

A political ecology analysis of tourism development and water equity in Barbados

Darren Carter¹

University of the West Indies at Cave Hill, Barbados

Ministry of Foreign Affairs and Foreign Trade, Barbados

Abstract

This article mobilizes insights from political ecology analysis. Specifically, it focuses on how power asymmetries between stakeholder groups may or may not produce uneven socio-environmental outcomes in the tourism-water nexus in Barbados. Small Island Developing States (SIDS) like Barbados, which obtains an estimated 90% of its water from groundwater aquifers, are particularly vulnerable to changing patterns of precipitation. While the data collected are preliminary, they point towards the production of uneven socio-environmental outcomes based on very prevalent power asymmetries.

Key words: climate change, water, power, political ecology, SIDS, Barbados

Résumé

Cet article mobilise les idées de l'analyse de l'écologie politique (la 'political ecology'). En particulier, il se concentre sur la façon dont les asymétries de pouvoir entre les groupes de parties prenantes peuvent ou non produire des résultats socio-environnementaux inégaux dans le lien entre le tourisme et l'eau à la Barbade. Les petits États insulaires en développement (PEID) comme la Barbade, dont on estime que 90 % de l'eau provient d'aquifères souterrains, sont particulièrement vulnérables à l'évolution des précipitations. Bien que les données recueillies soient préliminaires, elles indiquent la production de résultats socio-environnementaux inégaux basés sur des asymétries de pouvoir très répandues.

Mots clés: changement climatique, eau, pouvoir, écologie politique, PEID, Barbade

Resumen

Este artículo se basa en el análisis de la ecología política y, en concreto, se centra en cómo las asimetrías de poder entre los grupos interesados pueden o no producir resultados socioambientales desiguales en el nexo entre turismo y agua en Barbados. Los pequeños Estados insulares en desarrollo (PEID) como Barbados, que obtienen aproximadamente el 90% de su agua de acuíferos subterráneos, son especialmente vulnerables a los cambios en los patrones de precipitaciones. Aunque los datos recogidos son preliminares, apuntan a la producción de resultados socioambientales desiguales basados en asimetrías de poder muy prevalentes.

Palabras clave: cambio climático, agua, poder, ecología política, PEID, Barbados

1. Introduction

In the context of accelerating climate change, discussions around water use have come to the fore, particularly within Caribbean Small Island Developing States (SIDS). Globally, water consumption has tripled over the last 50 years (Carbon Disclosure Project 2010 cited in Gössling, *et al.* 2012), with an increasing proportion of the global population living under "water stress." Tropical regions are particularly vulnerable in the context of accelerating climate change, with estimates forecasting decreased precipitation by up to 30% in some Caribbean SIDS (Taylor & Clarke, 2019, p. 2908). This in turn will negatively affect groundwater aquifer

¹ Darren Carter, Foreign Service Officer, Ministry of Foreign Affairs and Foreign Trade, Barbados. Email: darrencarter96@hotmail.com. Research was conducted while at SOAS, University of London and The University of the West Indies at Cave Hill, Barbados. Thank you to two referees.

replenishment rates, and their subsequent ability to meet the water demands of tourism, agriculture and domestic use. This has particular consequences for Barbados, which receives an estimated 90% of its water from groundwater aquifers (as high as 98.6% of public supply water came from groundwater in 2000) (FAO, 2015, p. 6).

This article focuses on the water and tourism development nexus in Barbados. Specifically, I mobilize insights from political ecology analysis and focus on power asymmetries and their role in producing uneven socio-environmental outcomes. I map stakeholders involved in this uneven process of water distribution, their associated knowledge of the water issue, and their role in it. The article also identifies conservation practices among the various stakeholders initially identified; hotels, farmers, tourists and domestic users.

Significance of the problem

Given that Barbados is one of the most water-scarce countries in the world (FAO 2015, 9; UNEP; UWI 2012; UN-Water; FAO 2018), increasing and competing demands on the limited supply of fresh water have long term implications for growth and development. The nexus between water and development (UN-Water 2003; UN-Water 2006) has most often been discussed in relation to agricultural development, since farming accounts for around 70% of the total withdrawn for human use (World Water Council, 2000).

In comparison, in terms of global consumption, statistics place "direct tourism-related water use [at] significantly less than 1%" (Gössling, *et al.*, 2012, p. 1). This percentage is much higher in some locations like Barbados, and is subject to significant and sudden increases due to the seasonality of tourism arrivals. This fact, coupled with the increasing reliance of some Caribbean SIDS on tourism-generated revenue, means that demand on local water resources is likely to increase. This is significant because Barbados' current consumption of water is in excess of its total renewable water resources (see Table 1). Moreover, in Barbados in 2000, international tourist arrivals were estimated at 548,000 with an average length of stay of 10.1 days, but by 2021 the projection made prior to the global pandemic was 1,272,000 (Gössling, *et al.*, 2012, p. 2). A key characteristic of water distribution is that it is uneven across space and time; hence while scarcity is inherently a local issue, it may also be embedded at other scales.

2. Barbados and its water

Historical background

Barbados is the most eastern island in the Caribbean island chain archipelago with a total area of 430 km². Administratively, the island is divided into 11 parishes, with varying geological properties, and a total population of 286,000 inhabitants as of 2017 and a high population density (UN DESA, 2017). Having initially been settled as a British colony in 1627, Barbados remained one of the most politically stable, and economically successful, sugar-producing British colonies until independence in 1966. In the post-emancipation period in the Caribbean in the 19th century, following the peak of world sugar prices in the mid-1860s, "the profitability of the [sugar] industry in the British colonies declined [and] inflows of capital dried up" (DaCosta, 2007, p. 11). In order to avoid a stagnating economy, many of the still-British colonies began a diversification of their economies in the lead-up to independence. In Barbados, the newly developing tourism industry seemed promising, particularly with "the introduction of large-scale jet travel in mid-1950s [which] helped stimulate the development of a domestic services industry" (DaCosta, 2007, p. 19). However, the full re-orientation of the domestic economy would not occur until after independence.

Development framework

Following its independence in 1966, the dominant development framework of the island has shifted from "an agricultural economy in the early 1970s and 1980s to an economy based on manufacturing and tourism services in the 1980s and 1990s" (FAO, 2015, p. 3). At the turn of the century however, the importance of the manufacturing sector had "declined substantially and tourism [became] the main economic sector" (Government of Barbados 2008 cited in FAO 2015, 3). Despite its decline, agriculture still remains an important source of livelihood security for a significant proportion of the population, and a source of income for the island. This is also reflected in the land area dedicated to agricultural production; "In 2012, the total physical cultivated

area was estimated at 12,000 ha, of which 92 percent (11,000 ha) consisted of temporary crops and 8 per cent (1,000 ha) of permanent crops." (FAO, 2015, p. 1).

Beyond this, a number of initiatives remain in place to support farmers of all scales, as national food security continues to gain increasing political attention. The most recent of these initiatives is known as F.E.E.D – the Farmers Empowerment and Enfranchisement Drive – launched by the Ministry of Agriculture and the Barbados Agricultural Development and Marketing Corporation. The main aim of this initiative is to improve agriculture's contribution to GDP as well as to reduce dependence on food imports. In order to achieve this, land is leased to farmers at a subsidized rate; "\$300 per acre annually" (US\$150) (Barbados Agricultural Development and Marketing Corporation, 2019). Moreover, other inputs such as irrigation water, seeds, and equipment are also provided at subsidized rates in most cases (*ibid.*).

