Suriname: reconciling agricultural development and conservation of unique natural wealth

Agnieszka Ewa Latawiec[a,b,c,*], Bernardo B.N. Strassburg[a,d], Ana Maria Rodriguez[e], Elah Matt[c], Ravic Nijbroek[e], Maureen Silos[f,g]

A – International Institute for Sustainability, Estrada Dona Castorina 124, 22460-320, Rio de Janeiro, Brazil

B – Opole University of Technology, Department of Production Engineering and Logistics, Luboszycka 5, 45-036 Opole, Poland

C – University of East Anglia, School of Environmental Science, Norwich, NR4 7TJ, United Kingdom

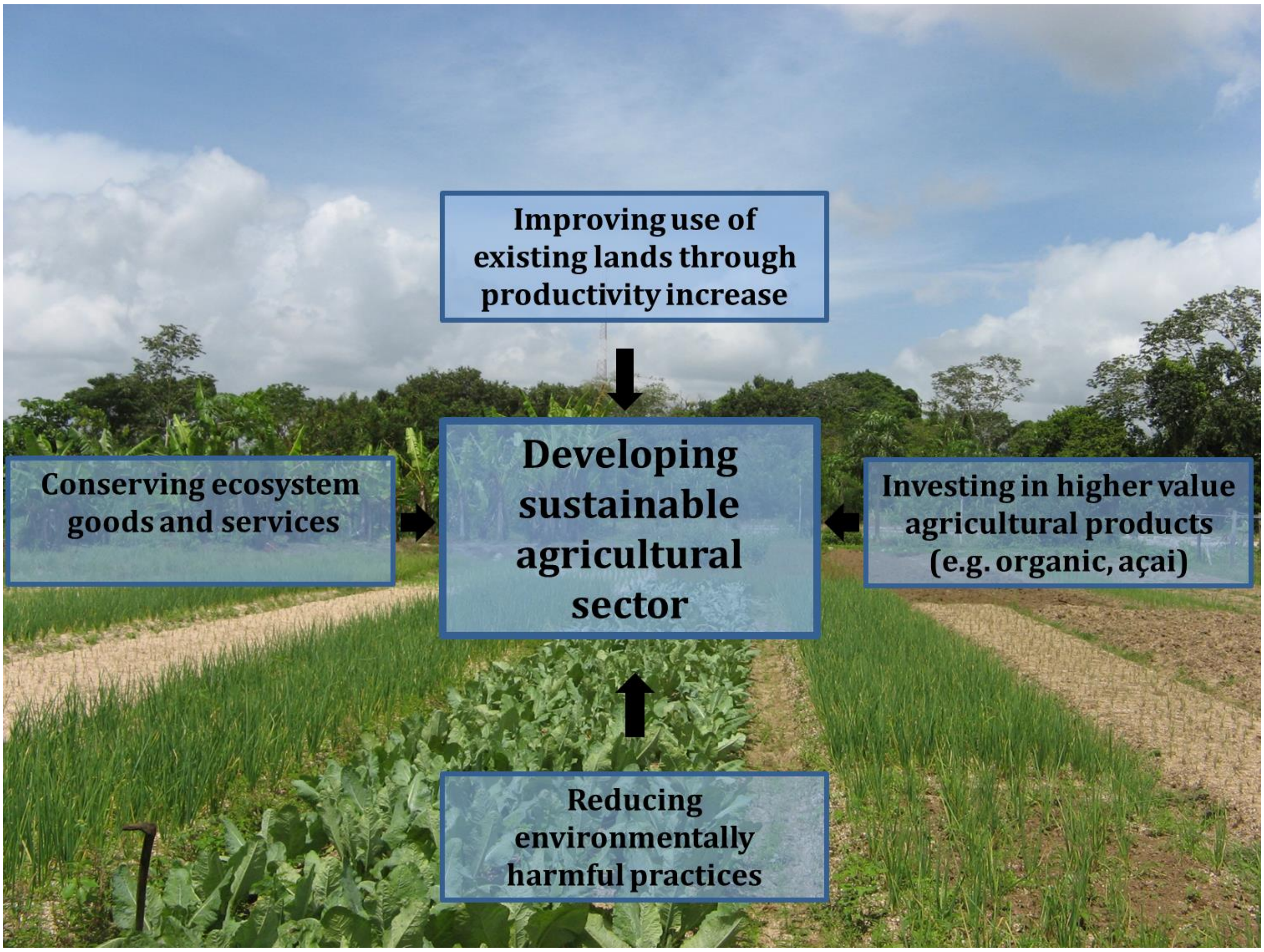
D – Department of Geography and the Environment, Pontificia Universidade Catolica, 22453-900, Rio de Janeiro, Brazil

