDonough and Braungart).[94]

According to the Ellen MacArthur Foundation, the circular economy is based on three core principles: design out waste and pollution; keep products and materials in use; regenerate natural systems.[95] With recent work on expanding this concept from the micro/business level to cities,[96] it is intended to expand into broad macro-level implementation to really have impact, with various countries and jurisdictions implementing circular economy-related laws and policies since the 1990s.[97] The last decade has seen more circular economy research and policymaking than ever before, particularly in the European Union and global corporations, with consulting firm McKinsey estimating that the greater resource efficiency facilitated by the circular economy could save European manufacturers US$630 billion annually.[98]

The Tearfund has presented case studies from the Global South of the benefits of supporting circular economy businesses,[99] as there is increasing interest in its applications in the developing world. These benefits include: increasing productivity and economic growth; improving the quality and quantity of employment; and saving lives by reducing environmental impacts such as water and air pollution, and climate change.[100] In the Caribbean, whose economies overwhelmingly rely on imports and the services sector, studies show that there is potential for the development of repair and remanufacturing services, as well as reverse logistics (i.e. the collection of products at end-of-use), thereby saving resources and generating employment.[101]

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[91] Benton, Dustin, Jonny Hazell, Julie Hill. 2014. The Guide to the Circular Economy: Capturing Value and Managing Material Risk. Dō Sustainability: Oxford, U.K.
[92] Ibid.
[93] Webster, Ken. 2017. The Circular Economy: A Wealth of Flows. Ellen MacArthur Foundation, 2nd edition.
[94] Ibid.
[95] Ellen MacArthur Foundation website. Circular Economy Overview. https://www.ellenmacarthurfoundation.org/circular-economy/overview/concept
[96] Ellen MacArthur Foundation. 2017. "Cities in the Circular Economy: An Initial Exploration," *Circular Cities Network.* https://www.ellenmacarthurfoundation.org/publications/cities-in-the-circular-economy-an-initial-exploration
[97] CIRAIG (2015). *Circular Economy: A Critical Literature Review of Concepts*. International Reference Center for the Life Cycle of Products, Processes and Services. Montreal, Canada. http://www.ciraig.org/pdf/CIRAIG_Circular_Economy_Literature_Review_Oct2015.pdf
[98] Gower, Richard, Patrick Shroder. 2016. "Virtuous Circle: How the Circular Economy can create jobs and save lives in low- and middle-income countries." Tearfund.
[99] Ibid.
[100] Ibid.
[101] Garcia Caicedo, Claudia Lorena. 2017. "Circular Island Economies for creating a more diversified, competitive and inclusive Caribbean." Americas Sustainable Development Foundation (ASDF), 17th February.

PART 2

System Dynamics Model: Land Use Change on a Caribbean SIDS

Introduction

The second central component of this major research exercise involves system dynamics modelling as a tool for development. The primary objective of this study is to simulate and forecast land-use changes in the Caribbean to provide a tool for planners, policymakers, governments and institutions to think about future policies for the accommodation of economic growth, production efficiencies, and climate events. Tantamount to this objective is the goal to portray and evaluate the uses of system dynamics modelling as a tool for planning and development as a beginner modeller. It is my hope that other students, academics, researchers and practitioners will also see the merits of this methodology.

The central question of this study is: What does sustainable land-use look like on a Caribbean small-island developing state? Germane to this inquiry are the implicit questions: What drives land-use change, and how can those drivers be manipulated to achieve patterns of land use that serve both human wellbeing and ecological sustainability? What are the socio-economic and environmental impacts of land-use change? For a region deeply vulnerable and dependent upon the external global socio-economic and environmental landscape, land-use patterns impact self-sufficiency, from food security to access to essential goods, to local enterprise success, to import/export ratios, to employment and climate resilience. The external drivers of land-use change thus include: loan, aid and trade agreements, multinational corporation agreements, technological transfers. The more internal drivers include population change, property rights and other demographic, socio-economic, political and institutional factors and systems. For the purpose of this model, I focus on the factors of economic growth and industry production efficiencies, as well as environmental conservation, and climate change impacts.

This analysis thus articulates the relationship between land uses (agricultural, forests, extractive, built), economic growth and climate change impacts. Using aggregate data for "Caribbean Small States" from the World Bank's World Development Indicators (WDI) to represent a single small island state, the model's results show a reasonable fit between the predicted and real data from the years 2000-2016, and taking a long-term view, projects the land use changes into the year 2100.

This section proceeds as following: (1) an historical overview of land-use planning and change in the Caribbean and small-island states, including current trends and challenges; (2) an introduction to

system dynamics modelling as a method and tool, with specific explanation of the STELLA® software; (3) a conceptual look at the model: its logic, assumptions and limitations, and data sources; (4) a presentation and explanation of the model and its structure, along with scenarios, expected findings and results, and a discussion on feedback; (5) lessons learned from the exercise, evaluation of STELLA and system dynamics modelling in as a planning tool; and (6) next steps for further research and development of the model.

Land-Use Planning and Change in the Caribbean

As outlined earlier Planning in the Caribbean has a consistent history of foreign-imported policies and practices, from colonial transplantation under British rule, to externally determined policies post-independence, finally to a newly emerging era of local designed frameworks based on the home context. The former Spanish colonies (Cuba, Dominican Republic, Puerto Rico) had different and earlier experiences of independence, allowing for a longer history of self-determined planning, while many of the French and Dutch still remain under "postcolonial" mandate today, with the exception of Suriname, whose trajectory more closely resembles that of the former British colonies, and Haiti with its own long, rich and well-known history.

The model focuses on the anglophone Caribbean, also known as the West Indies—the group of states most often assumed under the moniker "Caribbean." This sub-region shares similar legacies of British colonization that has influenced national planning processes, frameworks and institutions into the present day. Now, Caribbean governments find themselves in need of new planning mechanisms, practices, policies and visions.

Current planning challenges in the region include: rapid urbanization, urban sprawl, urban informality, environmental degradation, inefficient infrastructure, and poor access to basic services.[102] Furthermore, less than ten percent of the urban landscape is in compliance with zoning regulations and building standards. Many of these regulations face strong public criticism for their rigidity and exorbitance, based on outmoded and irrelevant planning legislation and codes all too reminiscent of colonial times. Since those first planning acts were passed under British rule, local elites have continued to re-appropriate, adapt and mediate Western planning processes, in many cases to secure and expand their own power at the expense of local planning expertise, which has thus been marginalized.

Administrative deficiencies, changing economic trends and political expediency have undermined spatial planning. There is a great need for a systems approach that facilitates greater public buy-in and less static policy-making.

[102] Mycoo, 2017

Understanding the Tool: System Dynamics Modelling and STELLA®

Models are by definition abstractions from reality; they are tools used to better understand the impact of alternate decisions on economic and other performance. They are indispensable to our understanding of the world because they enable us first to portray and manipulate real phenomena, and second, experiment and examine the results. We need models to generate new knowledge, as they help us to explain the world around us and potentially forecast the future. With modelling, we can simplify complex, real-world phenomena that are otherwise difficult to comprehensively study, by eliminating everything that we believe to be irrelevant to the specific question at hand. Thus the process of model building itself involves some dynamism: build, run, compare, change—each cycle improving one's understanding of reality. The goal in the end is a good model: one possessing elements that directly correspond to objects in reality, and that provides reliable answers to our questions.[103]

Unlike static models (think standard/basic economic modelling) that represent and/or compare particular phenomena at specific point(s) in time, dynamic models try to reflect changes in real or simulated time, taking into account that the model components are constantly evolving as a result of previous actions. Centered around a focussed question, the boundaries of the system containing said question need to be established, along with the appropriate time interval and level of detail needed. A defining feature of dynamic models is feedback: one component of the model causes changes in other components, and those changes then lead to further change in the component that set the process in motion in the first place.