In terms of settlement pattern, "the majority of the population lives within three coastal parishes on the south-east, south, and west coasts of the island" (Economic Commission for Latin America and the Caribbean, 2011, p. 14). This pattern of development is deeply rooted in the historical impact of the incorporation of Barbados into mercantile and capitalist systems during the colonial period, which has led to a highly skewed and spatially disproportionate distribution of settlement and economic activities in the southern and western coastal strips on an island only 34 km (21 miles) long and up to 23 km (14 miles) wide, with subsequent social inequalities (Suchorski, 2009). As discussed in this article, this settlement pattern has consequences in terms of the integration of both rural and urban areas with the existing water infrastructure on the island.

Tourism & development in Barbados

Since the aforementioned decline of the agriculture and manufacturing sectors as sources of income for the island, tourism has become the dominant earner of foreign exchange in Barbados. "Since 1980, its share of total foreign exchange earnings has hovered around 50 per cent. Tourism [has also] contributed between 10-12 per cent [direct] of overall gross domestic product since 1974" (Jackman & Lorde, 2012, p. 204). More recently, this percentage share has increased; its direct contribution as of 2017 was "13.0% of total GDP [however] the total contribution of Travel & Tourism to GDP was BBD 3, 814.4 mn [million] ... 40.6% of GDP in 2017" (World Travel and Tourism Council, 2018, p. 1). Given its importance to the economy, the development framework of Barbados has been increasingly oriented towards tourism development. This orientation takes several forms and is by no means a recent phenomenon; ranging from large-scale infrastructure construction (the construction of the Deep-Water Harbor in 1961) to more recently, a variety of tax incentives embedded in legislation.

The most recent of these incentives is seen in the 2002 Tourism Development Act (Government of Barbados, 2002). This latest legislation is a considerable expansion of the incentives for tourism development, and extends to restaurants, recreational facilities and hotels. Hotels and other hospitality sector establishments are subject to duty-free imports of certain items, and capital write-offs of up to 150% for certain activities, including improvement of infrastructure and staff-training. In addition, these businesses are also exempt from environmental levies and value-added tax on imported products (Government of Barbados, 2002). Given these incentives, as well as its considerable share of total employment (40.5% of total employment indirectly supported by Travel & Tourism [World Travel and Tourism Council, 2018, p. 1]) tourism expansion in Barbados is likely to continue for the foreseeable future. This is also evidenced by upcoming tourism development projects such as the Carlisle Bay Development Project which will see the construction of five new hotels (1,500 rooms), recreational facilities and a marina in the Carlisle Bay area (Nation News 2016; Barbados Tourism Investment Inc. n.d.).

The scale of these developments will increase the water and infrastructure demands of the tourism sector as a whole, considering that the total occupancy of the island is set to rise. Importantly, it should be noted that the overwhelming majority of hotels in Barbados are also concentrated on the Southern and Western coastlines of the island (see Figure 1). This has meant integration with existing water infrastructure in the island, compared to more remote locations of farms. It should also be noted that Figure 1 is by no means exhaustive, and nor does it show Airbnb or other holiday rentals which are increasing in popularity among visitors. However, it does offer a glimpse into the broader tourism development pattern within the island.

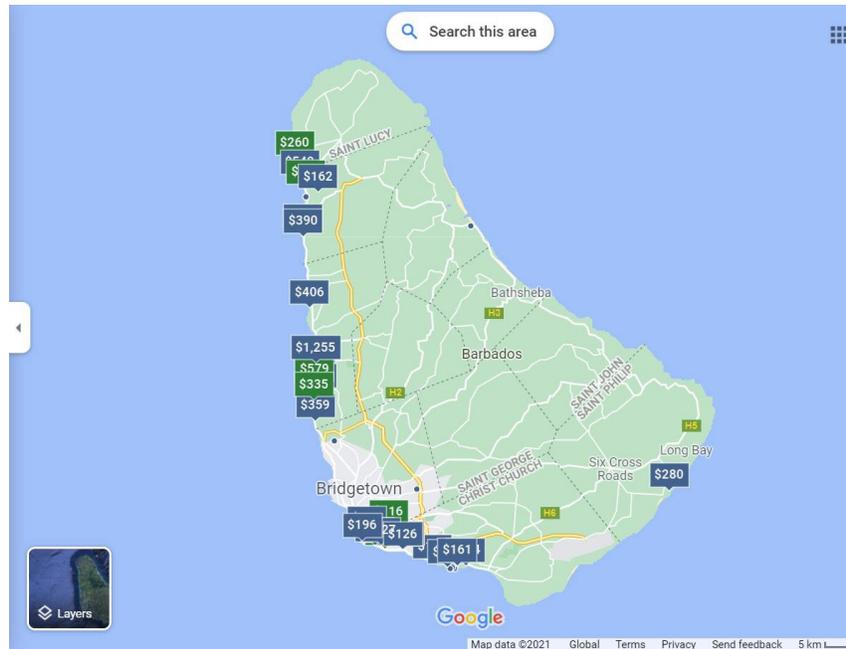


Figure 1: Barbados' hotel locations and avg. night stay price in USD. Source: Google Maps layer, 2021.

Tourism & water

Water stress "is a function of water availability, abstraction rates and the share of consumptive use" (Gössling, *et al.*, 2012, p. 1), and while globally, tourism accounts for typically less than 1% of global water consumption, this is uneven across regions and localities (Gössling, *et al.*, 2012, p. 7). The average domestic water use is around 160L per capita per day. Given Gössling, *et al.*'s definition of water stress, based on the figures (see Table 1), Barbados has been under "water stress" for some time. In 2000, water abstraction / use was greater than the total renewable water resources estimated for that year 80 million m³ / year vs. 84 million m³ / year. Tourism's estimated share of this consumption was around 2.6% (Gössling, *et al.*, 2012). However, an important caveat to this figure is that tourism also accounts for a significant proportion of "domestic" water consumption. This stems from issues in separating or retracting water use statistics of tourists outside of hotels / accommodation. As such, the majority of data tend to refer to 'direct' tourist water consumption based on figures from accommodation. Importantly, the data gathered here may also be incomplete particularly given that "sub-metering, which is one method of monitoring consumption, was not present in many of the hotels surveyed" (Environmental Planning Group Inc.; HLA Consultants, 2014, p. 6).

