Forest Policy and Economics 141 (2022) 102765

Contents lists available at ScienceDirect

Forest Policy and Economics

journal homepage: www.elsevier.com/locate/forpol

Livelihoods matter – A comparative political ecology of forest use on Hispaniola

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ARTICLE INFO

Keywords:
Political ecology
Sustainable land use
Dynamic comparative case-study

ABSTRACT

Forests provide grounds for human well-being through direct material, indirect environmental, and immaterial contributions. Here, we analyze the example of Hispaniola to understand reasons for (un)sustainable forest use. We pursue a dynamic comparative case study of the island's two countries from a political ecology perspective. From the literature, we derive a set of socio-economic hypotheses for the cause of de- and reforestation. Methodologically, we combine historical analysis and longitudinal comparisons with institutional analysis. We find that it was a governance mix of economic incentives, civil society driven initiatives, and alternative sources of energy that made the difference between reforestation in the Dominican Republic and deforestation in Haiti. We do not find evidence that it was population density or education levels that caused the difference. Colonial history can explain older differences but not divergent trends that started in the 1980s. Our findings suggest that if people shall stop overusing forests, they need alternative opportunities to maintain their livelihood and show how this has been accomplished in the Dominican Republic.

1. Introduction

In the search for ways to halt the increasing rates of environmental degradation, countries have recognized the world's forests as one of the main assets for fighting climate change and biodiversity loss (IPCC, 2019). The forests' ability to capture carbon dioxide from the atmosphere serves as an important mechanism to the ongoing climate changes. Forests are home to the majority of the world's terrestrial flora and fauna, a source of income for millions of people, and play an important role in reducing the impact of natural disasters and long-term environmental degradation (FAO, 2020). It is not only important to halt the current deforestation but to replant and create new forests, a strategy that is greatly emphasized by the Intergovernmental Panel on Climate Change (2019), the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES, 2019), the United Nations Environmental Programme (UNEP, 2021), the Food and Agriculture Organization (FAO, 2020), as well as stated in the Paris Agreement (UN, 2015) and under discussion for the post 2020 biodiversity agenda (CBD, 2020). The highest levels of biodiversity are found in tropical forests and rainforests, where many of the world's endemic species are found (FAO, 2020). Deforestation has already resulted in an extensive number of species going extinct or becoming endangered (ibid.). While tropical forests have great potential to store carbon, current deforestation releases as much or even more carbon into the atmosphere than is currently being stored (Baccini et al., 2017). Deforestation is a large-scale socio-economic and ecological challenge. Global population growth, urbanization and economic development require increased agricultural food production and extraction of resources which in turn drives humans to cutting down forests (Austin et al., 2019; Lambin et al., 2018; Rueda et al., 2017; Seymour and Harris, 2019; Sonter et al., 2017). The forests' contribution to human livelihoods and the regulation of natural processes are thus substantially and sometimes permanently reduced (IPBES, 2019). To halt deforestation, it is therefore important to understand what mechanisms are effective and why.

On the Caribbean island of Hispaniola, two countries share similar environmental and climatic conditions but show large differences in current and historic forest cover (Castilla-Beltrán et al., 2020; Higuera-Gundy et al., 1999). In the Dominican Republic, tropical forests cover about 40% of the country. In Haiti, the forest cover is down to an average of about 10% and is only slowly recovering (see Methods & Material, and Results for more indication on data sources and variations). The diverging forest management outcomes in Hispaniola's two

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https://doi.org/10.1016/j.forpol.2022.102765
Received 9 August 2021; Received in revised form 8 April 2022; Accepted 15 May 2022
Available online 3 June 2022

countries allow insights into which mechanisms lead to de- and reforestation. Yet, hypotheses on the causes of this difference vary greatly among scientists – ranging from colonial history to economic factors, energy infrastructure, human settlement, and political instruments.

This study pursues a comparative political ecology approach to answer the following research question: *What socio-ecological factors explain the difference in forest cover development in the Dominican Republic and Haiti?* In the search for an answer, we follow one of the central tenets of political ecology, namely that human-environment relations are inherently political. We review former research on deforestation on Hispaniola, derive, and test three broad hypotheses based on a combination of political ecology perspectives and earlier research. The hypotheses cover the areas of colonial history, human development, and local institutional context and are thus largely socio-economic, but we consider natural causes of forest cover differences too. The hypotheses are then tested using a dynamic comparative case-study approach (Fox-Wolfgramm, 1997) – using longitudinal data and process-tracing to identify a plausible sequence of events that can explain the countries' de- and reforestation pathways (Vanhala, 2017). We add to the literature by systematically testing these different hypotheses and add rigour by applying a method from comparative political science. The political ecology lens on the relation between humans and nature ensures a fairly comprehensive perspective. By analyzing the mechanisms that can help stop deforestation, we contribute to the general understanding of forest use in the tropics and potential pathways to make the usage patterns more sustainable.

The remainder of this article is organized as follows: in the next section we introduce the political ecology theoretical approach. In section three we present earlier literature and develop the hypotheses. Section four holds the description of our methodological approach of a dynamic comparative case study and sources for empirical material. We present results in section five and discuss them in section six.

2. Theoretical approach

Here, we present political ecology as an overarching theoretical framework that allows for an umbrella perspective on the relations between society and nature. Political ecology as a community of practice provides the framework to develop hypotheses on the causes of Hispaniolan de- and reforestation that we derive from earlier research in the subsequent section.

Political ecology is a field of critical research that studies human caused environmental degradation and its consequences. It focuses on human-nature relations and shares many conceptual similarities with both political economy and environmental justice but brings together their multiple aspects in a socio-ecological systems perspective. According to Robbins (2012), political ecology is neither a theory or a method but a community of practice. A once clear-defined theory has evolved into a wide and diverse set of approaches, theories, and methods over the last decades. What binds together all interpretations and variations of political ecology is a central tenet recognizing that human-environment relations are inherently political. This means to recognize the power structures and the institutions that govern humans in their use of the natural environment. Human-caused degradation of nature is assumed to be created by political and economic circumstances (Bailey and Bryant, 1997). Correspondingly, an analysis without the understanding of political and economic structures and their inherent power-relations cannot fully grasp the complex relationship between environmental degradation and society.

There are a set of commonly shared assumptions among political ecologists. One of the core tenets of political ecology is that unequal power structures and their practices often lead to marginalization and exclusion of access to resources. Such inequalities in turn lead to unsustainable land use practices born out of an urgent need and lack of alternatives. Socially and economically marginalized groups are pressed into areas where the soil is less fertile, the environment is less adaptable, and the ecosystems are less resistant. The difficulties of surviving on such lands force people to intensify the pressure on the environment, gradually impoverishing the soil and the community simultaneously in "a cycle of social and environmental degradation" (Robbins, 2012, p. 91). In the analysis, the history and development of power structures are therefore central for being a driving force behind marginalization, access to resources, and unsustainable land use. By studying larger long-term contexts, political ecology enables an understanding of influencing changes, path dependencies, relationships and structures (Andersson et al., 2011; Blaikie, 2016; Robbins, 2012). These long-term developments can also cause changes in people's perception of the environment, which in turn leads to changed behavior. Robbins (2012) suggests that starting a chain of positive environmental examples and trusting communities to be responsible helps the population to develop an identity of environmental stewardship. Accordingly, in our analysis, we take a perspective that allows us to study the development of land use over time, the human needs and economic capacities, the institutions and power structures.