E – Conservation International, 2011 Crystal Drive, Arlington, VA 22202, USA

F – The Caribbean Institute, Hoekstrastraat 5, Paramaribo, Suriname

G – The Centre for Agricultural Research in Suriname, Postbus 1914, Paramaribo South

* Corresponding author: Tel: +552193065007, email: a.latawiec@iis-rio.org, address: Estrada Dona Castorina 124, 22460-320, Rio de Janeiro, Brazil



Abstract

National and transboundary adverse effects of competition for land are being increasingly recognized by researchers and decision-makers, however the consideration of these impacts within national planning strategies is not yet commonplace. To estimate how increasing agricultural production can be conciliated with protection of natural resources at the national scale, we analyzed current land use in Suriname, and investigated opportunities for, and constraints to developing a sustainable agricultural sector.

Suriname is a remarkable case study. To date, Suriname has retained most of its natural resources with forest areas covering over 90% of the country. Surinamese forests combine extremely high levels of both biodiversity and carbon, making them top priority from a global ecosystem services perspective. Among other national and international pressures from increased demand for agricultural products, , the country is also considering significant expansion of agricultural output to both diminish imports and become a 'bread basket' for the Caribbean region, which collectively may pose risks to natural resources.

In this study, combining locally-obtained primary data, expert consultation and secondary data from the Food and Agriculture Organization we analyzed a range of scenarios, we show the complexities associated with current land management and we discuss alternatives for developing a sustainable agricultural sector in Suriname.. We show that Suriname can increase the production of rice, which is the most important agricultural activity

in the country, without expanding rice area . Rather, future increase in rice production could be promoted through an increase in rice productivity, and the employment of more environmentally-favourable management methods, in order to both diminish pollution and avoid encroachment of the agriculture into pristine areas. Further, we show a potential to both contribute to greening of the agricultural sector and to higher economic returns through expanding the production of ‘safe food’ and through possible development of organic agriculture in Suriname.

If Suriname develops a ‘greener’ agricultural sector, it may both increase economic returns from the agricultural sector and benefit from continuing protection of natural resources. Because most of Suriname forests present top levels of carbon and biodiversity, the country could benefit from so-called ‘early-action’ Reducing Emissions from Deforestation and Forest Degradation (REDD) finance, which is already being paid mostly through bilateral agreements. Further, by adopting land-use planning that protects natural resources, Suriname may be in extraordinary position to benefit from both improved-quality agricultural production and from incentives to conserve forest carbon and biodiversity, such as payments for ecosystem services. Given the high stakes and the severe lack of both primary data and applied analyses in Suriname, further research focused on better informing land-use policies would be a valuable investment for the country. Although this analysis was performed for Suriname, conclusions drawn here are transferable and may assist formulation of policy recommendations for land use elsewhere.

Keywords: sustainable agriculture; organic farming; development; avoiding deforestation; landscape approach; Suriname

1. Introduction

Over the next few decades land resources are forecasted to continue to be subject of competition from a range of uses (Alexandratos, 2012; Harvey and Pilgrim, 2011; Smith et al., 2010). According to the Food and Agriculture Organization (FAO, 2009), one of the main drivers of this competition stems from the anticipated growth in global population from seven to nine billion by 2050. Not only will these additional billions need to be fed, they also want to be fed well (Smith et al., 2010). With higher purchasing power comes higher overall consumption and the global appetite is projected to increase also with respect to other commodities, such as fuel or timber (Smith et al., 2010; Tilman et al., 2009). Furthermore, land degradation intensifies competition because it depletes the available pool of land for production while a share of land is additionally set aside for conservation purposes (Smith et al., 2010).

Competition for land is transboundary (Lambin and Meyfroidt, 2011; Strassburg, 2013), meaning that although increased demand occurs in one part of the world, pressure to provide commodities may be shifted elsewhere, given the economic benefits for commodity-providing countries and the globalization of agricultural markets. The World Bank (2011) demonstrated that there were about 45 million ha covered by large-scale land acquisitions, mostly in developing countries, with the production of food and biofuel in these areas destined for exports. These large-scale land acquisitions are also sometimes referred to as 'land grabs' (World Bank, 2011; Friis, 2010) and represent the adverse effects of demand displacement (Lambin and Meyfroidt, 2011). Notwithstanding the potential positive aspects of facilitated international land acquisitions, including poverty alleviation, improvements in infrastructure or job creation, in practice, these kinds of transactions are often accompanied by negative in-country effects. Loss of livelihoods and displacement of local population may occur, with the poorest being usually the first to lose their land (Zoomers, 2010).