Despite this, Table 1 provides a useful breakdown of the estimated size of tourism's share of domestic water consumption. Existing literature, in a variety of contexts, points to direct tourism consumption being between "84 and 2,000 L per tourist per day, or up to 3,423 L per bedroom per day." (Gössling, *et al.*, 2012, p. 7). Importantly, a desalination plant located in St. Michael is currently in use to supplement water supply for the island and partially supplies the inhabitants of St. James with potable water (Suchorski, 2009).² Another important caveat to acknowledge when discussing Barbados' water scarcity is the volume of water lost as a result of degrading infrastructure. Estimates of water loss as a result of failed infrastructure range from 40% (Cashman, Water Security and Services in the Caribbean, 2014) to 60% (Suchorski, 2009). This infrastructure

² See <https://www.water-technology.net/projects/barbados/>

failure is largely attributed to the age of the system in use as well as the lack of attention to leaks and replacements; "The need for replacement is well understood, especially as some pipes have in the ground since the 1860s" (Cashman, 2011, p. 161). However, efforts have been made to reduce the volume of water lost as a result of infrastructure failures such as the Leak Detection System (for a more detailed discussion see (Fricke & Chase)).³

Country	Total natural renewable water resources (million m ³ /year)	Desalinated water (million m ³)	Reused treated wastewater (million m ³ /year)	Total water use in 2000 (million m ³ /year)	Total household water use (10 ⁶ L/ yr)	% of renewable water used	International Tourist arrivals 2000 ('000)	Growth rate tourist arrivals	International Tourist arrivals 2020 ('000)	Average length of stay 2000	Water use per tourist per day	Total Int. t.-related water use, 2000 (million m ³)
Mauritius	2210	0	0	612	16	27.7%	761	5.3	2,138	10.4	400	3.17
Cyprus	780	0	11	244	62	31.3%	2,470	2.5	4,047	11	400	10.87
Malta	51	31.4	1.6	55	33	107.8%	1,171	2	1,740	8.4	400	3.93
Barbados	80	0	0	84	24	105.0%	548	4.3	1,272	10.1	400	2.21
Spain	111,500	-	-	35,635	4,576	32.0%	55,916	2.6	93,429	12.9	400	288.53
France	203,700	-	-	39,959	5,814	19.6%	75,910	2.3	119,622	7.5	400	227.73
Switzerland	53,500	-	-	2571	276	4.8%	7,229	1.7	10,127	8.1	150	8.78

Table 1: Water use and tourism parameters. Source: Gössling, *et al.*, 2012

Importantly Gössling, *et al.* (2012) point to indirect tourism as having a significant and often, unmeasurable share of total consumption. They highlight certain activities such as golfing and skiing as being particularly water intensive. Golf is particularly pertinent to Barbados; in 2006 the country became the second Caribbean island in history to host the World Golf Championships. There are no figures for estimated water consumption of Barbados' golf courses, but an estimate can be gauged from the work of Gössling, *et al.* (2012); "a standard golf course may have an annual consumption of 80,000 m³ - 100,000 m³ in the North of France ... Much higher values can be found in dry and warm climates" (*ibid.*, p. 7). Certainly, golf courses are a relatively large consumer of local water resources (Environmental Planning Group Inc.; HLA Consultants, 2014; UNEP; UWI, 2012).

Replenishment rates of groundwater aquifers are an important factor in Barbados. Here, the work of Jones & Banner (2003) is useful. They focus on determining the recharge threshold; the rainfall required for recharge to an aquifer (Jones & Banner, 2003, p. 131). Their study identifies that groundwater aquifer recharge is directly influenced by the occurrence of surface water runoff, with wet season rainfall (June–December) accounting for approximately 60% of average annual rainfall on the island. Most recharge occurs during these wettest 1-3 months, but only when monthly rainfall exceeds 195mm. This signals the precarity of the water-tourism nexus and the inherent vulnerability to external shocks caused by climate change.

3. Political ecology and its applications

Political ecology combines political economy and cultural ecology (Blaikie & Brookfield, 1987; Peet & Watts, 1996), in order to analyze the "constantly shifting dialectic" between human and non-human actors. It is fragmented; "in part because the specific definitions of politics, ecology and political economy are themselves hard to isolate and delineate." (Igoe 2010 cited in Mostafanezhad, *et al.* 2016, p. 4).

Despite this heterogeneity of topics and approaches from a broadly defined political ecology perspective, as Robbins notes there is a "unity of practice amidst much diversity of thought" (Robbins, 2004, p. xix). Most notably, three core assumptions linking political ecology inquiries are often highlighted:

³ Funding from the global Green Climate Fund is already being used to improve infrastructure. <https://www.greenclimate.fund/story/water-conservation-barbados-how-gcf-enhancing-water-security>

...political ecologists accept the idea that costs and benefits associated with environmental change are for the most part distributed among actors unequally [this in turn] reinforces or reduces existing social and economic inequalities ... [which has] political implications in terms of the altered power of actors in relations to other actors (Bryant & Bailey, 1997, pp. 28-29).

This focus on power relations or asymmetries as a mediator of socio-environmental relationships is central to the article. Specifically, an uneven distribution of costs and benefits suggests power inequalities. Understanding the way in which power manifests and is represented helps to understand how and why resource allocation – in this case water distribution – is the way that it is.

There are several studies analyzing the implications of competing demands of water use from a political ecology perspective. LaVanchy (2017) focuses on the impact of tourism development on freshwater provision in Southwest Nicaragua, situating tourism development within a larger capitalist discourse of market-friendly cost-benefit valuation. Tourism development reorients economies and resources to serve its needs, a feature in Barbados. Political ecologists interrogate how this reorientation takes place, and its outcomes. Becken's work shows how competing demands for a municipal water supply change over time in 21 countries. She notes that "... favoritism is supported by public policy that focuses on tourism growth rather than resolving conflict or improving corporate social responsibility" (Becken, 2014, p. 19). In the Barbadian context this occurs through tax incentives, urban planning and incorporating developments into water infrastructure.

The environment

A common focus is socio-environmental relationships and the "concomitant ways in which access to and control over land and natural resources are distributed" (Mostafanezhad, *et al.*, 2016, p. 6). Terms such as "socio-environmental" or "human-environmental nexus" (Robbins, 2004) are signifiers in political ecology. The environment, viewed from a political ecology perspective, becomes an "arena where different social actors with asymmetrical political power are competing for access to and control of, natural resources" (Bryant & Bailey, 1997). In addition, environmental knowledge is itself politicized and heavily contested, owing to the plurality of knowledges in particular contexts. Borrowing heavily from post-structuralism, some political ecologists show how power lead to the construction and privileging of certain environmental knowledge(s) over others. For example, Watts & Peet (2004) contend that most knowledges are not simply local, but complex hybrids, and unevenly distributed. This in turn has implications governing use, access and control of natural resources within specific contexts, particularly conservation practices and their implementation.

Political ecology vs. apolitical ecology

The processes mediating socio-environmental relationships and outcomes are viewed as inherently political. In other words,

...the environmental problems facing the Third World are not simply a reflection of policy or market failures (as, for example the World Bank would have it: see World Bank 1992), but rather are a manifestation of broader political and economic forces. (Bryant & Bailey, 1997, p. 3)

Importantly, "the Third World's environmental woes cannot be equated with the workings of the global capitalist system alone ... the state in the Third World may intervene in economic activity to promote environmentally destructive activities" (*ibid.*). In addition, there is a difference between political and apolitical ecology. That is, "the difference between identifying broader systems rather than blaming proximate and local forces; between viewing ecological systems as power-laden rather than politically inert; and between taking an explicitly normative approach rather than one that claims the objectivity of disinterest" (Robbins, 2004, p. 5). The use of water in Barbados cannot be divorced from socio-historical patterns of development which have and continue to produce(d) uneven socio-environmental outcomes.