[103] Ruth, M. and Hannon, B. (2012) Modeling Dynamic Economic Systems 2nd edition, Springer, Chapter 1.

STELLA

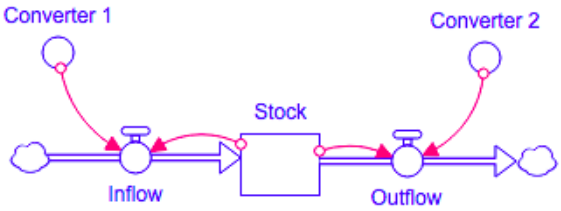
The STELLA® software used in this research provides an excellent example and resource for system dynamics modelling. It automatically generates the required differential equations based on a diagram of the system under investigation drawn by the modeller. Any user of the software can solve a complex system of equations without an extensive prerequisite knowledge of mathematics or statistics.

Figure 3

In STELLA®, the components of a model are represented by either a stock, a flow, a converter or a connector (figure above). These components can be arranged to model real-world behaviour: The stock of a certain variable starts off with a specific initial value, and can either increase or decrease, as a result of an inflow our outflow which are regulated by converters. Connectors are the information arrows that indicate a relationship between variables. For instance, in the diagram below, both flows are calculated using a converter and the stock, so the equation for the flows may look like:

Inflow = Stock*Converter 1; Outflow = Stock*Converter 2.

Figure 4

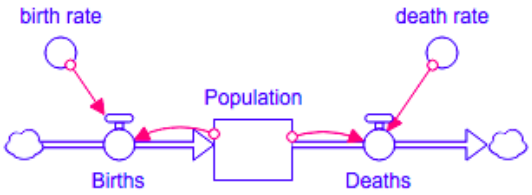


STELLA dynamic flow

This can be further explained with the example of the population dynamic depicted below. The stock of population, which is assigned an initial value is increased by the inflow of births and decreased by the outflow of the deaths. The birth and death rates help to determine the volume of the flows in either direction respectively. Thus the equations would look like:

Births = Population * birth rate; Deaths = Population * death rate

Figure 5



Population dynamic

The system can be expanded with more stocks, flows, converters and connectors to better represent a real dynamic system. Once the basic structure of the model is established, values and rates of various variables can be modified and manipulated to explore different policy options and the effects of forecasted events.

The Model: from Concept to Exercise

The logic of the model's structure is centred on the starting assumption of a Caribbean island before development and intensive human land-use changes. The island is mostly covered by forest (this includes wetlands, savannahs and other ecosystems), which is developed into either agriculture, extractive industries, or built-up industries (this includes urban, residential, manufacturing, and other industrial activities). As shown in the figure below, the forest is thus the primary supplier of the land demanded by the agricultural, built and extractive uses, which are driven for the most part by economic growth.

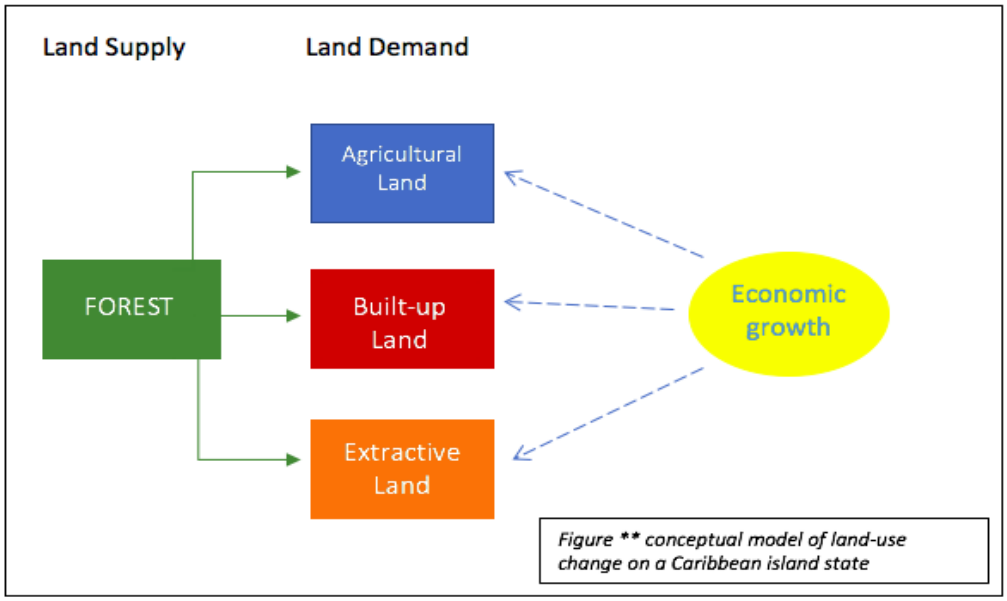


Figure 6

Productive efficiencies temper this demand, as increased efficiency means less land area is required to produce the same level of output, as will be shown and explained from the model structure below.

Using the World Bank's World Development Indicators (WDI), filtered for the aggregate Caribbean small states,[104] the model starts in the year 2000, using the data for land area per land-use, average GDP growth, and average value added to GDP per land use. This model was then operationalized with STELLA® software developed by ISEE systems incorporated:[105]

[104] WDI "Caribbean small states" includes: Antigua & Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, St. Kitts & Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad & Tobago.
[105] Link to STELLA site: https://iseesystems.com/

