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Testing the long-term sustainable development of a Central American country

The Genuine Savings of Costa Rica between 1890 and 2015

by

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Abstract

The purpose of this study is to test the sustainable development of Costa Rica between 1890 and 2015 based on Genuine Savings. The Genuine Savings estimations are composed of indicators on fixed capital, natural capital, and human capital. Indicators for this study were built with data from several sources including local and international projects, as well as governmental data. The data was then adapted and assembled to obtain all the components of Genuine Savings. The results suggest that the Genuine Savings of Costa Rica have increased over the whole period. During the first part of the 20th century, the savings were highly volatile due to irregular fixed capital investments and natural resources exploitation. However, the data supports the view that Costa Rica has been on a sustainable development path since 1950 according to the weak sustainability paradigm, and that capital accumulation was mostly led by fixed capital investments. The results also show that Costa Rica's savings, similarly to other Latin American countries, have significantly fallen during the debt crisis of the 1980s. This study finds that intangible capital such as education and technological change also participated in the increase of the Costa Rican Genuine Savings. Natural capital was expected to show a clear positive contribution to the savings based on the unusual and innovative conservation policies implemented in the country. Yet, in the 21st century, the reforestation benefits are outweighed by the social cost of the increasing CO_2 emissions. Overall, this study provides a new long-term analysis of weak sustainable development in Costa Rica and enables a better understanding of the country's development path. It is also the first Genuine Savings estimation for Costa Rica that covers a one hundred twenty-five year period.

Keywords: Genuine Savings, Weak Sustainability, Natural Capital, Development, Costa Rica

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To my grandparents…

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Abbreviations

ANS: Adjusted Net Savings

BCCR: Banco Central de Costa Rica

FAO: Food and Agriculture Organization for the United Nations

FDI: Foreign Direct Investment

FONAFIFO: Fondo Nacional de Financiamiento Forestal de Costa Rica

GDP: Gross Domestic Product

GFCF: Gross Fixed Capital Formation

GNI: Gross National Income

GS: Genuine Savings

ISI: Import Substitution Industrialization

NNI: Net National Investment

NNS: Net National Savings

PWT: Penn World Table

SNA: System of National Accounts

TFP: Total Factor Productivity

UCR: Universidad de Costa Rica

WB: World Bank

WWI: World War I

WWII: World War II

1 Introduction

Costa Rica declared the right to a healthy environment in 1994 (Morera, 2011), counts with one of the five blue zones of the world – five areas where people show remarkable longevity (Poulain, Herm & Pes, 2013), and plans to become a net zero-carbon emitter by 2050 (Timperley, 2020). These singularities are broadcasted around the world, and the country is often taken as an example of sustainability (The Guardian, 2021). Beyond the impressive headlines, there are investments, policies, and changes in economic dynamics which make it an interesting case study.

For decades, biologists and environmental scientists have been tracking biodiversity and ecological systems (Snow, 1977) and anthropologists study indigenous groups, rural and urban populations, demographic change (Madsen, 1951); more recently development economists, together with development agencies and international organizations, have created panel data seeking to identify growth trends in all Central American countries (Victor, 1985). Fewer are the authors who have painted a global picture of the economic situation of the country taking into account the knowledge on social and environmental dynamics and the role of natural resources in economic changes. By looking at Costa Rica through the prism of traditional economic indicators only, one misses out on major mid- to long-term development aspects. First, because the economy of the region is immensely linked to commodity exportation (Infante-Amate, Urrego Mesa & Tello Aragay, 2020), most of which are finite resources (minerals) or decreasing in quality when regenerating (forests, soils), making the model not sustainable in time. Second, because Latin America is home to a large part of the world's biodiversity and forest, thus a dramatic diminution thereof is a loss for the whole world (Infante-Amate, Urrego Mesa & Tello Aragay, 2020). Third, because Costa Rica has implemented important social and environmental policies which are linked to the country's economy. It has reoriented its development model towards a less resource-intensive economy and found other ways to take advantage of its natural capital, notably tourism and sustainable agriculture. In other words, merging the knowledge on natural resources and the knowledge on economic development is essential to understand the fundamental changes in the country. However, there are also some obstacles lying on the way to a comprehensive capital accounting, mainly that human and natural capital mostly have a non-market value. Even though many censuses on natural capital exist, estimating the monetary worth of resources remains at the center of the debates in environmental economics (Castro-Arce, Parra & Vanclay, 2019; Hein et al., 2016; Moreno Díaz, 2020).

For three decades, macroeconomists have sought to create a comprehensive stock accounting for Costa Rica (Orozco, 1996). In 1991, from a collaboration between Costa Rican and USA institutes, a pioneer study was published, with the purpose to integrate natural capital into Costa Rica's national account. It covered the period from 1970 to 1989. Unfortunately, this initial work did not grow to see a follow-up. In the same decade, the World Bank (WB) (1996) started working with various scholars to build Adjusted Net Savings (ANS) series for a large number of countries. It is one of the best-established national sustainability indicators. That project has evolved but is still ongoing today, with data on human and natural capital covering the period 1970 up to the present time (World Bank, 2021)

Today, Costa Rica counts many governmental agencies in charge of the management of different natural resources, consequently, data on exploitation and conservation is decentralized. Until recently, there was no natural capital accounting at the national level. However, in 2012, a unit in charge of compiling three types of natural capital indicators has been created at the Banco Central de Costa Rica (BCCR). This unit started as a common project between the Costa Rican government and the Wealth Accounting and Valuation of Ecosystem Services program from the WB (WAVES, 2017) but has evolved to a permanent unit of the BCCR. Their work is still at its premises. Today they have only published data on water usage, forest cover, and energy flows between 2011 and 2017. No comprehensive accounting has been made based on the data published by the BCCR (2021). Apart from a few short-term punctual economic analyses including natural capital, there has been no national sustainable accounting done for Costa Rica.

This summary of the existing projects on sustainable macroeconomic indicators in Costa Rica reveals three gaps in the literature:

- Natural capital series for Costa Rica are short- to mid-term but no study has been conducted on the 20th century and beyond, especially none of them look at the change in capital wealth during the first part of the century when heavy exploitation of natural resources happened, nor in the period around the civil war, where major policies changes were implemented.
- Natural capital was sometimes included in the national accounting of Costa Rica, but seldom was the human capital, another major aspect of sustainability.
- The studies of comprehensive wealth done internationally, for example ANS by the WB (2021), present national series but the analysis is regional and not specific to the case of Costa Rica. An in-depth analysis of the national case brings a better understanding of the trends. In addition, the WB's series do not account for total factor productivity (TFP) (Blum, Ducoing & McLaughlin, 2017).

Based on these literature gaps, the present thesis aims to create a long-term sustainable quantitative indicator for Costa Rica and observe the macroeconomic performances of the country.

This will be done by gathering data on fixed, natural, and human capitals, creating a dataset, and calculating the Genuine Savings (GS) of Costa Rica between 1890 and 2015. GS is a sustainable indicator building on wealth accounting methods and very similar to the WB's ANS (Lange, Wodon & Carey, 2018). GS relies on the idea that sustainability is the non-declining consumption capacity across generations and, that to maintain the consumption capacity, total capital must also be maintained (Hamilton & Clemens, 1999).

To account for total capital, GS complements the Net National Savings (NNS) indicator with proxies of natural capital, human capital, and sometimes technological change. Therefore, one objective of this research is to build a unique dataset on the country's multiple capital endowments. This thesis also has an objective to shed new light on the history of Costa Rica by discussing its sustainable development in the long run. Finally, this research envisions to give a practical example of the use of GS as a sustainability indicator for a small country that has implemented capital conservation policies for several decades.

The contributions from this thesis are multiple. First and foremost, it compiles data from various sources into one multiple capital dataset that is highly usable for further historical analysis or forecasts. Second, this paper offers an in-depth discussion on how to establish a natural capital estimate for Costa Rica. It also highlights the importance and limits of including carbon emission in wealth accounting. Third, it participates in the discussion on the development of a well-being indicator with the practical example of GS in Costa Rica. Over the last years, gross domestic product (GDP) and gross national income (GNI) have lost much of their power and credibility as an indicator of national performances, and alternative indicators are flourishing. In this context, GS comes as an interesting alternative, although many methodological limits remain, especially regarding indicators of natural capital. Fourth, if one recognizes that GS is among the most viable, accurate, and applicable alternative to GDP (Hanley et al., 2016), this research extends by 80 years the WB's measures and offer new perspectives on the impact of natural and human capital over the development of Costa Rica. Costa Rica is a particularly interesting candidate for a long-term analysis of GS because, even though it is located in a region that has endured centuries of natural resources exploitation, it has some of the world's most advanced conservation policies and a great part of the development of the country is related to the exploitation or conservation of the natural capital.

To fulfill the above-mentioned objectives, the research questions are the following:

RQ1: To what extend has Costa Rica been a sustainable country between 1890 and 2015?

RQ2: To what extend did natural capital and human capital influence the genuine savings of Costa Rica?

RQ1 directly addresses the numerous publications on environmental policies and environmental progress of Costa Rica. This question is an attempt to verify or invalidate Costa Rica's highly praised sustainable path. Costa Rica's sustainable history was marked by various turning points: the mining cycle of 1880-1930, the arrival of Figueres to the presidency after the civil war of 1948 who increased social investments, and the 1980s when the country counted with the smallest total forest area of its history (Fondo Nacional de Financiamiento Forestal de Costa Rica, 2016) and a pending objective of net-zero emissions for the first decades of the 21st century. All these events probably influenced the national savings. RQ2 seeks to decompose the elements of sustainable development.

This research has the ambition of offering a historic national account for Costa Rica over a hundred twenty-five years. Due to the scarcity and imprecision of the available data before this date, extending the historical series before 1890 was out of the scope of this study. Following previous studies on GS, this research adjusts NNS with human capital and natural capital but leaves out other forms of capital such as social or health capital. The main limitation of this research is the accuracy of early data. The other limitation is of course embodied in the constraints of establishing a monetary value of natural and human capital. Understanding the context of Costa Rica allows to build country-tailored indicators, however, parts of these capitals are intangible and count with many uncountable or inestimable aspects that cannot be capture in GS. Furthermore, a deep change in the market price of a resource can affect the trend when the extraction rate has only known a marginal change. Regardless of these limits, GS has been tested many times by scholars and international organizations (Hamilton, 2005; McGrath, Hynes & McHale, 2019) and has proved efficient to measure weak sustainability. Furthermore, the results presented in the paper are consistent with the historical events and with other studies. Therefore, even if those limits have to be kept in mind, the data and analysis presented in this paper are still deemed solid.

The thesis is structured as follows: Chapter 2 examines the literature by first discussing Central American and Costa Rican economic history and then by considering the theory of GS through its main authors. Chapter 3 presents the sources and calculations behind every GS component. Chapter 4 presents the method used to calculate savings. Chapter 5 shows and contextualizes the main results and compares them to other studies. Chapter 6 discusses the achievements and limits to sustainable performances and puts them into perspective based on structural and political changes. Chapter 7 offers concluding remarks and possibilities for future research.

2 Literature Review

2.1 Previous Research

2.1.1 Latin America as a commodity exporter

Oftentimes, historians attempt to date the start of natural resource destruction and exploitations in Latin America. Goebel (2013) summarizes the debate into two main trends: On the one hand, authors argue that natural resource exploitation started with colonization, international trade, and the rise of the western economic model (Castro, 2005). On the other hand, a minority of authors defend the idea that the demographic change in the indigenous population already created pressure on natural resources before the arrival of the Spaniards (Miller, 2007). Either way, Latin American history is deeply linked to what is commonly referred to as the *resource curse*. The region is abundant in mineral, timber, and other natural resources, and as a consequence of history, became the first provider of commodities in the world, relatively to its inhabitants (Infante-Amate, Urrego Mesa & Tello Aragay, 2020). This perpetual extraction and exploitation of resources and the economic dependency on developed countries through the trade of raw material is argued to be the source of economic struggle and the limited industrialization of the continent (Haggard, 1990). Between 1930 and 1980 Latin America attempted development based on Import Substitution Industrialization (ISI). With the increasingly strong liberal leaderships, a change occurred in the 80s' towards international markets (Infante-Amate, Urrego Mesa & Tello Aragay, 2020). Because of low industrialization rates and the focus on the exportation of non-manufactured goods, many countries are today, still bearing the burden of a negative balance of trade. The dependence of each country on the exportation of a small variety of products made them highly vulnerable to crisis and dependent on the world's economic health. Furthermore, Bulmer-Thomas (1983) argues that, due to the export-led model, shifts in strategies and production sectors provoked political instability, which on the long run hindered economic development.

In a recent paper, Infante-Amate, Urrego Mesa, and Tello Aragay (2020) deconstruct the Latin American international exchange flow to show that the declining terms of trade have development and environmental consequences. They highlight that Latin American has always exported more raw material than it has imported, in line with the comparative advantage theory cited by Bulmer-Thomas (1983). Therefore, the continent has been central in fueling the worldwide dramatic increase in production and consumption. Depending on the region and the extracted commodity, issues over the exploitation varied from disputes about externalities (for example pollution of the water) to conflicts over the control of the product (Infante-Amate, Urrego Mesa & Tello Aragay, 2020). Central America is an importer of fossil fuels but an exporter of biomass (agricultural product mostly). Natural capital tends to be unevenly distributed, increasing inequality. Nevertheless, Andersson and Palacio (2019) remind us that land is usually distributed in a more equal way than other natural resources, meaning that development based on agriculture is more likely to be inclusive. Furthermore. they argue that Latin American has lived an inclusive commodity boom in the 2000s because of the important investments in the agricultural sector (favored by external conditions) and the linkages between the agricultural sector and the industrial or the service sector. Yet, Infante-Amate, Urrego Mesa and Tello Aragay (2020) denounce the environmental destruction attributable to agriculture due to the intensive culture and the usage of polluting pesticides.

Since the 2000s, Latin America experiences a significant augmentation of its agricultural output, mostly due to investments and an increase in productivity (Andersson & Palacio, 2019). In parallel, it also observes a growth of its service sector at the cost of the manufacturing sector. This trend is observable in Costa Rica as will be discussed next.

2.1.2 Structural change in Costa Rica

Bulmer-Thomas (2003) offers one of the most comprehensive datasets of economic indicators in the long-term for all Latin American states. He highlights absence of systematic economic data before 1950 for most countries. However, the 'Proyecto de Historia Económica de Costa Rica en el siglo XX' [Project on the Economic History of Costa Rica during the XXth century] by León and Arroyo (2010) from the Universidad de Costa Rica (UCR) offers a deep dive, in the form of four books, into Costa Rica's political economy and growth dynamics throughout the 20th century. Their work is probably the most extensive study of the different aspects of production and consumption in the country before and during industrialization. They argue that importations are a good indicator of consumption in the first part of the 20th century because the country did not count on important manufactures. Thus, consumption in Costa Rica was unstable and very much dependent on international events. Until 1950, import and export are the only macroeconomic indicators available for the country, for the second part of the century, GDP figures are available.

Since colonization, international trade has been an important aspect of the Costa Rican economy. As shown in the following two paragraphs, most authors agree that the openness of the economy and the diversification of exportations are central to Costa Rica's economic health. During the Spanish domination, Costa Rica specialized in tobacco production. In 1821, Costa Rica was declared independent and in the same period, they inaugurated ports to increase international trade. Looking at international markets, coffee producers increased their output in the Central Valle and for the next one hundred years, the country's economic system relied on coffee production (Leon & Peters, 2019). The supremacy of the crop impacted the political system because large coffee producers held all powers in their hands. Smallholders also saw their situation improve as the international demand for Costa Rican coffee increased throughout the 19th and 20th centuries.

Based on this good economic start which allowed to build infrastructure and establish commercial relations with the US and Europe, Costa Rica added banana crops to its export basket (Leon & Peters, 2019). Andersson and Palacio (2019) highlight that Costa Rica is among the few Latin American countries that achieved diversification of their production within the agricultural sector during the 20th century: from coffee to banana to pineapple. Regardless, the

Costa Rican economy was greatly affected by the global crises between 1914 and 1945, followed by national instability. In Costa Rica, a few powerful coffee producers had ruled the country for decades, granting little social rights to the working classes. Yet, the successive global crises during the first part of the century reduced the power of the coffee oligarchy and the population started claiming more equality and democracy (Molina, 2005). The political weakness of the Coffee Barons opened the door to an unlikely alliance between the Catholic Church, the Republican party, and the Marxist party in the 1940s. This new leadership already established a more socially oriented system but without really fulfilling the people’s demands. In 1948, voices started to rise against the alliance, and among them José Figueres Ferrer, soon-to-be Leader of the Revolution. Figueres fomented a coup against the President which turned into a civil war that lasted less than a year.

Once peace was restored, with Figueres assuming the role of president, economic growth resumed based on agricultural export. Coffee and banana were the leading crops and the coffee boom gave Costa Rica a head start in industrialization (Barboza & Cordero, 2005). Following South America, Central America adopted a strategy of import substitution for industrialization (ISI) in the 1960s. It was based on a regional trade agreement and infrastructure development. This new strategy was beneficial to Costa Rica for two decades until the crises of the ’80s. Following the crises, Costa Rica abandoned the ISI model and reoriented its economy towards medium- to high-skilled industries. This new strategy decreased its dependence on raw material exports and thus its vulnerability to external crises.

Most authors concurred that the renouncement of the ISI model benefited Costa Rica’s economy. As highlighted in the Food and Agriculture Organization (FAO) report (Canle, Garcia & Canle, 2018), Costa Rica has managed to reduce its dependence on banana, coffee, sugar, and pineapple exportation during the period 1970 to 2011. Nevertheless, Barboza & Cordero (2005) argue that coffee and banana should benefit from a better exchange rate or lower tax to be more competitive. In 2018, agriculture corresponds to a little less than 40% of Costa Rica’s exports while tourism is estimated to be 11,3%. In Costa Rica, touristic activities are centered on eco-tourism and nature tourism, meaning that natural capital is an important component of Costa Rica’s interest for tourists (Canle, Garcia & Canle, 2018). According to Barboza & Cordero (2005), TFP barely increased since 1953 and economic growth is imputable to factor accumulation, not to an increase of efficiency. Leon and Peters (2019) also observe an important increase in national demand during the second part of the 20th century.

The authors mentioned above offer detailed analyses of the trade and industrialization processes but barely discuss the exploitation of natural resources, conservation policies, and education strategy.

2.1.3 Political changes in Costa Rica

The story of Costa Rica is unique compared to its neighbors because it has known political stability for decades and high economic development. In 2019 it was invited to become the fourth Latin American country to join the OECD. Various authors attempted to explain Costa Rica's path. One of the most productive authors of Costa Rica’s social and political history is

Molina. He analyses the creation of democracy through the electoral reformation in Costa Rica. The well-established election process in Costa Rica is argued to be a contributor to national stability; the democratic model encouraged social reforms in favor of the citizens rather than the rich landowners (Molina, 2005). This model notably allowed for investments in education, the central theme of another of Molina's publications (2017) who found that education is a key aspect of Costa Rica's diminishing agricultural production.

A recent and unusual study attracted attention in Costa Rica and internationally as it offered a counterfactual analysis of the development of Costa Rica in light of its early abolition of the military forces (Abaraca & Ramírez, 2018). The abolition of the army in 1949, right after the civil war led by José Figueres Ferrer was motivated by the fear of bearing another coup, by the presence of the American hegemon at the dawn of the Cold War and by a will to send a strong message to the population about a new socially-oriented regime. According to Abaraca and Ramírez's findings, even if the abolition of the army was not motivated by economic concerns, it had some economic effect on the budget and the socio-economic strategy. After the civil war and throughout the second part of the 20^{th}, Costa Rica's politics was increasingly oriented towards environmental protection which partly contributed to the growth of (nature) tourism, an essential aspect of the national economy (Moreno Díaz et al., 2011). However, Costa Rica still faced major ecological issues. According to Orozco (1996, p.8), the environmental problems in Central America and Costa Rica can be classified into three dimensions: unsustainable land use, waste and pollution, and unsustainable energy structure.

In this context, we understand why it is particularly relevant to include natural depletion and human capital in national accounting.

2.1.4 Natural capital in Costa Rica's national accounting

Various attempts to include natural resources in national accounting have been made without any success to get established as an accepted accounting method (Araya, 2013). Most notable is probably *Accounts overdue: natural Resource Depreciation in Costa Rica* (Solorzano et al., 1991) which attempts to include natural resources depletion based on forestry, soil and fishery into the System of National Accounts (SNA) between 1970 and 1989. In 1996, Orozco notes that the state-of-the-art lacks tools and methods to conduct empirical macroeconomic studies including environmental indicators. Such a tool would allow to better define the causality between economy, environment, and institutional decision-making. Since then, a large effort has been done in trying to value the natural capital of Costa Rica through quantitative and qualitative methods but no consensus has been reached about the accounting methods (Moreno Díaz, 2020).

Hamilton and Clemens (1999) calculate GS for developing countries between 1970 and 1993 based on the WB data. They find that Latin American performance on GS is correlated with the global oil crisis and is affected by political crises. The high-income countries show high GS rates but this should be put into perspective with the fact that those economies are (no longer) dependent on primary good production and exportation as acknowledged by Hamilton and Clemens (1999). Hanley, Dupuy, and Mclaughlin (2015) mention that Latin America has often been analyzed as a region but GS at the country level is still scarce. Precursors in offering national accounts estimations adjusted for sustainability, Pearce, and Atkinson (1993) include the depreciation of natural and productive capital to calculate the savings of eighteen countries, including Costa Rica which they classify as sustainable because the countries' savings are higher than its capital depletion. The other Latin American country to appear in their analysis is Mexico which is ranked as marginally sustainable due to its high depletion rates.