Agriculture has historically been the greatest force of land transformation (Lambin and Geist, 2006). Cropland area expanded from 3-4 million km^2 in 1700 to 15-18 million km^2 in 1990, a loss of 12-14 million km^2 of natural areas (Goldewijk and Ramankutty, 2004). Gibbs et al. (2010) also showed that tropical forests were primary sources of new agricultural land in the 1980s and 1990s. Throughout the tropics, between 1980 and 2000 more than 80% of new agricultural land came at the expense of intact and disturbed forests (Gibbs et al., 2010). According to forecasts, global land under crop cultivation may increase by some 70 million hectares by 2050, mostly in developing countries (FAO, 2006).

On account of the future population projections, increasing demand and environmental degradation, and with the recent figures showing Food Price Index up by 1.4% as a result of fears of food shortages following poor harvests (FAO, 2012a), there has been increasing interest in research and implementation towards more sustainable land management (de la Rosa et al., 2009; EC, 2012; FAO, 2012b; Ingram and Morris, 2007; ORC, 2012; Powlson et al., 2011; Reidsma et al., 2011; Sutherland et al., 2012). For instance, sustainable intensification of agriculture - that is producing more food from the same area of land while reducing the environmental impacts (Royal Society of London, 2009) - has been indicated as paramount to meeting growing demands from a growing global population while simultaneously protecting the remaining natural resources of the planet and ecosystem services they provide (Foley et al., 2011; Foresight, 2011; Godfray et al., 2010; Mueller et al., 2012; Tilman et al., 2011; Tilman et al., 2002). Global-scale estimates demonstrate spatially 'yield gap' between observed yields and those attainable in a given region (Licker et al., 2010; Mueller et al., 2012) and recent studies have investigated alternatives to sustainably close this gap (Licker et al., 2010; Mueller et al., 2012; Tilman et al., 2011). However, in practice, it is the local land-management policy and socio-economic constraints determining whether a sustainable intensification and conservation path is pursued by under-yielding nations (e.g. Mueller et al, 2012).

In order to form a better view on how intricate factors, such as local socio-economic circumstances, play a role within the broader concept of sustainable intensification and protection of natural resources, we analyzed available data and policies, and investigated possibilities for developing sustainable agriculture in Suriname. Suriname is an interesting case study when considering competition for land and development that simultaneously protects natural environment. Suriname is the smallest sovereign South-American country, with a total land area of approximately 164 000 km^2 (ATM, 2013) situated in northeastern part of the continent (Fig. 1). It has a tropical climate, with an average daily temperature of 27º C in the coastal region and an annual average rainfall of 1900 mm and 2700 mm for the coastal areas and the central part of the country, respectively (ATM, 2013). Suriname retained most of its forest resource (Griscom et al., 2009), with forest land covering over 90% of the country including pristine tropical rainforest of the Amazon (ATM, 2013; Country Strategy Paper -CSP, 2008). There are multiple factors that historically contributed to low deforestation rates. Suriname is a low populated country (currently just over 500 000 and the population density of approximately 3 inhabitants per square kilometer), with the majority living along the coast in urban and peri-urban areas (ATM, 2013). Its colonial history influenced establishment of coastal plantations in vicinity of ports to facilitate shipping of agricultural products to Europe. Historically, lacking infrastructure and the presence of a significant population of Maroons (descendants of escaped slaves) prevented settlers from expanding into the forest because of the risks of being attacked. Strict control of the government and regulations on logging concessions have also contributed to diminishing uncontrolled timber extractions.

Currently there are fears however that low deforestation rates between 0.03 and 0.04 % per year (ATM, 2012) may not be sustained. Expansion of palm oil, sugarcane and other plantations, and small to medium scale mining have been reported as emerging threats to natural ecosystems in Suriname (ATM, 2013; WWF, 2012; CIS, 2010).