Power

Uneven power relations mediate socio-environmental interaction and the problems which stem from them. As Bryant & Bailey (1997) argued; "these unequal relations need to be related, in turn, to the power that each actor possesses in greater or lesser amounts, and which influences the outcome of environmental conflicts in the Third World" (*ibid*, p. 39). Fragmented and uneven power relations must also be placed in the unique socio-historical context of each area of study. In the case of Barbados and other former British colonies, particularly those "involving large-scale plantations, centralized irrigation authorities, and other modernization efforts, theories of environment were linked to theories of political domination" (Robbins, 2004, p. 63). This political domination, as Gilmartin (1995 cited in Robbins 2004) notes, is tied to "the definition of the environment as a natural field to be dominated for productive use [which in turn complemented] the definition of the British as a colonial-ruling class over alien peoples" (Gilmartin, 1995, p. 211).

Given the centrality of power to political ecology, it is no surprise that works from outside the – albeit fragmented – field of study e.g. post-structuralism and post-colonialism, have had a great deal of influence on it. The work of Foucault (1977) is particularly important within political ecology. Robbins (2004) acknowledges the importance of Foucault's governmentality for his work; "the way governmental management and governance become normalized within communities and individuals themselves" (Robbins, 2004, p. 75). This in turn has implications for what such normalization can lead to; e.g., increasing politicization of 'governed' subjects or governed subjects acting in a way that those in power can anticipate and pre-empt (Thompson-Carr, 2016, p. 27). However, beyond this, Foucault's work is also important for political ecology, and by extension for this work as it shows how power is diffuse in a society; i.e., that power is not confined to those in government – "power permeates human relationships, throughout all of society, therefore, power can be wrested back from those in governance as an outcome of political action." (Thompson-Carr, 2016, p. 28).

Thus, from a Foucauldian point of view, power can be understood as unevenly distributed within a society, with different actors possessing different levels of power at different times. This will be crucial in terms of coming to an operational definition of power in this research. Gender, historically, has proven to be an important determinant of inequality of outcome, and has been mobilized within political ecology as well. Most importantly, is the feminist contribution of intersectionality to wider political economy which in turn has implications for political ecology. In its original formulation, intersectionality was deployed to understand how women of color's intersectional identity as both "women" and "persons of color" – "within discourses that are meant to respond to one or the other, women of color are marginalized within both" (Crenshaw, 1991, p. 1224). However, since then, the scope has been widened to further the understanding of race, gender, class and ethnicity as independent and interlocking rather than disparate and exclusive social categories (Cole, 2016, p. 33). As such, some of the aforementioned social categories are key vectors of power, particularly in relation to control and access to natural resources.

The work of Svarstad, Benjaminsen, & Overå (2018) highlights and discusses three of the main approaches to power within political ecology; an actor-oriented approach, a Neo-Marxist approach and a Foucauldian approach. These three approaches, while providing nuanced differences in the expression, mechanisms and outcomes of power asymmetries, still present a degree of overlap which lends itself to the conceptualization of power as a combination of these three perspectives. A brief overview of the three approaches, as well as their implicit connection to the empirical situation of this research will be provided.

Actor-oriented power approaches conceptualize of power as being exercised by actors, thereby centering the notion of agency in its analysis. Thus, outcomes of power asymmetries within this approach are usually negotiated results of processes where different actors have exercised power, rather than the total fulfilment of only one actor. Under this approach, structures play a less important role in the production of outcomes, however they still have a degree of influence in constraining or enabling various types of outcomes. Additionally, the authors highlight the concept of "power resources" as being a central theme in writings from this perspective. "Power resources refer to means, or various types of capital, that different actors have available and may use in order to realize their intentions ... power resources may be political or symbolic and consist of means to influence policy-making and governance. These power resources are possessed by actors, but at the same time they have structural aspects." (Svarstad, Benjaminsen, & Overå, 2018, p. 353). In the Barbadian

context, the reorientation of the Barbadian economy in the 1970s to center of tourism as the primary industry, has inadvertently shifted these "power resources" to actors within the tourism sector – whether it is through capital, land or share of national employment. This in turn, has allowed greater influence to be exercised on legislative and policy decisions which have produced inegalitarian outcomes.

Marxist and neo-Marxist approaches to power within political ecology do include some considerations of agency, but greater weight is attributed to the class relations and historically established social structures within which this agency is constrained. While seemingly static in its conceptualizations of agency / power, this approach's utility is revealed when applied to instances or processes of modernization and accumulation. As Hall, Hirsch, & Li (2011) noted "processes of modernization associated with economic growth, industrialization and urbanization have generally led to de-agrarianization, which means that agriculture becomes progressively less central to national economies and to the livelihoods of people even in rural areas." Ultimately, it is through this process of de-agrarianization that new power relations are formed. While the process of exclusion will of course be context-specific, the production of winners and losers is perennial. Again, returning to the current empirical situation in Barbados – as aforementioned, the country did experience some form of de-agrarianization during the economic reorientation of the economy in the early 1970s. As this process of de-agrarianization continued, the prioritization of the maintenance of, and addition to, the existing water infrastructure shifted from more rural areas in the interior, to the urbanized spaces along the Southern and Western Coasts of the island.

Lastly, with reference to poststructuralist power perspectives within political ecology, its deployment tends to be centered on discursive power and governmentality. (Svarstad, Benjaminsen, & Overå (2018) define discourse as a socially shared perspective on a topic, [thus] discursive power is exercised when actors such as corporations, government agencies or NGOs, produce discourses and manage to get other groups to adopt and contribute to the reproduction of their discourses" (Svarstad, Benjaminsen, & Overå, 2018, p. 356). This notion of discursive power was central in arriving at an operational definition of power, particularly in an attempt to gauge the type(s) of discourse(s) which was / were most prevalent among respondents with reference to the water scarcity issue.

4. Methodology

The methodological framework outlined by Cole (2012) was used, but with an increased focus on power imbalances as a mediator of socio-environmental relationships and outcomes. Given that Cole's work was focused in Bali, another tourism-dependent Small Island Developing State where tourism employs approximately 25% of the work force and contributes roughly 30% of Bali's GDP, this made sense. The island is also water-scarce.

I used Cole's mapping of stakeholders and the inequalities between major actors to gain a better understanding of the tourism-water nexus in Barbados. Fieldwork was triangulated with secondary sources from academic articles and reports from UNEP and the FAO as well as some forecasting from the regional SPI. As aforementioned; "these unequal relations need to be related, in turn, to the power that each actor possesses in greater or lesser amounts, and which influences the outcome of environmental conflicts" (Bryant & Bailey, 1997, p. 39).

Participants

Between June 18th and August 20th 2019 seventeen (17) interviews were conducted. The participants consisted of five farmers, five tourists, five domestic users and two hotel property managers. The aim was to gain insight into their associated knowledge of the water scarcity issue, the strategies they use (if any) to mitigate its impacts and the ways in which they may unevenly experience the impacts of water scarcity. I did not stratify the sample according to other social determinants e.g., gender and class, so this initial group arose from opportunity, snowball and random sampling under time constraints. Table 2 shows the coding frame for the selected participants.

Code	Stakeholder Group	Sex	Location
F1	Farmer	M	St. Phillip
F2	Farmer	M	St. Michael
F3	Farmer	M	St. Andrew
F4	Farmer	M	St. Andrew
F5	Farmer	M	Christ Church
T1	Tourist	F	Christ Church
T2	Tourist	F	Christ Church
T3	Tourist	F	Christ Church
T4	Tourist	M	St. James
T5	Tourist	M	St. Michael
D1	Domestic User	F	Christ Church
D2	Domestic User	M	Christ Church
D3	Domestic User	M	St. Phillip
D4	Domestic User	M	St. Phillip
D5	Domestic User	M	St. John
H1	Hotel Property Manager	M	St. James
H2	Hotel Property Manager	F	Christ Church

Table 2: Participants' coding frame.