Since then, Costa Rica has appeared among various bundles of countries when GS was constructed for large panel datasets[1]. To our knowledge, no analysis of Costa Rica's long-term development path has been done in light of the GS approach which can help to understand the dynamics between development and conservation in the long term.

2.2 Theoretical Approach

GDP, often controlled for population growth, is the most widely used indicator of economic growth, mostly because of the ease of access to data. Since the 1990s, criticisms are rising against GDP as a sole indicator of growth (World Economic Forum, 2020). This movement opened the door to intense debates on how to generate new economic statistics. Development scholars are active in the search for alternatives indices focusing on human variables such as life expectancy, freedom, and access to resources[2]. An increasingly discussed approach is well-being, especially in light of the work of Amartya Sen (2007) on well-being capabilities. The problem with those indicators is that they require data that is extremely complex to obtain such as qualitative data. They are also very context-dependent which diminishes the possibility for cross-regional comparisons.

Seeking to find a viable and simple alternative to GDP, many authors have drawn attention to the possibility to include natural capital and human capital, two essential factors of present and future well-being, in the SNA. The UN's System of Environmental-Economic Accounting is the first international comprehensive wealth accounting method but has several flaws such as lack of homogenous conceptualization (United Nations, 2014). One of the solutions has been to look at GS, theoretically described by Hamilton and Clemens (1999, p.336) as the "investment in produced assets and human capital, less the value of depletion of natural resources and the value of accumulated pollutants". GS has been made famous with its use by the WB (1997) and is increasingly used by economic scholars and the private sector. The rest of chapter 2 offers a theoretical discussion on the debates regarding the construction and the use of GS as an alternative to GDP.

2.2.1 Sustainability, intergeneration well-being, and GS

With the idea of greening the economy, appeared two different schools of thought: environmental economics and ecological economics. The former takes its roots in neoclassical

[1] E.g.: Ferreira and Vincent (2005).
[2] See Comim (2016) for a detailed summary of Human Development Indices

theories and argues for weak sustainability while the latter rejects neoclassical theory and argues for strong sustainability. Environmental economics often receives criticism for not departing from the growth theory and not advocating for environmental protection (Tisdell, 1997).

In a weak sustainability paradigm, all capitals (i.e.: produced, intangible, natural, human) are perfectly substitutable (Neumayer, 2013) according to Solow's (1956) factors substitution assumption. Following the Hartwick rule, offsetting declining stocks of exhaustible resources with reproducible capital allows for intergenerational equality (Hartwick, 1977), thus, a nation can accumulate its savings in any form of capital, provided that depletion is taken into account. This means that weak sustainability is achieved with non-declining total wealth. The early writings on sustainable development economics suggested that total natural capital should be non-declining meaning that there should not be environmental damages (Pearce, Barbier & Markandya, 1990). However, scholars have moved to argue that natural capital depletion can happen if the cost is borne by the economy, thus natural capital should be reinvested in other forms of capital to maintain total capital stock (Hanley et al., 2016).

Instead, the strong sustainability paradigm claims that exhaustible natural capital cannot be substituted by produced capital., Thus, to qualify as sustainable, an economy's natural capital must be non-decreasing (Hanley, Dupuy & Mclaughlin, 2015). This approach rejects neoclassical theories and capital approaches to sustainability and defends a non-monetary value of nature (Goebel, 2013). Some scholars argue that there exists a critical natural capital that can be estimated according to its usage (Ekins et al., 2003). That capital should be unconditionally conserved to avoid irreversible changes.

Although academic debates insist on a radical distinction between monetary and non-monetary approaches, in reality, policy-makers tend to include both of them in their decision-making (Engelbrecht, 2016). Following one or the other paradigm is a choice since neither paradigm has been proven true or false (Neumayer, 2013). GS is considered to be a weak sustainability approach. It is distant from strong sustainability because it allows for the substitution of natural capital by fixed capital. It contrasts with neoclassical growth models because it is centered on consumption capacity instead of production and because it pays attention to nature and intangible capital (Ferreira, Hamilton & Vincent, 2008). This comprehensive approach, putting environment and knowledge on the same level as production, make GS an interesting tool in the debate regarding sustainable approaches to economics.

2.2.2 Debates on comprehensive wealth estimations

The formation of fixed capital is the only form of investment for future available assets that are included in the SNA (Bolt, Matete & Clemens, 2002). NNS is the depreciation of fixed assets deducted from investments and represents the first step to a sustainable indicator replacing GDP (Hamilton & Clemens, 1999). GS enhances the sustainability aspect of NNS by adding other components of wealth.

Comprehensive wealth accounting consists of an index of all capital possessed by a country. Dasgupta (2009) argues that comprehensive wealth reflects well-being if shadow prices are held constant. GS is then an assessment of changes in wealth according to the chosen shadow prices and reflecting the consumption capacities. According to Hanley, Dupuy & Mclaughlin (2015, p.783), "the rate of change of comprehensive wealth (i.e.GS) will indicate evolutions in intergenerational well-being".

A body of literature challenges the assumption of ever-increasing consumption made by GS scholars, arguing for its incompatibility with sustainable principles. Even scholars using GS warn against the "consumption peak". A scenario where GS is growing faster than its real interest rate will necessarily peak and decline (Hanley, Dupuy & Mclaughlin, 2015). An alternative to the consumption-based approach of GS is Inclusive Wealth Accounting based on the deduction of the multiple capital depletion from GDP (Arrow et al., 2012). In policymaking, these methods are mostly used by UNEP and UNU-IHDP (Muñoz et al., 2014). Neither provides an accurate tool according to Engelbrecht's (2016) empirical comparison of both methodologies. Mainly because neither permits to distinguish between critical and non-critical natural capitals and also both overlook some intangible capital such as social and institutional.

2.2.3 Debates on capital stock valuation

In Pearce and Atkinson's (1993) paper, laying the first stone for GS, national accounting is adjusted with consumption and natural capital. Later on, human capital also became a standard factor of comprehensive wealth which is consistent since man-made capital is nothing without the appropriate knowledge (Tisdell, 1997).

Hanley, Dupuy & Mclaughlin (2015) defend the idea that two time-dependent factors have to be taken into account when computing GS: technical change and population growth. They present technical change as a form of capital and argue that technical progress is "unequivocally good for sustainability" (p.787) because it improves resource allocation and can also serve to balance out produced capital depreciation. Ecological economists, however, do not consider technological change as having a systematically positive impact, notably because of the use of natural resources in the development process (Tisdell, 1997). Controlling for population growth in GS started in the early 2000s. Although population growth increases human capital, Hanley, Dupuy & Mclaughlin argue that it also increases total resource consumption and the pressure on future well-being (2015). Yet, when testing for wealth dissolution in developing countries, Ferreira, Hamilton & Vincent (2008) found that population change is not significant. The impact of population change over time only has a marginal role in explaining the correlation between current savings and future well-being in developing countries. Thus, the focus should rather be on improving national account data and natural capital data (Ferreira, Hamilton & Vincent, 2008).

Fixed capital accounting is measured according to the NNS indicator, a commonly accepted indicator of fixed capital, calculated as the difference between gross fixed capital formation (GFCF) and public and private consumption (Bolt, Matete & Clemens, 2002). Natural capital and human capital are subject to more debates.

Natural capital

Whether to give a monetary value to the "gifts of nature" (Hanley, Dupuy & Mclaughlin, 2015, p.779) is a major dispute. For example, there is a divide between those who argue that a forest should be protected for its intrinsic value and those who defend protection for its instrumental value (Castro-Arce, Parra & Vanclay, 2019). According to the weak sustainability paradigm, natural resources are treated as any other form of capital and can be valued on a monetary scale. How to put a number on nature is another debate that has as attracted even more attention. The following paragraphs present various methods to value natural capital with a focus on the discussion among GS scholars.

The first studies giving an economic value to forests had an objective to map the forest exploitation possibilities (Goebel, 2013). During the 20th century and the birth of tourism, the value of natural scenery was also recognized. In environmental economics, natural capital valuation often builds from the ecosystem services theory which postulates that natural capital provides services to human beings for survival and well-being, for example through freshwater, clean air, or even sceneries (Kandziora, Burkhard & Müller, 2013). These services are often divided into four categories according to the UN framework (United Nations, 2020): Provisioning services (ex: food), Regulating services (ex: disease), Cultural (ex: educational), Supporting (ex: biomass production). This method has been applied to Costa Rica by many authors[3] however they require a large amount of data, often qualitative data too, which limits their usage. They also do not reflect the market value and sometimes have been misleading in policymaking (Moreno Díaz, 2020). Although this methodology serves to give a rather comprehensive overview of the national natural capital, it is not suitable for the GS estimations because of its complexity and qualitative approach. Another method proposed by the UN has been to value environmental degradation according to its cost of restoration (Hamilton & Clemens, 1999), however, this method involves important assumptions and the impossibility to give a positive value to natural capital.

For Hamilton and Clemens (1999), the reduction of natural capital is shown by the resource rents (revenues of trading a certain resource) from the extraction of nonrenewable resources (minerals, oil, natural gas, coal) and the depletion value of forests that were not replaced. They recognize that the absence of soil erosion and fish stock changes in their analysis is a weakness, especially in agricultural and fishery societies. According to Bolt, Matete, and Clemens (2002), resource rents of mineral and energy sources should be calculated as the market value of the extracted material subtracted from the average extraction cost. Atkinson and Hamilton (2007) highlight that the market prices of natural resources tend to remain constant or diminish, which is counter-intuitive in regards to the resources' increasing scarcity. A non-changing price, sometimes estimated as present value, is problematic because it means that extensive extraction until exhaustion is optimal and thus natural capital owners have an incentive to use up the resources. In GS analysis, many authors use the Hotelling rule to calculate rent (Ferreira da Cunha & Missemer, 2020), meaning that changes in rent are equivalent to the changes in interest rates (van der Ploeg, 2010).

[3] E.g.:Rothenhäusler, 2021; Hein et al., 2016

Atkinson and Hamilton (2007, tab.1) report on some common practices among GS scholars for natural capital accounting based on user cost. All methods assume constant resource prices but vary the extraction prices. The *total rent approach* subtracts gross rents at a constant price to a constant marginal cost of extraction. The *marginal rent approach* argues for an increasing marginal extraction cost. However, the authors highlight that this approach holds the main drawback that it implies an optimum extraction plan, which is rarely the case. The *exhaustion approach* estimates marginal cost based on the exhaustion point and the optimal extraction process. The *quasi-optimal approach* calculates increasing marginal costs of extraction based on elasticity. According to Labat, Román, and Willebald (2019), the most common method of natural asset valuation is the Perpetual Inventory method which looks at investment flows and at the present discounted value of future net income flows generated by an asset. They use a method of valuation based on annual variation to account for both depleted and created assets.

Bolt, Matete, and Clemens (2002) argue that forest rent should only be accounted for the wood extraction that is not replaced with regrowth. In this approach, a forest that is well managed, meaning wood exploitation can happen but replacement is ensured, is considered sustainable. However, this argument overlooks the necessary time to reforest, the fact that a timber forest does not have the same environmental properties such as the capacity to absorb CO^2 and to contribute to soil regeneration. Furthermore, forest exploitation also comes with potential irreversible damages to biodiversity (Oubraham & Zaccour, 2018). Unlike other resources, the elimination of forestry creates a new resource which is cropland (Goebel, 2011) meaning that deforestation might be motivated by either (or both) demand for soil or wood. However, if the land is no longer used, a forest can be replanted which makes it a renewable resource.

Damages of pollutants

One of the most controversial and uncertain aspects of environmental accounting is air and water degradation, mostly caused by emission and pollution. In their comprehensive assessment of human-induced perturbation of the *Earth system*, Rockström et al. (2009) name many consequences of emissions on the ecosystem such as ocean acidification or pollution, which can have an impact on human well-being. In practice, most environmental economic studies only accounting for CO_2 emissions (Atkinson & Hamilton, 2007) effects on climate change because it is one of the most observable, quantifiable aspects of emissions, even though it is still marked with high uncertainty on long-term consequences and tipping points (Labat, Román & Willebald, 2019). Hamilton and Clemens (1999) argue that the damage of pollution on produced assets is included in the depreciation term and damages are included in the SNA. Therefore, the adjustment on emissions serves to account for welfare change and can be valued as the willingness to pay to avoid suffering from pollution. Yet, the usage has taken another path. In policy-making, including CO_2 emissions in the analysis is sometimes done by deciding on a maximum threshold. For example, the IPCC Reports (Masson-Delmotte et al., 2018) presents different climate warming scenarios allowing countries to decide on a strategy according to a preferred scenario (European Commission, 2021). Inclusion of emissions into economic and financial analysis is based on shadow prices on carbon emissions (Atkinson & Hamilton, 2007) because it allows to easily vary the level of emissions and the price. It is also convenient for cross-country comparisons. Pricing, derived from the social cost of carbon calculation, is discussed and criticized by many actors: from some policymakers who call out on measuring a national question with a global scale (Q&A: The Social Cost of Carbon, 2017) to scholars who argue that it misestimates the real impact of emissions (Ferreira & Vincent, 2005). Virtually all scholars working on savings agree that one of the reasons why GS indicators are often showing inaccurate sustainable behavior is because of the inadequate pricing of carbon emission (Kunnas et al., 2014).

One major aspect of carbon pricing is the use of a discount rate, justified by the smaller effect of emissions in earlier times and by the uncertainty of the consequences of emissions in future times. While most authors (Nordhaus, 2014; Pezzey, 2019) agree that a discount rate is needed to calculate carbon costs over time, the only scholars who use constant prices are McLaughlin et al. (2012) as they are using exceptionally long-term series, yet they do not recommend it. There is no consensus on whether the discount rate should be constant or declining and which variables should influence the rating (Anthoff, Tol & Yohe, 2009; Pezzey & Burke, 2014). The debate rather revolves around future estimations and scholars try to assess the risks in a situation of high uncertainty (Guo et al., 2006). In the end, every scholar uses their method or index, although usually derived from the GDP deflator. For past estimations, the WB uses a standard 3% per year discount rate (Lange, Wodon & Carey, 2018) which is also adopted by various recent and important studies (Rothenhäusler, 2021).

Human capital

According to Bolt, Matete & Clements' (2002), traditional saving measures only integrated fixed capital investment, and education was labeled as consumption not explicitly considered. However, they argue that, given the importance of knowledge and skills in economic development, education has to be referred to as human capital. Human capital is embodied in knowledge and institutional capital such as culture and governance (Tisdell, 1997) yet the most common indicator of human capital is education expenditure (Hamilton & Clemens, 1999) because knowledge tends to disappear without a constant sharing strategy and the main tool for its preservation is education (Tisdell, 1997).

Molina covers the educative history of Costa Rica since 1869 when primary school became free and compulsory. He argues that primary and secondary education is mostly powered by the public system (Molina, 2018). On the other hand, Trejos (2014) found that in 2013 a household would spend on average 239.256 Colones per month to provide private education to members of the house. This private investment also contributes to increasing human capital.

According to Ferreira and Vincent (2005), the poor capacity of educational expenditure to measure human capital is a major limit to the use of GS as an indicator of future well-being. In a comparative analysis between Argentina, Mexico, and Costa Rica on the future perspectives for a knowledge-based economy, Mungaray-Moctezuma, Perez-Nuñez, and Lopez-Leyva (2015, p.225) present "education and human resources" as a combination of literacy, college enrollment, and public expenditure. They also highlight that education is not the only component of growth, but stable institutions, innovation strategies, and communication tools to share knowledge are equally essential. Using data from 2007 to 2010, they found that Costa Rica shows good performances but still has a large margin for improvement in the field of education. Chen Quesada et al (2018) conducted a systematic analysis of the influence of education in sustainable development and also concluded that education not embedded in a functioning and innovative system, loses its effect. They also emphasize the need to educate children on sustainability with qualified faculty members.

2.2.4 Empirical applications of Genuine Savings

Originally, adjusted saving estimations served as an alternative to GDP and to measure well-being at a *t* moment (Hamilton & Clemens, 1999). Hanley, Dupuy, and Mclaughlin (2015) present GS as a way to predict future well-being in a country or a region. However, they emphasize the fact that it is a poor indicator of the future if not enough capitals are taken into account or if the past period is too short. They also highlight the utility of GS to understand the development path of a country according to its characteristics and history.

GS is especially interesting to use in low- and middle-income countries to understand the paradox of low growth in resource-abundant countries. Ferreira and Vincent (2005) found that for non-OECD countries, GS for a given year is correlated with consumption change in the decade. This relation did not verify in OECD countries. Comparing GS across a large set of resource-abundant countries, van der Ploeg (2010) argues that the Hartwick rule and the estimations or resource rent according to the Hotelling rule are distorted by unfair distributions of resources and benefits due to corruption, the limited rule of law, and instability. Therefore, some resource-abundant countries which should be benefiting from extraction and export of resources by increasing private capital consumption do not see a positive effect of the extraction because of the absence of reinvestments of the rents. He concludes that resource-abundant countries with high population growth rates should have a positive saving rate to maintain well-being.

Hanley, Dupuy, and Mclaughlin (2015) offer a concise overview of the major analysis with GS and conclude that comparison of GS results across studies is virtually impossible because they all use different estimations. Nevertheless, most studies seem to report that countries can achieve weak sustainability in the long term as shown by non-declining GS. Going in the same direction, Engelbrecht (2016) argues that comprehensive wealth analysis as done by the WB is not suitable for cross-country comparison because it is not adjusted to purchasing power parity. Therefore, the analysis is better done across time for one country or region because it is adjusted at a constant exchange rate. Blum, Ducoing and McLaughlin (2017) also argue that a global GS indicator would be relevant since CO_2 emissions are global.

Most authors meet in saying that long-term analysis is missing at the national level and such an analysis would allow for an in-depth understanding of the countries individual development path (Hanley, Dupuy & Mclaughlin, 2015). Recently, GS regains interest and scholars have used it to understand the long-term economic history of a nation. Blum, Ducoing, and McLaughlin (2017) constructed data on six developed countries and five resource-abundant Latin-American countries for the period 1900 to 2000. They show the importance of the national stories and the macroeconomic events. Labat, Román, and Willebald (2019) build the GS trend for Uruguay from 1870 to 2014 and find that the savings of the countries are decreasing. This is likely due to the large part of the economy dedicated to agro-exploitation, confirming the theories on the discrepancy of natural resources due to exportation. Qasim, Oxley, and Mclaughlin (2020) studied New Zealand between 1950 – 2015 and observed a constant positive GS for the whole period. Larissa et al. (2020) in a study on the GS in the 21st century in Eastern Europe and the Baltic country found that there often, but not always, is a link between economic growth and environmental damages. In one direction, there are scenarios of compensation of the natural resources damages with GS and in the other direction, all environmental damages produce growth. Finally, Grath, Hynes, and McHale (2020) constructed a long-term GS indicator for Ireland which allows them to highlight the essential role of the institution in increasing savings.

In sum, the previous literature review showed the need to have a more comprehensive approach to national accounting by including human and natural capital to tend towards sustainability. It also discussed the previous attempts to value the non-tradable capital and include it in national accounting methods. However, it also highlights the absence of comprehensive accounting for Costa Rica in the long run.

3 Data

To establish the data series between 1890-2015, this research has mostly used secondary data from Costa Rican researchers adapted to the purpose of the study. Some of the series have their latest year completed with primary data from governmental institutions.

3.1 Productive capital estimation

NNS is an indicator of produced capital when accounted for the depletion of capital over time (Figure 1). Concretely, net investment is obtained by subtracting fixed capital consumption from the GFCF and adding overseas investment to the result (Bolt, Matete & Clemens, 2002). GFCF has been calculated by various scholars for different periods.

In an article published by the CEPAL, Tafunell (2013) presents an index of GFCF in terms of investment between 1856 and 1950 for most countries of the Americas including Costa Rica. The same paper proposes a way to distinguish capital in the form of machinery and equipment, and in the form of construction. Consumption of machinery and equipment was calculated following Tafunell (2013) and Consumption of construction capital was computed based on the standard depression rate presented in Tafunell and Ducoing (2016). Both series of consumption were then removed from the GFCF to obtain net capital formation. This method admits certain approximations, especially regarding capital consumption. Yet, the results are still deemed highly representative of the Net National Investment (NNI) of Costa Rica given that all measures and estimations are based on reliable sources.

For the period 1951-2015, the variable capital stock at constant prices from the Penn World Table (PWT) version 10.0 (Groningen Growth and Development Centre, 2021) is used and NNI is calculated as the yearly difference. This source is highly reliable and representative based on the size of the project and the preciseness of the indicators. Finally, overseas investments as a foreign direct investment (FDI) as measured by León Sáenz and Arroyo Blanco (2010) were added to the NNI to obtain NNS. Figure 1 shows investments in fixed capital and overseas investments. It displays negative values for the year 1981 which means that in 1981 depletion of fixed capital was higher than investments in fixed capital, which is consistent with the debt crisis of that period.