3. Literature-based hypotheses

While sharing an island, Haiti and the Dominican Republic display significant contrasts in historic developments, economy, political institutions, culture, religion and in environmental conditions (Alscher, 2011; Metz, 2001). There is a vast body of literature focusing on various aspects of these differences, and partially also on their reasons, sometimes from a comparative angle. Many studies on the Hispaniolan socio-ecological system have been conducted, often in the context of development cooperation or regional studies (Ehrlich et al., 1985; Metz, 2001; USAID, 2016). The island of Hispaniola portrays a telling example of human environmental destruction and the strong interlinkage between society and nature (Tarter et al., 2016). The research does elaborate on historic developments but only on one and not both parts of the island (ibid.). It also reveals that humans have had serious effects on their environment. There are in depth ecological studies that show substantial losses in biodiversity on Hispaniola but do not include analyses of driving societal factors (Hedges et al., 2018). There are comparative studies that focus on economic factors (Jaramillo and Sancak, 2009), or on socio-environmental phenomena such as vulnerability to Hurricanes (Pichler and Striessnig, 2013) or climate adaptation (Sheller and León, 2016). Alscher (2011) shows how environmental degradation has intensified the regional and international migration flows of Hispaniola. Such research on the binational island's asymmetrical environmental conditions has not yet reached a consensus about the explanation for the forest cover disparities, or even the exact forest cover (Pauleus and Aide, 2020). There are many hypotheses on why and how Hispaniola have come to suffer from such aggressive deforestation throughout history, and how the forest cover has started to differ so dramatically between the island's two countries (UNEP, 2013). Here, we present a compilation of the literature and derive a set of causal hypotheses for diverging forest use on the two sides of Hispaniola. We have grouped the array of hypotheses from earlier research into three categories: colonial history, human development and demography, and local institutional context.

3.1. Colonial history

Political ecology emphasizes how the history of colonialism, systems of economic inequality and environmental impoverishment are all intertwined. Historically colonized lands were considered valuable to the colonizers primarily because of their natural assets, raw materials, slave labor, or luxury goods. The lands were drained of its people and resources, irrespective of the indigenous or enslaved populations, the environment, or the history of knowledge found in their interconnected relation (Bailey and Bryant, 1997). In addition to the very tangible effects on the economic systems, colonial rule also changed the countries'

political and administrative jurisdiction of the environment. The indigenous peoples' relation to the environment was considered primitive and attempts to 'rationalize' the environment for profit were carried out. Political remnants are still seen in the environmental legislation of many countries today (Bailey and Bryant, 1997). The combination of the economic, social, and political remains of the colonial period has put many of the countries in a path dependency that continues to support the disproportionally disfavoring of poor and earlier colonized countries.

On Hispaniola, the two countries share a common colonial history but have also spent a substantial amount of the last centuries subjugated to different colonial powers. Hispaniola was the first base of the Spanish colonial empire in the Americas in 1492 (Hartlyn, 2001). The island stayed under Spanish control for more than 200 years until France gained power over the Western third of the island in 1697 (Greene, 2001). While both countries experienced colonialism, the two colonial powers had different strategies and presence over time, resulting in different colonial legacies in nowadays institutions and therefore an indirect effect of contemporaneous land use. Thus:

H1. *The difference between the countries' forest cover stems from variations in their institutional and environmental colonial legacy.*

3.2. Human development and demography

Political ecology conveys that economic and social circumstances greatly affect the risk of human-caused environmental degradation (Blaikie, 2016). Living standard as well as distribution of wealth, resources, education, population pressure and other circumstances play an important role in the marginalization of people and land (FAO, 2000; Smucker, 2001). Poverty and lack of opportunities to change one's circumstances cause people to exhaust the land for survival, which ultimately worsen circumstances for the most vulnerable even further (Sheller and León, 2016). A study by Dolisca et al. (2007) suggests that the education level of the head of the household influences Haitian families' tendency to deforest. Similarly, Pichler and Striessnig (2013) find that qualitative education in the population has a strong effect when comparing the countries' hurricane vulnerability. From a political ecology perspective, aspects such as overpopulation and lack of education are rather another outcome of marginalization than the ultimate cause for unsustainable land use. Faria and Sánchez-Fung (2009) emphasize the importance of the environment in explaining the economic differences between the countries. They believe that the economy and the environment cannot be separated when analyzing why the countries display such different levels of economic development. Translating their assumption into a political ecology perspective, one could say that economic opportunities matter as they reduce the marginalization and offer alternative livelihoods and reduce pressure on land. Additionally, the population of Hispaniola has traditionally relied on slash-and-burn practices including forest use for fuelwood and partially large-scale charcoal production (Malik, 2001; Oxfam, 2010; Tarter et al., 2016). Therefore, we stipulate that substituting fuel wood with other energy sources may also reduce pressures on forests.

There are thus multiple aspects of well-being that one can test a general human development hypothesis against, such as population (life expectancy or density), education levels, economic development, and energy usage. While aiming at such specific tests, we generally hypothesize that.

H2. *Differences in socio-economic opportunities caused the deforestation disparity between Haiti and the Dominican Republic.*

3.3. Local institutional context

In political ecology, the local institutional context is decisive in creating, upholding or escaping situations of marginalization (Andersson et al., 2011). The political context in which communities exist shapes the behavior and possibilities of its inhabitants through the rules in use and steering effect of these institutions (Holifield, 2015) but also the economic development. Jaramillo and Sancak (2009) concludes that the higher level of economic growth and environmental conditions in the Dominican Republic is largely due to the country's efficient policy decisions aimed at protecting the environment. While Haiti has also tried applying similar policies, they have not been as successfully implemented. The institutional context can thus affect both the material circumstances that cause people to degrade the environment. It can shape ideas of how the environment is valued and perceived and therethrough how people act towards the environment (Robbins, 2012) and among themselves. Institutions shape how society perceives and treats certain groups of people such as women (Chancy, 2012) or how structural racism plays out (Law and Tate, 2015) and are therefore a mechanism for either ex- or inclusion. Land- and forest related legislation regulate land access, land use and conservation measures. Land tenure and ownership affects the land distribution, land security and the possibilities for acquiring new land (de Ceara, 1986; USAID, 2016). According to a study by Dolisca et al. (2007), the land tenure status of Haitian farmers' influences the number of felled trees. Other institutional contexts such as inequal or discriminatory access to resources and services, or disproportionate focus on the perspectives of certain groups in national policy, could also be highly relevant (Rocheleau, 2005). Hence,

H3. *The differences in forest cover is a consequence from the local institutions that govern the land use of communities.*

4. Method & material

For the comparative analysis of forest management on Hispaniola, we make use of a most similar systems design (Anckar, 2008), and apply process tracing to track down causal effects (Vanhala, 2017), making it a dynamic comparative case-study approach (Fox-Wolfgramm, 1997). We proceed by laying out the analytical approach before detailing the data sources. Our research question asks for what factors that have caused the differences in forest use in Haiti and the Dominican Republic. To answer this question, we test hypotheses generated by earlier research (see Literature-based Hypothesis). Beyond the empirical analysis of these, partly competing hypotheses, we aim to explain the underlying causal mechanism of the observed developments. To do so, we draw upon political ecology as a theoretical underpinning (see Theoretical Approach). To build a theoretically sound and empirically grounded explanation, we thus make use of an abductive approach with a mixture of inductive and deductive strategies. Here, we lay out the employed logic of inference from a research design point of view.

4.1. Dynamic comparative case study

We use a dynamic case-study approach that combines a comparative case study approach with data covering long-term developments. It integrates aspects of Mill's (1882) Method of Difference, in particular the associated logic of inference of a most similar system design (Anckar, 2008). The logic of inference here is that in sufficiently similar cases, a difference in an outcome variable can not be explained by what is the same but only be caused by diverging explanatory variables. This comparative case-study design is complemented by a process-tracing type of analysis (Collier, 2011). In this regard, the logic of inference is that the cause can only precede the effect, and not the other way around. While the use of process tracing in (comparative) environmental politics holds explanatory power for causal inference, it remains under-used (Vanhala, 2017). Our combination of a temporal, chronological dimension into a comparative case study approach is however not entirely novel, and has for example been outlined by Fox-Wolfgramm (1997), who called it a dynamic comparative case study approach. This design allows us to track down when diverging aspects across both cases

started to emerge, and thereby identify preceding development that may therefore have driven the difference.