Several international companies are now interested in reviving the palm oil industry in Suriname and it has been demonstrated that palm oil and sugarcane for ethanol may be responsible for the biggest expansion in production area (CIS, 2010). Globally, palm oil is one of the crops of which harvested area has most rapidly been expanding (Phalan et al., 2013). Recent data suggest that the Surinamese government is considering new production on 90 000 hectares of oil palm[1]. The government has already signed Memorandums of Understanding with Indian and Chinese companies ('Fats, Foods, and Fertilizers' and 'China Zhong Heng Tai', respectively). Suriname was previously engaged in the production of palm oil, which led to deforestation. In 1969, in the districts of Marowijne and Para, 80 000 hectares primary forest were designated for palm oil production of which 6000 hectares were cleared and put into production. A combination of palm tree disease, lack of technical expertise, and civil war in the late 1980's eventually caused these investments to fail.Furthermore, an area of 12 000 hectares that was previously used for rice production is now to be turned into sugar cane by the State Oil Company (CIS, 2010). Being successful, this can result in further expansion, with areas in West Suriname (never put into production before) being prepared for sugarcane production with likely little benefits to local population (CIS, 2010).

Concurrently, the country is aiming to significantly expand agricultural output and become a 'bread basket' of the Caribbean region[1]. Rice is the main agricultural product in the country and if demand exists, there is a risk of continued rice expansion into coastal wetlands.

To date there is a general lack of centralized land-use planning in Suriname. The Planwet (Planning Law) of 1973 includes directions for developing Structuurplannen (Structural Plans) and Bestemmingsplannen (Zoning Plans), but the law is not being implemented. The coastal zone is protected by law and is governed by Multiple Use

1 www.president.gov.sr and CIS, 2010

Management Areas (MUMA) regulations[2] but mangrove forests may however be under threat (including from housing development) in the north of the capital city, which has not been declared a MUMA.

Taking into consideration global and local policy, environment, and socio-economic factors, this study presents opportunities for greening of the agricultural sector in Suriname. We analyzed agricultural data (both from the Food and Agriculture Organization and local estimates), and discuss different scenarios of future rice production and productivity and their implications for land-use dynamics. Based on interviews and expert opinion, we then propose alternatives to be implemented within sustainable agricultural management. Finally, we investigated the possibility for developing organic market in Suriname and present a framework of opportunities to expand this market both at national scale as well as for external markets.

To our knowledge this is the first study on developing a sustainable agricultural sector in Suriname and we present alternatives, opportunities, constraints and policy-oriented recommendations for developing sustainable agricultural sector in the country yet with worldwide recommendations, especially for developing countries. Here we offer a complementary view to previous global-scale studies on yield gap, sustainable intensification and sustainable land management by presenting regional analysis of feasibility of such actions in real-world circumstances. Further, because local interventions in tropical rainforests have global consequences (Davidson et al., 2012), and because conclusions formulated in this study can be translated to other forest- and carbon-rich countries (often finance-poor countries), the recommendations drawn here may direct towards better resources management not only due to benefits from improved agricultural sector but also by benefiting from the international schemes and incentives to protect rainforests. The results of this study may inform policy and support a range of actors such as non-governmental organizations (NGOs), private enterprises and other stakeholders.

2. Methodology and data collection

2.1. Study area

Suriname was selected as a study area to investigate how sustainable agricultural sector in combination with conservation of natural resources can be pursued. First, it is one of the countries with the highest prime forest cover (as percent of the country area) in the world (FAOstat). Over 90% of the country is covered by forest (ATM, 2013), which presents highest values of both carbon and biodiversity (Strassburg et al., 2010). At the same time, the country currently has plans to expand its agricultural sector and become a ‘bread basket’ of the Caribbean. Second, Suriname has received increasing attention from capital-rich countries to purchase land for sugarcane and palm oil production, which, in absence of in-force

---

[2] http://www.stinasu.com/muma.html; http://www.conservation.org/where/south_america/suriname/Pages/suriname.aspx; http://www.celos.sr.org/projects/ongoing_projE.asp

environmental legislation, may pose a threat to its natural environment (CIS, 2010). Therefore, Suriname may be at crossroads with a few alternatives ahead including sustainable development of agriculture with conservation of natural resources or development that undermines Suriname's natural capital. Further, there has been little research analyzing opportunities for and constraints to developing sustainable agricultural sector in Suriname and the analysis presented here can directly contribute to aid decision-making.