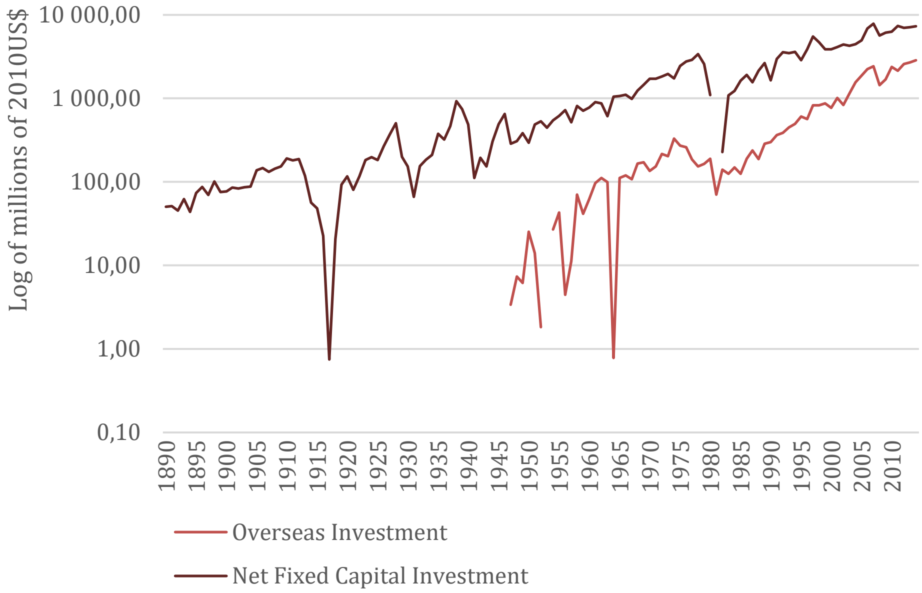

Figure 1: National and overseas capital investment

Source: own calculation from Tafunell (2013); Gröningen Growth and Development Centre (2021); León and Arroyo (2010)

3.2 Natural capital indicators and estimations

In GS, natural capital is often conceptualized into two aspects: air degradation and depletion of natural resources. The WB only accounts for wood and mineral extraction but most GS scholars include forest, mineral and energy, and fishery extraction in their analysis (Atkinson & Hamilton, 2007). The proxies for natural capital are the resource rents which are the revenues from the extraction and trade of that resource. In the following paragraphs, this conceptualization is discussed and adapted to Costa Rica's situation. Indicators and data sources are explained.

3.2.1 Forest

In GS, forest resource rents are calculated with the variation of woodland converted into volume and multiplied by the yearly market price of Latin American wood. Forest and wood are probably the natural resources that have the largest impact on Costa Rica's economy both in terms of exploitation and conservation.

Numbers of national bureaus and scientists have already studied the shrinking and growing of the Costa Rican forest and there are many possible sources to construct series on forest coverage. However, there is significant variation in woodland accounting across sources including discussions on whether wood areas are actually increasing in recent years (Montero et al., 2021). These debates are due to two main factors, first, because every author adopts a different definition of forest (mangroves, dry forest, etc.) and whether or not extractive forests are considered as forest areas; second because accounting has often been made with satellite images at different point of time and that older pictures are not as accurate as of the recent observations (Kleinn, Corrales & Morales, 2002; Rothenhäusler, 2021). Furthermore, data on forest coverage are punctually collected meaning that there are some gaps, and it is often expressed in percentage of coverage meaning that it bears with approximations.

To build the most accurate series on woodland change, we plotted the data from five different governmental and scholarly sources (Figure 2):

- Fondo Nacional de Financiamiento Forestal (FONAFIFO) (2016)
- El sector forestal de Costa Rica: Antecedentes y perspectivas (Fournier, 1985)
- Forest area in Costa Rica: A comparative study of tropical forest cover estimates over time (Kleinn, Corrales & Morales, 2002)
- Bosque, cobertura y recursos forestales 2008 (Calvo-Alvarado et al., 2009)
- Cuentas ambientales (BCCR, 2021)

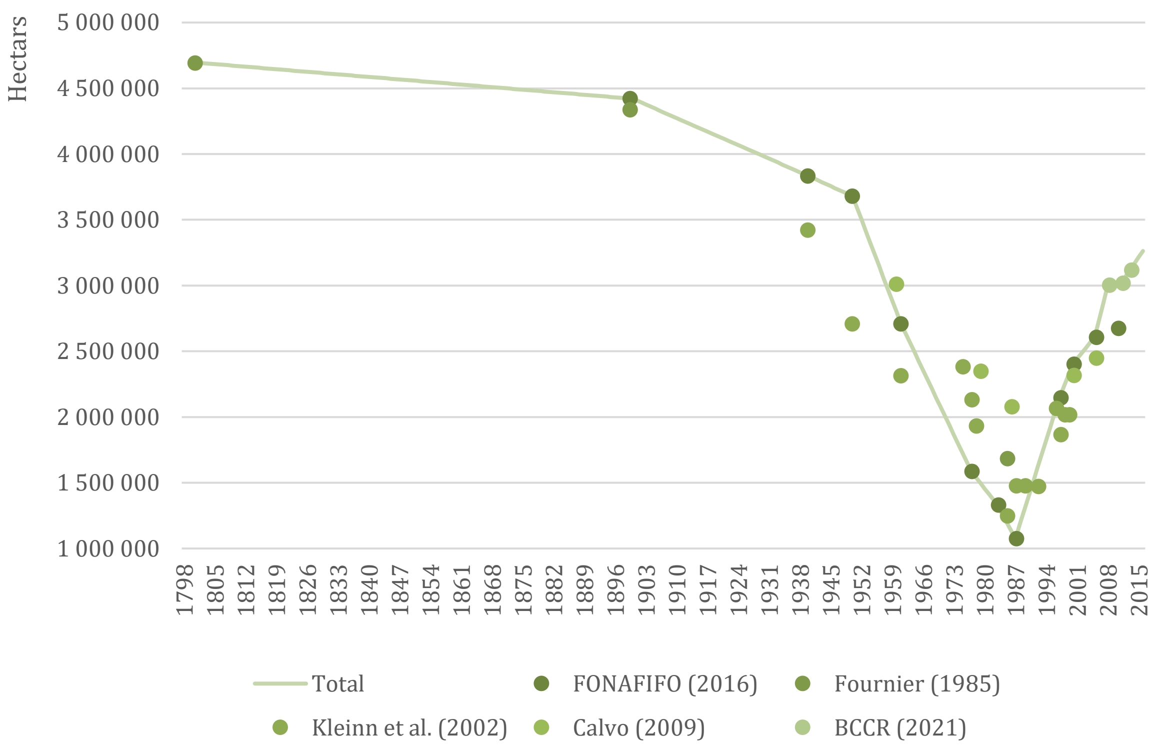

Figure 2: Forest coverage in hectares according to five sources

Based on this, we observe that the data from the FONAFIFO offers the most plausible data and it is also a reliable source. However, the data come in the form of widely broadcast maps with percentages of forest cover, which required a conversion based on the total size of the country (51100km^2).

The earlier estimation from the FONAFIFO dated back to 1898, we expended the series based on Fournier's estimation given the similarity with the FONAFIFO data in 1898. The latest

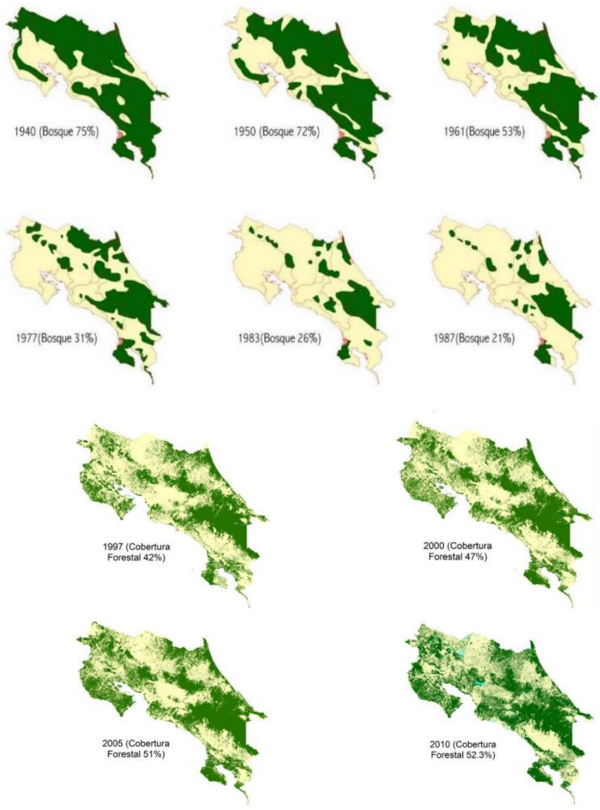

Figure 3: Forest cover of Costa Rica as mapped by FONAFIFO

Source: FONAFIFO (2016)

observation from FONAFIFO is in 2010. Since 2008 the BCCR has been generating natural capital accounting data by collaborating with the other actors, among which FONAFIFO. We, therefore, use their estimates from 2008 on, since it is the most recent available data. Based on these punctual observations, we derive the yearly woodland change for the whole period.

From the woodland variation, we derive the variation in the volume of wood according to the FAO's (2000) conversion estimates for Costa Rica. The conversion estimates indicate the volume of wood that can, on average, be extracted by square meters of Costa Rican forest, based on its density. Then we multiply the volume change by the price of timber in Latin America according to the FAO timber pricing (2010) to obtain the forest resource rents from Costa Rica. As reported in section 2.2 of this paper, most authors argue that rents should be diminished from the extraction costs. However, many authors argue that wood extraction is done at a low cost (BCCR, 2021; Goebel, 2013), explaining its popularity as raw material and as a source of energy. Therefore, the extraction cost of wood is not considered in this study. This is reinforced by the fact that data on the extraction cost of wood is scarce since most authors consider it neglectable.

Rents from deforestation should not be considered as an accurate measure of forest revenues but as a reliable proxy for forest depletion. Goebel (2013) argues that deforestation in Costa Rica is motivated by foreign demand for cheap wood but also by the local need for energy, especially with the growing agricultural sector and it is partly due to the need for more land for coffee crops and cattle (ed. Charles A.S. Hall, Carlos Leon Perez & Gregoire Leclerc, 2000).

The wood that is removed to create cultivable soil is not always marketable. In this respect, it cannot be argued that all deforested areas generate direct monetary revenue, but sometimes create a new form of natural capital and thus new consumption possibilities in the form of cultivable land. Thus, it is acceptable to use rent as a proxy for savings.

3.2.2 Minerals and energy

In the 19th century, small reserves of oil have been discovered in the Caribbean region of Costa Rica and but their exploitation only started in the 1960s and was very soon at the center of environmental debates leading to a moratory issued in 2002 (Pier, 2020). Since then, no oil has been extracted in Costa Rica. Given the small extracted quantities, the short period, and the fact that the contribution of oil to the economy is so neglectable that it has hardly ever been mentioned in scholarly analysis, the present study will overlook energy resources extraction as an indicator of natural depletion. Gonzalez (2003) found that since 1921, petroleum takes over coal as Costa Rica's main source of energy but, since the resources are mostly imported, this will rather be reflected in CO_2 emission damages.

Although at a rather small-scale, non-energetic mineral extraction did take place in Costa Rica, especially gold, silver, and magnesium. Mining in Costa Rica has known three high periods: 1820-1850, 1880-1940, and 1980-2010. After this period, the industry shrank. It briefly reappeared at the beginning of the 2000s only to be prohibited a few years later (Figure 4). Data on the exportation of mining is available from 1884 to 1977 (León & Arroyo, 2010). Exportation is deemed a representative proxy of extraction since most companies were financed by Norther American capital for the same market (Araya, 1976).

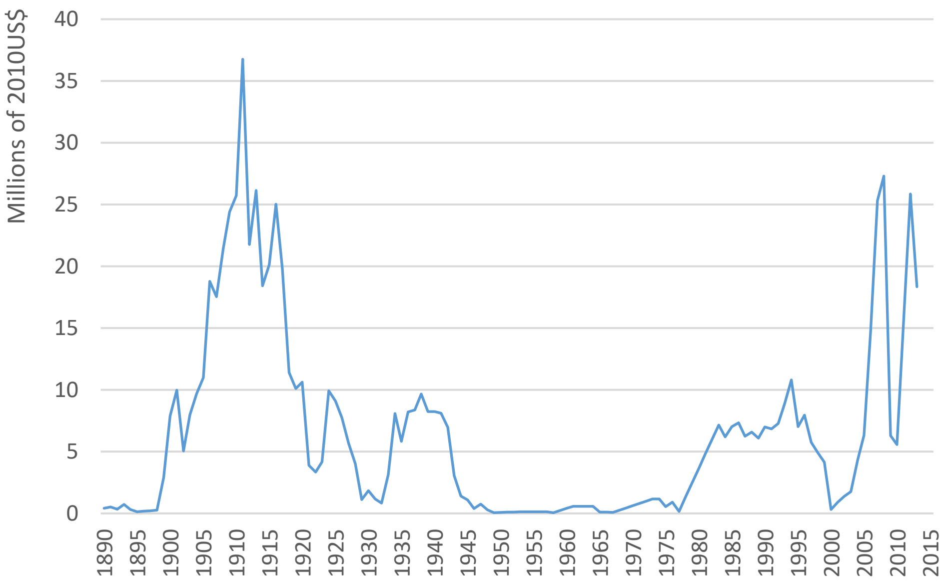

Figure 4: Net rents from mineral extraction

Source: Own calculation, Data from León and Arroyo (2010); Arauz (2014)

Unlike wood exploitation, mineral extraction requires capital investment. Araya (1976) argues that, in Costa Rica, the main cost of mineral extraction is not labor, which is almost neglectable in the two first mining cycles but is buying machinery. Data on labor in mines is never available because most workers were immigrants from mining countries such as Honduras or Perú. Because the turnover was high most of them do not appear in the statistics (León, Arroyo & Montero, 2016). Investment in machinery started in the 20th century. Before that, capital and technological improvements were almost entirely invested in the monoculture of coffee. Data on the importation of mining material is available from 1903 to 1946 which is a good proxy given that most fixed capital from mining was provided by the US during the second mining cycle. Equipment cost was subtracted to export to obtain net rents from mineral extraction between 1884 and 1977.

The gold extraction continued after the second mining cycle and until the moratory on mining that was issued in 2010 (Costa Rica Primero de América Latina En Prohibir Minería de Oro a Cielo Abierto, 2010). Arauz (2014) shows the gold extraction in kg and the international prices of gold for the period 1983 until the activity ceases in 2013. In the same article Arauz argues that the extraction is mostly artisanal and in open sky mines and thus cost of extraction is not deduced. The interval between 1977 and 1983 is linearly extrapolated. (Figure 4).

3.2.3 Total resources accounting

As discussed in the literature, standard genuine savings estimation includes changes in forest, mineral and energy, and fishery resources. The two formers are discussed above and the latter is not included in the present estimation. Until recently, fisheries in Costa Rica were a means of subsistence for coastal communities. Artisanal methods were used with low economic (and environmental) impact, thus there are few records of the private activities and consumption (Herrera-Ulloa et al., 2011). However, the 90s have seen a significant increase in demand for marine products both from foreign markets and the booming local tourism industry. Consequently, large industries have entered the market with new infrastructure and technology and exploit marine resources more intensively (UNDP, 2019). Because of the recent nature of this exploitation and the low impact of the sector on the total economy, fisheries have not been included as a proxy for natural capital in this study since it only covers the development of the country since 2015.

The total resource accounting (Figure 5) shows a positive rent (meaning depletion) until 1988. Beyond this date, natural capital was restored and is reflected in the data series by hypothetical negative rents. The data also shows a strong dependency on the prices.

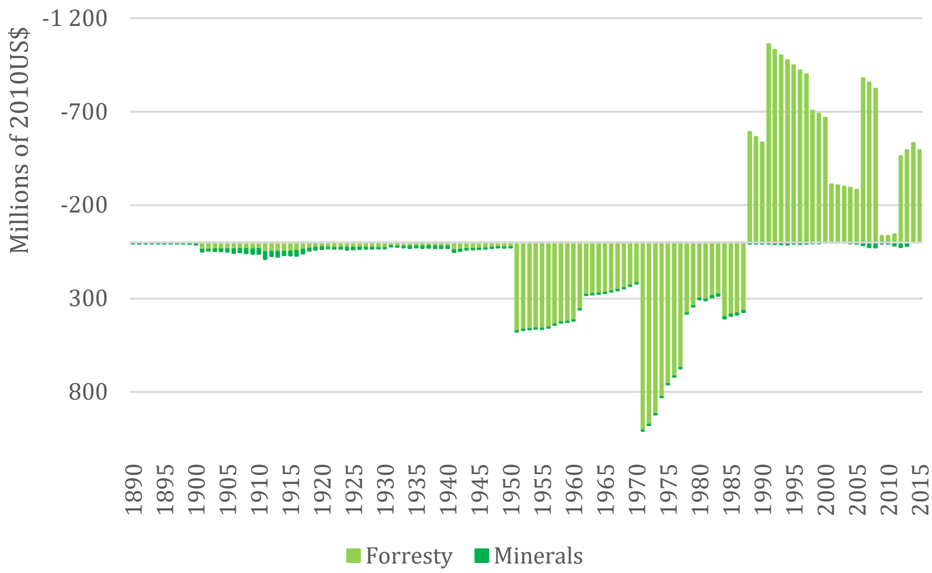

Figure 5: Rents from natural resources

Source: Own calculation, Data from León and Arroyo (2010); Arauz (2014)

3.2.4 Pollutants

Some authors on GS have included estimations for up to seven types of gaze emissions (McGrath, Hynes & McHale, 2019). However, given the limited scope of this research, emissions, CO_2 emissions will serve as a proxy for the pollution damages, but the reader has to keep in mind that it, de facto, underestimates the real environmental impact of total emissions.

Carbon emissions have been estimated for the period 1960 to 2019 by Friedlingstein et al. (2020) as part of the "Global Carbon Project" based on fossil fuel consumption, on foreign goods and service production nationally consumed, and net transferred emissions from trade. International transportation emissions are left out from the national accounting. The data has been adapted and merged into one CO_2 emission indicator by another unit of the project: the "Global Carbon Atlas"(Global Carbon Atlas, 2021). In this study, we use their data, and thus, the estimation of the CO2 emissions between 1960 and 2015 is therefore deemed highly accurate.

Boden, Andres & Marland's (2017) findings show emissions from fossil fuel consumption only up to 1950. The present analysis extends by ten years the data from the Global Carbon Atlas, based on the trend of fossil fuel consumption. This method seems reliable because the fossil fuel consumption used by Friedlingstein et al. (2020) for the period 1960 to 2019 is equal to the data used by Boden, Andres & Marland (2017) for the same period. Based on their observations for eleven countries in Europe and the Pacific, therefore, with a high degree of confidence, the data from Friedlingstein et al. (2020) is extrapolated.

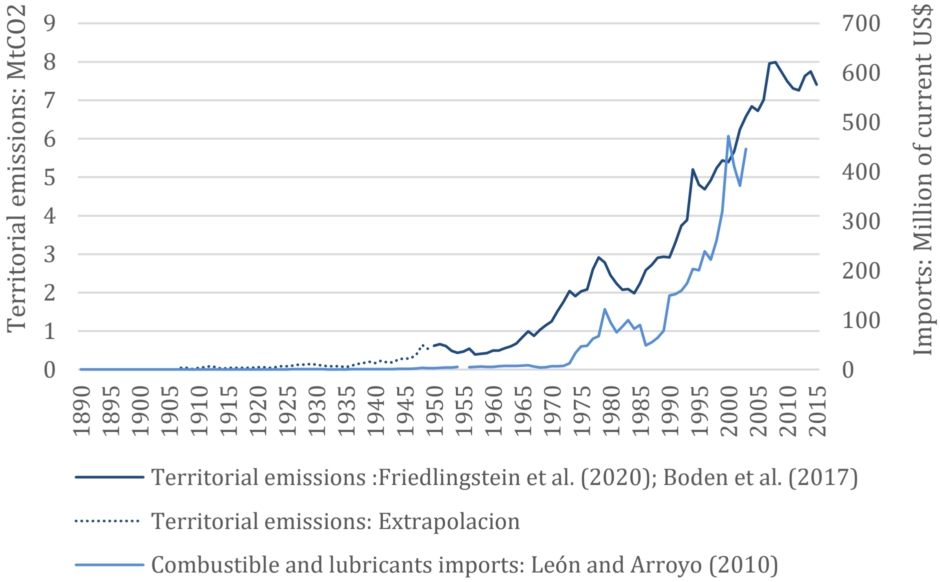

Figure 6: CO2 emissions trend comparison and extrapolation

Source: Own calculation, Data from Friedlingstein et al. (2020); León and Arroyo (2010)

León and Arroyo (2010) present data on the importation of combustible and lubricants between 1907 and 2000. As shown in Figure 6, the importation trend is similar to the CO_2 emissions trend, consequently, this study extrapolates the previously discussed CO_2 emissions data back to 1907 based on the importation trend. This method presents less reliable results than for the period 1950 and onwards, however it is still deemed representative of the CO_2 emissions from fossil fuels. Finally, the data is extrapolated back to 1890 based on Gonzalez's (2003) estimations per decade of the consumption of modern energy. Since his estimation is made on a double-decade basis, the emissions for the period 1890 to 1907 are constant. In practice, there was indeed no major yearly variation and thus the data are deemed reliable as such.