In this study, the approach is exercised by compiling historic Haitian and Dominican forest cover data, from which a timeframe of forest cover disparities is identified. Working from this timeframe, the three hypotheses detailed earlier are evaluated by comparing the countries' longitudinal developments. Yet, to understand the causal mechanism we need more than just such indications – even if they logically allow the establishment of a cause-effect chain. To grasp the complexity of socio-ecological system management approaches, we also need to develop a better understanding of the mechanisms at play. Therefore, we combine the logic of inference from the dynamic comparative case-study design with an abductive theory building. That is to say, the identified candidate cause, will then be reasoned out in terms of how it may have caused the observed differences in forest cover (see Discussion).

4.2. Data & operationalization

The material used for this article can be divided into two categories: i) secondary, scientific and gray literature on institutions and development and ii) forest cover and environmental data, and time series of quantitative development indicators.

For the dependent variable, historical development of de- and reforestation on Hispaniola is operationalized as forest cover as percentage of a country's total area. Forest cover is the general measurement for studying de- and reforestation, used by the Food and Agriculture Organization of the United Nations (FAO, 2020). Forest cover data is mainly gathered from the FAO and the World Bank to ensure some consistency over time (see the appendix for details on data sources). However, we triangulated the data with compilations from further scientific publications and reviews (Hedges et al., 2018; Pauleus and Aide, 2020). The FAO has conducted environmental assessments of forest conditions in the Global South since mid-century, with many of the studies including forest cover data for Haiti and the Dominican Republic. However, since the data collection and estimation technology evolved considerably during the 20th century, it should be noted that later estimations are more accurate than earlier ones. During early 2021, the World Bank data records on forest cover has substantially increased, also for past times, possibly due to a change in underlying FAO data. We maintain both sets of data. The forest cover measurements used include both primary and planted forest and recently planted forests that are expected to reach the height and density of the measurement indicators, but the exact measurements differ sligthly (see Results). By the research design, comparing the nations on one island should ensure that there are no large bio-physical or climatic differences between the countries.

For the explanatory variables, we use both qualitative and quantitative data. Regarding the hypothetical effect of colonial history on present day forest cover, we study the colonial remnants that have affected the political, economic, or cultural relation between society and nature. A primary focus is placed on the differences in the French and the Spanish colonial rule and their strategies on forest and land-related management. The hypothesis on human development and demography is operationalized through a combination of expected life expectancy at birth (World Bank, 2021), population density measurements (Our World in Data, 2021a), GDP per capita adjusted for price changes over time (inflation) and price differences between countries (Our World in Data, 2021b), and mean years of schooling (Our World in Data, 2021c). The local institutional context hypothesis is studied by reviewing literature on the countries' forest legislation, land tenure and ownership, and (in) equality in relation to de- and reforestation.

5. Results

In this chapter, the analysis is divided into two parts. First, longitudinal data of the dependent variable forest cover is presented and interpreted. Thereafter, the hypotheses on Hispaniolan de- and reforestation are analyzed by applying the dynamic case study approach.

5.1. Forest cover development on Hispaniola

The map in Fig. 1 shows a 2015 snapshot of the forest cover on both sides of the island, displaying a considerable difference between land covers, in particular regarding large scale grasslands on Haiti and large scale forest areas on the Dominican Republic. However, this snapshot does not cover the dynamics of land use change that has occurred. The deforestation on Hispaniola has a long history. There are, however, very few reliable sources for pre-colonial times. Pollen analysis points to extensive, small scale agro-forestry and increasing clear cuts and large scale plantation monocultures during colonial times (Castilla-Beltrán et al., 2020; Castilla-Beltrán et al., 2018; Higuera-Gundy et al., 1999; Hooghiemstra et al., 2018). Starting in the 1950 there are more recorded observations on forest cover on both sides of the island.

Fig. 2 shows that both countries had rapid deforestation after the second world war up until the mid 1980s. The Dominican Republic started off with about twice as high a percentage of forest covered land as Haiti in the 1960s. While the Dominican Republic started reforestation during the 1980s, Haiti keeps deforesting, but at a slower rate than before. From 1980 to 2015, the Dominican forest share increased from below 30% in the 1980's to more than 40% in 2018. The plotted Haitian trend shows a small increase for forest cover from the 1980s. This is rather driven by new satellite imagery data analysis that re-estimate the Haitian forest cover at substantially higher shares, partially driven by somewhat varying definitions of what constitutes a forest (Churches et al., 2014; Pauleus and Aide, 2020). There is however also contrasting evidence, at least for primary forest cover (Hedges et al., 2018). The two World Bank data sets show a slight ongoing decline from the 1990s onward.

The time-series thus indicates that some change must have occurred in the 1980s that caused Dominican Republic forest cover to start increasing and the country's forest cover development starts to diverge from Haiti's trend. We display this in Fig. 2 with the vertical dashed line in 1985, with a light shaded uncertainty period, and plot this in subsequent figures, too for better traceability. With this information on our dependent variable development, the subsequent analysis gains a specific timeframe against which the hypotheses can be tested with some accuracy in terms of establishing temporal sequences.

5.2. Natural causes of forest cover differences

While sharing an island, the geological, biogeographic, and climatic circumstances in Haiti and the Dominican Republic are not identical. Here, we present some of the corresponding differences.

The Dominican Republic geography is characterized by large plains, valleys and basins as well as the highest mountain range in the Caribbean (Wilson and Kluck, 2001), from which most surface water runs down on the Dominican side of the border (Diamond, 2005). There are higher mountain ranges on the Dominican Republic side, but the layers of different soils and altitudes are at an North-West to South-East angle (see Ramón and Méndez-Tejeda, 2017), and therefore not congruent with national borders, so this cannot fully explain forest cover differences.

The mixed forests on Hispaniola belong to the particularly biodiverse neotropical ecoregion, with wet forests in the North-Eastern lowlands on both sides of the island and predominantly pine forests in the higher altitudes with higher ranges on the Dominican Republic (WWF, 2022). Haiti however has a lower percentage of arable land, a higher portion of mountainous areas and has thinner soil layers, creating a higher soil erosion tendency than in the Dominican Republic (Wilson and Kluck, 2001; Smucker, 2001). Soil erosion can affect the likelihood of regrowth after deforestation and may therefore be relevant for the long-term developments.