Suriname is largely covered by tropical rainforest (Fig. 1) and has a surface area of about 166 km^2 (CSP, 2008). The country´s terrain is very diverse in terms of ecosystems and habitats and consists of a young and old coastal plain interspersed with brackish and freshwater wetlands, a central plateau region with savannas and swamp forests, and a highland region in the south with densely forested tropical vegetation (ATM, 2013). Northern Coastal Plain is well described and mapped, while hilly landscapes of the interior have been little investigated. Although much of this area remains unknown, the areas above 400 m represent peculiar landscape features, with rare and potentially unique habitats, such as cloud forest (ATM, 2013). The country has a positive balance of payments with an export value larger than imports. According to the World Bank, Suriname has a GDP of U$ 4,7 (data for 2012) which has steadily been growing at a mean rate of around 4% since 2001, with a minor setback during 2007-09, and a low percentage of foreign debt (Department of National Accounts-ABS, 2010). The agriculture sector is the third largest formal employer after the civil service and trade with approximately 11 500 jobs or 12% (ABS, 2010). Agricultural production in Suriname is primarily composed of rice, bananas, oranges, vegetables, plantains and coconuts. Rice and bananas also compromise the majority of exports, $32.3 million and $33.1 million respectively in export earnings (2008 figures). In terms of cultivated area, contribution to GDP (3% in 2002), foreign exchange earnings (approximately USD$14 million in 2002) and direct employment (8 000 jobs in 2002), rice is the most important crop in Suriname (Poerschke, 2005). Production has traditionally been concentrated in the north of the country in the Nickerie district, accounting for more than 75% of productive land dedicated to rice, followed by Saramacca with around 10% and Coronie with approximately 7%. Regarding land ownership, over 80% is under hereditary long-term lease or land lease, less than 10% is rented, and less than 5% is owned as allodial property (Rees et al., 1994).

2.2. Data collection

Upon a literature review on agricultural sector in Suriname and consultations with local stakeholders, we preliminary selected four key areas that may contribute to developing sustainable agricultural sector in Suriname. These were: 1) improving use of existing land through increasing productivity of rice; 2) reducing environmentally harmful practices in rice sector; 3) investing in higher value agricultural products (e.g. organic agriculture) and; 4) conserving ecosystem goods and services. We then validated these alternatives during a focus group (n = 25), with local researchers, NGOs, private sector, business sector, farmers and government representatives in Suriname.

For the analysis of land use and land availability for expansion of rice sector in Suriname (see subsection 2.3) we used FAO data on rice production (in tons per year) and productivity (in tons per hectare) (FAOstat, 2012), which we verified with local estimates (obtained from 'Anne van Dijk' Rice Research Centre Nickerie; ADRON). The recommendations of the techniques for improving rice production systems were based on a literature review (mainly governmental documents, research reports and articles, bulletins and briefs) and validated during the focus group while interviews with farmers and researchers at ADRON (n = 20) served to confirm major constraints that the sector was facing. The information on opportunities for developing organic farming in Suriname was collected on the basis of interviews (expert opinion) with the organizations from Suriname that are leading the development towards organic farming in field (the Caribbean Institute and Center from Agricultural Research in Suriname- CELOS). Additional information on organic farming was collected from farmers and private stakeholders from Suriname within the focus group. The opinion of a European policy expert was employed throughout the duration of this study to explore opportunities for organic products from Suriname to be exported overseas.

The results of the analysis of the four key alternatives contributing to development of sustainable agricultural sector were then presented at the final workshop at the Anton de Kom University of Suriname wherein final feedback on conclusions and recommendations was received from researchers, members of NGOs, farmers and private sector (n = 22, including three participants of the focus group) and incorporated into final conclusions. Because there is relatively little environmental monitoring in Suriname and relatively few data exist, we opted for focus groups and expert opinion as triangulation for our literature review and analysis of FAO and International Federation of Organic Agriculture Movements (IFOAM) data (for organic farming). In the circumstances of little data availability, expert opinion is important as a valuable source for environmental analysis (see for example, Krueger et al., 2012), while focus groups have been indicated as an ancillary validation method within multi-method study design, alongside and triangulating other methods, especially when data is scarce (Bloor et al., 2001).

2.3. Modeling of future land demand for rice

FAOstat data (2012) on rice production and productivity in Suriname were used to analyze land availability for a range of productivity scenarios over the next decade. The interplay between production targets and productivity changes determines the area necessary for future land demand. The area (in hectares) necessary to meet rice production targets is dependent on the production target (in tonnes of rice) and productivity (in tonnes of rice per hectare). For each of these two parameters, we analyzed three scenarios: (i) stagnation, where values remain constant until 2022; (ii) modest increase, where there is an increase of 1% per annum until 2022; and (iii) high increase, where there is an increase of 3% per annum until 2022. These values were selected based on trends observed in FAO data (FAOstat, 2012) and were validated during the focus group (n = 20) by researchers and farmers from Rice Research Center in Suriname (ADRON). Table 1 summarizes the three scenarios for both parameters. We then calculated how much area would be needed, if rice production increases with and without productivity increase.