This calculation between 1890 and 1950 disregards the trends in the emissions from the wood-burning of locally exploited timber. Yet, these emissions could be compensated with reforestation, taking into account that secondary forests hold less carbon than primary forests although it increases with age (Rothenhäusler, 2021).

The second step of establishing an emission indicator is shadow pricing, more specifically the social cost of carbon. Blum, Ducoing, and McLauglin (2017), similarly to other authors, consider that the Worlds Bank's carbon pricing (20 2010\$/tCO_2) is inefficient to discount the damages of carbon emission in savings because it is not representative of the real social costs.

Instead, they follow Pezzey and Burke (2014) who offer pricing based on a modified Dynamic Integrated model of Climate and the Economy (DICE) model (Nordhaus, 2014)and according to two scenarios, one where future emissions can be controlled (p.148) and one where they are not. The second pricing (1455 2010$/t$CO_2$) is extremely high compared to the usual prices and counterbalances all other scenarios that are usually deemed underestimations of the real social price of carbon (Tol, 2021). In this analysis, we test different prices: the WB and both scenarios from Pezzey and Burke (2014) (Table 1). The latter is tested with and without a 3% annual discount rate for past data (See Appendix A for the full series).

Table 1: Carbon pricing scenarios

Sources: Nordhaus (2014); Pezzey & Burke (2014); World Bank (2021)

Scenario	**Source**	**Maximum global warming**	**Social cost of CO2 Emissions (SCC) in 2005$**	**Discount rates**	**label**
	World Bank Shadow prices	-	23,81$/tC	Constant at 1,0199$/year	a
Optimal control of industrial CO2 emissions	Modified DICE Model (Pezzey and Burke)	2.0°C	131$/tC	None	b
				3%	c
No control of industrial CO2 emissions	Modified DICE Model (Pezzey and Burke)	6.0°C	1455$/tC	None	d
				3%	e

3.3 Human capital indicators and estimation

As discussed earlier, Molina (2017) created a comprehensive database on yearly public spending for primary, secondary, and superior education between 1870 and 2016 (Figure 7). His data between 1870 and 1948 is derived from the Government's records on public expenditure at the national level (Roman, 1995). As often as possible, this data is cross-checked with other ministries' national records but very few sources exist about that period. Since 1948, data from the Central Government is used and data from third parties is more abundant, allowing the author to cross the sources and present more reliable data on the actual governmental spending on education. We use his dataset as the indicator of human capital because thorough research is deemed reliable.

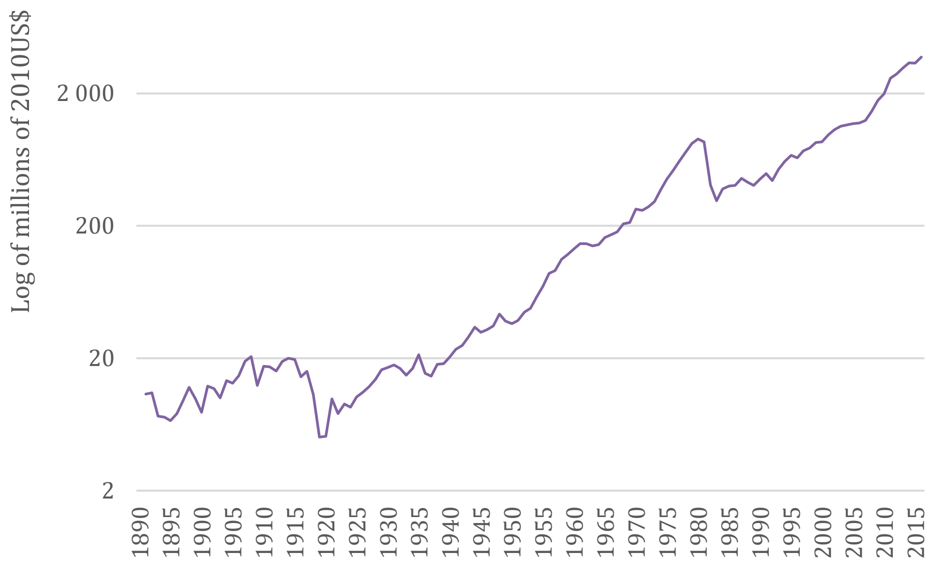

Figure 7: Education expenditure

Source: Molina (2017)

The main weakness of this data is that it mostly overlooks municipal investments and other sources of local sponsorships for schools. It disregards private schooling which is an increasingly used form of education (Trejos Solórzano, 2014), and thus attains to the representativity of the indicator. Few studies on GS include private schooling investments but it has been done for the case of Uruguay (Labat, Román & Willebald, 2019).

In Costa Rica, private schooling is favored by many families who paid the equivalent of 22.7% of the public investment in education for private schooling (Molina, 2018). Furthermore, Costa Rica counts with many private universities and in 2013, 52.6% of university students attended a private institution (Trejos Solórzano, 2014). However, Molina (2018) argues that the variations in the quality of education in private institutions diminish the real impact of education. Therefore, it is a very unreliable indicator of human capital and will be left out of this analysis.

3.4 Technological change

For Hanley, Dupuy, and Mclaughlin (2015), technological change should be included in GS using TFP as an indicator in absence of a better one. Technological improvements are embodied in patents, R&D investments, and energy as well but it is difficult to convert these factors into monetary values. Therefore, TFP is often calculated as a residual of the production function (Weitzman, 1997). TFP was calculated by scholars of the Groningen Growth and Development Centre (2021) as a percentage of GDP and adjusted for the present value of future change on twenty years based on a Kalman filter (construction of TFP at present value is detailed in Appendix B). The PWT (2021) only provides data on TFP for the period 1955-2019 and to my knowledge, no other source is available to derive reliable TFP data.

3.5 Control variables and conversion

GPD was calculated by the Groningen Growth and Development Centre (2021) for the period 1950-2019. There exist no proper calculation of GDP before 1950 (León, Arroyo & Montero, 2016) although the Maddison project has an estimation of GDP since 1920 (Bolt & van Zanden, 2014).

The population statistics from Molina (2018) have been constructed on data from Héctor Pérez Brignoli and Instituto Nacional de Estadística y Censos of Costa Rica.

All prices were converted to constant 2010 $US based on the UCR historical exchange rate series (León & Arroyo, 2010) for the period 1890 to 1950 and the BCCR exchange rate as presented by Molina (2018) beyond that. Until the end of the 19th century, the country was using pesos but the currency changed to Colones at the turn of the century. At its introduction Colones were on par with the Peso. Prices were then adjusted to inflation (CPI Inflation Calculator, 2020).

4 Methods

The most ardent debates around GS are exposed in chapters 2 and 3 regarding indicators and measurements of natural and human capitals. The calculation of estimations has received fewer critics (Ferreira & Vincent, 2005) but theoretical debates revolve around the inclusion of more capitals such as health capital (Engelbrecht, 2016), control variables, and treatment of growing natural capital (Labat, Román & Willebald, 2019).

In practice, the World Bank's methodology, explained by Bolt, Matete, and Clements (2002), is a relatively straightforward way of calculating the changes in the total wealth of a country by adding all capitals and subtracting for its depletion.

1: Net National Savings (NNS) = (Gross Fixed Capital Formation – Capital Consumption) + Foreign Direct Investments

2: Green Savings = NNS – (Forest rents + Mineral rents)

3: NNS Human capital = NNS + Human Capital

4: Green Savings CO_2 = Net National Savings – (Forest rents + Mineral rents) – Damages from CO_2 emissions

5: Genuine Savings (GS) = Green Savings CO_2 + Human capital

In this analysis, TFP is added to the World's bank methodology for the period 1950-2015 to account for technological change, following Blum, Ducoing, and McLaughlin (2017):

6: GSTFP = Genuine Savings + Net Present Value of TFP (TFP PV)

And two estimations are proposed to control for the impact of population growth:

7: GS Population = GS / Population

8: GSTFP Population = GSTFP / Population

5 Empirical analysis

5.1.1 Components and contextualization

Figure 8 shows the results of saving estimations 1, 2, and 3 on a logarithmic scale meaning that each gap represents values under zero, also called negative savings and is considered unsustainable according to the GS theory. All three estimations present overall similar upward trends, but magnitudes of the shocks vary.

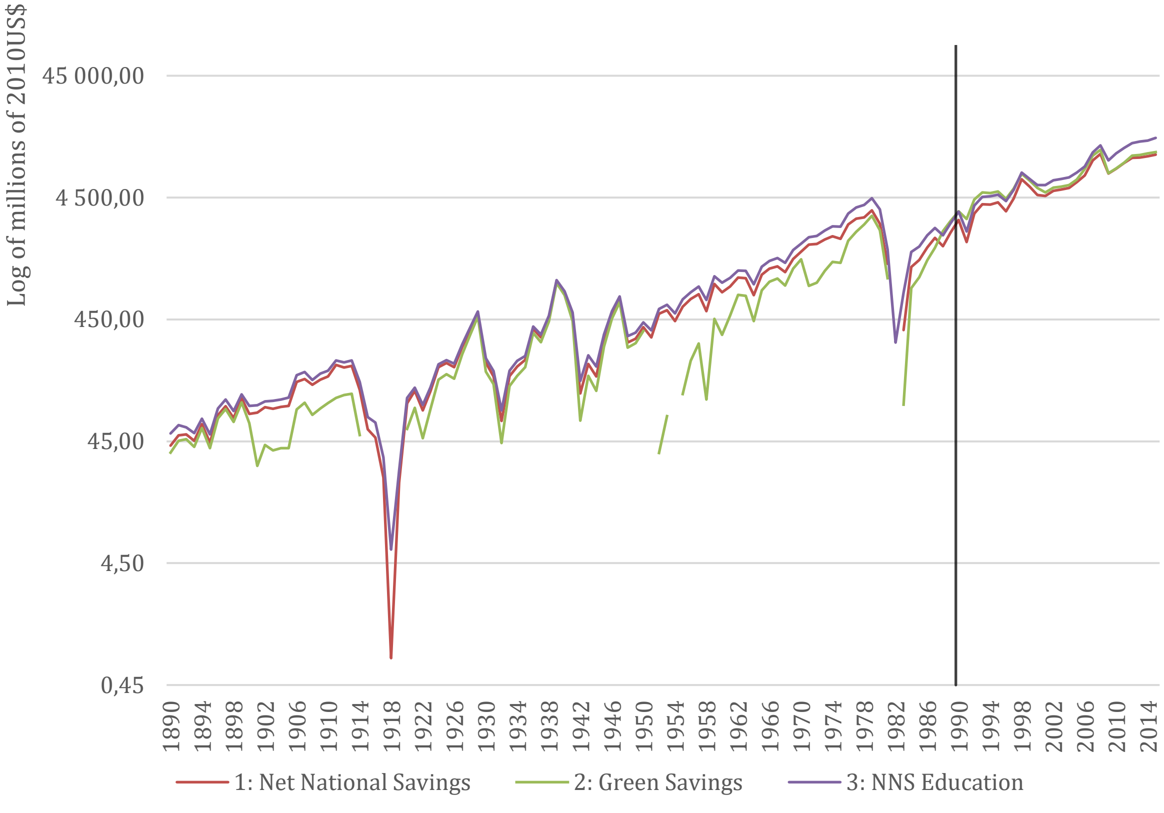

Figure 8: NNS, Green Savings, NNS Human capital

Source: Own calculation

The first significant decoupling episode of NNS and Green Savings happen in 1900 when Green Savings drops. This is a consequence of the more intensive exploitation of natural mineral resources and forest exploitation simultaneous to an increase in timber market prices. This intense natural resource exploitation in a global crisis time lead to negative Green Savings during the World War I (WWI) period. The following three decades show very unstable savings even if there has been a global increase in savings over the whole period. That can be explained by local and global instabilities (Molina, 2005) in a period when production was intensified.

The global tensions of the 1940s, and the subsequent shrinking of demand for the few commodities that the country exported, triggered the shift from the agro-exporting model to the ISI model in Costa Rica (Abaraca & Ramírez, 2016). Industrialization took off after the establishment of a new regime in 1948 and came together with high governmental investments and the creation of many national instances such as the institute for electricity, the institute for tourism, and the BCCR. Policies and low interest rates were established to encourage industrial development and a protected common market between central American countries was signed. Industrialization was supported by northern American development programs. Over the period 1950-1979, the government invested and nationalized Costa Rican companies. The whole industrialization process, oriented towards heavy industries like concrete, required important investments in fixed capital which maintained steady growth in NNS.

In the 50s, the second episode of decoupling between NNS and Green Savings can be explained by a significant variation of timber prices at a time when deforestation accelerated. This leads to unsustainable Green Savings. During the same period, the social-democrat regime was established after a short civil. The new government, wanting to show that social development is a priority, took the unprecedented decision of abolishing the armed forces. The effects were multiple. First, all costs related to having an army disappeared, allowing to invest in other aspects of the economy such as social policies; Second and even more important, it played an essential role in political stability which enabled democratic reform and allowed the social-democrat government to intervene in the economy with health or education policies for example (Abaraca & Ramírez, 2018). The same socio-democrat government-initiated education and conservation policies in the following decades. Many Costa Rican authors concur on the important investments in social policies in the second part of the century (Chen Quesada et al., 2018), even though the sums were highly dependent on the economic health of the country. Before 1950, the attendance rate to primary school had increased but it is only after the change of government that secondary and tertiary education grew in importance (Molina, 2018). Figure 8 shows a small but consistent increase in human capital savings.

The negative NNS between 1981 and 1983 is an effect of Costa Rica's debt crisis that interrupted several decades of growth. According to Leon and Peters (2019), the crisis had four causes:

- The increase in the price of petrol on a global level
- High national debts
- Crisis in other countries of the Central American Common Market which were essential trading partners of Costa Rica since 1963
- Global recession

In other words, degradation of the terms of trade and sharply increased the external debt and put an end to the fixed capital investments. Barboza and Cordero (2005) insist that the high governmental investments on social matters created inflation, discouraged job creation, and shrank the savings; when the 80s crisis came, the country was stuck with its debts which altered its resilience. The present study show rather different results. Among the three estimations, only the NNS augmented with human capital remained positive during a time of crisis showing that

human capital investments increased resilience. Furthermore, the fact that all three estimations have an upward trend confirms that returns from human and natural capital investments were used in productive capital creation which is in favor of weak sustainability.
The Green Savings drops at a larger magnitude than the two other curves due to the intensive deforestation activities of Costa Rica. Deforested areas peaked in 1987 (the exact year is subject to debate).

The conservation efforts and the subsequent increase in forest endowment present a certain challenge to our estimations. According to the WB's method, resource rents should only be accounted for GS when negative, imposing a significant limit to sustainability measurement (Bolt, Matete & Clemens, 2002). However, other authors have gone against this advice and found solutions to include forest growth in the natural capital accounting (Labat, Román & Willebald, 2019). In this case, NNS and Green Savings would join into one curve starting from 1977. However, as argued in section 3.2.1 of the present study, rent is a proxy for natural depletion. Negative rents, even if they have no empirical meaning, can also be considered as a proxy for reforestation. Forests provide countless ecosystem services which can be considered as a form of consumption that has to be represented in the saving accounting. They also have an economic contribution, mainly by attracting tourism (Moreno Díaz et al., 2011). Attempts to value the forest have been made based on the *cost of travel* however no national estimates are available (Moreno Díaz, 2020). In absence of a better proxy for the economic returns of standing forest and because rents can be considered as a shadow price for wood possession we decide to keep the negative rents in our Green Saving and GS data.

Green Savings are adjusted with CO_2 emissions in Figure 9. The significant increase in CO_2 emissions in the 70s and the 2000s are visible in both scenarios that maintain constant prices. As discussed earlier, pricing is subject to debate, thus we present five different scenarios. Pricing at \$1455/tCO_2 whether it includes a discount rate or not shows a clear decoupling from other trends and both become negative savings. Those scenarios are important because they show that savings can be highly impacted by pollution if no mitigation efforts are conducted. Yet they are also estimating extreme paths and very few authors of environmental economics argue for such a high shadow price. Therefore, this scenario is dropped. According to the other three scenarios, Green Saving CO_2 only show negative values in the 50s and the 80s. In light of the above discussion, this is due to the productive and resource rent components of Green Savings rather than CO_2. Compared to the WB's small shadow pricing, the \$131/tCO_2 does not show radical variations, however, the importance of a discount rate is made visible in Figure 9. The scenario of a shadow price of \$131/tCO_2 with a constant 3% discount rate is deemed the most credible based on the literature and the current results. This scenario will be used for the rest of the analysis.

So far, the results have been consistent with historical events and have not shown any inexplicable trends. When looking exclusively at NNS, Costa Rica seems to only have known one unsustainable episode between 1981 and 1983, however, Green Savings show a different story at various points in time. In the following paragraphs, we analyze the total saving trends.

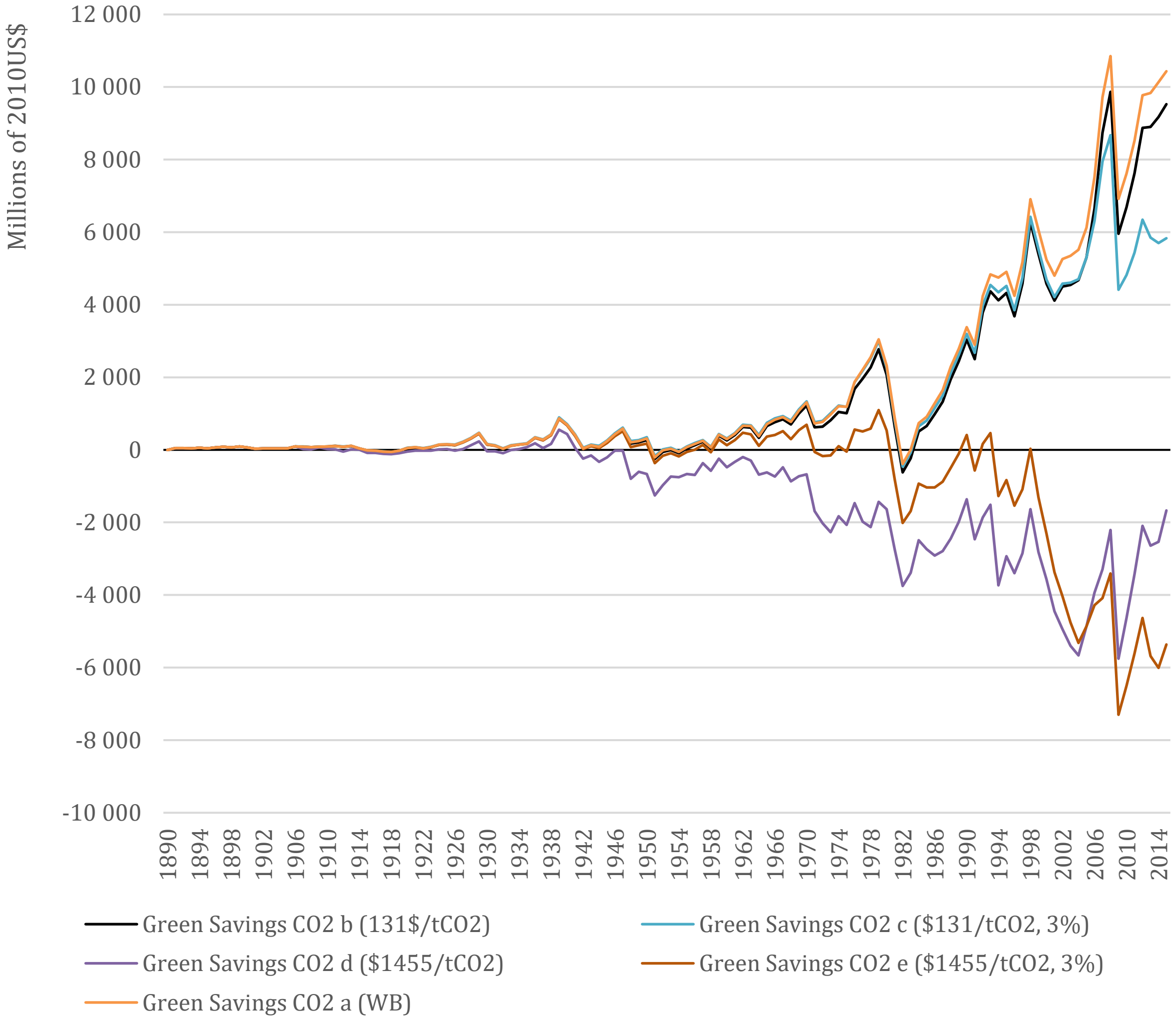

Figure 9: Green Savings CO_2 according to five pricing senarios

Source: Own calculation

5.1.2 GS analysis

The GS estimation is presented according to the different CO_2 pricing scenarios in Figure 10. It clearly shows that Costa Rica is on a sustainable trend according to scenarios a, b and c but if the CO_2 shadow prices were underestimated, and follow a scenario d or e, then Costa Rica can no longer be considered sustainable. Although scenario d shows a slightly upward trend since 2004, this scenario excludes a discount rate which is not recommended in the literature (Anthoff, Tol & Yohe, 2009).