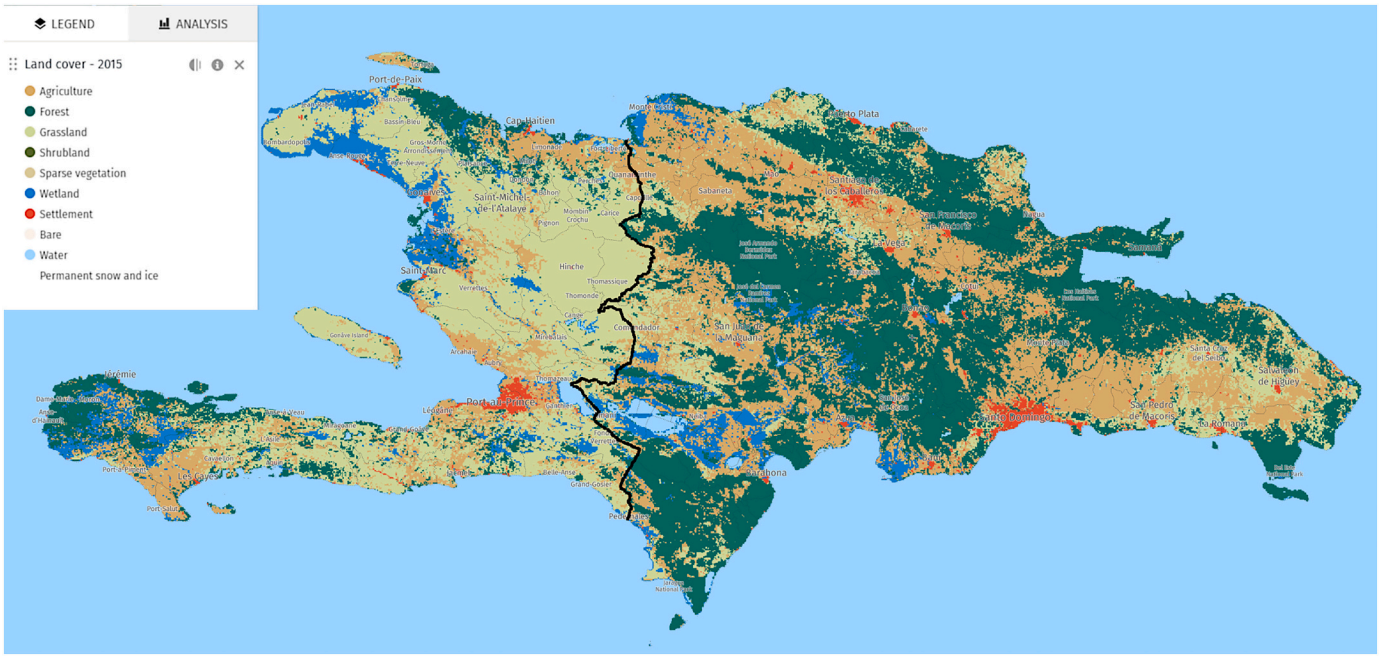

Fig. 1. Forest cover map in Haiti (left) and the Dominican Republic (right). The national borders are displayed in a black North-South line between 72 and 71W. In dark green (dark gray in grayscale imagery), the map displays 2015 tree cover at 300 m spatial resolution provided by ESA Climate Change Initiative - Land Cover data curated by UCLouvain (2017, version 2.07). Image source: an interactive visualization of the data can be explored at Global Forest Watch: https://gfw.global/36La6ky

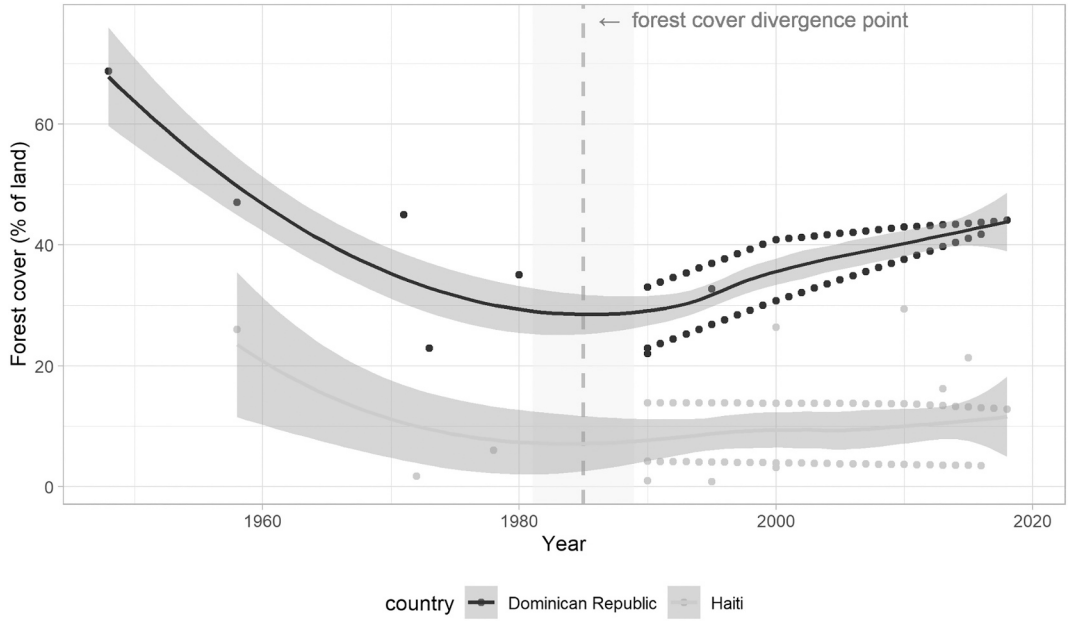

Fig. 2. Forest cover in Haiti and the Dominican Republic. Trends are plotted with a loess smoothing function. Double entries are due to a change in World Bank data with both values displayed. Further data sources are cited in Appendix 1.

Mean precipitation levels are generally comparable between the two countries, with slightly higher average levels in the Dominican Republic (Our World in Data, 2018; Jaramillo and Sancak, 2009). This is because Hispaniola is situated in the path of the Atlantic trade winds, which brings moisture from the North-East (cf. Diamond, 2005; Sanchez-Fung and Faria, 2009). When precipitation travels over the island, it falls down mainly on the north-east side of the mountain, creating a rain shadow on the Haitian areas West-South-West of the mountain range (cf. Alpert, 1942). When analyzing the dynamics of rainfall (see Fig. 3), there are similar movements along an oscillating weather pattern. There is however a longer gap between the two countries to be found around the 1970s until the 1990s. As this precedes the observed forest cover divergence in both countries, it may have helped the forest regrowth in the Dominican Republic through increased water availability. As the differences close again in the 1990s it is unlikely to have been the cause of continuous forest cover divergence.

In summary, geological, geographic and climatic elements are important natural conditions for forest cover in the two countries (see e.g. Lane et al., 2011 and Crausbay et al., 2015 for regional paleoclimatic analyses). Such factors may largely explain the countries' historic forest

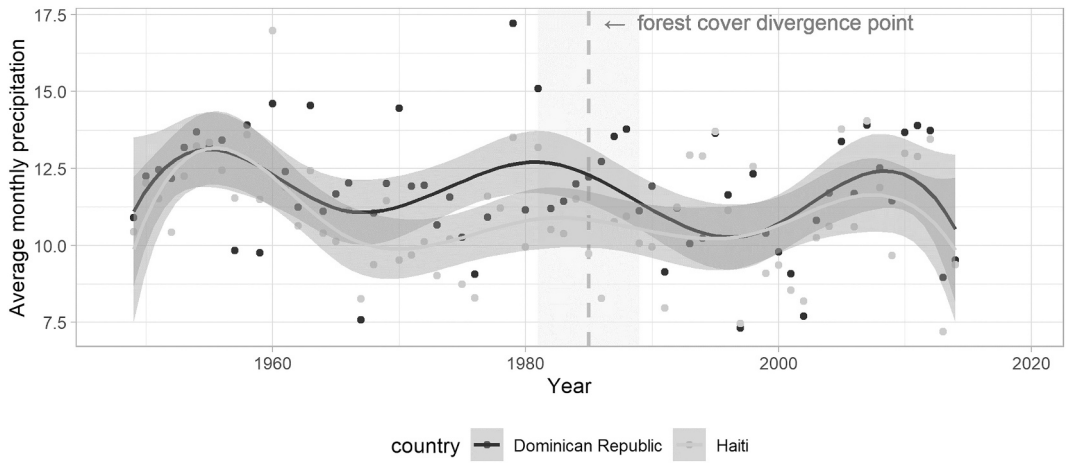

Fig. 3. Average monthly precipitation in Haiti and the Dominican Republic. Trends are plotted with a spline function of the sixth degree piecewise polynomial. Source (Our World in Data, 2018).

differences and may - while largely constant - also vary over time. Within the timeframe of a decade or so we would however argue that human-made land use change is far more dynamic and impactful. Diverging weather patterns may thus have helped but cannot fully explain the quick pace of reforestation in the Dominican Republic from the 1980s - which therefore must be partly human-induced but may well be exacerbated by weather variations (cf. Lane et al., 2009).