3. Results and discussion

3.1.Improving use of existing lands through productivity increase: developing sustainable rice sector

The rice sector in Suriname has faced a steady decline over the last 30 years. Rice production in Suriname reached its peak during the mid 1980s and since then the sector has had small recovery periods, but with an overall downward trend, of a decline little over 2% per year both in terms of production volume and harvested area until 2007. There are several reasons for this decline. First, while Europe has been increasingly more open and transparent in trading around the world, this has had a negative impact on Suriname through the reduction of its preferential access to this market and an increased competition from other exporting countries. Second, according to Elmont (2010), deterioration of milling infrastructure contributed to falling rice production in Suriname because of underutilized milling capacity, leading to higher processing costs that, in turn, lead to uncompetitive products in the international market. Third, there is no value added to rice and rice by-products and waste of rice production barely utilized. Fourth, there is a lack of structured product development research. Furthermore, most of Suriname's exports now take place from the Paramaribo port, which translates into increased transport costs. In addition, limited irrigation system (currently rice farmers in Suriname generally use traditional flooding systems to irrigate their fields) and the maintenance of this key service to the farmers also represents a limiting factor that contributes to the sector's current challenges (Mertens, 2008). Finally, high interest rates (between 12 to 13%) have increased farmer defaults and have reduced the level of investment on farm equipment for the past 15 years. This recession resulted in all main machinery suppliers closing their shops, including repair shops and spare part supply, which now, in turn is perceived as limiting factors to stimulating rice sector.

In this context the country has now ambitions to increase its rice production. Because productivity levels impact on the demand for land from the rice sector, if rice productivity stagnates at current levels (approximately 4.2 tonnes per hectare; FAOstat; ADRON), rice production area in Suriname would need to increase by more than 20 000 hectares by 2022 (Fig. 2A), if high production targets are to be met (of 3% annual increase). Even if production does not increase by 3% but only by 1% per year, without productivity increase, additional land will need to be converted into rice production (Fig. 2A). Similar trends have been observed historically: extensive agriculture driven by increasing demand led to expansion of agricultural areas (Gibbs et al., 2010). In fact, over the period 1999-2008, rice was one of the 10 most important crops by area increment, which accounted collectively for over two thirds (69.7%) of the net increase in area in tropical countries (Phalan et al., 2013). In 2008, rice was one of the three crops (along with maize and wheat) with the greatest harvested area globally (Phalan et al., 2013). Furthermore, rice is the crop grown over the largest area in tropical countries (18% of tropical cropland) and is the most widespread crop in both the moist and dry broadleaf forests biomes (Phalan et al., 2013).

If rice productivity increases by 1% per year in Suriname, the country may meet increased production targets, without converting additional land (Fig. 2B). If, however, productivity increases by 3% per year, combined with modest increases in production targets (1% increase per year), 10 000 hectares could be liberated from rice production (Fig. 2C), and spared for other land uses. In the scenario of modest increase, rice production would reach

255 thousand tonnes in 2022, the highest value since 1992 (FAOstat; Table 1). An accelerated increase of 3% per year would increase rice production by almost 40% in 10 years, reaching 323 thousand tonnes in 2022 (Table 1). This would surpass the record production of 1984 of 302 thousand tonnes of rice per year (FAOstat, 2012). In relation to productivity, the 3% scenario would bring productivity to approximately 6 tonnes per hectare, a level close to the estimated potential yield of Suriname farms using technologies and cultivars available today as estimated in the study of FAO and IIASA of Global Agro-Ecological Zones (GAEZ; van Velthuizen et al., 2007).

Sustainable intensification has indeed been indicated as an alternative to achieve food security (Foresight, 2011; Godfray et al., 2010; Phalan et al., 2013; Tilman et al., 2011). For example, Pretty et al. (2003) found improvements in food production (improvements in per hectare yields of staples) through introduction of low cost, locally available and environmentally sensitive practices and technologies, such as increased water use efficiency, improvements to soil health and fertility, and pest control with minimal or zero-pesticide use. The 89 projects with reliable yield data reveal an average per project increase in per hectare food production of 93% (Pretty et al., 2003). Sustainable increase of agricultural productivity has also been discussed within REDD+ scheme as viable means to control demand displacement (leakage) that may follow implementation of forest-protection measures (Strassburg et al., 2009). Further, Herrero et al. (2010) showed how by smart investment in sustainable food production, it is possible to increase food production for the poorest, concurrently limiting impacts on the environment. In Suriname, sustainable agriculture intensification can be achieved, for instance, through adoption of practices that can help improve the performance of rice and optimize the use of water (Wassmann, 2010), such as the use of cultivars and genetic material adapted for specific environmental or biotic conditions, land leveling that improves irrigation efficiency and weed control, selection of appropriate seeding method, improving soil organic matter content or mulching (Bouman, 2007; Wassmann, 2010). Use of mulch for keeping soil moisture and for weed control is being commonly practiced in China for rice production (Bouman et al., 2007).Current limitations to incorporating these practices in Suriname include the low capacity to produce certified seed, lack of legislation to protect intellectual property rights, little extension to assist farmers to incorporate these practices, difficulties with access to credit and inappropriate infrastructure (Graanoogst and Grijpstra, 2007; Poerschke, 2005; Mertens, 2008).