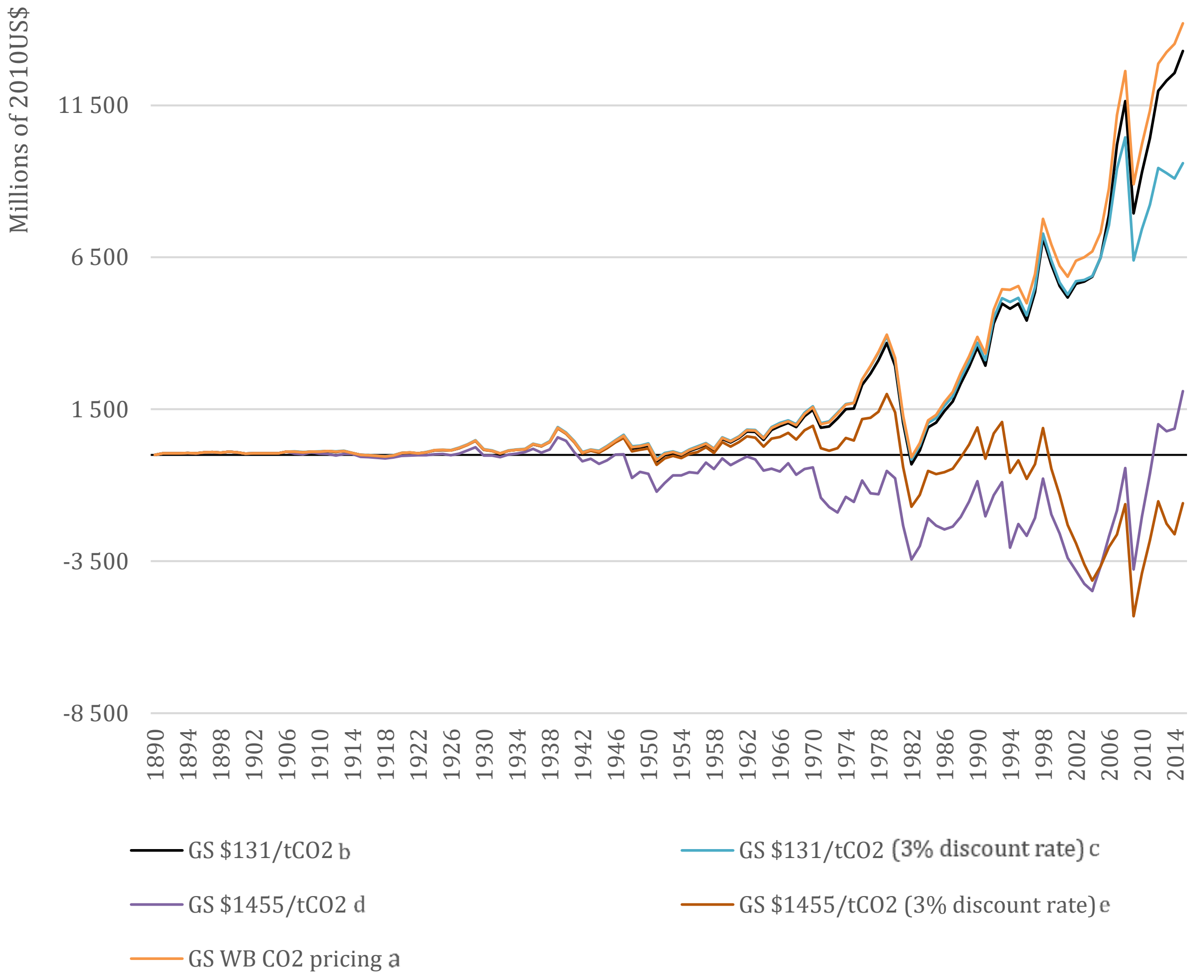

Figure 10: GS according to CO_2 pricing scenarios

Source: Own calculation

Figure 11 is built according to a 2010US$131/t$CO_2$ 3% discount rate pricing scenario and shows the annual changes of each of its components. According to the GS theory, loss of natural capital can be compensated by human or productive capital (Pearce & Atkinson, 1993) which is why it is important to compare components. Figure 11, shows the prominence of fixed capital in the savings but also the increase in natural resources depletion for over thirty years (1950-1980). Yet, natural resources decrease is compensated by productive capital increases at all time except in 1951 which is an indicator of weak sustainability. Since 1988, natural capital is positive, yet productive capital does not cease to increase which is also an indicator that productive capital is not dependent on natural resource extraction. Finally, the growing negative effect of CO_2 emissions must be acknowledged as an important obstacle to sustainability.

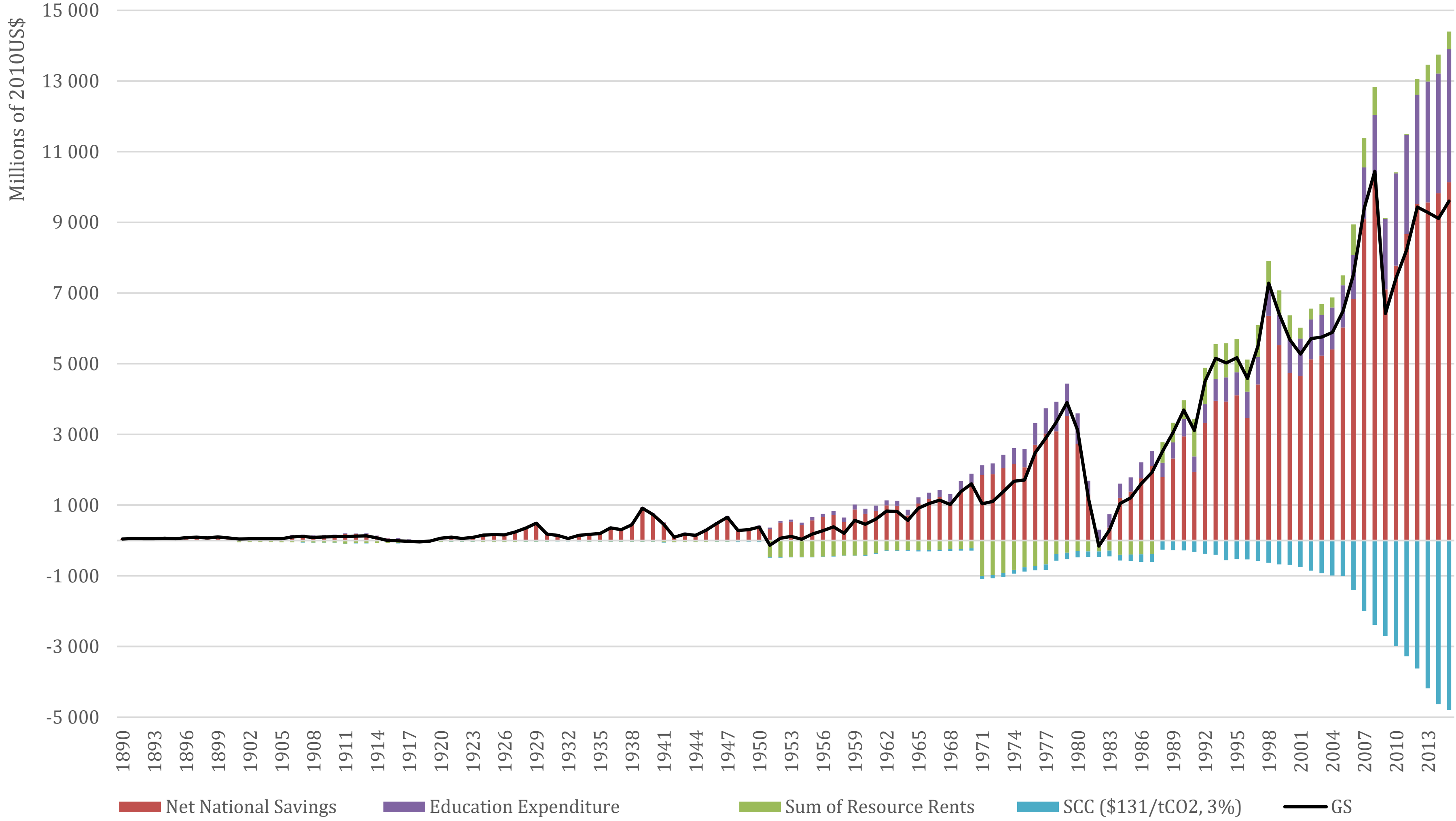

Figure 11: GS and components

Source: Own calculation

The Hodrick-Prescott (H-P) filter is commonly applied to long-term macro econometrics data (Yamada, 2018) to distinguish between the growth and cyclical components of a series (Hodrick & Prescott, 1997). The H-P filter is useful because it allows distinguishing the real changes in saving and independently from the natural effect of growth over time. Figure 12 presents the filtered GS (Appendix C details the calculation). It shows that savings started increasing in the twenties, they were slowed down by World War II (WWII), only to rise more steeply between the 50s and the 70s until the 80s crisis. Since 1996, the slope is flatter although somewhat upward, showing a slow but positive accumulation of savings. Overall, the trend is increasing, meaning that weak sustainability is verified.

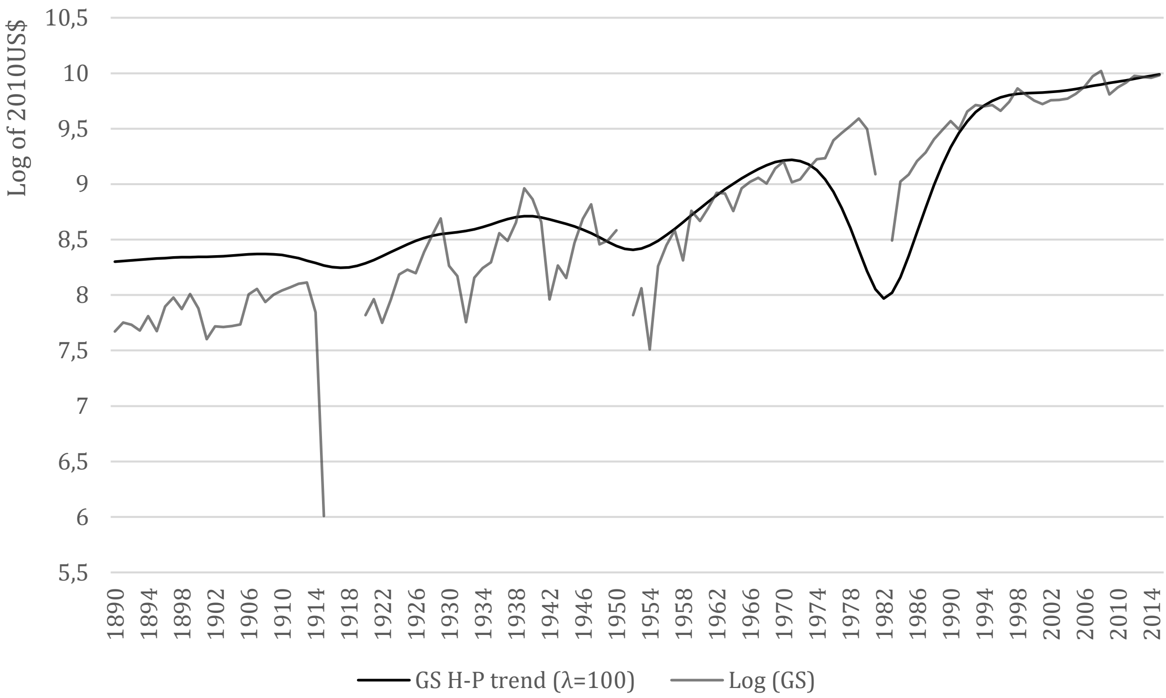

Figure 12: Hodrick-Prescott filter applied to GS

Source: Own calculation

Figures 11 and 12 show that the period between 1955 and 1978 display the highest rate of increases in savings because it is a period of good economic health and an attempt towards industrialization to reduce the dependence on commodity exports (Leon & Peters, 2019). The government sets up an aggressive industrialization policy that encouraged investments in factories and reinjects the gains from the 1970s coffee boom into industrial machinery and technology (Barboza & Cordero, 2005). The period is also marked by the growth of public services and investments in public infrastructures. However, these investments were associated with high debts.

Effect of TFP

Figure 13 adjust the GS for TFP. It shows that productivity increase through technological change has a significant impact on total savings compared to human and natural capital which are standard components of GS. In the case of Costa Rica, TFP negatively impacted savings between 1974 and 1997.

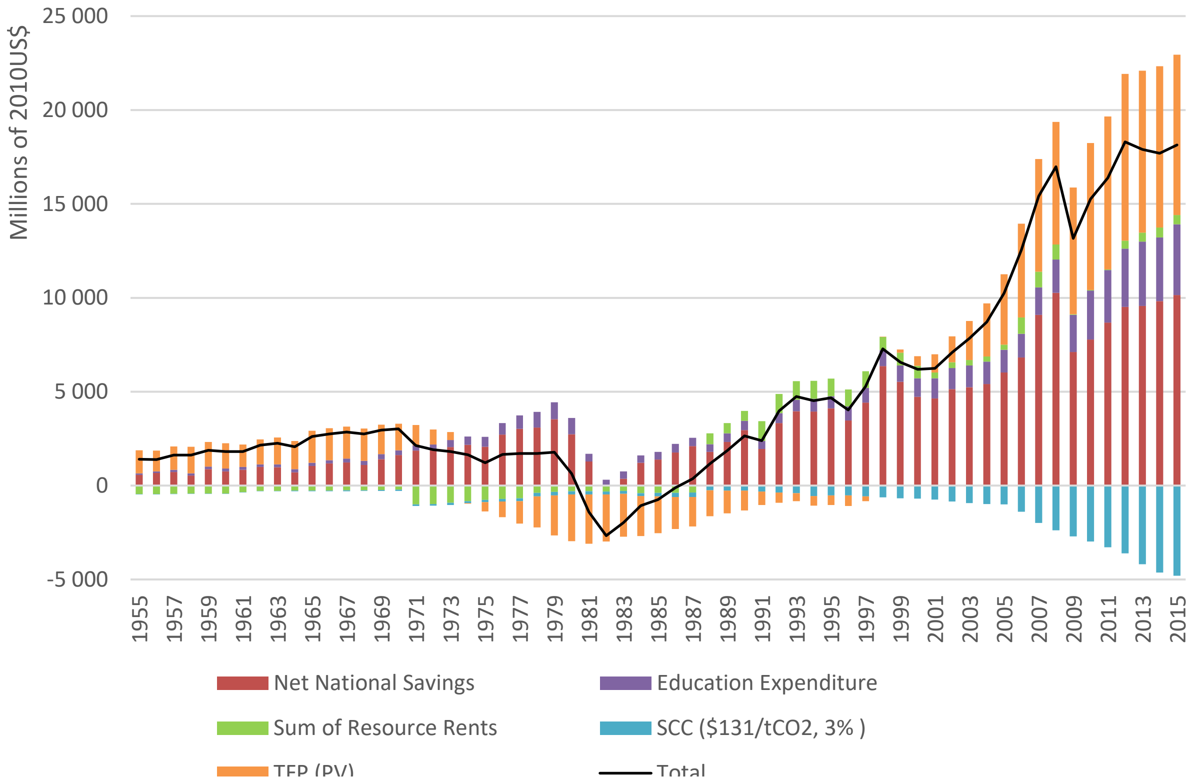

Figure 13: GSTFP and components (1955-2015)

Source: Own calculation

GSTFP shows that TFP affected the recovery from the 1980s crisis (Figure 14). However, the empirical explanation for this behavior is limited although one hypothesis could be that the crisis reduced the capacity to invest in R&D and in updated, more technological machinery that could increase productivity (Bradford De Long, 1992).

According to Barboza & Cordero (2005), the low growth of TFP before 1995 demonstrates that Costa Rica has developed based on "factor accumulation as opposed to efficiency gains" and therefore, the growth path is very fragile.

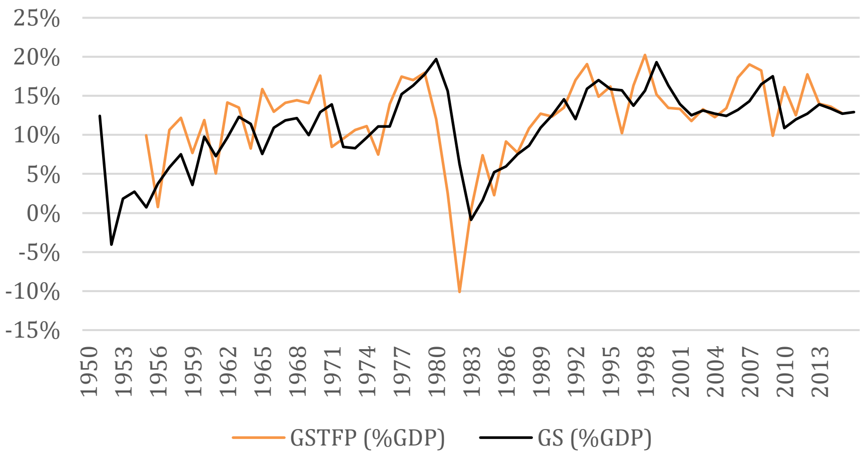

Figure 14: GS (%GDP) and GSTFP (%GDP) (1950-2015)

Source: Own calculation

Controlling population effect

Finally, controlling GS with population shows that the savings have been growing together with the population (Figure 15). The GS estimation shows the same results when adjusted per capita. The major difference is that the magnitude of the crisis is more important in GS per capita. This is in line with Ferreira, Hamilton and Vincent's (2008) observation on the little impact of population changes.

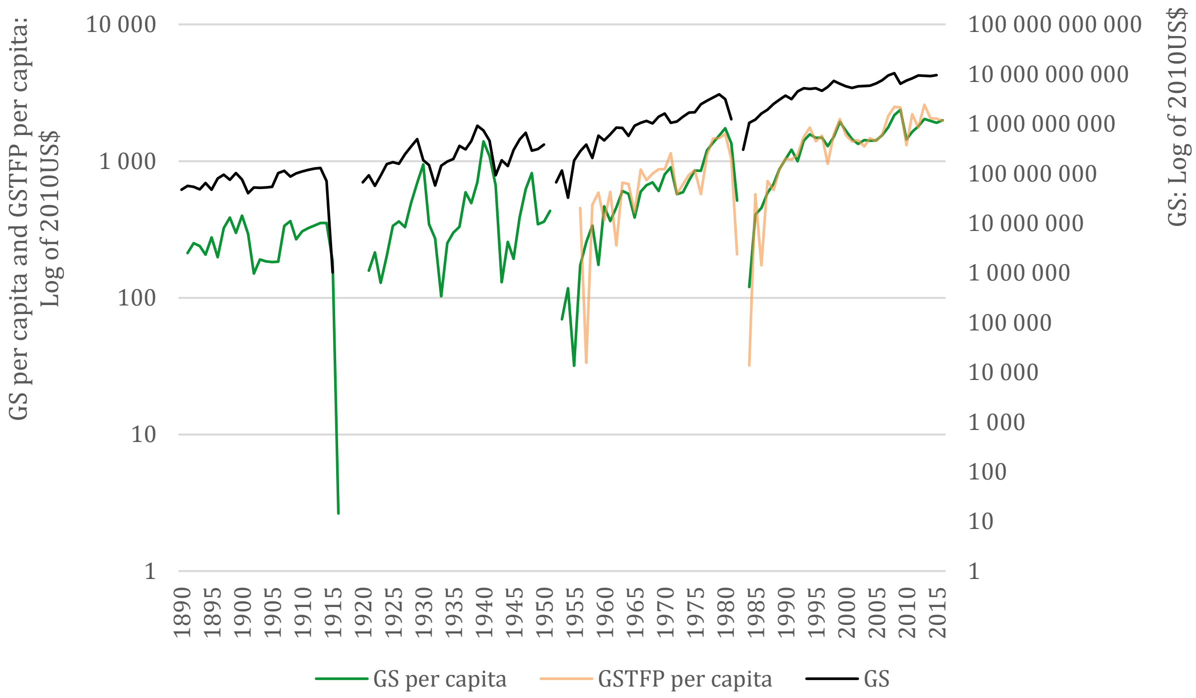

Figure 15: GS per capital, GSTFP per capita, GS

Source: Own calculation

Overall, Costa Rica displays increasing GS during the whole studied period but also suffers from the volatility of its savings (see Appendix D and E for detailed GS). It counts with a few episodes of negative savings that are the reflection of internal or international crises. An increase in GS means an increasing consumption capacity which is a proxy of well-being in weak sustainability.

5.1.3 Comparison across countries

One of the motivations for developing GS estimations is to have an alternative for GDP, therefore it should, to some extent, be comparable across countries. Yet, long-term GS estimations are not available for all countries and sometimes, the methodology differs to such an extent that cross-country comparisons are irrelevant. Nevertheless, one study can be used for the embedment of Costa Rica's GS within the regional trends (Blum, Ducoing & McLaughlin, 2017). This comparison also allows to check and better understand the results on Costa Rica from the present study.

A comparison of GS between Costa Rican and two Latin American (but large) economies: Colombia and Mexico and one small, open (but European) economy: Switzerland was possible based on the data from Blum, Ducoing & McLaughlin (2017). It is presented in Figure 16 as a share of GDP (See Appendix F for further comparison).