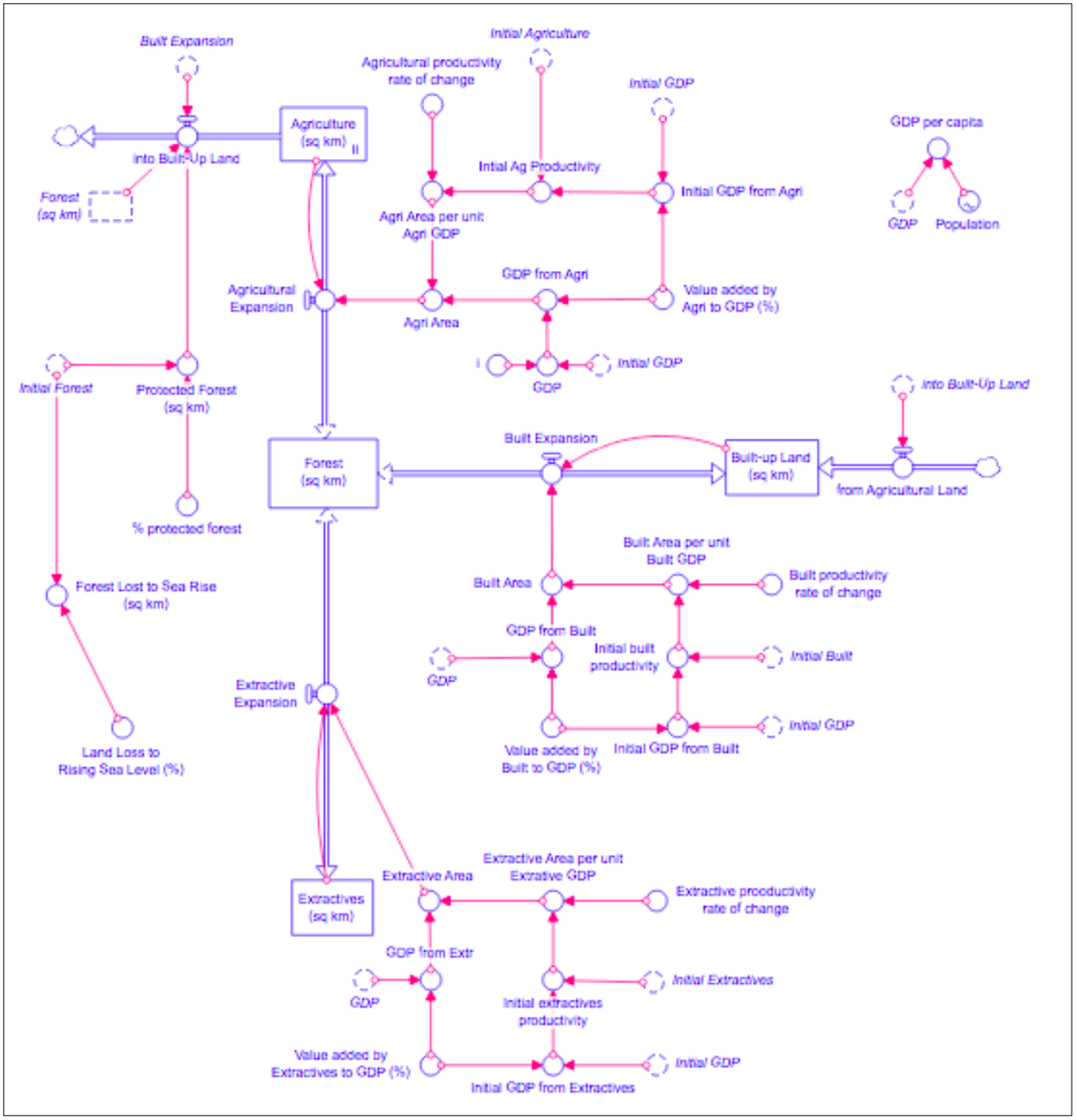


Figure 7:*Caribbean Land Use Model*

The dynamics of the demand for land works structurally in the same way in all three of the demand land uses. Taking the extractive industry as an example, extractive expansion is determined by the "Extractive Area" required by the sector. This value depends on: (1) the amount of the state's GDP ($) garnered from the industry; and (2) the productivity of extractives, namely the amount of land (square

kilometers) required to generate $1 of GDP. The amount of the state's GDP generated by the extractive industry is calculated using the total national GDP multiplied by the value added by Extractives to GDP (%), extrapolated from the historical data available. To determine the productivity level of extractives, the initial level of productivity is calculated using the value added to GDP(%), Initial GDP($) and Initial Extractive land (sq. km), then by factoring a rate of change of extractives productivity, we can generate current (and future) productivity. Thus, based on the amount of GDP generated by the extractive industry, and its productivity—i.e. the amount of land required to produce one dollar of GDP—to determine the land needed by the sector. The extractive expansion flow then is the difference between this required extractive area and the actual Extractives land stock at that point in time.

The process runs quite the same in the Agricultural and Built-up land uses. To protect the Forest from complete depletion, we have a measure of Forest land protection through conservation efforts and policies. By determining what proportion of the forest we want to protect, we can calculate how much land is to be protected using the initial value for Forest Land. We also allow for the threat of land loss to sea level rise, which we account for in the same way as forest conservation. We determine the proportion of land loss to calculate the area of land loss, which can then be included in the equation for Forest. For the other land uses only land lost to sea level rise is taken into account. (Refer to Appendix xx for the full list of model algorithms and equations).

Having provided for some Forest conservation and overall land loss to sea level rise, we need to introduce a measure to ensure that the other land-uses can still expand as needed if the amount of Forest now available for development becomes depleted. Since Built-up Land has the highest value added to GDP, we assume that it is the one chosen by policymakers to continue to develop, taking from land previously designated for Agriculture. Thus if/when the land required for Built-up Area is no longer available from the available Forest, we have an additional flow to take from Agriculture. For a closer step by step look at the model (as well as the scenario experimentations in one of the upcoming sections), you can visit the site created with the interface where you can interactively learn about the model structure and manipulate the control variables yourself:
https://exchange.iseesystems.com/public/aliciarichins/caribbeanlanduse.

Assumptions and Limitations

The model assumes four major land uses: forest, agriculture, extractives and the built environment, where forest acts as a supply of land. "Forest" here ought not to be conflated with "forestry"

as a sector that contributes to GDP; it is simply a stock in this model. It is also assumed that the main driver of land-use change is economic growth, while the industries' productive efficiencies also influence land demand in the opposite direction (higher productive efficiency, lower demand for land). Since fishery activity would have minimal impact on the on-land land-use pattern, it was left out of the model. Population has been left exogenous and is used to calculate GDP per capita.

Given the relative simplicity of this model, and the novice level of its modeller, there are a number of clear limitations. The data source, while reliable includes non-island states in its considerations (Belize, Guyana, Suriname), which potentially has the effect of skewing the land use patterns. The use of aggregate instead of average or individual case study data may also significantly change land use patterns in addition to overestimating land mass, population, etc. There is also a lack of developed feedback loops, resulting in the model doing as designed and not portraying truly dynamic and potentially surprising results. For instance, GDP might be made more endogenous, to relay the feedback between changes in GDP and changes in land use.

It is important to always keep in mind that a model is the product of the modeller's own perception; as an abstraction it will always be by definition incomplete in some way or other. Therefore it is important to maintain an open and flexible modelling approach, just like the real systems that they are designed to emulate, and plurality and even competition amongst models should be encouraged in order to truly improve our collective understanding of real-world processes. Thus, my disclaimer: my model is imperfect and incomplete. I hope to continue developing it, and to encourage others to develop similar and competing models, so that we can generate ever-improving answers and solutions.

Scenarios and Expected Findings

There are five (5) scenarios run in this exercise: Base Case, increased GDP growth, increased Productivity Growth, Forest Conservation and Sea Level Rise, followed by a composite scenario of all interventions and events. The details of each scenario are outlined in Table 1 below: (Each variable is expressed as a decimal).