Participant profiles

F1 was the first farmer interviewed and from the parish of St. Phillip, in the St. Patrick's area, which is predominantly residential, with a few pockets of small farms dotted across the area. F1 is a beneficiary of the aforementioned F.E.E.D Programme, which is seeking to expand farm production across the island. F2 is a farmer who works across several farms in the island as a "farm-hand." At the time of interview, he was farming in the Ivy area of St. Michael which is predominantly urban but again with some farmland. Similarly, F3 and F4 do not own the land that they farm on, but rather are employed on neighboring farms in the parish of St. Andrew. F4 is a weekend farmhand, employed as a general worker across other establishments. F5 was the only farmer interviewed who owned the land that he farms, passed down to him by his father. He is located in the area of Briar Hall which is a predominantly suburban area, and he has indicated that his farm location has brought complaints from his neighbors on multiple occasions.

Of the tourists interviewed, only T3 was staying at a small holiday rental (Airbnb) in Christ Church. The remaining tourists were staying in larger hotels in their respective parishes. T1 was in residence for five days at the time of interview, T2 indicated she was here for three days, T3 was on her ninth day, T4 was here for two days, and T5 was here for seven. Importantly, all of the tourists interviewed are repeat visitors, with T2 having made five visits.

The domestic water users were also dispersed around the island, but not all parishes were represented. D1 was in the suburban area of Kingsland Terrace Christ Church, in an apartment complex. D2 was closer to the coastline in the area of Atlantic Shores. D3 was located in Parish Land, St. Phillip which is just on the urban fringe. D4 was located in Ruby St. Phillip and D5 in the parish of St. John – given the parish's recent and very publicized water issues, special effort was made to ensure a resident from the parish was included among the respondents.

Hotel owners and property managers were very reluctant to be interviewed, and this was a research constraint. H1 was a hotel property manager in the tourism belt on the West Coast with 96 rooms, and H2 was managing a smaller hotel with 58 rooms in the Christ Church area. Neither owned the hotels they were working at, and only H1 manages more than one hotel property. Especially among the larger hotels, potential respondents raised the sensitive nature of water usage and brand association, despite knowing they could remain anonymous.

Operationalizing power in the research design

Different social actors with asymmetrical political power are competing for access to and control of, natural resources in this case. Power can be operationalized along three broad axes, in the form of access to water, power in the form of knowledge (both of the water scarcity issue and of coping strategies) and lastly in the form of uneven socio-environmental outcomes (Table 3). Interviews were designed to highlight these axes of power, to achieve a greater link between the questions and the overall research aims. However, and importantly, there was a degree of flexibility built into the interview guide, such that elaboration on certain questions often led to other questions being asked which varied from participant to participant.

Main Research Question	Sub-Questions	Interview Questions
1. How does power mediate socio-environmental and economic relationships?	a. How does power in the form of access to water, mediate socio-environmental and economic relationships?	i. Has your household / farm / business / stay been adversely impacted by increasing water scarcity? ii. When was the last water outage, and how long did it take to resolve this issue?
	b. How does power in the form of knowledge of the water scarcity issue and water conservation practices, mediate socio-environmental and economic relationships?	i. Where would you rank Barbados globally in terms of water scarcity? ii. What water conservation strategies do you / your establishment employ? iii. What strategies do you employ to cope with service disruptions?
	c. Does increasing water scarcity affect the various stakeholder groups in different ways?	i. When was the last water outage you experienced and how long did it take for it to be resolved? ii. Was there any assistance from the Barbados Water Authority during this time?

Table 3: Research design.

A mixture of sampling techniques were used. In order to ensure sufficient participation under time constraints, opportunity and snowball sampling was used for the farmers' group, opportunity sampling for the domestic users and property managers and random sampling for tourists.⁴ There was insufficient time to probe differences in class and race among the respondents.

Positionality

Positionality can be broadly understood as "the researcher's awareness of [their] position in the world relative to her informants (Ortbals and Rincker 2009 cited in Mosely 2013). Berger (2015, 220) argues that the impacts of positionality on the research process are multiple and varied, most notably; on the ability to access information, specifically on what a participant is willing or able to share with the researcher. "Interviewees and

⁴ Ethics clearance was obtained at SOAS. Participants were kept anonymous, and were fully informed of the aims of the study and data management arrangements. Prior to the start of the interview, informed consent was obtained via a consent form signature.

potential interviewees use various social, physical, linguistic and cultural markers (ranging from eating habits and dress to accent and hair type) to make sense of a given researcher" (Mosely, 2013, p. 12).

With a dual role as citizen and researcher, I was already implicated in the process of water distribution in my country by living in Barbados. My appearance as a local, Afro-Caribbean man with locs perhaps allowed me to access information from participants, particularly among the farmers, who would have been less forthcoming with a person who appeared to be a non-national.

I did have to be wary of the "local trap" in which "political ecologists assume that organization, policies action at the local scale are inherently more likely to have desired social and ecological effects than activities organized at other scales" (Brown & Purcell, 2005, p. 607). Therefore, it was important to try to avoid any inherent biases stemming from my own local identity, so as to avoid a romanticization of the local. Also, positionality affects how the data are analyzed, what questions are formulated prior to the investigation etc. Hence, Berger's statement that researchers should "have an internal dialogue and critical self-evaluation of [their] positionality as well as active acknowledgement and explicit recognition that this position may affect the research process and outcome" (Berger, 2015, p. 220). My positionality may have had an impact on my understanding and interpretation of the data gathered.

6. Results and discussion

These findings are based on the interviews carried out from June to August 2019, with later reflections when returning to live in Barbados and by following current events. I present short interview excerpts to present the findings and triangulate with secondary empirical data. At this point, it should be noted that in analyzing and interpreting the results of the interviews, my aforementioned positionality as a local – inherently implicated in the tourism-water nexus in Barbados – may have an impact on my understanding and interpretation of the data gathered.

Power as access

Access to water is a central indicator of power in Barbados and mediates socio-environmental relationships. Access was a focal point of discussion for the majority of research participants, particularly among farmers. Questions revolving around this were asked in order to ascertain how power (in this case in the form of access). Examples of some responses are:

Q: When was the last water outage you experienced, and how long did it last?

F1: All now the water's off, this is going on the fifth week now more or less, and we aren't hearing about anything being done to fix it really.

Q: During this time did you receive any assistance from the BWA or any other governmental organizations?

F1: None, that Rapid Response thing doesn't come down here, and at the end of the day I still have a water bill to pay to them. They're also giving different reasons for the outage, first, it was because the water levels were too low to pump, then it's because of an issue with the pumping station so we really don't know.

Of all the groups interviewed, the farmers reported the longest or most frequent outages. This signals a power asymmetry between actors. In the context of competing and simultaneous demands on a scarce but essential resource, continued access to, and a relatively consistent supply of water, can be understood as a vector of power. Uneven service disruptions signal a power asymmetry between groups. Additionally, this power asymmetry is inextricably linked to the historical development of Barbados in its shift from a colonial to postcolonial society. This is well understood in the literature that investigates the underlying interests behind the distribution of water. For example (Swyngedouw 2009 cited in Cole 2012) notes "the mobilization of water for different uses in different places is a conflict-ridden process and the organization of the flow of water shows how social power is distributed in a given society."