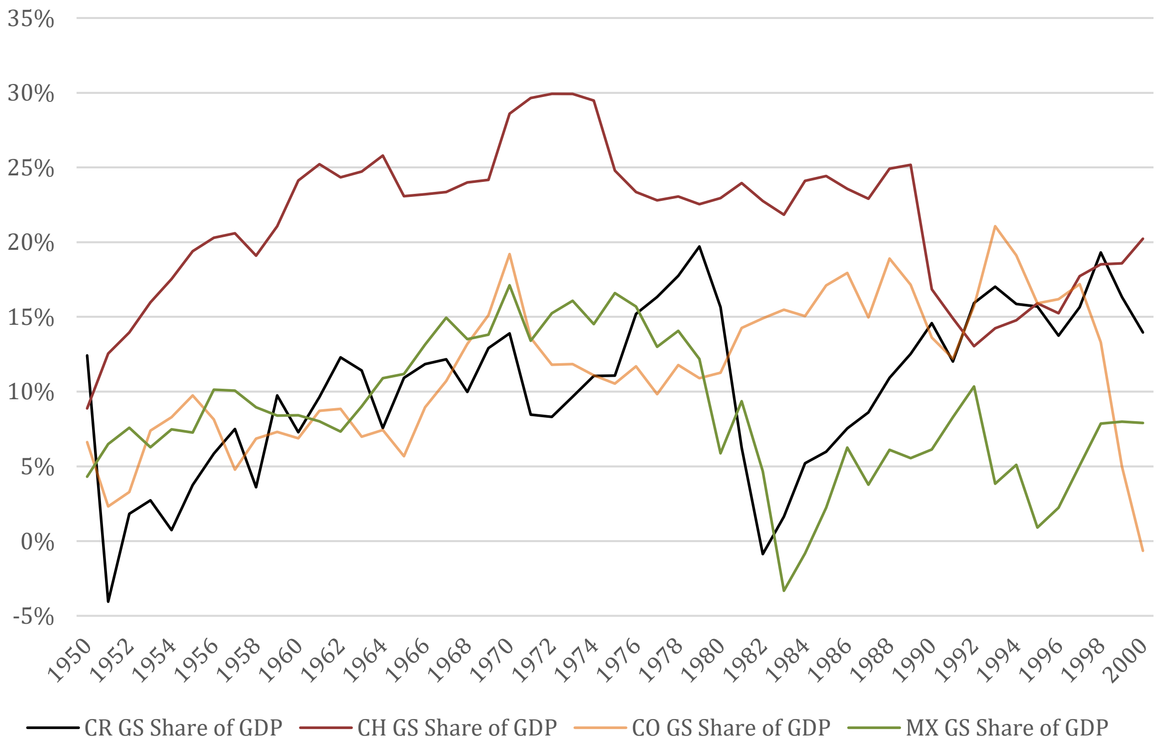

Figure 16: GS of Costa Rica, Switzerland, Colombia, Mexico (1950-2000)

Source: Own calculations for Costa Rica; Blum, Ducoing and McLaughlin (2017) for Switzerland, Colombia and Mexico

The relevance of the comparison with Switzerland is motivated by the similar size but also by the fact that Costa Rica has often been referred to as the "Switzerland of Central America"(Mundo, 2015). However, the GS data does not show many similarities except in the upward trend between 1950 and 1970, which is common to all four countries. The differences beyond that point are probably due to the late industrialization period of Costa Rica (after 1950), the strong Costa Rican dependence on the US and Mexican markets and investment, and the absence of tradable natural resources in Switzerland.

All three Latin American countries are resource-abundant economies that have known economic and political development paths of their own, however, the comparison is relevant because they operate in the same market. The three Latin American country comparison reveals that although they all know a similar upward trend until 1980, Costa Rica goes through a short period of flat or decreasing savings between 1962 and 1972 which, rather than being explained by production changes, reflects the increase in natural resources rents and decrease in education investments. Similarly, to Mexico, Costa Rica's savings have been greatly affected by the 80's crisis but the latter has better recovered to a steady upward trend. The good performances of Costa Rica since the 90s compared to its petroleum-producers neighbors can partly be explained by the conservation efforts in Costa Rica.

Second, Labat, Román, and Willbald's GS estimations on Uruguay offer an opportunity to compare Costa Rica with another small, resource-abundant Latin American country that shows similar GDP and HDI (UNDP, 2020) has also recently been invited to join the OECD and is abundant in so-called renewable resources such as forestry. Similarly, to Costa Rica, Uruguay has known high volatility in its savings, especially related to the agro-exporter model which made them vulnerable to global tensions and crisis. In both cases, the diversification of the economy coincides with an increase in savings. However, Labat, Román, and Willibald find that savings of Uruguay do not increase as clearly as Costa Rica's, this might be due to the Uruguayan development path but also to methodology differences as they have conducted a more comprehensive natural and human capital accounting.

5.1.4 Comparison across sources

World Bank: Adjusted Net Savings from 1977 to 2015

The most standardized comprehensive wealth accounting has been done by the WB. Figure 17 compares this study's GS to the WB's ANS (World Bank, 2021). CO_2 emissions have been excluded from both estimations because of the price variations discussed above.

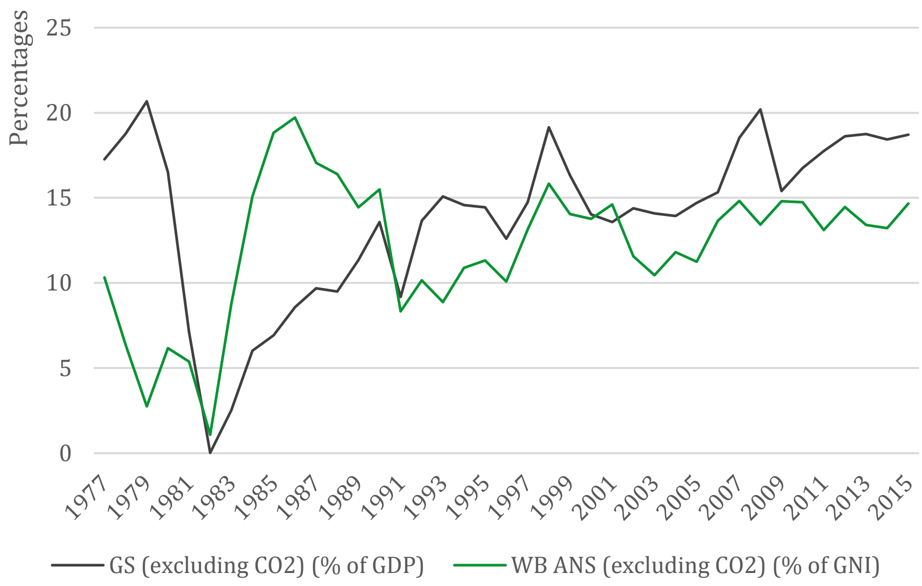

Figure 17: Comparison with the World Bank's ANS (%GNI) (1977-2015)

Sources: Own calculations; Word Bank (2021)

The comparison is not perfect with a major gap between both series between 1977 and 1989. This is due to the important difference between the NNS (Figure 18).

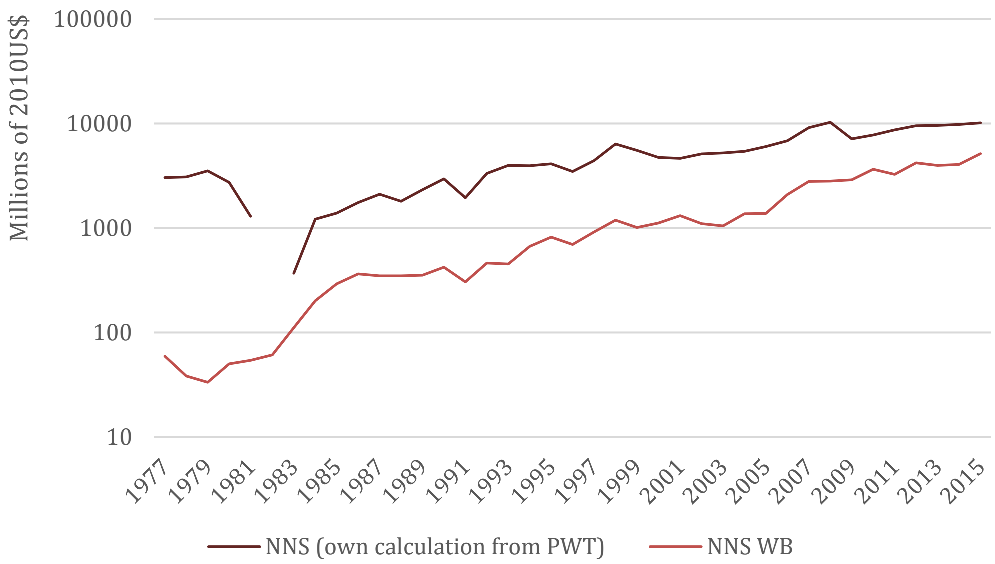

Figure 18: Comparison of own calculation's NNS with World Bank's NNs (1977-2015)

Source: Own calculations; World Bank (2021)

The NNS in this study was derived from the PWT's (2021) changes in fixed capital, with a negative value representing larger depletion than investment in 1981. The NNI used by the World Bank does not show a consumption that was larger than the investments and always presents positive values for NNS. This negative value and the difference in accounting for NNI between sources are reflected in the dramatic drop of savings in 1982 (see Appendix G for further comparisons between datasets). Apart from this difference, Figure 17 and Figure 18 show relatively similar trends between this study's estimations and the WB's, which confirms the reliability of this paper's GS and NNS. Furthermore, the differences discussed above should not be considered as invalidating the research, especially because the PWT (2021) is a reliable source, but should rather be seen as a call to refine the calculation on NNI and to further discuss the capital valuation methods.

Accounts overdue: the first NA of Costa Rica with natural capital inclusion

The "Accounts Overdue" project (Solorzano et al., 1991) suggested including natural capital to the SNA that they call "outdated". Their natural capital indicators are deforestation (loss of standing volume, loss of future harvests growth of secondary forest), soil erosion (total nutrient loss), and overfishing (loss of resource value). This method is relatively different from the present study's, however until 1980, both results are very closely evolving (Figure 19). The results from this study are different from the data from "Account Overdue" for the years 1980 to 1982, similarly as it was in the ANS comparison. After 1983, the trends are similar again.

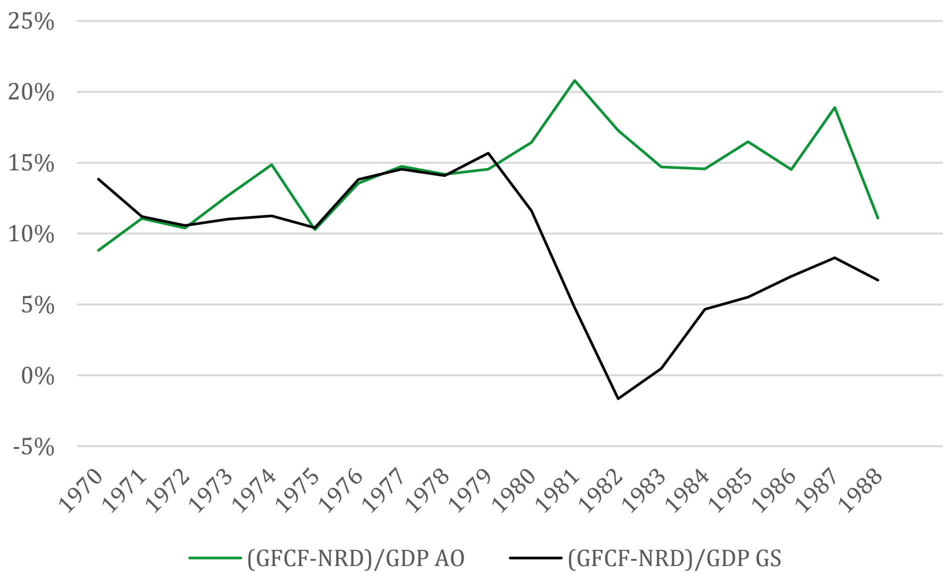

Figure 19: Comparison with "Account Overdue" Project (1970-1988)

Source: Own calculation; Solorzano et al., 1991

Overall, both comparisons confirm the validity of our results for the whole of the 1970-2015 period but draw attention to a possible shortcoming between 1980 and 1990.

6 Discussion

So far, it has been shown that Costa Rica has a volatile but globally increasing GS over the whole period under study. Based on this, the present section discusses the sustainability of the trends. To better understand the variation in human and natural capital, it also offers a discussion on the relationship of capital change with structural and policy changes.

6.1 Sustainability between 1890 and 1950

Before 1940, the increasing resource exploitation, the lack of diversification of an economy centered on coffee production, and the numerous crisis that the country experienced over the period suggested that the country's savings would be decreasing. Yet, the data and estimations presented in the empirical analysis showed the opposite.

The turn of the century is marked by great progress in maritime transportation which reduced the costs of Costa Rica's wood exportation capacity and thus stimulated production. On the other hand, it also killed the small manufacturing area that could not compete with international importations. Until the 1940's Costa Rica did not have an industrialization strategy, and the government only offered punctual support to starting industries. Therefore, the country counted three types of industries that required a minimum of infrastructure:

- Transformation of agro-industrial production including sugar mills, drying factories of coffee (called *beneficios*), and wood sawmills. The latter usually consisted of private production that grew in size to become a small wood exporting factory (León, Arroyo & Montero, 2016)

- Extraction of gold and silver peaked between 1890 and 1930 generating important investments in mining equipment. The mining sector was very dependent on the US, not only as a client but essentially as an investor. During the Great Depression and the following years, as foreign investment lowered, mining companies were limited in their growth and it strongly affected the sector and marked the end of the second mining cycle of Costa Rica (Araya, 1976).

- Small manufactures: Due to the high starting cost of industrial production, the state considered manufacturing as a side activity next to the well-established sector of commodity exportation, which provided the country's main revenues. The few textile factories that were established before WWII were financed by private investments but set a basis for the future industrial development of the country's revenues (León, Arroyo & Montero, 2016).

In all sectors, the industrial units remained small due to limited investment capacity. Yet this tells us two things: first the benefits from commodities exports were reinvested in fixed capital which enabled the country to maintain or increase total wealth. Second, there was a sound basis for industrialization in the second part of the 20th century.

Even if extraction and industrialization were done at a small scale, it still had an important and growing negative impact on natural capital. Overall, natural capital depletion draws NNS down by 8,39 percentage points for the period 1890 to 1899, by 45,62 percentage points between 1900-1909, and by 688,34 points between 1910 and 1919, a period which mostly showed negative Green Savings. Therefore, qualifying the whole period before 1950 as sustainable must be done very cautiously. Deforestation was mostly motivated by the demand for agricultural products (especially coffee, but crop diversification was increasing) and thus for cultivable land. Yet, wood was not always marketable (Goebel, 2013). In other words, even if deforested land generated agricultural revenues, it did not directly participate in the economic sectoral transition process but rather contributed to increasing the country's dependency on international markets. Since the end of WWI, the USA became the first importer of Costa Rican wood and the demand was mostly oriented towards cheap, rapidly growing wood. The areas of culture do not have any ecological function and the forest is only for commercial use. Due to high pressure imposed by importers (mainly the USA but also Europe and other Latin American countries) on the Costa Rican forest, Goebel (2013, p.301) considers that importers have an "ecological debt" towards Costa Rica.

To summarize Costa Rica has known increasing savings for the period 1890 to 1950, unlike what was expected at the beginning of this study. However, it has also endured three episodes of decreasing savings due to global crises, one of them leading to negative green savings and negative GS. This volatility highlights the vulnerability of the economy due to the lack of diversification. Based on this suboptimal economic situation and the rapidly decreasing natural resources, I argue that Costa Rica cannot be considered a sustainable country before 1950, even in terms of weak sustainability.

6.2 Sustainability between 1950 and 2015

GS relies on the weak sustainable development theory (Neumayer, 2013), meaning that natural capital can be decreasing if it is used to increase productivity and human capital or TFP (Hanley, Dupuy & Mclaughlin, 2015). Under this definition, our data shows clear weak sustainability between 1950 and 2015, except for the crisis of the 1980s – which is not as noticeable in the WB and "Accounts Overdue" data.

1951 to 1978 correspond to Costa Rica's most intensive industrialization period and GS in terms of GDP rose by 18 percentage points over the whole period, mostly driven by the investments in fixed capital. The period is characterized by increasing government investments and the nationalization of important Costa Rican companies including concrete and fertilizer producers (Abaraca & Ramírez, 2016). It is also marked by a dependency on oil importation as the main source of energy (Gonzalez, 2003). There has been a regain of interest for gold exploitation in 1974 due to a rise in international prices (León Sáenz, Arroyo Blanco & Montero Mora, 2016) which has a small negative impact on GS. In other words, it is important to note that industrialization has been done at the cost of natural capital.

After 1979, the country's economy was greatly affected by the banking crisis which decreases the investment capacity and abruptly drew the savings to a negative figure. Between 1980 and 1982, Costa Rica is unsustainable because its savings decreased and it was living off the savings it had been accumulating. According to this study, it took eleven years for the savings to regain their level of 1979. A period during which there was little public investment that affected infrastructure linked to transportation and education for example (Abaraca & Ramírez, 2016). Since the 1990s, economic diversification has been achieved with growing tourism, ICT, and medical equipment sectors. Savings have known another period of increase based on an increase in fixed capital and reforestation, and more marked if TFP is included.

Consequently, following the theory of GS which postulates that consumption capacity is a proxy for well-being (Pearce & Atkinson, 1993), this study argues that well-being is maintained, and even increases since 1950 except during the years 1980 to 1982.

6.3 Natural and human capital in GS

6.3.1 Conservation policies and natural capital

Unlike what is usually implied in public discussions when promoting Costa Rica's conservation strategy (Costa Rica's Green Paradox, 2019), the shift towards conservation in the 80s' has not been radical. It is embedded in more than a century of conservation discussions and required decades of evolutions and implementation which are still in progress. The following paragraphs, discuss the changes in natural capital in light of the conservation policies.

Goebel (2013) argues that the policies played an essential role in shaping the relationship between the people and the forest during the 19^{th} century. In 1828, the Costa Rican government encouraged nature protection for well-being and water conservation (Morera, 2011) but when the ambitions for a modern economy took over, deforestation was favored to keep up with the demand for wood and agricultural products. Yet, even if the Costa Rican state promoted production and exports, it did not follow the strict "laissez-faire" in forest management. In 1863, the first forest regulation was enacted, although motivated by the poor returns on exportations (Goebel, 2013). For the next decades, the government made small, reluctant attempts to regulate deforestation without any effect. The country was still mostly lead by an elite who drew their wealth from the transformation and exportation of coffee, thus they had a large interest in seeing a growth of the coffee sectors who found benefits in deforestation. After the civil war, the government increased in power and took the radical and unique action of abolishing the army. According to Flagg (2018), it sets a precedent in unusual political strategies, and its success allowed the country to follow an innovative path towards natural conservation. In 1969, Costa Rica established the "forestry law" which addressed the protection of wildlife, encourages environmental education, improved land management. Flagg (2018) argues that even if the law has no immediate effect on deforestation, it established the interventionist approach of the government towards land management.

Since 1979, Costa Rica has implemented fiscal and monetary incentives for conservation, but it became operational in 1988 (ed. Orozco, Segura-Bonilla & Alonso, 2017). According to Flagg (2018), deforestation in the 80s was motivated by the need for land to produce beef, yet in the middle of the decade, the prices dropped, and the sector lost its attractivity. Soon after these policies and market changes, deforestation decreased and for the first time had a visible impact on GS. By the beginning of the 1990s, Costa Rica had gained international fame for its well-established conservation and peaceful politics. It attracted an increasing amount of (eco-) tourists to a point that, in 1993 tourism took over the traditional export sectors in revenues. The fixed capital formation is also influenced by the growing place of tourism in the economy. In 2010, a moratory on open-air mining was enacted and led to the total interruption of gold mining activity even though the market prices still made it attractive (Arauz, 2014). This measure affects the GS but to a limited extent, rendering it almost neglectable compared to CO_2 emissions.

Emissions contribute to diminishing well-being. Since 2000, the estimated SSC is larger than the gains from natural resources restoration, meaning that damages from emissions are larger than the conservation capacity (Appendix H). The high emissions in Costa Rica are mainly caused by agricultural production (45% of total emissions in 2000 and 39% in 2005) and by transportation (28% in 2000 and 31% in 2005) (Chacón, Montenegro & Sasa, 2009). In 2009, the “National Strategy on Climate Change” defined the plan for carbon neutrality and sets an ambitious objective of carbon neutrality for 2021, yet the GS series shows no real signs of emissions reduction. In 2015, the goal was revised to 2050. The pledge mostly planed on businesses acting by reducing their emissions and compensating the remaining ones with payment to the FONAFIFO to offset emissions with forest conservation (Flagg, 2018). However, the data of the GS shows that the reforestation program is far from balancing out the effect of emissions in terms of social cost. Furthermore, as previously mentioned, recent forests have a small carbon absorption capacity (Rothenhäusler, 2021)

The Costa Rican government also relies on technological change to reach its goal to become a net-zero emitter by 2050 (Costa Rica Bicentennial Government, 2019). Many authors argue that technological progress can help to reduce world carbon emissions. For example, one study presents a scenario based on the usage of local biofuel, electrical trains, and smart grids for electrical cars and better urban planning, that would enable Costa Rica to reach its net zero-emission goal (Godínez-zamora et al., 2020). However, the plan requires major political leadership and multilateral action. It is estimated at US$ 26.7 billion. Yet, they argue that this cost will be entirely compensated by lower operating costs. Such an investment would be considered as savings in the form of fixed capital and TFP investment. This shows the importance of TFP increase in GS since it can help decrease natural depletion. In the series of this study, TFP partly reflects the already existing efforts to shift towards green energy sources (Chacón, Montenegro & Sasa, 2009). However, TFP has paradoxical effects, for example in agriculture: on the one hand, the augmentation of productivity reduces the surface of needed land for equal output, on the other hand, more intensive exploitation of land comes with soil erosion and degradation. Coffee production, for example, increased in productivity based on pesticides and bean collection machinery. It stopped being the cause of deforestation but to use modern tools, farmers removed the many fruit trees that provided shades to the plantation (Adams & Ghaly, 2007). Those trees enhanced biodiversity, help soil regeneration, and provided local fruits to farmers (Montero et al., 2021). This effect puts in light an aspect that is barely visible in the media or academic literature: the intensive use of fertilizers in Costa Rica which has a major impact on soil and biodiversity (Pimentel et al., 1987). Their use started in 1883 with imported chemicals. In the 20th century fabrication of fertilizer becomes an important branch of the Costa Rican economy. Production peaked at 17% of GDP in 1975 and ceased in 2002 (León, Arroyo & Montero, 2016). Yet the country now relies on importation and consumption remains among the highest of the region (Reyes & Cortés, 2017). Soil deterioration is not yet used as a standard indicator in natural capital valuation for GS (Biasi et al., 2019) which leads, in the case of Costa Rica to an important omission of natural capital depletion.