SCENARIOS	GDP growth	Agricultural Productivity	Built Land Productivity	Extractive Productivity	Forest Conservation	Land Loss to Sea Rise
Base Case	**0.02**	**0.01**	**0.01**	**0.01**	**0.00**	**0.00**
GDP Growth	**0.04**	0.01	0.01	0.01	0.00	0.00
Productivity Growth	0.02	**0.03**	**0.02**	**0.01**	0.00	0.00
Forest Conservation	0.02	0.01	0.01	0.01	**0.12**	0.00
Sea Level Rise	0.02	0.01	0.01	0.01	0.00	**0.08**
Composite	0.04	0.03	0.02	0.01	0.12	0.08

Table 1 : Scenarios

The expected findings of the model are that a higher rate of GDP growth leads to faster forest depletion, while increased productivity efficiencies can counter-balance this effect. Forest conservation limits land available to other sectors, and in the case of high growth, induces other land-uses to become the supply for the highest value-generating use (here, built-up land). Sea level rise, while not necessarily affecting the pattern of land-use, decreases the size of the overall land mass, which, given the right conditions may also lead to more built-intensive land use patterns.

Scenario Results and Implications

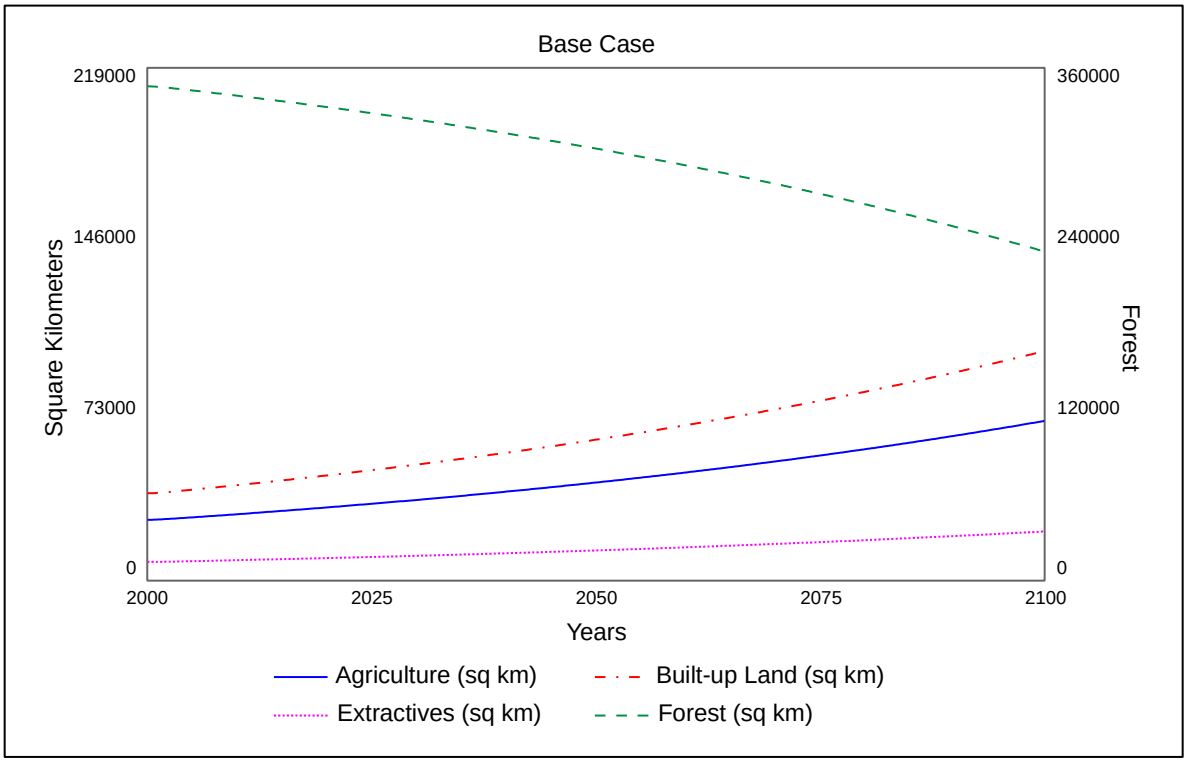
The initial values of the land stocks used in each scenario:

STOCK	**Forest**	**Agriculture**	**Built-Up**	**Extractives**
INITIAL VALUE (square kilometers)	347 006	25 977	37 334	8 000

1. Base Case

Here, the annual GDP growth rate is roughly 2%, productivity growth rates for each sector are 1%, and there is no forest conservation or land loss to rising sea level. By the end of the century, about a third of the forest land is lost, while extractives, agriculture, and built uses grow at increasing rates respectively. Forest is the only stock measured on the right axis with its own scale since its initial value is so much greater than those for other land-uses. Assigning forest to its own axis and scale makes the graph easier to read, as it eliminates empty space and spreads the graph lines for the other land uses that would otherwise be much more concentrated at the bottom of the graph.

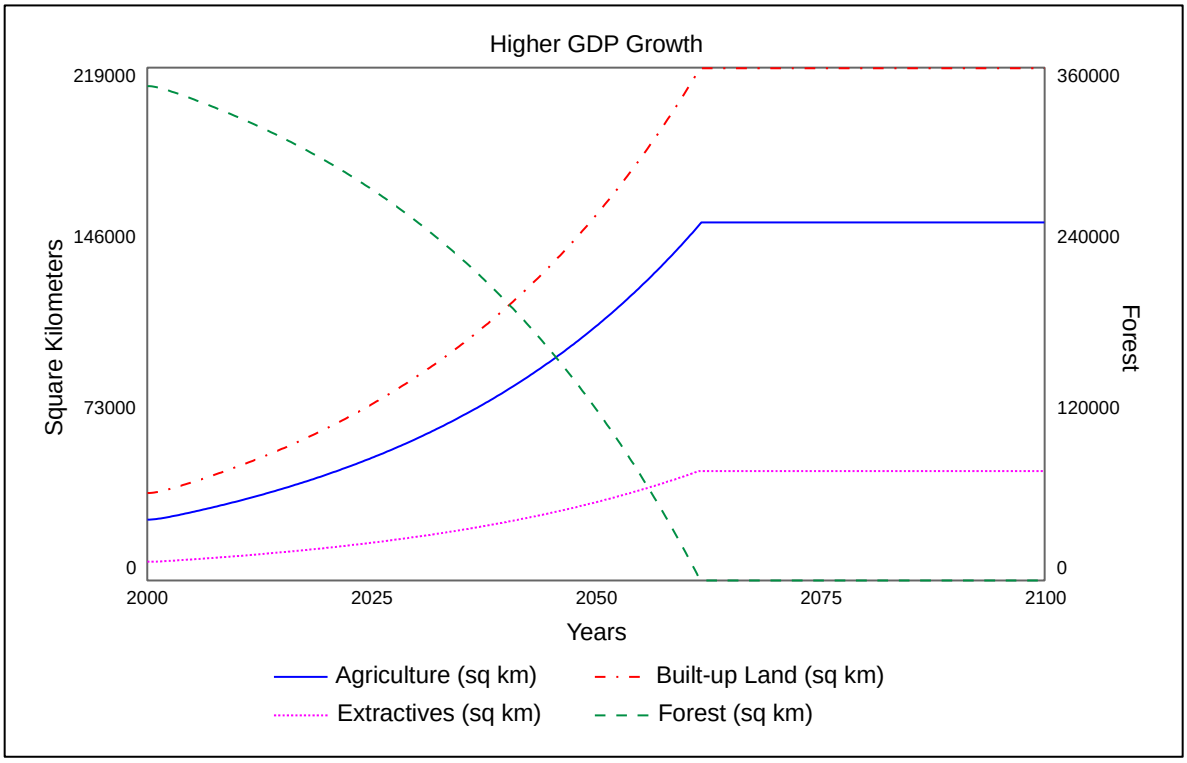
Thus the Base Case allows for gradual land use expansion without complete forest depletion by the end of the century. Here also GDP per capita is maintained at $32,300.