5.3. Socio-economic drivers of de- and reforestation on Hispaniola

In the following section, the hypotheses on Hispaniolan de- and reforestation are tested in relation to the development of the dependent variable. Here, the basic logic of inference is that a cause must precede a consequence in time. We present the analysis in three subsections on colonial history, human development and local institutions.

5.3.1. Colonial and younger history

Haiti and the Dominican Republic have both experienced colonial pasts. Both were colonized by Spain from 1492 until Haiti was occupied by France in 1697 (Greene, 2001). The colonizers' effect on forest cover is difficult to determine as there was no extensive forest cover documentation at the time. Recent studies on sediment records have however been able to determine area-specific historic land use developments in western Haiti and western Dominican Republic, close to the Haitian border (Castilla-Beltrán et al., 2020; Castilla-Beltrán et al., 2018; Higuera-Gundy et al., 1999; Hooghiemstra et al., 2018). Before the settlement of Spanish colonists, the land had been shaped by indigenous presence consisting mostly of subsistence farming and a development of slash-and-burn driven agro-forestry practices. The first changes following the start of the Spanish colonization in 1492 was the introduction of European cattle farming and the decimation of original indigenous population due to both spread of European-brought diseases and forced labour at mines at the centre of the island. The local population decline caused forest regrowth in the area (ibid.). As the Spanish colonizers found more profitable lands in South America during the 1500's, they lost interest in Hispaniola and the colony's economy stagnated. The settlement and the general pressure on the land decreased drastically. This situation persisted until the French seizure of the western part of the island, currently Haiti, in 1697 and the competition caused a renewed Spanish interest (Hartlyn, 2001). On both sides of the island, many areas on the island were cleared for agriculture, cattle farming, firewood and construction, causing wide-spread deforestation and watershed erosion (Castilla-Beltrán et al., 2018; Higuera-Gundy et al., 1999; Hooghiemstra et al., 2018). Between 1750 and present day, all studied ecosystems in the Dominican Republic and Haiti were severely degraded through deforestation (ibid.).

The French created a profitable economy built on slave labour-intensive agriculture, wood extraction and large-scale monoculture farming (Jean et al., 2021). They brought large numbers of enslaved West- and Central-African people to the island and began a harsh and intense colonial rule. Large cash-crop-plantations were established and the agricultural pressure was further intensified, causing rapid deforestation in the low-lands. The forests were also cleared to sell on domestic and international wood markets (Tarter et al., 2016). The French success partly spread to the neighbouring colony, and the bad Dominican economy was temporarily improved. The French colony was notorious for its cruel and abusive treatment and after over a century of French colonization on Hispaniola. The enslaved Haitians carried out the first successful slave revolution in the world in 1791 but with immense losses of almost half of the Haitian population (Hartlyn, 2001). At the end of the revolution, slave-run plantations were burned down to hinder reinstatement of slavery. With the newfound freedom, many Haitians settled in small communities in mountain areas. This move from the lowlands led to forest regrowth in the areas earlier used for plantations (Higuera-Gundy et al., 1999; Tarter et al., 2016). However, the reforestation trend did not continue for long. Following the independence in 1804, France had demanded reparations of 90 million francs. With the threat of war, the Haitian government was forced to accept the debt, which would usurp up to 80% of the national expenditure (Alcenat, 2021). To pay off the large debt, Haiti intensified tree cutting for timber all over the country (Tarter et al., 2016) and loaned money from European and U.S. banks. These loans were the start of what would become a long-term U.S. influence on Haiti's finances and politics (Alcenat, 2021). When Haiti struggled with paying off part of the loans U.S. forces invaded Haiti in 1915, backed by the Monroe Doctrine. A U.S. protectorate was established and a new Haitian constitution was enforced (Alcenat, 2021). Debt, anti-union policies and widespread food security issues led to large-scale labour migration. The loans financing the debt were not fully repaid until 1947 (Alscher, 2011). This is an example of how persistent direct effects of colonial history can be, but there may also be more indirect even more long-term colonial legacies.

The Dominican Republic had a smoother transition from colonial to younger history but not by much. After the French-Spanish power struggle over the reign of Hispaniola, the Spanish restored their power in the Dominican Republic in 1809 (Hartlyn, 2001). Independence was declared in 1844 but was contested up until the late 19th century (ibid.). The 20th century saw several (dictatorial) presidencies, and US intervention to prevent communism in 1965. Democratic reforms facilitated free(er) elections from the 1980s onward (ibid).

The colonial and younger histories of Haiti and the Dominican

Republic can explain a substantial part of the socio-economic, cultural and environmental differences in the countries, such as the different levels of forest cover at the beginning of the 1960's. That the Dominican Republic has developed more favourable capabilities for reforestation than Haiti, may well be a consequence of long-term socio-economic and ecological developments stemming from colonial presence, but this would rather be an indirect historical socio-ecological effect. Especially notable in this regard is however the Haitian independence debt to France and its long-term consequences on the local economy and thereby natural resource use in forests.

5.3.2. Human development and demography

The hypothesis on human development is operationalized through measurements of life expectancy, population density, GDP per capita, average years of schooling, and fossil fuel energy consumption. Fig. 4 shows that life expectancy has constantly been higher in the Dominican Republic than in Haiti and that it has increased similarly in both countries since the beginning of records in 1960. There are no changes that stand out in relation to the analysis' time frame of interest around the 1980s. The smooth development over time is due to a 5 year interpolation by the data-provider (World Bank, 2021, based on UN Population Division data). However divergent trends would nevertheless have shown. In addition, population density gives indications about general population growths.

Fig. 5 indicates a constantly higher population density in Haiti, but the countries' developments are fairly similar. They both experience a steady increase in population density throughout the time-period without any evident trend discrepancies, except a slight slope change in Haiti around the late 1970s. Since then, Haiti's population density has increased more than that of the Dominican Republican, causing the already existing gap to widen further. Regarding data quality, the data is based on age group cohorts and 5-year interpolations, which explains the smooth trends and shows general trends but not one-year events (World Bank, 2021). Overall, pressure from population trends may thus explain the generally lower forest cover in Haiti, but there is no obvious change that precedes the increase in forest cover in Dominican Republic from the 1980s. We therefore rule out population pressures as a cause for reforestation.

Fig. 6 shows that there is a notable initial difference between the countries' GDP per capita development. Before the 1970's the Dominican Republic was poorer than Haiti. From then, there has been a strong increase in national income per capita and in 2018 GDP per capita had increased almost six-fold compared to 1968. To the contrary, Haiti's GDP per capita rather decreased in constant international dollar terms. As the disparity in income started in the 1970, here is a first candidate explanatory factor for the reforestation 1980-onward in Dominican Republic. Temporally speaking there first was an increase in wealth from 1970 for diversified domestic production, then the reforestation started in the 1980s, and then economic development accelerated further, for example through the expansion in tourism in the late 1980s, early 1990s (Malik, 2001; Worrell, 1992). We seek to explain this development and its possible causal mechanism with regard to forest cover in the discussion.

Fig. 7 on years of schooling depicts a continuous increase on both sides of Hispaniola, with an accelerated trend starting in the 1970s. The data is compiled from various sources, for details see Our World in Data (2021c). There is a rather constant difference in education of about two years more in average school years in Dominican Republic. There is no obvious temporally coinciding disparity among the two countries that may explain the reforestation in the Dominican Republic from the 1980s.

Fig. 8 shows data compiled from the International Energy Agency, which in turn collects data from nation states through surveys (see World Bank, 2021 for further detail). Generally the fossil fuel energy consumption share in the Dominican Republic is generally higher than in Haiti. Additionally, there is an increase of this share, pushing its levels from below 60% around 1980 to above 85% in the 1990s. As this change coincides with if not precedes the reforestation in Dominican Republic, the substitution of fuel wood with fossil fuel as an energy source may explain reforestation through lower pressures. We will return to this in the discussion section.