All of the farmer's interviewed reported no assistance from the BWA's RRU (Rapid Response Unit). This unit is responsible for responding to outages stemming from infrastructural failure (e.g., burst mains) as well as for deploying water tankers to affected areas. The starkest contrast was between farmers and tourists. None of the tourists interviewed experienced any water outages, service disruptions or falls in water quality, owing in part to their length of stay and contact with the water infrastructure system in Barbados:

Q: During your stay have you experienced any water issues, in terms of disruption to services both at your place of residence or at any business you may have visited?

T2: No not any that I can think of. The water pressure was a bit low on my 3rd day here but other than that everything's been fine. I'm actually a repeat visitor this' my 5th time coming here and I've never had any issues with the water here.

Similarly, the two hotel property managers revealed that at their sites, complete service disruptions were rare, but that they do get "a few every now and again." However, one interview revealed an important connection between electricity and water; "we don't really get outages here, sometimes there're issues with the [water] pressure, but you find that whenever the electricity goes off, it either drops or goes off completely because the pumping station can't pump" (H1). Conversely, of the five domestic users interviewed, three reported a service disruption within the past two weeks. D1 described her most recent outage as occurring three days ago and lasting for eight hours before service resumed.

The varying impacts and implications of these service disruptions are discussed below. They beg the question: why do the farmers report the most frequent or longest service disruptions? One likely reason is their geographical location and the extent of their integration into the water infrastructure of Barbados. Three of the five farmers were located in areas which are known locally for infrequent water supply and infrastructural problems (St. Andrew & St. Phillip).

Impacts and implications

The data show that power asymmetries play a key role in determining socio-environmental outcomes. The various stakeholder groups experience water scarcity in different ways, varying from loss of livelihood to daily routine interruption. Again, farmers appeared to be impacted the most in terms of their livelihoods, with many reporting crop losses.

Q: Has your farm been adversely affected by the ongoing water scarcity? If so how?

F1: Definitely, I had to cut my chives because they just dried right up, a normal harvest that size would've been about \$3,000 [BBD] (US\$1,500) but now I had to clear off most and start again. (Figure 2)

Figure 2 shows F1's plot, and to the right are the rows of chives which had to be cleared because of insufficient water. He expects water shortages to continue and to reduce his earnings. Other farmers interviewed reported losses of equal or greater amounts; Figure 3 shows part of (F5's) losses, specifically, his damaged bean crop.



Figure 2: F1's damaged chives.



Figure 3: F5's Damaged bean crop.

While F5's outage was ongoing for two weeks at the time of the interview, he was already being impacted by losses, as shown in Figure 3. The dried-out crop of beans was only sold for \$18 BBD (US\$9), against a healthy harvest fetching \$300-\$400 BBD (US\$150-200). While he acknowledges that beans are only a minor commercial crop for him, the loss was still damaging to his daily operations. Interestingly, he highlighted the fact that his cows are not very water demanding even with sporadic rainfall, and there is a watering hole near where he puts them out to pasture.

Among the domestic users, D1 described the impacts as follows: "Typically when it happens, it mostly affects showering and washing dishes or clothes and preparing meals depending on what time it goes off and how long it's off for." Other domestic users raised the point of the impact this is having on their livelihood with (D5) noting he had to miss work because "the water was off, and I couldn't shower, while my boss might understand at the end of the day it still counts as a 'sick' day so I have one less for the year." Among residents, the uneven distribution of impacts is visible. Some groups experience water service disruptions more frequently, or at greater cost or inconvenience.

Mitigation strategies

The mitigation strategies (or lack thereof) employed by each group points towards power imbalances between them. Some are forced to employ mitigation strategies more readily, most commonly the use of water tanks, but not among tourists. Among the two hotels interviewed only one had water tanks and H1 noted that they "have one water tank for the kitchen and one for one block of rooms, but we have more planned for the near future." When further probed he indicated that this was to minimize disruptions to their services in the kitchen and restaurant on site, and for an establishment of this size (96 rooms), this was deemed an adequate starting point.

All of the farmers interviewed except one, had water tanks as well. Beyond this they implemented a rain catchment system to help supplement the tank(s) in times of extended periods of water service disruptions. In doing so, this allowed at least some water via rooftop runoff to be used to refill the water tanks and therefore continue operations. Each tank was 1,000 gallons (3,785l) but F5 highlighted the immediate cost of roughly \$800-\$1000 BBD (US\$400-\$500) as being too steep for some farmers to pay immediately without taking loans. However, the importance of kinship ties in enabling this was revealed in an interview with F1 who pointed out that he was able to obtain his tank at a lower cost of \$500 BBD (US\$250) through a "family friend." Another mitigation strategy is switching to more drought resilient or less water-intensive crops. F1 noted that he is now "plant[ing] more cassava, and for these I hardly have to water them and it doesn't affect the end crop. The only downside is that cassava is a 6-month crop so it would take a while to see the money." For him this switch is to ensure that he still "get[s] something from the year, but [I] can't rely on it alone because what about in between the harvest?"

All of the domestic residents stored water in sealed containers or buckets in the event of water disruptions, but only one possessed a water tank. However D2 pointed out that they "really need to invest in a tank, because even though I have these buckets, if the water stays off for three days, then I'm out by the third day." The BWA launched a PTP (Personal Tank Programme) in 2017 in order to increase water-scarcity resilience among the local population, particularly for the most drought-prone areas of the island. These tanks can also help if there are water service disruptions due to natural disasters, such as hurricanes. Figure 4 shows the ongoing Personal Tank Programme launched by the BWA. When asked how many knew of the PTP, only one domestic user was aware of the program. Increased awareness about the importance of a water tank and this scheme is needed.

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Figure 4: BWA's personal tank program.

Knowledge of the water scarcity issue

Watts & Peet (2004) highlight that environmental knowledge is unevenly distributed within local societies with implications for governing use, access and control of natural resources within specific contexts. Similarly, knowledge of the water scarcity issue is likely to have an impact on water conservation strategies employed by each group as well as their overall attitude towards the issue. Each participant was asked to rank Barbados globally in terms of water scarcity. According to UN-Water (2019) Barbados is among the most water scarce countries in the region and fifth among the top 22 in the world (Figure 5). Barbados' level of physical water stress was estimated at above 70% which is considered to be "seriously stressed", far above the global average of 13% (UN-Water; FAO, 2018, p. 12).

According to UN-Water & FAO (2018), Barbados is one of seven countries with a water stress percentage of between 70-100%, the only Caribbean country within the global top 22. Similarly, when asked, the farmers knowledge of the extent of the scarcity reflected this to some extent, with all of them suggesting Barbados would rank "in the top 15 for sure" (F3), or nearby e.g. "I would say, if I had to guess we would be number 12 or so" (F2). Compared to this, the tourists interviewed were far less aware of the extent of the level of water stress. One prototypical response came from T3 who responded: "I know water scarcity is a really big issue all over, with climate change and all that, but I don't think a small place like here wouldn't really rank that high, I reckon it would be in the 40s." Other tourists interviewed offered responses in this range (30-40%) which in turn, suggesting they are shielded from the true extent of water scarcity.