STOCK	**Forest**	**Agriculture**	**Built-Up**	**Extractives**
FINAL VALUE (square kilometers)	231 000	68 200	98 000	21 000

2. Higher GDP growth rate

In Scenario 2 we have instituted a higher GDP growth rate of 4%, spurring land demand in all three of the demand sectors. The available forest is completely depleted by the end of the year 2061 in order to meet this demand; from the year 2062, no further land use expansion is possible. Meanwhile, as expected, we see considerable growth in GDP per capita, from $32,300 in the base case now to $225,000.

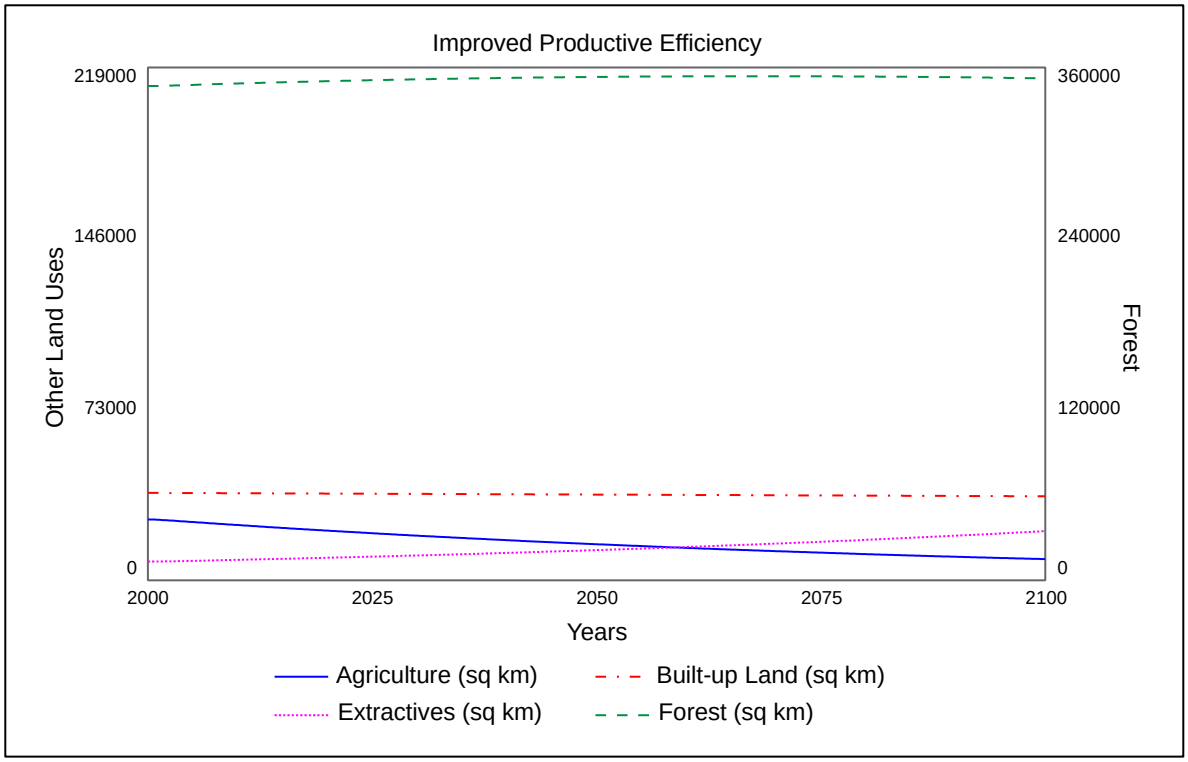


1 Higher GDP Growth Rate

STOCK	**Forest**	**Agriculture**	**Built-Up**	**Extractives**
FINAL VALUE (square kilometers)	0	153 000	219 000	46 700

3. Higher productivity growth rates

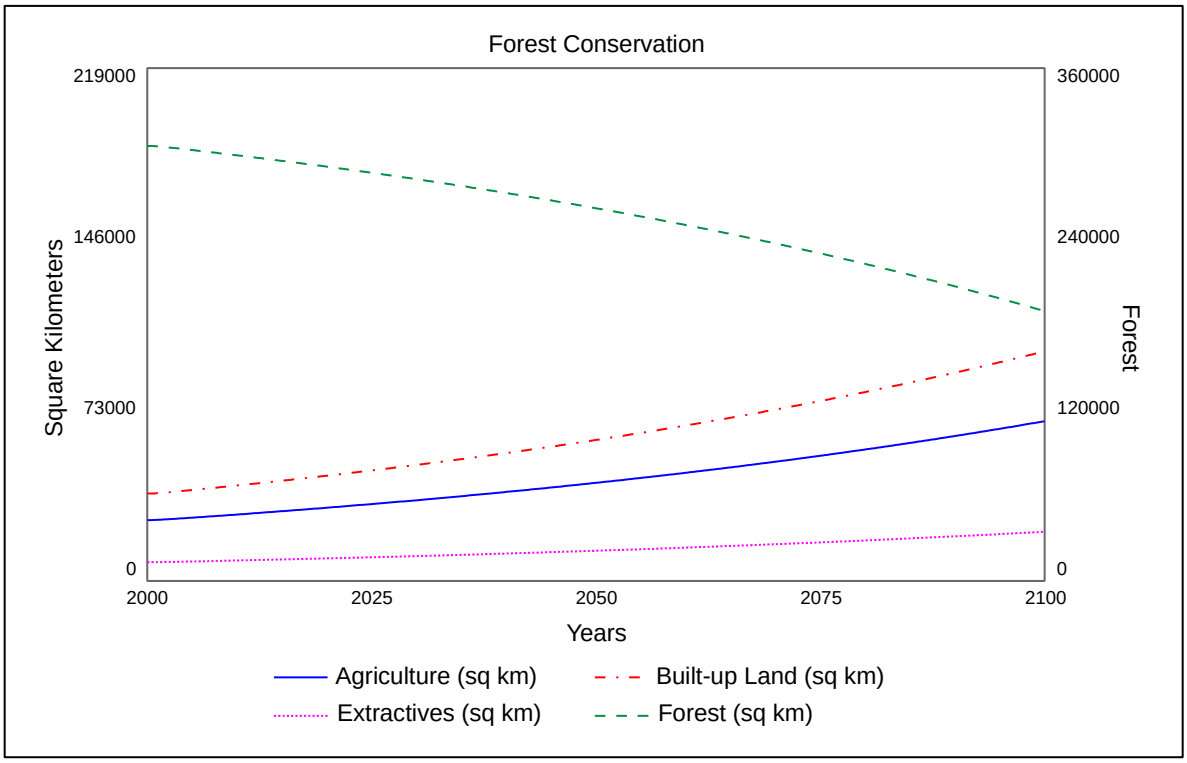
In Scenario 3, the productivity growth rates increase for both Agricultural and Built-up land uses, to 3% and 2% annual growth respectively. With the increase in productivity growth rates in the demand sectors, we see more gradual growth in their land grabs, as they require fewer square kilometers to produce goods and generate GDP. The forest manages to survive until the year 2096. Note the different slopes in the land expansion graphs: Agriculture is declining in physical size as its productivity efficiency grows increasingly every year; Built-up is also declining, though much more slowly; and Extractive land grows as its productive efficiency grows the slowest. Without the increased GDP growth, GDP per capita is back to $32,300 for this scenario.