Agricultural intensification may not automatically lead to positive economic and environmental outcomes. If complementary measures (for instance policies) are not implemented, it can lead to ‘rebound’, a classic economic effect where increased productivity leads to an increase in demand for its input (here land) (Lambin and Meyfroidt, 2011). This threat is also pertinent to biofuels production in Suriname. If complementary measures, such as good governance, law enforcement and increasing the value of standing forests are however in place, sustainable intensification may lead to land-sparing for nature (Ewers et al., 2009; Hodgson et al., 2010; Phalan et al., 2011a; Phalan et al., 2011b). For example, Phalan and co-authors (Phalan et al., 2011a) demonstrated the benefits for wild species, where larger land areas were designated for conservation. They concluded that restricting human requirements for land globally is important in limiting the impacts of increasing food production on biodiversity. For extensive discussion on circumstances under which yield increases can facilitate land sparing (recognising that policies and social safeguards will need to be context-specific for example to avoid rebound and leakage) see Phalan et al. (2011a). In accordance with others, our analysis demonstrates that if rice production is sustainably intensified it may lead to land sparing (Table 2) and according to Mertens (2008), up to fifteen thousand hectares that were abandoned could be reincorporated into the rice sector in Suriname. Adding to this area the 53 000 thousand hectares already under rice production, results in a total area already cleared for the rice sector equal to 68 000 hectares.

Providing that productivity increase keeps pace with production targets (Table 2), 15 000 hectares could be available for other crops. This area is three times larger than the area currently used for the cultivation of vegetables and fruit crops in Suriname (FAOstat, 2012) and it could be liberated (land spared) for other uses (in particular higher value crops such as vegetables and fruits or high-cash products such as açai). Economic returns from these crops are on average ten times higher than returns from rice production (FAOstat, 2012). When productivity increases are higher than production targets, even more land could be available. Further analysis should investigate which fraction of these areas would be biophysically and economically suitable, and socially acceptable for alternative production systems.

The scenario where rice production targets are high but productivity stagnates presents a serious threat to natural ecosystems (Table 2). In this scenario, even if 15 000 hectares potentially available to be reintegrated to rice production are used, there would be an additional demand for more than 6 000 hectares. This reinforces the need to invest in productivity increase, for example through technologies discussed above, in order to avoid conflict between agricultural productions and environmental conservation. Indeed, according to expert opinion from Suriname and the literature (WWF, 2012), there is a risk of agriculture encroachment into the mangroves, which are vital for providing environmental services. For instance, mangroves harbor a diverse marine life, including large predatory fish, and serve as nesting grounds for migratory birds. The Guiana's marine waters (including Surinamese) provide animal protein and may rank among the 10 most productive marine systems in the world (WWF, 2012). Mangroves also play an important role in the global carbon cycle (WWF, 2012)and are paramount for protection against extreme weather events (Costanza et al., 2008), which are predicted to escalate in the future. Globally, rice cultivation is an important cause of wetland loss (Donald, 2004) and rice is the main crop found in the mangrove biome (Phalan et al., 2013). Mangroves are indeed most at risk now from agriculture in Suriname (also due to nutrient loads and pesticide use). A history of the growth of the rice sector in Nickerie shows that coastal wetlands have constantly been transformed over the years starting in Nickerie and slowly moving east toward the large Coronie Swamp. The construction of a dam to stop coastal erosion near Coronie (worth 50 million euros), is partly blamed on the conversion of freshwater wetlands (crucial for freshwater fisheries and water availability during drought) to rice production (CIS, 2010). This slowed the flow of freshwater to the coastal mangroves which is necessary to create the right brackish conditions for optimal mangrove growth. Local environmentalists are concerned that the large Coronie Swamp may be drained to be converted into agricultural land as well.