Conversely, the domestic users and hotel property managers had better awareness, but with a wider range among the former. The furthest outlier in this group was D4 who's estimate placed Barbados at "number 60 in the world." The others had estimates ranging from 12th position (D2) to 24th (D1). Hotel property manager H1 suggested a ranking in the top 30, and H2 suggested 23rd. This points towards an uneven distribution of knowledge of the water scarcity issue between (and to some extent among) the various stakeholder groups, which of course has implications governing use.

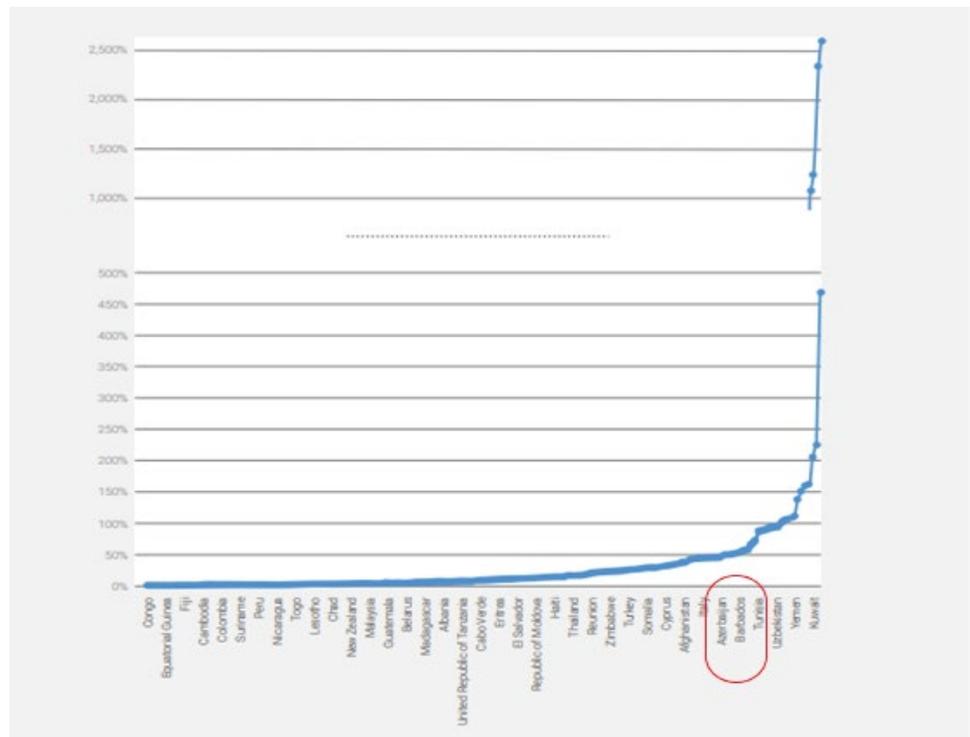


Figure 5: Distribution of water stress by country (%). Barbados highlighted. Source: UN-Water; FAO, 2018

Estimating water use

In order to gauge a brief sketch of the estimated water use of each group (except for tourists), the participants were asked to provide an estimate of how much water they use in a month. Interestingly, the farmers could not provide an amount in volume, signaling the lack of monitoring in the form of metered connections of water. Instead, they were able to provide their bill in "\$" amounts e.g. F5 "I couldn't really tell you that accurately, I know my water bill is usually around \$1,100 BBD (US\$550) [per month]." By comparison the domestic users interviewed had water bills in the range of \$112-\$200 BBD (US\$56-\$100) [per month] (D1). According to the Barbados Water Authority's pricing scheme the "commercial rate of [water is] \$4.66 (US\$2.33) per cubic meter (m^3) for the first 40 m^3 , then moves to \$7.78 (US\$3.89) for the additional m^3 used, up to a maximum of 12,000 m^3 " (BWA, 2019). This could potentially be a locus of intervention; helping farmers and domestic users alike better monitor their usage, particularly the former as none of those interviewed had any metered connection.

Furthermore, two of the five farmers cited the use of open water sources for their inability to accurately account for their total volume. For example F2 noted that "I can't say for sure in terms of volume, because at our farm we rely a lot on spring water nearby to water our crops which keeps the bill fairly low at the end of the month."

However, the hotel property managers were able to give precise usage both in terms of volume and cost per month. H1 was also able to provide statistics as to how usage might vary in accordance with tourist season; "In February we usually see higher occupancy, which is around 250 persons – close to our max occupancy – and our total volume usage for that month was 3,868 m^3 , however in July when total occupancy slumps a bit, we had a total volume usage of 3,541 m^3 ." As the literature suggests, this is far above the usage of any of the groups interviewed and within the range estimated by Gössling, *et al.*, (2012).

Current perceptions

Lastly, all participants were asked whether they foresee the problem improving in the future or becoming worse, and how things are right now. All of the farmers and domestic users interviewed pointed towards the general lack of rainfall as compared to previous years, as well as increased heat in the dry season. For example Farmer 4 suggested its "definitely hotter now especially in the summer, which I find dries out the soil more so, before you could water some crops today and by tomorrow when you go to water again, the soil is still a little damp, but now if I water in the morning, and by the evening I look at them, they look like they never got watered today."

In order to triangulate these perceptions, data was taken from the Caribbean Regional Climate Center precipitation index, which is calculated by the Caribbean Institute for Meteorology and Hydrology (CIMH) (Figure 6). The SPI is essentially a "representation of rainfall in units of standard deviation. Positive values indicate greater than median rainfall; negative values indicate less than median rainfall; negative values indicate less than median rainfall" (Caribbean Regional Climate Center, 2019). As such, the perceptions of the farmers and domestic users are in a sense confirmed when compared with the SPI for the period January to June 2019 which shows Barbados receiving less than median rainfall for this period; hence being classed as "extremely dry" (Caribbean Regional Climate Center , 2019).

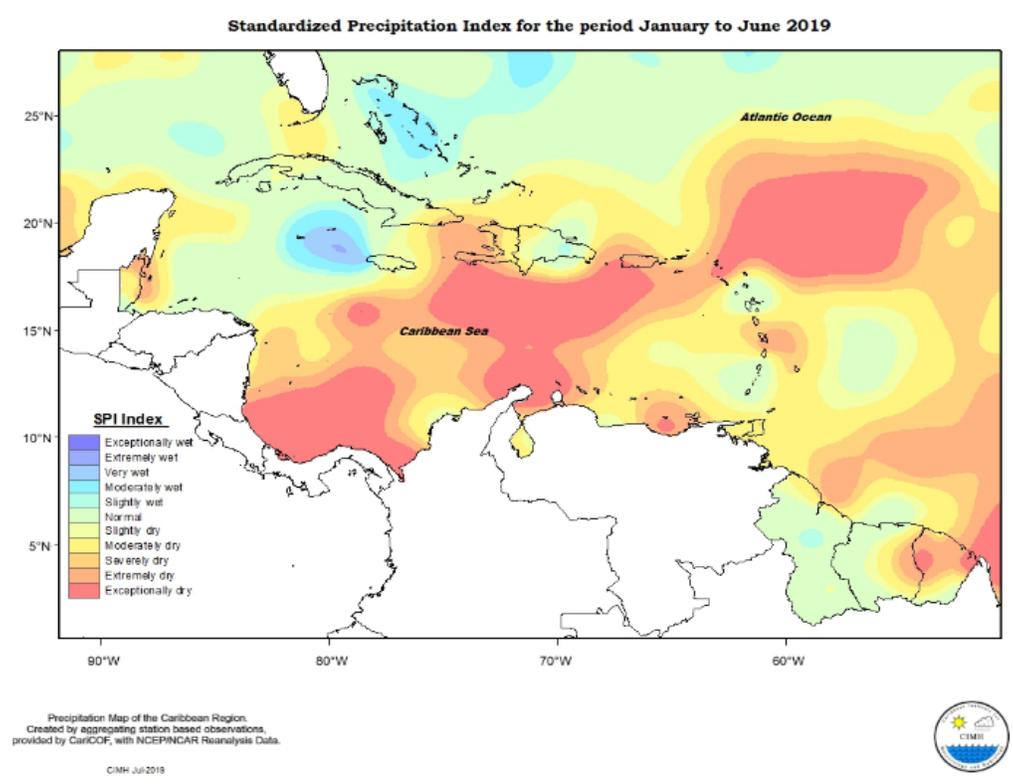


Figure 6: SPI January to June 2019. Source: Caribbean Regional Climate Center, 2019.