STOCK	**Forest**	**Agriculture**	**Built-Up**	**Extractives**
FINAL VALUE (square kilometers)	352 000	9 050	35 900	21 000

4. Forest Conservation

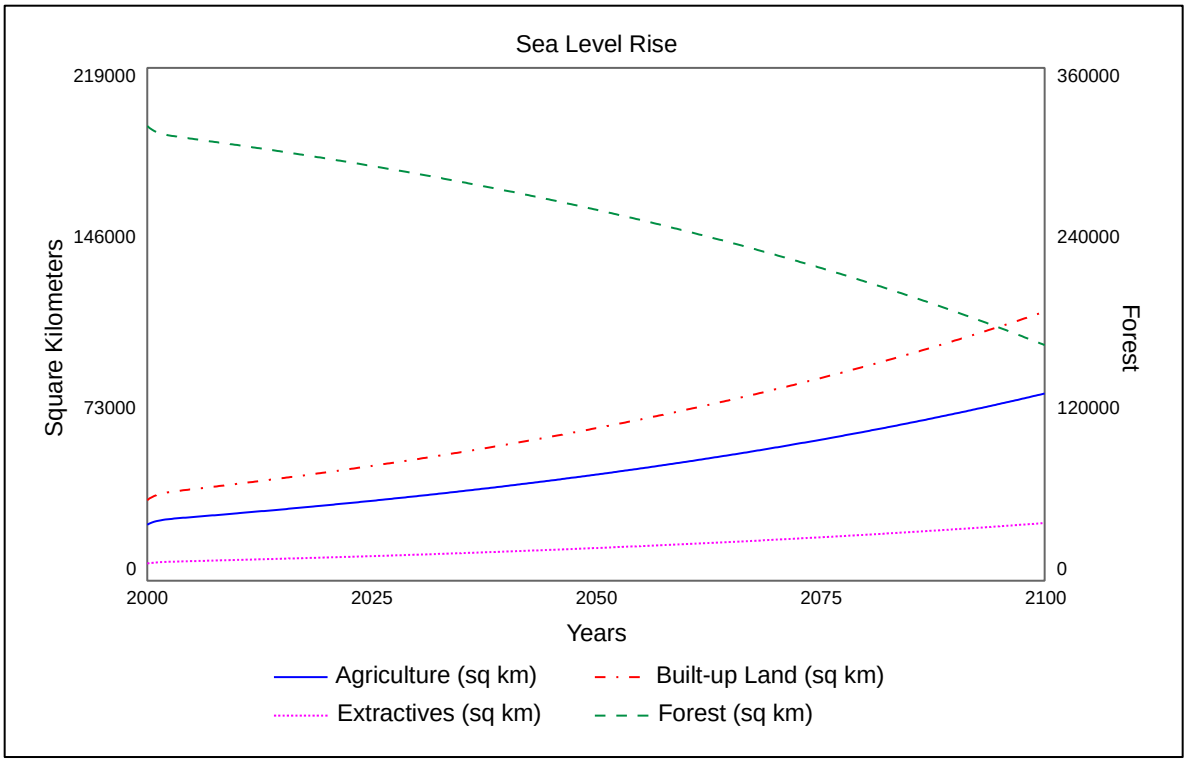
Scenario 4 now institutes a forest conservation measure, protecting 12% of the initial forest land from development (i.e. 41,640 square kilometers). Compared to the base case, the Forest land available for development is used up at a faster rate, given the lower initial available stock. All other behaviour is similar to Scenario 1 while the Forest is protected from complete depletion. Here too GDP per capita is maintained at $32,300.



STOCK	**Forest**	**Agriculture**	**Built-Up**	**Extractives**
FINAL VALUE (square kilometers)	189 000 (230,640)	68 200	98 000	21 000

5. Sea Level Rise

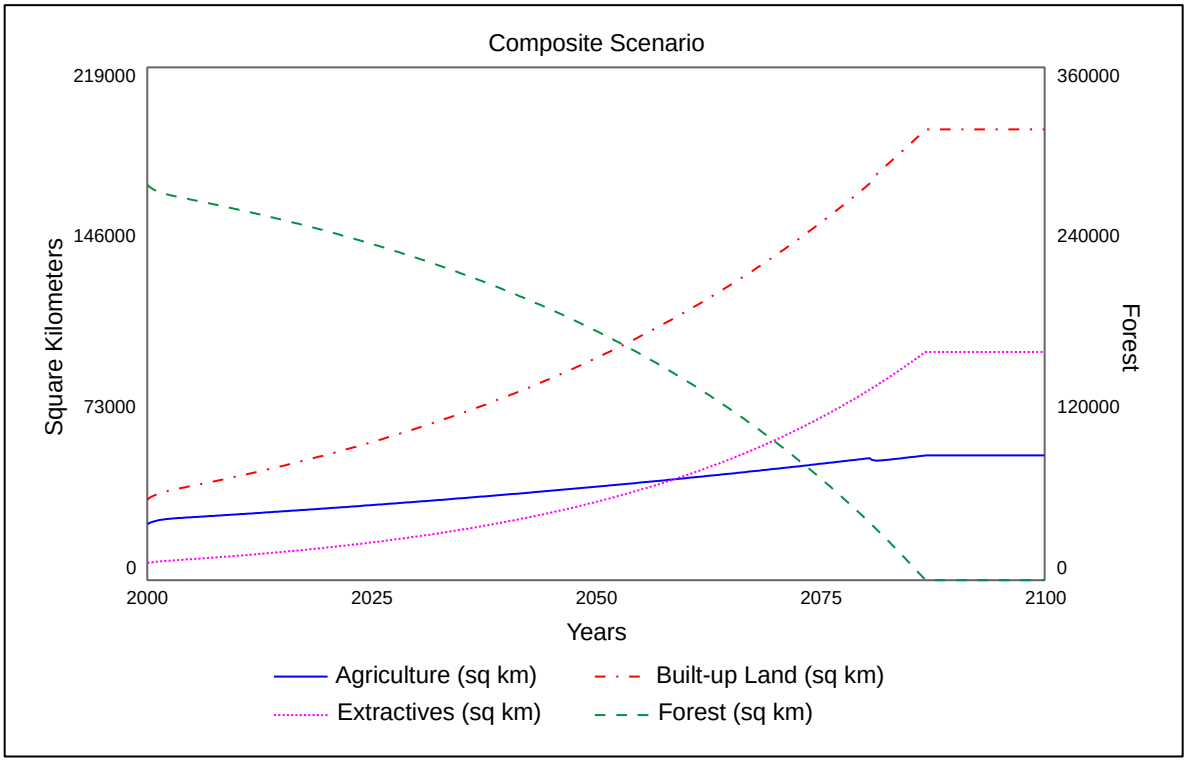
In Scenario 5, the rising sea level takes 8% of the island's total land mass, causing similar behaviour to the last scenario, as there is now just less land overall to be developed. Note that the separate right axis for the Forest stock makes it appear that Built-up land exceeds Forest, but this is not the case. The other land use patterns remain the same, with lower actual values across the board, and GDP per capita continues at $32,300.