This discussion shows that, during the second part of the century, policies contributed to shaping the GS in the long run because well-established practices take time to change. This has been facilitated by the fact that the price of the international market influenced the governmental decisions on exploitation and regulation, for instance in the cases of forest conservation in the 19th century, and gold extraction in the 1970s.

In a nutshell, it can be considered that natural capital and conservation policies had a positive impact on genuine savings because both exploitation or conservation strategies of the government are reflected in the GS in the long run. However, this needs to be qualified by the fact that natural capital only plays a small role in total GS and by the increasing damages done by CO_2 emissions to the well-being. It is also important to note that Costa Rica is endowed with many other natural resources which are not reflected in the GS estimation.

6.3.2 Human capital

Since the 19th century, Costa Rica considers education as an essential aspect of its development (Rodiguez-Clare, 2001) and it reflects in the constant impact of human capital onto the GS. The only time where investment in education decreased was the period 1986 to 1998 (Abaraca & Ramírez, 2016). Rodiguez-Clare (2001, p.313) qualifies it as the “lost decade”, yet the generation benefited from an education that made them computer literate, which was quite unique in the region. This, and other institutional factors attracted high-tech FDI since the 1990s, which in turn generated spillovers in Costa Rica and stimulated technological improvement (Rodiguez-Clare, 2001). Human capital and TFP are two forms of capital hard to dissociate, especially in the case of Costa Rica because, as discussed in the literature, an improvement in technology and machinery is barely of any use without qualified workers to operate it.

Overall, human capital has had a positive impact on GS because, even if some periods have seen a shrinking in education investments, we have seen that NNS augmented with human capital remained positive at all times. In addition, the share of education investments in total GS, on average, increased over time and generated spillovers with technological change.

7 Conclusion

The present study analyzed the long-term sustainable development of Costa Rica in the light of the Genuine Savings theory and based on a dataset built for that purpose. More precisely, the study aimed to answer two questions:

RQ1: To what extend has Costa Rica been a sustainable country between 1890 and 2015?

RQ2: To what extend did natural capital and human capital influence the genuine savings of Costa Rica?

Regarding RQ1, Costa Rica had increasing genuine savings (GS) over the whole period meaning that it can be considered sustainable in the weak sense of the term (Atkinson & Hamilton, 2007). The country has known poor weak sustainability between 1890 and 1940, but a shift operated in the middle of the 20th century and the subsequent development of the country can be qualified as sustainable. The savings are mostly led by NNI; however, education played a small but stable role in increasing savings. The consumption and conservation of natural capital are reflected in the GS variations. Thus, the answered RQ2 as detailed through the decomposition of the GS results, is that natural and human capital have a significant impact on GS. Furthermore, the scope of this analysis enables to observe the long-term effect of structural changes and shifts in conservation policies and to note that the economic and political changes are reflected in the changes in GS.

The data and results are broadly consistent with previous comprehensive wealth accounting done for Costa Rica, notably by the World Bank (WB) for the period 1977-2015, however, no study had offered an assessment of Costa Rica's GS before 1970. Nevertheless, our findings are consistent with research using other methods. It is aligned with studies that observe the high exploitation rates (Goebel, 2013) and the poor productive diversification and subsequent low resilience of the economy before the civil war. It is also in line with the literature that discusses the industrialization and conservation process of the second half of the 20th century (Abaraca & Ramírez, 2016). The present study integrates for the first time all those different variables into one long-run estimation.

The data collection process enables to identify of some shortcomings in using the standardized GS in the case of Costa Rica. As the country is already advanced in the conservation process, one issue was to account for natural capital restoration because GS usually does not integrate positive rents nor the cost of restoration. For example, in Costa Rica positive rent could be accounted based on tourism revenue and the cost of restoration based on the financial retribution that is distributed since 1988 for forest conservation. Another issue is that it overlooks some aspects of environmental degradation, especially decreases in soil quality due to the use of pesticides. The production and importation cost of pesticides could be deducted from the natural capital. This study also contributes to the understanding of the sustainable development of Costa

Rica in the long run. Using GS as an indicator of sustainability allows deconstructing the development of a country into many factors. Thereby the positive effect of education on savings was highlighted. Unexpectedly, natural capital does not always have a positive influence on GS and this is due to the increasing CO_2 emissions.

The findings are a participation in the discussion on sustainability in developing countries. Costa Rica is not as abundant as its neighbors in non-renewable resources such as oil or minerals and has never been dependent on their production. However, it has also known a long unsustainable period when the economy exclusively relied on resource exploitation and the agro-exportation model. GS clearly shows that the shift to weak sustainable development began with investments in fixed capital. Furthermore, the observation, inspired by Flagg (2018) that conservation policy does not have immediate repercussion on GS is probably an important lesson for any country that is turning towards conservation.

This study has several limitations, mostly coming from the data collection. First, data covering the period before 1950 are often approximation rather than measures, especially for net national savings (NNS) and CO_2 emissions. The indicator of the changes in forest areas is constructed with the help of extrapolation methods because there is no yearly assessment of forest areas. In addition, the definition of forest area greatly varies between sources, meaning that estimations might not always be consistent. To avoid this bias, only three sources were used to build the whole forest rent series. Finally, natural capital rents are estimated based on regional prices which might present small differences with the actual rent. Furthermore, the estimations used in this analysis only allow to determine if total wealth is maintained as an indicator of weak sustainability (Hanley et al., 2016). The method disregards the strong sustainability theory and this approach could lead to the acceptance of irreversible natural capital destruction to create productive capital. However, GS still serves as a tool to put natural, human, and economic capital on the same level, which makes it an important instrument in the shift towards a more sustainable approach to economics.

The present study opens many doors for future research. The discussion on the sustainable performance of Costa Rica called for many components to be added to the GS series of the country. For example, the natural capital estimations could be augmented with other sources of emissions, revenues from nature tourism, soil erosion could be taken into account or private education could be added to the human capital estimation. Furthermore, the data and results can already be used to forecast the future performance of Costa Rica.

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Appendix A: Social Cost of Carbon

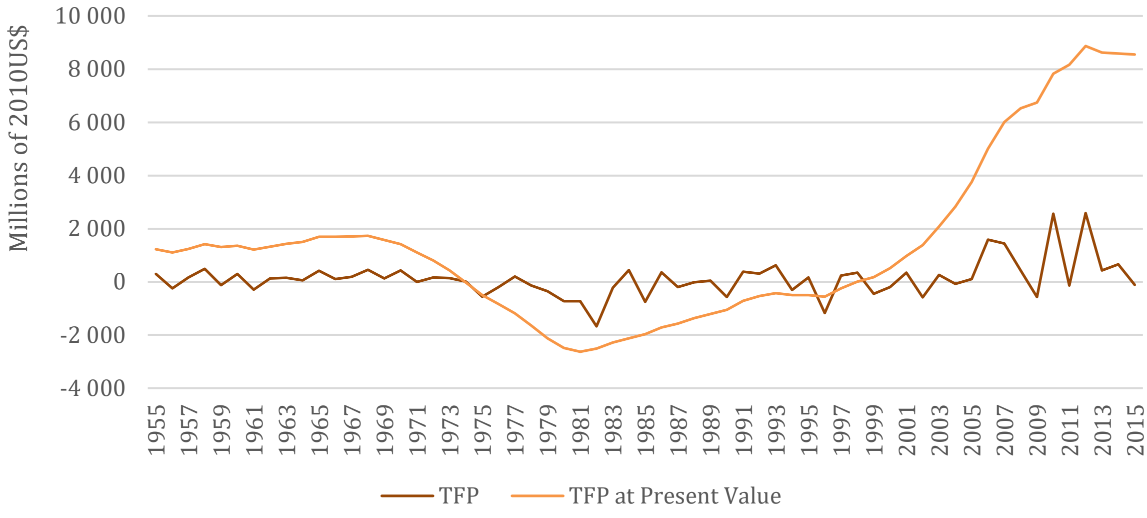
		Pricing according to Pezzey & Burke (2014)				Pricing according to the World Bank (2021)
	CO2 emissions ktCO₂	$131/tCO2 2010 USD	$131/tCO2 (3% discount rate) 2010 USD	$1455/tCO2 2010 USD	$1455/tCO2 (3% discount rate) 2010 USD	Excluding CO2 damage 2010 USD
1890	0,04	5374,96	161,85	59699,04	1797,70	2814,54
1891	0,04	5374,96	166,86	59699,04	1853,30	2915,10
1892	0,04	5374,96	172,02	59699,04	1910,62	2987,52
1893	0,04	5374,96	177,34	59699,04	1969,71	3059,93
1894	0,04	5374,96	182,83	59699,04	2030,63	3163,67
1895	0,04	5374,96	188,48	59699,04	2093,43	3366,28
1896	0,04	5374,96	194,31	59699,04	2158,17	3511,20
1897	0,04	5374,96	200,32	59699,04	2224,92	3588,78
1898	0,04	5374,96	206,51	59699,04	2293,73	3703,03
1899	0,04	5374,96	212,90	59699,04	2364,67	3781,40
1900	0,04	5374,96	219,49	59699,04	2437,81	3860,53
1901	0,04	5374,96	226,27	59699,04	2513,20	3897,98
1902	0,04	5374,96	233,27	59699,04	2590,93	3935,79
1903	0,04	5374,96	240,49	59699,04	2671,06	3973,98
1904	0,04	5374,96	247,93	59699,04	2753,67	3972,00
1905	0,04	5374,96	255,59	59699,04	2838,84	4010,53
1906	0,04	5374,96	263,50	59699,04	2926,64	4131,24
1907	41,08	6142816,91	310454,19	68227470,24	3448174,43	4719067,81
1908	41,08	6142816,91	320055,87	68227470,24	3554819,00	4620458,17
1909	12,33	1842845,07	98986,35	20468241,07	1099428,56	1441996,02
1910	41,08	6142816,91	340159,28	68227470,24	3778105,00	4951328,85
1911	61,63	9214225,36	526019,51	102341205,36	5842430,42	7271798,83
1912	82,17	12285633,82	723050,87	136454940,49	8030832,19	9888676,83
1913	61,63	9214225,36	559059,95	102341205,36	6209406,33	7412814,20
1914	20,54	3071408,45	192116,82	34113735,12	2133816,61	2469707,54
1915	41,08	6142816,91	396117,16	68227470,24	4399621,87	4987332,35
1916	41,08	6142816,91	408368,20	68227470,24	4535692,65	5035714,46
1917	41,08	6142816,91	420998,15	68227470,24	4675971,81	4725051,16
1918	41,08	6142816,91	434018,71	68227470,24	4820589,49	3999836,13
1919	41,08	6142816,91	447441,97	68227470,24	4969679,89	3345134,96
1920	61,63	9214225,36	691920,57	102341205,36	7685071,99	4349921,50

1921	61,63	9214225,36	713320,18	102341205,36	7922754,63	3726647,35
1922	41,08	6142816,91	490254,42	68227470,24	5445192,19	2812597,65
1923	61,63	9214225,36	758125,39	102341205,36	8420400,29	4561023,66
1924	82,17	12285633,82	1042096,75	136454940,49	11574433,39	6078336,37
1925	82,17	12285633,82	1074326,55	136454940,49	11932405,56	6199295,26
1926	102,71	15357042,27	1384441,43	170568675,61	15376811,28	7745260,01
1927	123,25	18428450,73	1712711,05	204682410,73	19022859,32	9384476,14
1928	123,25	18428450,73	1765681,49	204682410,73	19611195,18	9762651,76
1929	143,80	21499859,18	2123671,90	238796145,85	23587348,15	11848744,95
1930	123,25	18428450,73	1876587,83	204682410,73	20843017,51	10358172,83
1931	102,71	15357042,27	1612188,86	170568675,61	17906372,43	8979655,40
1932	82,17	12285633,82	1329640,30	136454940,49	14768142,21	7986081,67
1933	82,17	12285633,82	1370763,19	136454940,49	15224888,88	8959505,17
1934	82,17	12285633,82	1413157,93	136454940,49	15695761,73	9594689,29
1935	61,63	9214225,36	1092647,88	102341205,36	12135898,24	7119041,17
1936	102,71	15357042,27	1877401,86	170568675,61	20852058,84	11859159,82
1937	143,80	21499859,18	2709652,17	238796145,85	30095755,03	16763887,74
1938	164,34	24571267,63	3192520,97	272909880,97	35458916,08	18758388,04
1939	205,42	30714084,54	4114073,41	341137351,22	45694479,49	24392891,96
1940	164,34	24571267,63	3393050,24	272909880,97	37686168,65	20101674,89
1941	225,97	33785493,00	4809736,16	375251086,34	53421115,36	27907936,70
1942	184,88	27642676,09	4056947,09	307023616,09	45059984,84	22123750,43
1943	184,88	27642676,09	4182419,68	307023616,09	46453592,61	20081971,62
1944	267,05	39928309,91	6228116,36	443478556,58	69174880,18	27809465,22
1945	287,59	42999718,36	6914641,48	477592291,70	76800025,58	29933740,42
1946	287,59	42999718,36	7128496,37	477592291,70	79175284,10	29918833,41
1947	390,31	58356760,63	9973595,80	648160967,31	110775434,31	38099181,01
1948	636,82	95213662,08	16775988,60	1057525788,77	186328728,36	54523004,03
1949	534,10	79856619,81	14505344,32	886957113,16	161108976,96	42907859,44
1950	616,27	92142253,63	17254572,94	1023412053,65	191644302,49	50999242,04
1951	660,93	98819660,55	19077304,34	1097577145,86	211889143,66	55225675,36
1952	606,50	90681570,86	18047662,08	1007188439,73	200453040,70	47551271,22
1953	486,35	72716353,99	14919775,11	807651107,33	165712006,03	38111747,25
1954	436,89	65321470,54	13817020,46	725517096,42	153463853,21	34568099,55
1955	464,44	69440842,55	15142643,40	771270426,82	168187375,12	37104562,82
1956	542,66	81136142,35	18240189,01	901168603,97	202591412,24	44216492,01
1957	390,55	58393435,78	13533411,09	648568313,46	150313840,70	32131185,15
1958	409,15	61174075,58	14616349,73	679452518,86	162341899,63	33301167,28
1959	422,56	63179782,98	15562447,74	701729650,63	172850087,48	34025106,82
1960	490,98	73408890,70	18641321,79	815343022,64	207046742,00	39917452,32
1961	490,98	73408890,70	19217857,51	815343022,64	213450249,49	39897573,43
1962	549,60	82173461,91	22177682,27	912689977,68	246324639,00	45094356,26
1963	600,90	89843583,08	24997691,44	997881018,17	277646114,84	49781784,21
1964	674,06	100782102,86	28908430,98	1119373737,91	321082191,44	56384482,18

1965	845,91	126476261,21	37400584,50	1404755420,34	415403438,59	71446010,94
1966	992,47	148389184,39	45237634,17	1648139414,39	502448532,15	83782802,28
1967	875,25	130863032,27	41128501,02	1453478717,19	456808923,53	73096896,72
1968	1036,40	154957379,77	50207249,72	1721091508,13	557645407,16	85629528,09
1969	1146,20	171374130,35	57243700,07	1903430226,38	635798348,06	92722551,79
1970	1248,70	186699421,19	64291516,63	2073646242,96	714077532,05	97873310,86
1971	1527,00	228309454,76	81051836,92	2535803486,02	900232234,47	114744175,75
1972	1761,30	263340826,89	96379667,94	2924892390,26	1070476464,58	129584713,68
1973	2043,40	305519017,58	115274632,24	3393360080,77	1280340381,03	148731566,96
1974	1904,10	284691573,54	110738433,34	3162032362,63	1229957408,53	132869396,63
1975	2035,80	304382703,33	122059615,58	3380739185,89	1355700310,44	128948982,11
1976	2081,90	311275346,34	128684138,29	3457294877,25	1429278024,55	122388794,62
1977	2607,40	389845495,96	166150281,13	4329963332,98	1845409611,07	146951796,23
1978	2912,00	435387774,88	191299156,75	4835795514,93	2124734908,91	155667929,39
1979	2781,00	415801305,62	188343631,37	4618251142,52	2091908272,09	139493569,01
1980	2448,50	366087557,28	170953629,16	4066086991,18	1898759774,24	111481012,38
1981	2236,20	334345515,86	160959689,41	3713532256,35	1787758382,33	90341705,11
1982	2070,60	309585826,47	153649431,47	3438529599,32	1706564296,05	76784569,01
1983	2088,80	312307000,06	159793780,80	3468753321,29	1774808786,73	74260872,15
1984	1980,90	296174328,05	156226186,39	3289569826,76	1735183978,58	69671484,58
1985	2242,50	335287460,57	182327424,31	3723994313,95	2025087041,02	77224266,02
1986	2577,50	385374996,48	216046126,80	4280310075,46	2399596293,82	86905814,91
1987	2723,90	407263997,25	235378741,40	4523428366,46	2614321135,42	91796260,45
1988	2905,90	434475733,19	258871957,26	4825665586,14	2875257235,18	95883376,59
1989	2933,30	438572445,08	269394726,70	4871167233,50	2992132269,81	94764998,86
1990	2912,00	435387774,88	275709826,18	4835795514,93	3062273260,25	91151547,71
1991	3287,30	491500766,61	320869530,84	5459035232,22	3563856239,53	99699553,50
1992	3741,20	559365639,90	376468228,96	6212801572,96	4181383764,43	111094772,54
1993	3891,00	581762991,78	403651807,76	6461566053,78	4483308246,48	114307112,78
1994	5200,30	777523023,95	556163309,96	8635847327,03	6177233709,88	151136635,11
1995	4801,90	717956234,96	529438249,72	7974246731,85	5880401933,88	138065060,70
1996	4686,70	700732103,21	532718308,66	7782940535,66	5916833122,87	133311359,53
1997	4916,70	735120560,70	576145857,84	8164888670,42	6399177275,99	138357605,94
1998	5235,50	782785953,09	632477621,23	8694301998,09	7024846861,80	147255376,38
1999	5439,00	813212262,22	677383048,50	9032243065,15	7523605614,98	152902900,00
2000	5394,50	806558843,27	692619522,45	8958344404,29	7692835153,91	151576379,19
2001	5665,90	847137223,12	749964492,71	9409043203,32	8329758296,88	157499276,22
2002	6244,80	933691475,48	852155000,00	10370390052,08	9464775000,00	171734487,01
2003	6583,20	984287362,51	926115979,38	10932352003,40	10286250000,00	180950463,55
2004	6841,60	1022922046,93	992234385,52	11361462429,59	11020618556,70	187959377,21
2005	6723,40	1005249370,07	1005249370,07	11165174301,20	11165174301,20	182736201,90
2006	7005,60	1047442512,27	1396456753,95	11633808056,12	11982822297,80	188369379,40
2007	7961,30	1190334028,91	1983587164,21	13220885588,27	14014138723,56	211776753,20
2008	7991,10	1194789576,88	2389123127,20	13270372781,38	14464706331,70	210295600,84

2009	7748,90	1158577035,99	2702756810,67	12868164789,03	14412344563,72	199660660,52
2010	7493,70	1120420799,67	2987076063,25	12444368423,85	14311023687,43	196927488,28
2011	7309,40	1092865179,17	3277761289,28	12138311722,82	14323207832,93	190080967,82
2012	7258,90	1085314670,02	3616749001,51	12054449197,58	14585883529,07	188574562,21
2013	7632,70	1141203389,20	4183250896,91	12675197948,77	15717245456,48	199974371,73
2014	7748,60	1158532181,48	4632802162,35	12867666595,81	16341936576,68	202665373,94
2015	7407,10	1107472797,85	4797639792,22	12300556647,89	15990723642,26	197208266,86

Appendix B: TFP at Present Value



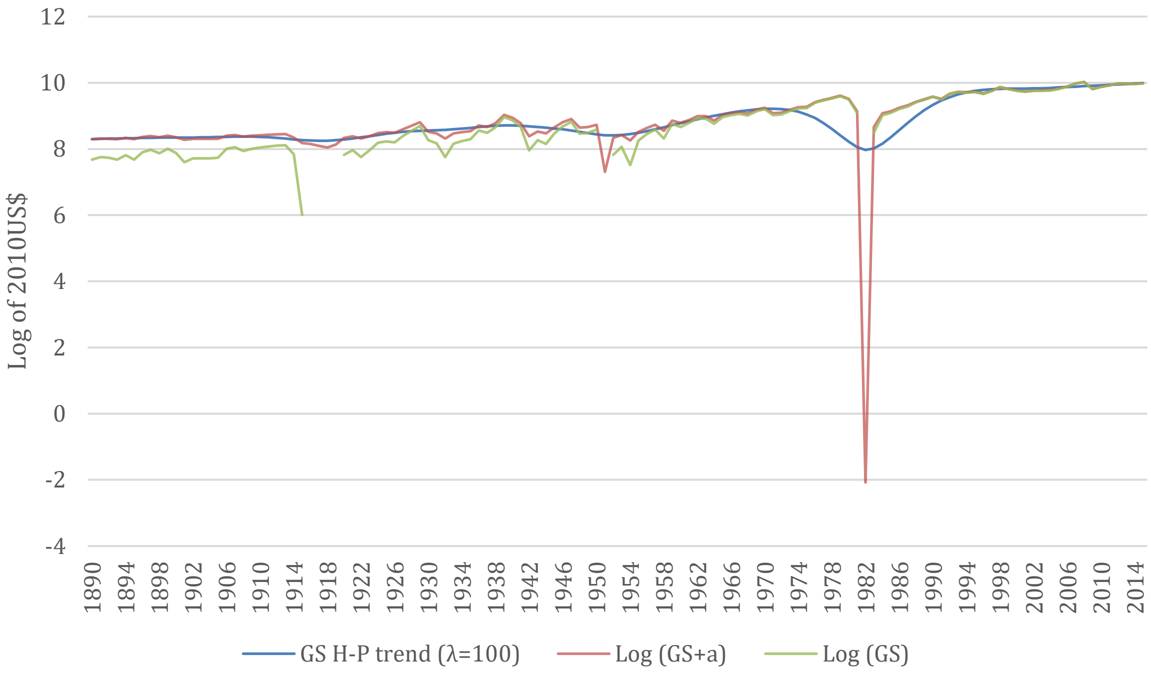
TFP and TFP at present value of future change (1955-2015)

Source: Own calculations

The above figure shows a significant difference between TFP at current value and TFP at present value of future change.