5.3.3. Local institutional context

The local institutional context of communities that suffer from or contribute to deforestation currently differs widely between Haiti and the Dominican Republic but have somewhat similar histories. Before the forest cover changes that started in the 1980s, both countries suffered from unequal land distribution, insecure land tenancy and ownership rights, and marginal soil (de Ceara, 1986; Dolisca et al., 2007; IBP, 2013). They had a similar situation with urban elite being discriminatory towards rural and poor communities, as well as government services lacking in the countryside (Oxfam, 2010). However, ownership structures are different: the majority of Dominican forests are state owned (USAID, 2016) while most Haitian forests are private as a consequence of concessions for financing external debts (Tarter et al., 2016).

The Haitian land tenure system's legal framework is a mixture of remnants from French colonial legislation and later additions inspired by agricultural economy (IBP, 2013), and includes both formal and informal elements (Tarter et al., 2016). This confusion has resulted in many land disputes, land fragmentation and a disregard for formal regulations (ibid.). The Duvalier family ruled Haiti between 1957 and 86

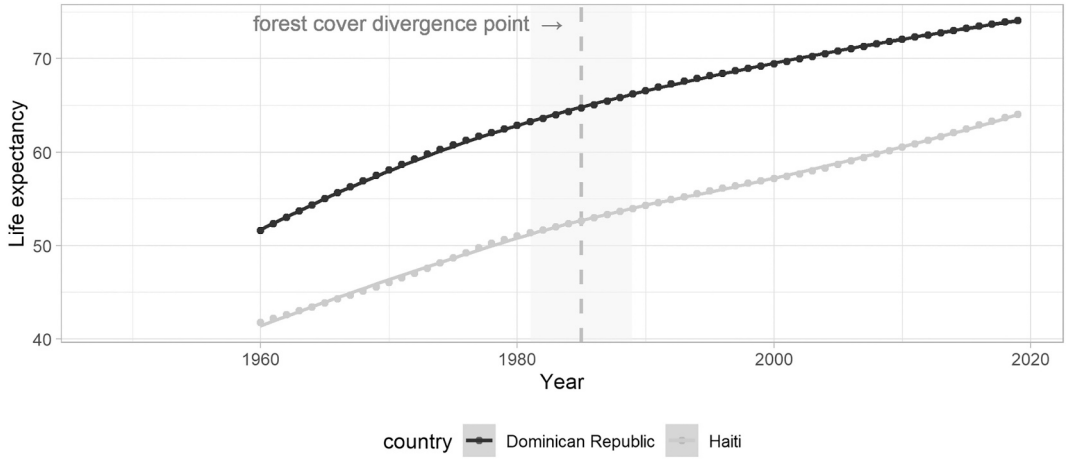

Fig. 4. Life expectancy at birth in total years. Trends are plotted with a loss function. Source: World Bank (2021).

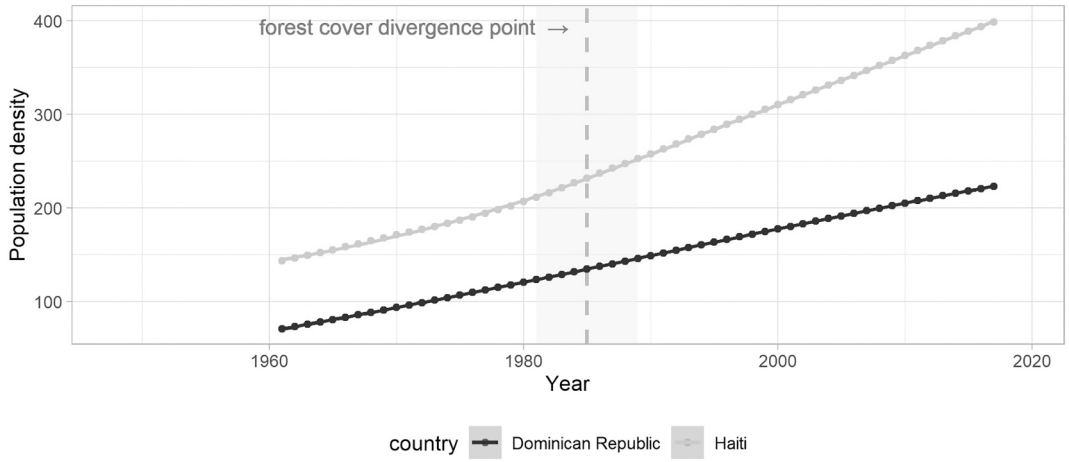

Fig. 5. Population density, people per km^2. Trends are plotted with a loss function. Source: (Our World in Data, 2021a).

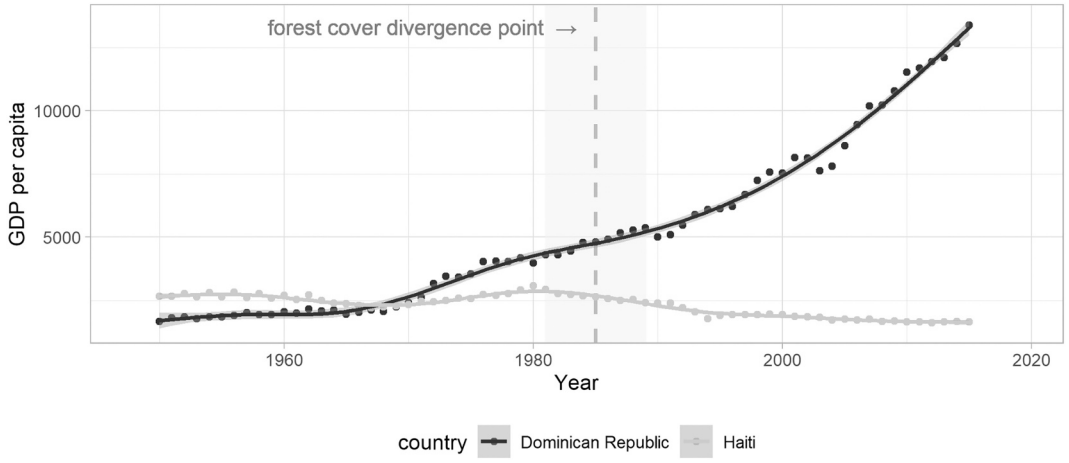

Fig. 6. GDP per capita adjusted for price changes over time (inflation) and price differences between countries, measured in international-$ in 2011 prices. Trends are smoothed with shrinkage cubic regression spline function of a generalized additive model. Source:(Our World in Data, 2021b).

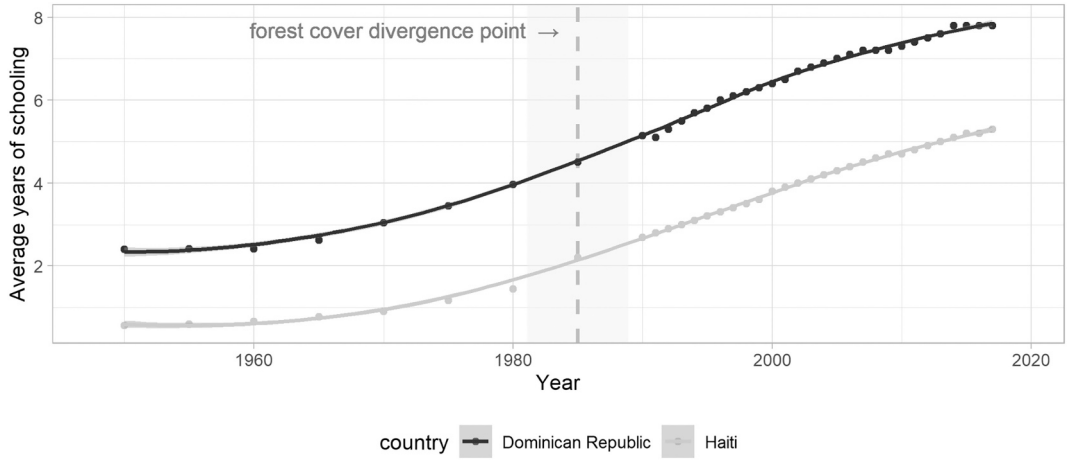

Fig. 7. Average total years of schooling for adults. Trends are plotted with a loss function. Source: (Our World in Data, 2021c).