STOCK	**Forest**	**Agriculture**	**Built-Up**	**Extractives**
FINAL VALUE (square kilometers)	165 000	79 900	115 000	24 600

6. Composite Scenario

This Scenario serves to display the composite effects of the policy decisions to: increase the rate of growth of GDP, increase the productivity growth rates across sectors, conserve some forest land; in addition to facing the impending challenge of rising sea levels. While GDP per capita rises to $225,000, the Forest is completely depleted by the year 2087. Built-up land is able to expand despite this using the flow from Agricultural land, whose stock is left growing at a much slower overall rate than the other land uses.



STOCK	**Forest**	**Agriculture**	**Built-Up**	**Extractives**
FINAL VALUE (square kilometers)	0	53 300	193 000	97 400

The table below presents a summary of the final results by the year 2100 for each scenario. As expected, GDP per capita was only affected by the increased growth rate in the second scenario.

SCENARIOS	FOREST (sq km)	AGRICULTURE	BUILT-UP	EXTRACTIVES	GDP per capita ($)
Base Case	231,000	68,200	98,000	21,000	$32,300
GDP Growth	0	153,000	219,000	46,700	$225,000
Productivity Growth	352,000	9,050	35,900	21,000	$32,300
Forest Conservation	189,000 (*41,640*)	68,200	98,000	21,000	$32,300
Sea Level Rise	165,000	79,900	115,000	24,600	$32,300
Composite	0 (*41,640*)	53,300	193,000	97,400	$225,000

Discussion: Policy Responses as Feedback

While the model structure lacks feedback loops built into its design, it is worthwhile to consider the feedback that is likely to occur between the system outcomes of the model scenarios and policymaking/policy responses. In this way we may contemplate not only the way that the policy decisions implied by the scenarios affect model output, but then also how the model output may affect future policy responses and decisions. Thus we can make educated guesses about the institutional learning

and evolution of planning frameworks that would occur in tandem with the changes in land use projected by the model.

Base Case: The most likely response in this case would follow along with the business-as-usual policymaking already at work in the Caribbean. While certain environmental concerns may be addressed—in the case of this model, conservation policies to protect the forest—for the most part, policymakers would concern themselves with the pursuit of increased economic growth. This would mean, in addition to monetary and fiscal policies, the pursuit of foreign direct investment and financing. The implications for land use would be an expansion in the built environment and extractive industries in particular, to the detriment of green spaces (forests) and agriculture, as seen in Scenario 2 (increased economic growth rate).

Higher GDP growth: While economic development most narrowly defined is served in this scenario, the complete decimation of forested lands would spur policy responses for ecosystem and natural environment protection. It is hoped that action would be taken before the complete depletion of the forest, however, responding to the model output as at the year 2100, we would expect extensive "greening the city" policies to regrow the natural landscape to the extent possible, and more critically, policies and technological transfer investments into increasing productive efficiencies in order to allow a contraction of land uses, particularly in agriculture and the built environment.

Productivity Growth: With productive efficiencies secured, policymakers would presumably seek out ways to increase GDP, through monetary and fiscal policy, and foreign investment and financing. While increasing GDP would also increase land use expansion, the high levels of productive efficiency attained should significantly protect the forest and natural environment from extensive devastation.

Forest Conservation: Having natural environment safeguards in place, the most likely response here would also be to seek increased economic growth. It can also be argued that policymakers so concerned with forest conservation in the first place would also seek increases in productive efficiencies in order to continue to conserve forested lands. Higher GDP growth would induce more land use expansion, which would be constrained if efficiency gains are secured, otherwise we may have to rely on the original (or expanded) forest conservation measure to protect the natural environment from depletion.

Sea Level Rise: In the case of rising sea levels and a base case policy scenario (in addition to taking into account the fact that most urban centres in the Caribbean are located on coastlines), we would expect major relocation and resettlement policies to emerge, expanding the built environment to the further detriment of the natural. In conjunction with these efforts would be technological transfer policies to improve productive efficiencies in order to contend with decreasing land mass.

Composite Case: In response to the composite scenario where high productive efficiencies and economic growth are secured, along with forest conservation policy, we would expect the pursuit of even more increases in productivity rates to allow for the regeneration of forest land available for development. This may unfortunately occur in tandem with the retraction of some conservation areas to provide more immediate access to land development, especially considering the effect of land loss to rising sea levels on the built environment in particular.

On this account we find that an extrapolation of the feedback between system outcomes and policy responses is a possible and valuable exercise, as it enhances not just the model, but the understanding of system under simulation.

Model Output: Lessons Learned

As is often quoted by Professor Peter Victor, the real output of any model is the improved understanding of the real-world phenomena under examination that the modeller (and if communicated well, its users/readers) gains from the exercise. While this project was an exercise in patience and deep thought, and many rounds of trial and error, I believe I've developed some confidence in my modelling skillset, while there is still ever more to learn.

From this project I've gained a better understanding of the dynamics of land use change both in general, and in the Caribbean context. While there are many model limitations, this exercise has challenged me to think about the systems and factors involved in land use change, and the policies implicated in the scenarios created. For instance, attaining the goal of increasing productive efficiency would rely upon expanded education, research and innovation, as well as technological transfers and technical assistance from external parties, whether they be other states or multilateral organizations. As shown from the model in Scenario 3, the most sustainable way to simultaneously protect ecosystems, industries and human wellbeing is to improve productivity—industries become less land-intensive, goods and services are provided for, and with a more modest growth rate, the forest would not be depleted.

I believe that the discussion on feedback between the model output and corresponding policy responses also greatly enhanced my consideration and understanding of the dynamics of land use change in this Caribbean context, allowing for a longer-term frame of reference for both the implied policies of the scenarios, and the subsequent policy responses to the output generated by each scenario.

While in reality forest conservation measures are very much in place across the Caribbean, increasing urbanization along with population growth and the desire to attract foreign investment and tourism income sees many conservation or land protection boundaries receding to make way for residential developments and private international hotel chains. It is my hope that the model was able to

provide a clear if simplistic justification for the maintenance—and perhaps even expansion in some cases—of land conservation and protection policies founded on the notion of nature as value, having intrinsic worth above and apart from human use.

Blaming the Tool: "only a poor tradesperson blames their tools"

STELLA® is a fantastic tool. It allows for clear visualization of intangible processes over time; in the model-building process, one is able to give figures and direction to concepts beyond mere graphs and tables. This is possible through the visualization of as wide a span of variables as the modeller can imagine, and learning how exactly the dots may connect to create change. It is user-friendly software, but not particularly easy to use due to the critical and strategic thought required to produce a model that simulates reality and is able to forecast the future based on current reality. Being able to communicate model results in the interface is particularly helpful as the audience does not require any knowledge of the software, just of the problem and the variables at hand.

The only real limit that was felt particularly given the land-use focus of this model was the inability to incorporate geographical, physical visualizations of the land-use changes and patterns generated by the model. Incorporating GIS analysis to add this layer would be imperative for future development.