7. Conclusions

Water and power

As a result of tourism's considerable dependence on water, which is a resource with intersecting and multiple uses (e.g., local use for food production, domestic hygiene etc.), its usage and distribution is invariably subject to uneven outcomes, spatially and across social groups. While globally, tourism may represent a small proportion of water use, and in most nations, agriculture is the largest user; "in some countries, as well as regionally tourism can be the main factor in water consumption" (Gössling, *et al.*, 2012, p. 13). Barbados is one.

While the data collected in Barbados was preliminary, it does signal power asymmetries between different stakeholder groups involved in the human-water nexus in Barbados, and differential outcomes based on these asymmetries. This power is manifested in different ways, particularly through service disruptions, through awareness of the water scarcity issue, and in general impacts on livelihoods through cost and lack of affordable storage for fresh water. These asymmetries in turn have an impact on these groups' experiences of the water scarcity issue and the degree to which each individual is affected. Most apparent is the uneven distribution of risks and impacts *vis-à-vis* associated water use. While hotels interviewed (and by extension the tourists who stay there) were the largest user in terms of volume of water, the implications were unevenly spread, such that residents, particularly small-medium sized farmers, are experiencing crop loss and subsequent decreases in earnings and earning potential.

Tourism development has been and continues to be encouraged in Barbados. Viewed through the taxation system, the 2002 Tourism Development Act (Government of Barbados, 2002) or through upcoming projects such as the Carlisle Bay Development Project anchored by a large Hyatt hotel, the continued expansion of the tourism sector in Barbados is apparent. With this continued expansion coinciding with increased changes in the global climate system, these power asymmetries and subsequent impacts stand to be exacerbated.

As a result, and as argued by Gössling, *et al.* (2012, p. 13) these situations will require "a more integrated approach to tourism's role in water management at a catchment level than what has hitherto been the case." Beyond this however, increased representation from other groups such as farmer's associations e.g., the Barbados Agricultural Society is necessary to represent the interests of farmers in discussions on, and strategies of, water management.

The political ecology of uneven access and control of fresh water in Barbados identifies the main elements of the problem, but in a context of an expanding tourist sector and high water costs, water scarcity needs to be addressed centrally by the different actors identified.

Recommendations for government

- First and foremost, access to greater international financing, particularly with the aim of improving climate resilience in key infrastructure areas is absolutely necessary. Barbados, like many other developing countries, faces the challenge of balancing debt servicing⁵ with other domestic obligations including the provision of social services and investment into climate resilience initiatives. Importantly, it should be noted that the current administration is already pursuing this through what is known as the "Bridgetown Initiative" which essentially seeks to restructure the global financial architecture to improve access to financing to address climate resilience needs of climate vulnerable countries. The Bridgetown Initiative pursues alternative financing mechanisms that are more responsive to climate crises.
- While the establishment of the BWA's RRU (Rapid Response Unit) is certainly a step in the right direction, coverage could and should be extended, particularly to farmers in drought affected areas who already possess water tanks. This could assist in reducing crop loss and the effects on livelihoods for farmers.

⁵In 2018, the current administration implemented an Economic Recovery Programme (BERT) to address skyrocketing debt which at the time stood at 176.3% of GDP (Ministry of Finance, Economic Affairs & Investment, Barbados, 2022).

- Increase awareness for domestic users for the Personal Tank Programme in an attempt to raise water-stress resilience among local people. This could be done in the form of radio advertisements, news slots etc., and extending this to a low-cost or interest free program for farms.
- Mandate the implementation of rain catchment systems for large volume users of water e.g., irrigation, hotels (lawns, gardens, golf course watering) in an attempt to lower groundwater abstraction. Further, these rain catchment systems can also be implemented by domestic users for activities such as garden watering, car washing etc. Here, the state can play a strong role in incentivizing the implementation of rain catchment systems through tax rebates, government subsidies or legislative requirements stipulating new residential and hospitality structures must be built with a rainwater catchment system. This is by no means revolutionary, with countries such as Brazil, Germany and India having set a precedent in the implementation of some of these incentives.
- Introduction of certification for hotels, aiming for a certain percentage of water to be re-used.
- Lastly, while there is certainly a need to incentivize the establishment of hotels and other tourism-related and potentially water scarce activities here in Barbados, this incentivization, particularly through the tax regime needs to be re-evaluated with a view to ensure the sustainability of the sector. The introduction of a new environmental / water use levy on hotel resorts over a certain room occupancy could be considered. This could be accompanied by environmental audits, which assess the sustainability of the hotel, thereby allowing them to re-claim potentially lost revenue through tax returns. Ultimately the goal here would be to amend the existing tax regime, to not only encourage greater sustainability in the country's tourism sector from the private sector side, but to generate revenue which can be funneled to creating more climate resilient and equitable infrastructure, by the government, without passing the cost onto the consumer.

Recommendations for domestic users

- The addition of personal water tanks could greatly reduce the impacts of service disruptions and can increase resilience to increasing water stress.
- The implementation and use of rain catchment systems (for example those that capture rainwater fall runoff from roofs) are cost-effective ways to reduce overall water usage by the household and can be used for tasks listed above.

Recommendations for hotels

- Raise further awareness among guests as well as staff about the level of water-stress being experienced in Barbados, such that they may be more cognizant of their water use potentially resulting in a change in practices.
- Increased focus on water management, e.g., strategies to decrease overall water use.
- Introduction of mandatory water tanks to raise the overall resilience to increasing water stress.
- The implementation of rain catchment systems to carry out water intensive activities such as golf-course/garden watering, waste removal etc.

Recommendations for farmers

- Where feasible, consider the implementation of water tanks and rain catchment systems for farm operations.
- The addition of drought and water-stress resilient crops such as cassava to supplement income in times of crop-loss. Several feasibility studies have been conducted on cassava in

the region, and while overall profitability depends on the extent of forward linkages with other processing enterprises (of which there are few in Barbados), the crop remains a viable option for income supplementation for small holder farmers. In 2016, the price per metric ton stood at US\$140/MT (Ospina, *et al.*, 2016, p. 36). However, should this recommendation be properly pursued, several structural constraints on cassava production must be addressed to ensure its viability for small-holder farmers. These include: the predominance of low-yielding varieties, the lack of agro-processing activities with added value for the crop, and the lack of agronomic training for small-holder farmers (Ospina, *et al.*, 2016).

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