and continuously encouraged the cutting of forests, primarily because it decreased the possibilities for opponents to form resistance bases in the forests, and because it was profitable to grant allies lucrative logging business (Greene, 2001). The country's largest reforestation program was set to start in 1980, but the reforestation efforts did not halt the deforestation development, as logging and tree cutting continued at a considerably high rate (ibid.). At the same time, there was no forest legislation that in any way protected forests from exploitation (FAO and UNEP, 1981). Following the end of the Duvalier rule, some efforts were made to reduce deforestation. In 1987, a law was passed that made it a

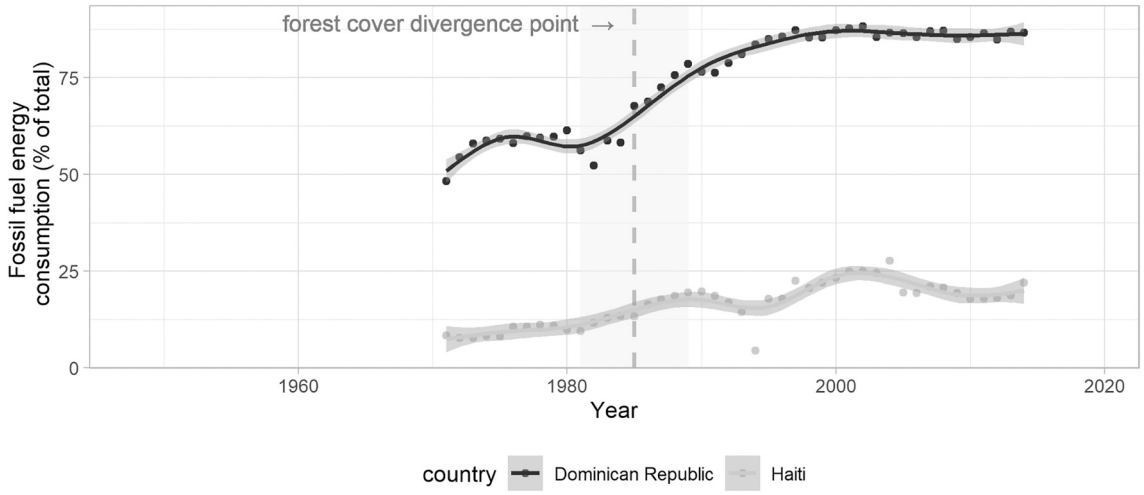

Fig. 8. Fossil fuel energy consumption (% of total). Trends are smoothed with shrinkage cubic regression spline function of a generalized additive model. Source: (World Bank, 2021).

sanctioned crime for landowners to contribute to soil erosion (ibid). In 1995, an institute for land reform was created but had mixed successes (Malik, 2001). Thereafter, there are not many initiatives aimed at reforestation or halting deforestation. Some attempts were made to strengthen women's land rights in 2006, but land- and forest initiatives are largely lacking from modern Haitian history (ibid.) In 2010, there were still no national policy or active national program in Haiti (FAO, 2010).

In the Dominican Republic, deforestation and land security had worsened during the Trujillo dictatorship (1930–1961) which allowed large-scale logging business to exhaust the soil and forcibly remove farmers from their lands. The fall of the regime was followed by several parallel events regarding deforestation and land use. An agrarian reform was commenced, through which over 409,000 ha of land would be redistributed between 1962 and 1990 (Hartlyn, 2001). The government attempted to stop the deteriorating deforestation by instating protected areas and banning commercial tree-felling on public lands and all tree-cutting without permit in 1967, causing the Dominican sawmills to close the same year (FAO, 1981). The strategy was to reduce deforestation through top-down control, and the laws were enforced by the military (Geilfus, 1998). This focus on the deforestation issue created a newfound appreciation for the forest and its importance for sustaining biodiversity and watersheds among the urban population who did not directly rely on the forest for income (Casanova, 1998). The rural experience was very different, and the authorities considered rural farmers to be environmentally ignorant and uneducated (Geilfus, 1998). The laws were harshly executed and detrimental for large parts of poor rural communities. Farmers could be jailed for cutting trees on their own land, and many were forced to pay to use their own wood (Geilfus, 1998). The laws failed to target the original causes of deforestation, and instead tried to terminate the poor population's access to the remaining forests (Dotzauer, 1993). Being dependent on forest resources, people started clearing land illegally. As tree cutting had suddenly become dangerous, the incentives for tree re-plantation had also decreased remarkably (OEA, 1984).

The harsh top-down approaches fostered a negative and suspicious perception of forestry, as any forest related activity risked the livelihood and safety of the farmer. The rural communities primarily criticized the land reforms for being badly managed, not transferring land ownership rights correctly and for providing marginal lands. Most of the redistributed lands were for example devoted to forestry and were not adequate for farming. While the mean farm size did decrease substantially because of the reform, the distribution was still very unequal with 2% of farms owning more than half of the country's farmland in 1981 (Geilfus, 1998). The general dissatisfaction caused a wave of land seizures in the mid-80's, which served as an awakening for the government that there was still much to do (USAID, 2016). From 1979, several new foreign and domestic reforestation initiatives started (Geilfus, 1998). In 1982, halting deforestation was deemed a national priority, and the government eased the access to forests again. In 1980 a new forest policy was issued that included increased resources, new reforestation initiatives, forest incentives and a forestry fund.

More reforestation initiatives were commenced throughout the 1980's, many with international funding (Malik, 2001) and new alternative, democratic approaches. They based their operations on the needs of the rural population, with concerns to their circumstances (Geilfus, 1998). Instead of focusing on top-down education, NGO projects such as the South-based initiative Environment and Development Action (ENDA-Caribe) in the Zambrana-Chacuey area in 1984, focused on economic opportunities for farmers through agroforestry and a participatory approach, including women's groups and rural federations (Rocheleau, 2005; Rocheleau et al., 2001). After several decades of soil exhaustion, land reform and illegal clearings, many in the poor rural population found themselves with small marginal plots of land at a time of low prices. The many technical and agri-forestry alternatives provided by such organizations encouraged smallholder farmers to incorporate forestry on their lands. Farmers became tree-farmers rather than "tree-haters" (Geilfus, 1998) and had thus transformed their relationship with forests. The farmer participation in such projects helped the government to change their perception of farmers and land degradation (ibid). This is evident in the 1987 sustainable forestry plan where the first aim was to enable a "*production and management of forest resources to meet the needs of rural areas and subsequently also surplus for sale and income generation*" (Casanova, 1998, p. 252, translated by authors).

The initiatives spread, and state projects started to incorporate similar approaches. Between 1990 and 1995, farm forestry increased remarkably (Geilfus, 1998), the government initiated the Forest Action Plan with the aim of achieving Dominican wood self-sufficiency (FAO, 2008). The perception of forests had become much more positive than a few years earlier, and their importance for the establishment of first ecotourism initiatives helped this further (Casanova, 1998). It therefore seems likely that this mix of and civil society driven approaches to develop alternative livelihoods and government initiatives to provide economic incentives, has spurred a positive trend in forest cover.

6. Summary

In Table 1 we provide a comparative summary of the factors

Table 1
A summary of comparative evidence for the difference in forest cover on Hispaniola and potential drivers.