TFP at present value was derived from the GDP, TFP growth, and a filtered TFP growth. The GDP and TFP growth are calculated from the PWT (2021) to guarantee consistency. Filtered TFP is derived with the Kalman filter which is used to reduce the noise of past, present, and future value (Welch & Bishop, 2006). The interest rate was derived from the CPI used in the rest of the analysis for consistency and is constant at i= 0,02699. TFP at present value of future change was calculated over a 20 years' time horizon following Blum, Ducoing & McLaughlin's (2017) estimations.

Appendix C: Hodrick– Prescott Filter on GS



Genuine Savings with the H-P filter

Source: Own calculations

The Hodrick– Prescott filter was applied to GS in the following way: Log (GS) + a was calculated, where a = -149654636,79 is a constant according to the lowest value of GS. The Hodrick-Prescott filter was then applied to Log (GS) + a with a λ =100 as commonly used for long-term series (Hodrick-Prescott Filter for Trend and Cyclical Components, 2021).

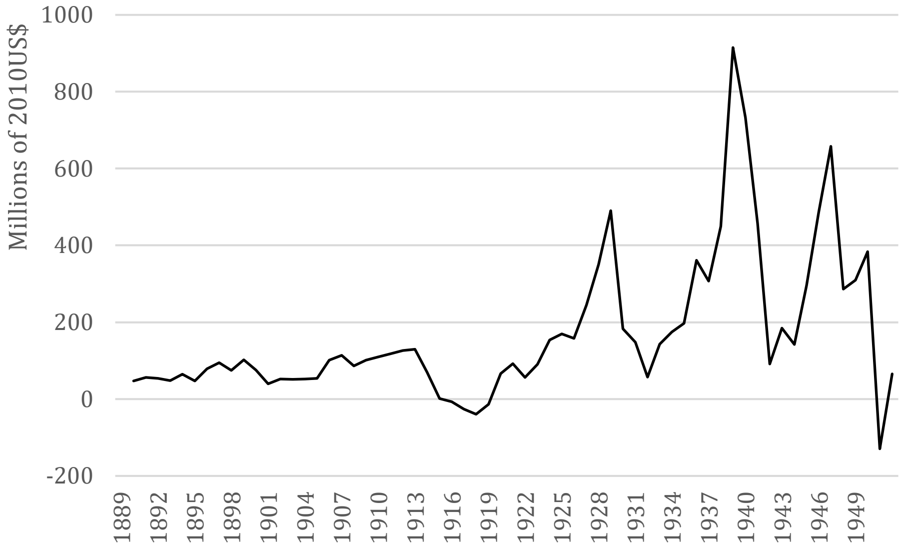
Appendix D: Saving estimations

	NNS 2010US$	Green Savings 2010US$	Genuine Savings 2010US$
1890	41446335,46	36273842,87	46986588,26
1891	50262495,19	45472477,16	56439945,74
1892	51339730,09	46734465,65	54051432,49
1893	45419531,73	40585793,90	47770639,69
1894	62106425,44	57830999,36	64591116,82
1895	43806152,86	39598695,65	47226992,53
1896	73949648,99	69297275,09	78823209,54
1897	87406958,12	82676031,79	94705293,72
1898	69644949,63	64765649,52	74659537,45
1899	101403238,05	94176809,93	102003832,22
1900	75546729,95	63424622,29	75734820,49
1901	77223843,42	28301922,57	40095891,22
1902	85775161,21	42134253,61	52147445,68
1903	83435219,47	37973694,38	51557830,11
1904	86274720,10	39463899,31	52460098,76
1905	87910855,40	39437018,76	54191836,25
1906	137937509,35	82370540,66	101352395,80
1907	146149712,12	93439779,09	113656933,24
1908	131349325,99	74152721,19	86318281,67
1909	144519660,59	83659392,77	100964354,65
1910	153470223,26	92884489,65	109760860,27
1911	190829070,60	102117455,41	117625607,08
1912	181055175,83	108021745,62	126182001,59
1913	187118560,30	110561483,43	130010261,69
1914	118859499,85	50530644,29	69911878,54
1915	56458969,18	-13106480,25	1019741,43
1916	48398959,73	-22432312,68	-6897307,91
1917	22615790,52	-36188353,84	-25974517,83
1918	748421,04	-43708718,69	-39065246,44
1919	20622931,25	-18343885,30	-13649737,13
1920	92502326,60	56918618,22	66075918,01
1921	116672444,13	84887267,78	91798554,64
1922	80716355,75	47663459,34	56190143,15
1923	116117831,63	82743316,61	90527833,34
1924	183121581,78	144353889,04	153504722,48
1925	197563775,21	159948179,28	169949647,12
1926	182864459,16	146911339,53	157728797,48
1927	266565813,30	232203460,31	244361239,29
1928	369309655,14	336086165,68	350651029,17

1929	505684597,08	475026200,86	489972794,18
1930	199090924,73	167346508,09	183307654,81
1931	153565372,76	132858849,42	148010989,96
1932	66051400,09	43552672,47	57127219,20
1933	153943394,21	127972957,68	143372355,13
1934	184936609,80	154696543,64	174606014,12
1935	210204189,86	182705616,77	197001036,27
1936	378242127,92	348678157,21	361476962,48
1937	321146199,08	292169495,17	307479886,37
1938	464999261,47	434277136,64	449268460,22
1939	928193118,45	898588978,84	914963073,83
1940	741933061,88	712494722,72	732485911,25
1941	487356555,31	437104784,04	457327122,06
1942	111461833,54	66488672,32	91374587,74
1943	193625013,40	154763023,09	184876586,36
1944	153575098,51	116968934,76	142227887,06
1945	305125251,28	269627126,78	295623847,40
1946	490793089,35	458638057,56	486534823,01
1947	653299106,18	624760595,80	658039053,90
1948	290593867,17	264600463,47	285947590,28
1949	313727274,58	287639770,69	309699830,51
1950	388059425,45	362276867,12	383634874,82
1951	320643136,92	-154884347,92	-129416107,30
1952	502760701,95	36184547,23	65922298,96
1953	535339909,54	72238785,01	115208747,06
1954	436013301,56	-23644340,03	32446481,38
1955	571470090,78	110099166,75	182369632,22
1956	660739430,89	206151416,49	280039877,20
1957	726158586,60	286127366,29	384108098,58
1958	527066400,65	99280157,85	206074993,35
1959	880942007,86	455922109,15	573939228,97
1960	753683057,12	335665190,28	464078362,36
1961	839232652,16	482160960,74	609800582,32
1962	995980823,56	714438582,61	833209565,69
1963	981576516,99	703712779,55	822680606,50
1964	710069767,02	435789705,65	570083852,17
1965	1050065821,85	780585394,01	914767899,37
1966	1177548155,79	915552414,44	1050622115,40
1967	1227552414,25	973418660,88	1140150927,28
1968	1097924363,17	853832114,50	1015150762,13
1969	1406363864,33	1174715991,06	1385312307,06
1970	1623584901,58	1404271815,07	1602371831,75
1971	1853980911,45	846261639,77	1042909837,03
1972	1875482796,71	898900417,09	1107558397,97
1973	2044217940,24	1124586628,28	1386363727,91
1974	2162844883,24	1334501411,95	1675427432,16
1975	2070483895,21	1311939175,45	1711252528,08
1976	2710207192,64	1992586811,02	2482318374,40

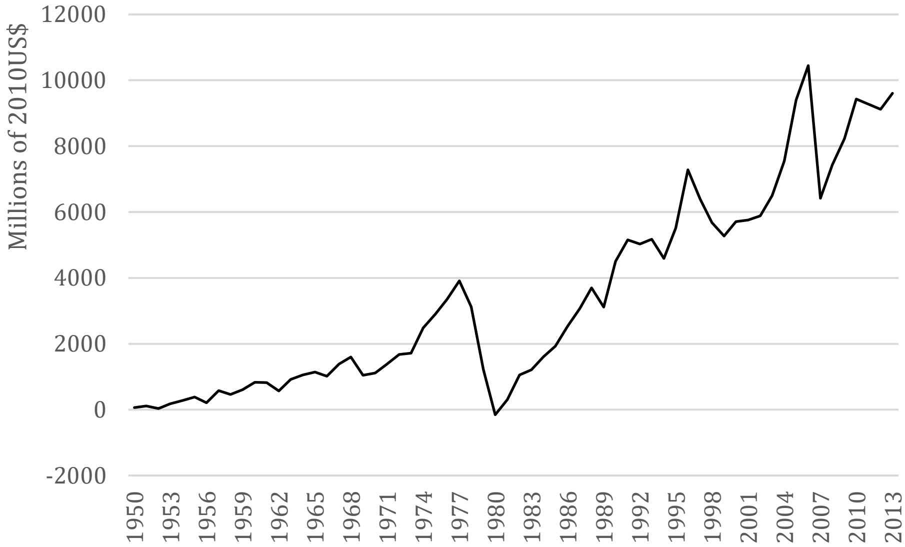
1977	3025636714,74	2352550051,02	2902664804,16
1978	3088388133,95	2708006745,70	3353432876,76
1979	3531566630,77	3188657093,47	3906669753,55
1980	2735813051,18	2432225554,27	3123503267,38
1981	1288466154,84	978418531,97	1222885627,45
1982	-18057400,01	-311557740,47	-155632111,83
1983	368346119,57	82628888,08	302328821,90
1984	1211742798,90	804990286,01	1049149711,81
1985	1384113314,10	990307979,79	1211378555,34
1986	1754748402,86	1367687730,42	1609518153,15
1987	2108479981,74	1735872353,78	1927484494,70
1988	1797033817,86	2381477526,67	2527528919,79
1989	2323966340,16	2881741234,56	3064267232,44
1990	2946115635,16	3474086568,36	3694081386,24
1991	1939654443,60	2993892251,41	3111943724,94
1992	3323238062,47	4346047131,95	4507969417,05
1993	3957961507,47	4949209318,44	5158864762,55
1994	3935394241,29	4899774319,54	5024657213,78
1995	4106893611,49	5048158280,40	5172689115,50
1996	3469101800,52	4382250251,00	4588900866,44
1997	4420308869,27	5314994779,49	5515139574,61
1998	6361069351,78	7059854175,39	7280792080,40
1999	5530910377,28	6215221644,37	6399137860,79
2000	4729080550,21	5394838702,68	5679112728,32
2001	4647958759,68	4957920471,02	5273712319,63
2002	5125667268,31	5430333963,55	5711660005,40
2003	5233643432,97	5531094590,36	5759909583,62
2004	5409120592,08	5696262903,54	5886702315,11
2005	6027911651,56	6303499440,82	6493372489,43
2006	6829844684,30	7693963389,52	7547394683,11
2007	9091450338,51	9920587797,95	9398273915,03
2008	10264429842,81	11060176391,85	10447781842,36
2009	7106262676,20	7135012582,97	6422333568,88
2010	7780915889,97	7809890675,57	7430166227,86
2011	8675680702,81	8703690694,61	8225808943,72
2012	9512635317,37	9948176758,33	9433960574,57
2013	9570131380,46	10044922988,09	9278183569,94
2014	9820165635,30	10351524308,12	9116190268,54
2015	10137476999,62	10631394490,82	9601182471,51

Appendix E: Genuine Saving graph



Genuine Savings (1890-1950)

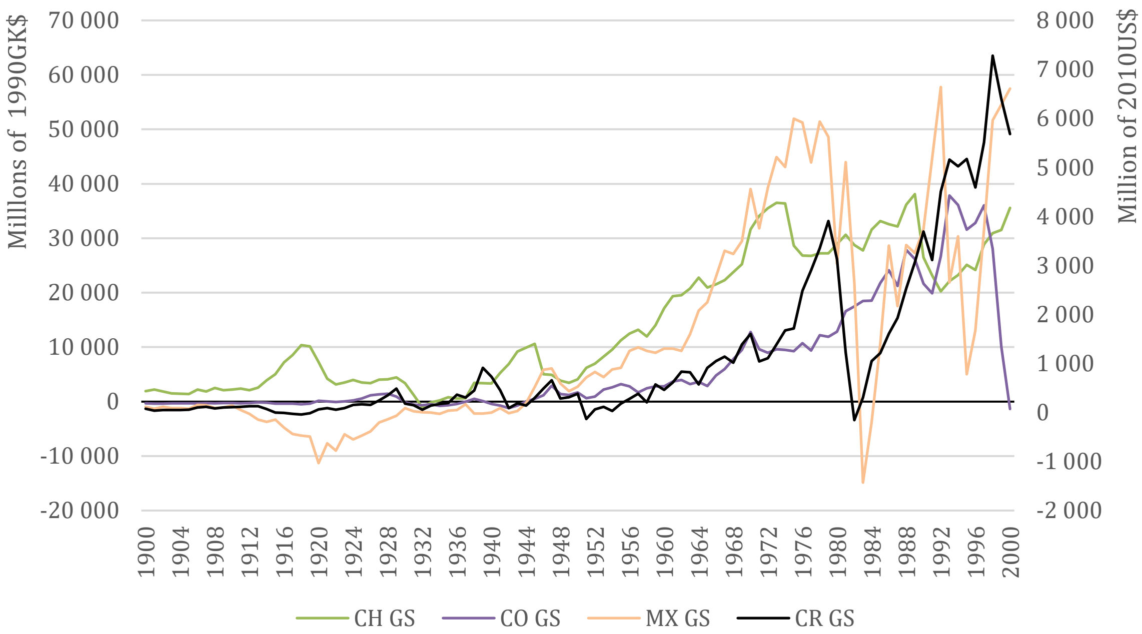
Source: Own calculations



Genuine Savings (1950-2015)

Source: Own calculations

Appendix F: Cross-country comparison

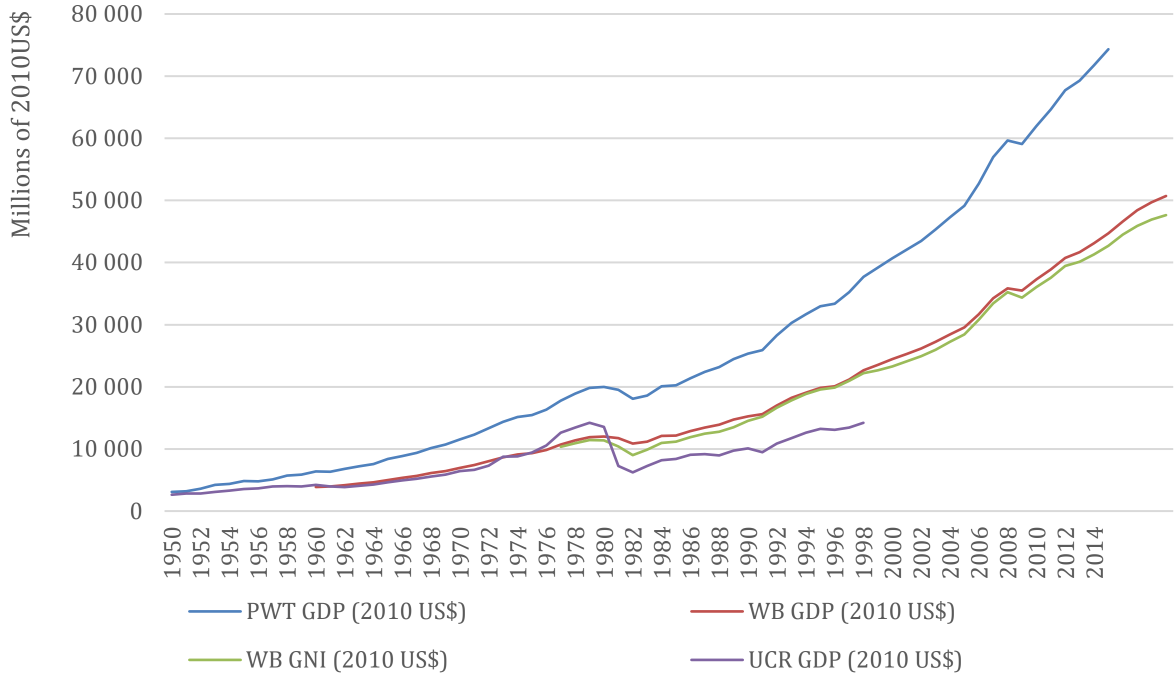


Cross-country comparison in real value (1900-2000)

Left axis: Switzerland GS, Colombia GS, Mexican GS
Right axis: Costa Rica GS

Source: Own calculations for Costa Rica; Blum, Ducoing and McLaughlin (2017) for Switzerland, Colombia and Mexico

Appendix G: Comparison of GDP



GDP and GNI from three sources

Comparison of the GDP values from two of our main sources: PWT (Groningen Growth and Development Centre, 2021) and the ‘Proyecto de Historia Económica de Costa Rica en el siglo XX’ (León & Arroyo, 2010) with the WB GDP and GNI. Even though different in magnitude, all sources show similar trends which confirm the validity of combining the sources into the present dataset.

Appendix H: Impact of natural capital on GS (1988-2015)

	Forest rents as a share of total GS %	Mineral extraction rents as a share of total GS %	Emissions as a share of total GS %	Natural resources – Emissions 2010 US$
1988	23,38%	-0,26%	-10,24%	325571751,56
1989	18,40%	-0,20%	-8,79%	288380167,70
1990	14,48%	-0,19%	-7,46%	252261107,03
1991	34,10%	-0,22%	-10,31%	733368276,97
1992	22,85%	-0,16%	-8,35%	646340840,51
1993	19,39%	-0,17%	-7,82%	587596003,21
1994	19,41%	-0,21%	-11,07%	408216768,30
1995	18,33%	-0,14%	-10,24%	411826419,20
1996	20,07%	-0,17%	-11,61%	380430141,83
1997	16,33%	-0,10%	-10,45%	318540052,39
1998	9,66%	-0,07%	-8,69%	66307202,37
1999	10,76%	-0,06%	-10,59%	6928218,59
2000	11,73%	-0,01%	-12,20%	-26861369,98
2001	5,89%	-0,02%	-14,22%	-440002781,37
2002	5,36%	-0,02%	-14,92%	-547488304,76
2003	5,19%	-0,03%	-16,08%	-628664821,99
2004	4,95%	-0,07%	-16,86%	-705092074,06
2005	4,34%	-0,10%	-15,48%	-729661580,81
2006	11,65%	-0,20%	-18,50%	-532338048,73
2007	9,09%	-0,27%	-21,11%	-1154449704,77
2008	7,88%	-0,26%	-22,87%	-1593376578,16
2009	0,55%	-0,10%	-42,08%	-2674006903,90
2010	0,47%	-0,08%	-40,20%	-2958101277,65
2011	0,53%	-0,19%	-39,85%	-3249751297,47
2012	4,89%	-0,27%	-38,34%	-3181207560,55
2013	5,31%	-0,20%	-45,09%	-3708459289,27
2014	5,83%	0,00%	-50,82%	-4101443489,53
2015	5,14%	0,00%	-49,97%	-4303722301,01

The above table represents the impact of the three indicators of change in natural capital on the total GS. Since 1988, forest areas have increased, leading to a positive impact of natural capital on GS. However, since 2000, the CO_2 emissions have increased to a point where, for 131 2010US$/t CO_2, the impact of natural capital on GS is negative again.