Next Steps

Given the limitations of this beta model, it is important to identify next steps to further develop and improve the model:

- Taking the model from the aggregate to the state level, and running for each individual country I believe would prove useful in identifying similarities and differences in patterns across the region, and seeing more clearly the impact of the scenario modifications.
- As mentioned earlier, this model lacks true feedback loops, due mostly to my lack of modelling prowess, and asking questions with closed instead of open answers when building the model itself (i.e. flaws in my model-building process). Finding ways to incorporate feedback into the model dynamics would be at the very top of my list for further development. This would necessarily include feedback loops between changes in GDP, land use expansion, and GDP again.
- This model is also limited to internal dynamics—further development ought to include the ways in which external dynamics and events bear on local land use changes for a more comprehensive and thorough picture of what's happening.
- I would also venture to expand upon the sectors themselves: the Forest would include a forestry sector that contributes to GDP; fisheries would be included; "Built-up" would be broken down into smaller subcategories. Finally, the model logic of forest as the main source of land supply would be amended to incorporate the ways in which all land-use types can be both supply and demand.

While limited by experience and time, I believe this exercise produced a useful tool and even more useful skills and insights that will spur more questions and answers for myself and others.

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APPENDIX

STELLA® Algorithm

"%_protected_forest" = 0

Agri_Area = Agri_Area_per_unit_Agri_GDP*GDP_from_Agri

Agri_Area_per_unit_Agri_GDP = Intial_Ag_Productivity*(1-Agricultural_productivity_rate_of_change)^(TIME-2000)

Agricultural_productivity_rate_of_change = 0.01

"Agriculture_(sq_km)"(t) = "Agriculture_(sq_km)"(t - dt) + (Agricultural_Expansion - "into_Built-Up_Land") * dt

INIT "Agriculture_(sq_km)" = Initial_Agriculture*(1-"Land_Loss_to_Rising_Sea_Level_(%)")

INFLOWS:

Agricultural_Expansion = Agri_Area-"Agriculture_(sq_km)"

OUTFLOWS:

"into_Built-Up_Land" = IF("Forest_(sq_km)"-"Protected_Forest_(sq_km)")>=0 THEN 0 ELSE Built_Expansion

Built_Area = Built_Area_per_unit_Built_GDP*GDP_from_Built

Built_Area_per_unit_Built_GDP = Initial_built_productivity*(1-Built_productivity_rate_of_change)^(TIME-2000)

Built_productivity_rate_of_change = 0.01

"Built-up_Land_(sq_km)"(t) = "Built-up_Land_(sq_km)"(t - dt) + (Built_Expansion + from_Agricultural_Land) * dt

INIT "Built-up_Land_(sq_km)" = Initial_Built*(1-"Land_Loss_to_Rising_Sea_Level_(%)")

INFLOWS:

Built_Expansion = Built_Area-"Built-up_Land_(sq_km)"

from_Agricultural_Land = "into_Built-Up_Land"

Extractive_Area = Extractive_Area_per_unit_Extrative_GDP*GDP_from_Extr

Extractive_Area_per_unit_Extrative_GDP = Initial_extractives_productivity*(1-Extractive_prooductivity_rate_of_change)^(TIME-2000)

Extractive_prooductivity_rate_of_change = 0.01

"Extractives_(sq_km)"(t) = "Extractives_(sq_km)"(t - dt) + (Extractive_Expansion) * dt

INIT "Extractives_(sq_km)" = Initial_Extractives*(1-"Land_Loss_to_Rising_Sea_Level_(%)")

INFLOWS:

Extractive_Expansion = Extractive_Area-"Extractives_(sq_km)"

"Forest_(sq_km)"(t) = "Forest_(sq_km)"(t - dt) + (- Agricultural_Expansion - Built_Expansion - Extractive_Expansion) * dt

INIT "Forest_(sq_km)" = Initial_Forest-"Protected_Forest_(sq_km)"-"Forest_Lost_to_Sea_Rise_(sq_km)"

OUTFLOWS:

Agricultural_Expansion = Agri_Area-"Agriculture_(sq_km)"

Built_Expansion = Built_Area-"Built-up_Land_(sq_km)"

Extractive_Expansion = Extractive_Area-"Extractives_(sq_km)"

"Forest_Lost_to_Sea_Rise_(sq_km)" = Initial_Forest*"Land_Loss_to_Rising_Sea_Level_(%)"

GDP = Initial_GDP*(1+i)^(TIME-2000)

GDP_from_Agri = GDP*"Value_added_by_Agri_to_GDP_(%)"

GDP_from_Built = "Value_added_by_Built_to_GDP_(%)"*GDP

GDP_from_Extr = "Value_added_by_Extractives_to_GDP_(%)"*GDP

GDP_per_capita = GDP/Population

i = 0.021632954

Initial_built_productivity = INIT(Initial_Built/Initial_GDP_from_Built)

Initial_extractives_productivity = INIT(Initial_Extractives/Initial_GDP_from_Extractives)

Initial_GDP_from_Agri = Initial_GDP*"Value_added_by_Agri_to_GDP_(%)"

Initial_GDP_from_Built = Initial_GDP*"Value_added_by_Built_to_GDP_(%)"

Initial_GDP_from_Extractives = Initial_GDP*"Value_added_by_Extractives_to_GDP_(%)"

Intial_Ag_Productivity = INIT(Initial_Agriculture/Initial_GDP_from_Agri)

Land = "Extractives_(sq_km)"+"Forest_(sq_km)"+"Agriculture_(sq_km)"+"Built-up_Land_(sq_km)"

"Land_Loss_to_Rising_Sea_Level_(%)" = 0

Population = GRAPH(TIME)

(2000.00, 6530691), (2001.00, 6577216), (2002.00, 6623792), (2003.00, 6670276), (2004.00, 6716373), (2005.00, 6761932), (2006.00, 6806838), (2007.00, 6851221), (2008.00, 6895315), (2009.00, 6939534), (2010.00, 6984096), (2011.00, 7029022), (2012.00, 7074129), (2013.00, 7118888), (2014.00, 7162679), (2015.00, 7204948), (2016.00, 7245472)

"Protected_Forest_(sq_km)" = Initial_Forest*"%_protected_forest"

"Value_added_by_Agri_to_GDP_(%)" = 0.046551579

"Value_added_by_Built_to_GDP_(%)" = 0.242606443

"Value_added_by_Extractives_to_GDP_(%)" = 0.066027873

****

INITIAL_VALUES:

****

historical_GDP = GRAPH(TIME)

(2000.00, 32257000000), (2001.00, 33177000000), (2002.00, 34949000000), (2003.00, 37501000000), (2004.00, 41179000000), (2005.00, 46656000000), (2006.00, 52416000000), (2007.00, 58371000000), (2008.00, 66597000000), (2009.00, 55887000000), (2010.00, 60945000000), (2011.00, 66198000000), (2012.00, 70648000000), (2013.00, 71285000000), (2014.00, 71393000000), (2015.00, 69516000000), (2016.00, 66707000000)

Initial_Agriculture = 25977

Initial_Built = 37334

Initial_Extractives = 8000

Initial_Forest = 347006

Initial_GDP = 32257000000

Initial_Population = 2200000

****