	Haiti	Dominican Republic	Comparative Conclusion
Forest Cover	Continues to decrease until present day (or at least recently)	Starts to increase after deforestation in about the 1980s	The cause for Dominican Republic reforestation is to be found around the 1980s.
Natural forest cover causes	Partly in the rain shadow of the Cordillera Central. Potentially a higher soil erosion tendency.	Captures Atlantic trade-winds on the North-West of the Cordillera Central	Abiotic factors can explain a generally higher level of forest covers but not the dynamic divergence from the 1980s.
Colonial history	Under French occupation till at least 1791, U.S. invasion in 1915 and French colonial debts unpaid until 1947.	Independence from Spain in 1844 with a continued contestation, US intervention in 1965 and democratic reforms from the 1980s	Colonial history can explain historical difference, but not the dynamic divergence from the 1980s. However democratic reforms in the Dominican Republic may have played a role for reforestation.
Human development	Life expectancy is steadily increasing, as is population density.	Life expectancy is steadily increasing, as is population density.	Population pressures follow very similar development patters (but may explain constant differences).
Economic development	GDP per capita (in constant prices) does not rise.	Economic development starts increase in the 1970s and starts an exponential path in the 1980s.	Economic development in terms of broadening options for generating income may explain a decreasing pressure on forest resources in the Dominican Republic
Human capital	Schooling is steadily increasing.	Schooling is steadily increasing.	Educational factors follow very similar development patters (but may explain constant differences).
Energy consumption	Fossil fuel energy consumption rises slightly.	Fossil fuel energy consumption rises from just before the 1980s to a ~ 85% plateau from the 2000s.	Substitutes for fuel wood may have lowered the pressure on forest resources from the 1980s
Forest policies and local institutions	French colonial, insecure tenure system, reforestation programme in the 1980s but no forest conservation policy.	Agrarian reform from 1960s, and subsequent protect area designation and top-down command and control forest conservation. Policies based on improving livelihoods and economic opportunities from the 1980s, including South-South development cooperation. Larger scale agro-forestry approaches applied from the from the 1990s.	A mix of land-tenure reforms, centralized conservation initiatives, and economic instruments targeting income and opportunities, accompanied by cultural shifts and civil society cooperation has very likely played a decisive role in facilitating successful reforestation in the Dominican Republic.

presented in more detail above.

7. Discussion

The comparative dynamic process tracing allows us to test hypotheses derived from the literature. Results indicate that colonial history may explain historical disparities in forest cover between the two Hispaniolan states but not the divergence in terms of reforestation that started in the 1980s in the Dominican Republic but not in Haiti. Results also indicate that human development indicators such as life expectancy, population density and education have rather moved in parallel in both countries over the last 6–7 decades (Figs. 2,3,5) and can therefore also be ruled out as explanatory candidates for the forest cover divergence from the 1980s. There remain few factors that can explain the successful reforestation in the Dominican Republic. Here, we discuss them with a focus on possible causal mechanisms from a political ecology perspective, and present further research directions.

There was a slow increase in economic growth in the 1970s in the Dominican Republic, for domestic diversification and trade liberalization after the 1965 civil war (Malik, 2001), see Fig. 4. New economic opportunities arose from income diversification and more equitable wealth distribution and very likely led to reduced pressure on the Dominican forests because agriculture was no longer the only means of survival. In the 1980s there was a shift away from top-down regulatory approaches for forest protection, and towards more bottom-up initiatives based on principles of voluntariness and participation. This transformed rural relations with forests because they were now seen as a source of income and government elites' perceptions of rural population changed because they were no longer objecting policies (Geilfus, 1998). This coincides with the increase in forest cover that started around the 1980s and thus provides a plausible candidate for causal explanation. However, so does the increased consumption of fossil fuels (Fig. 6). Alternative energy sources to fuel wood would reasonably decrease the pressure on forests (on Haiti up to 70% of energy consumption if fuel wood based, cf. Smucker, 2001). Therefore, we cannot isolate a single cause for the reforestation in the Dominican Republic. Rather, it seems to be a mixture of factors that facilitated the overall transition away from an extractive towards a more sustainable relation with natural forests. Alternative sources of income, alternative sources of energy, and a bottom-up governance approach for forest conservation seem to have facilitated effective reforestation.

Such findings resonate with a political ecology perspective on marginalization of people and land; Marginalized people do not exhaust land because of ignorance, but for survival (Robbins, 2012). The circle of environmental and social marginalization can thus be broken by enabling people to choose differently without risking their economic or physical safety. While strict policies can get some results, such as the 1967 mill closing policy, a general change in perception and behavior was apparently rather possible through participatory approaches and policies. We would argue that to change the behavior of land users, their circumstances cannot be ignored but their livelihoods and opportunities need to improve for them to collaborate willingly and effectively in line with national priorities.

Here, we contribute to the literature that finds that it is a variety of drivers that cause people to cut down forests such as alternative land use for plantations (Austin et al., 2019), cattle ranching (Seymour and Harris, 2019), mining (Sonter et al., 2017), international demand for forest products (Lambin et al., 2018), or values (Rueda et al., 2017). We add by providing a systematic test of multiple hypotheses and a comprehensive analysis through a comparative political ecology perspective. We conducted a dynamic case study approach and can at least narrow down the candidate causal drivers to a governance mix that facilitates livelihoods while can reduce pressures on the environment through offering alternatives.

For the Hispaniolan case we provide evidence that it has been particularly effective by building on a bottom-up, participatory approach that does not neglect economic opportunities and lowers risks rather than increases them. For the case of the Dominican Republic, partially successful responses to the oil crises, orthodox economic adjustment policies, and direct regulations such as bans on fuel wood production led to decrease in deforestation. Effective reforestation was built around projects such as the Zambrana-Chacuey region initiative that were designed with both long-term environmental and short-term social welfare gains in mind. Possibly its south-south learning approach also facilitates a project design that matched local livelihood realities. The softer policy approach in the 80's, such as creating economic incentives and informational campaigns both domestic and south-south learning set the base for subsequent reforestation. Economic opportunities in e.g. tourism, enabled a transition with more sustainable forestry and led to a diversification of the economy. Large-scale

government investments in reforestation in the 90's helped increase the forest cover further. While this delivers an empirically grounded answer to our research question, this nevertheless instigates some further research questions on the Hispaniola case such as: How far are developments in the 1970 like the economic liberalization, starting democratization, and institutional changes like national forest conservation policies a precondition for the subsequent reforestation that occurred from the 1980s onward? Are all forest areas within the island following the same trajectories of change? Are plantations of introduced species, rather than native forests, becoming predominant? Is ecotourism indeed a multiplier of emerging reforestation? What is the role of transnational governance, development aid, and North-South relations? What are the biodiversity effects of introduced agro-forestry species (cf. Dawson et al., 2013)?

Regarding external validity, we can only provide some cautious thoughts, particularly on the suitability of the method for other cases and potential ways forward. As the two countries on Hispaniola share some similarities with other developing countries in the tropics, namely a colonial history, a somewhat constraint, often extractive model of economic development, a high dependency on international lenders, and a generally high natural vegetation potential, our findings may be of some relevance when it comes to fostering reforestation in such countries. In particular, it would require a dynamic, i.e. a temporal perspective to trace changes over time, in conjunction with a comparative perspective between administrative units such as countries or regions, to facilitate the dynamic comparative case study approach that we used. This could well be expanded by a more regionally detailed approach to trace land cover change (see e.g. Pauleus and Aide, 2020).

As a concluding remark, the political ecology of Hispaniola and its two country's forests show that livelihoods of those who most depend on forests through either income, primary production or in some other way, are a crucial leverage point. By offering them alternatives, pressures may be eased, and forest conservation initiatives possibly gain more track.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

The conception of this paper is based on MM's Bachelor thesis under ND's supervision. The original draft of the paper was then co-developed. For further specification see the author statement. We thank Christie Nicoson, Georgia de Leeuw, David Heidenblatt, and two anonymous reviewers for the constructive feedback and helpful comments that improved the paper substantially.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.forpol.2022.102765.

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