3.2. Investing in higher value agricultural products: organic farming as an opportunity to green agricultural sector in Suriname

Organic farming may provide a wide range of economic, environmental and social benefits to agricultural sector in Suriname. Although certified organic farming market as such does not exist, the development of so called 'safe food' sector is a significant step towards development of organic products market in Suriname. The initiative of safe food was a response to the increasing concern over the overuse of pesticides and risks associated both with excessive use (direct risk for farmers), and consumption of agricultural products contaminated with chemicals. This in turn has led to increased interest in healthier and more environmentally-friendly products.

The Caribbean Institute in Suriname led a country-wide safe food initiative, assisting farmers in their transformation towards greener agriculture through diminished use of chemicals and the use of organic compost. This initiative demonstrated that not only the demand for better quality, chemical-free and more natural products in Suriname exists, but also that the demand surpassed supply. In fact, discontinuous supply of safe-food products to the market was indicated as one of the barriers to further expansion of the safe-food market in Suriname (expert opinion, Suriname). One reason for disruption of supply of safe-foods is the scarcity of organic compost necessary to provide nutrients in organically-managed farms and biocidies (as substitutes to chemical pesticides). There are currently efforts to promote compost production and management that may facilitate a move towards larger scale safe-food production. The Caribbean Institute is now also formulating an organic farming standard in Suriname based on CARICOM organic standards.

Over the past two decades, global markets for certified organic products grew rapidly and sales are expected to continue to increase over the next years (Fibl, 2012). The global organic agricultural land area has steadily increased, with Oceania, Europe and Latin America having the largest areas of organically-managed agricultural land. There has recently been a rapid growth in organic land area in European Union countries, likely related to financial support to this sector (Argyropoulos, 2013; Schader, 2013). While sales are concentrated in North America and Europe, production is global, with developing countries increasing their share of production and exports. Moreover, recent studies in Africa, Asia and Latin America suggest that due to expanding markets and price premiums, organic farmers generally earn higher incomes than their conventional counterparts (UNCTAG, 2008). Organic production is particularly suited for smallholder farmers, who comprise the majority of the world's poor. It may contribute to reducing dependency on external resources and facilitate higher and more stable yields and incomes, enhancing food security and providing more resilience (Rattanasuteerakul and Thapa, 2012). Organic farming may also strengthen communities and give youth an incentive to continue farming, thus reduce migration (expert opinion, Suriname).

When developing a market for organic farming, mandatory organic legislation may facilitate organic farming practices, however it is not a prerequisite for the development of an organic sector. Compulsory legislation, especially when inadequately formulated, may hinder rather that stimulate the development of production. In early stages of development of the organic market what really is of prime consideration is promotion and support for organic farming practices and products, rather than a series of compulsory requirements. In that, participatory guarantee systems (PGS) may support and encourage organic market to grow (IFOAM, 2011). PGS are locally-focused quality assurance systems which certify producers based on active stakeholder participation. They are built on social networks and knowledge exchange, and provide a credible guarantee for consumers seeking organic products. Thus, they provide an alternative to third-party certification, and are especially adapted to local markets.

When developing an organic sector, international, foreign or domestic development agencies and their programs can also greatly influence the process. In fact, in countries where fully operating organic farming legislation is not in place, NGOs and private sector may be in charge of organic farming and its exports. In many developed countries (including EU countries), where sophisticated legal organic farming frameworks are now in place, the early development of organic farming has been initiated by either NGOs or by private companies, and sometimes both. In some countries, such as New Zealand, where the organic market reported in 2009 amounted to around EUR 220 million, there is no organic market regulation and the market surveillance is regulated in the Fair Trading Act.

A viable organic sector will not necessarily emerge due to the policy environment but adequate policies and standards may provide good foundations for the growth of the organic agricultural sector. If mandatory organic regulation is desired in Suriname, it is of critical importance that such a regulation is “farmer-friendly” and “trade-friendly”. For example, where mandatory regulation on organic farming exists, there may be exemptions for small farmers from certification, which means that the farmers can make the organic claim and have to follow the standards but do not have to be certified (and incur extensive costs). Inadequately drafted organic farming regulation is likely do more harm than good. Importantly, if the aim is to support the export sector there is no need for mandatory regulation. It is sufficient to create a governmentally-supervised system for export and marketing of organic products. For example, in New Zealand, exports of organic products were estimated at EUR 110 million in 2009, there is a voluntary, government-managed certification scheme accepted in the EU, USA and Japan (IFOAM, 2011).The key to gaining access to external organic markets lies in establishing close relations with competent and qualified certification organizations, and efforts to strengthen them should have priority.

Notwithstanding concerns over ‘food miles’ (Van Passel, 2013), Europe is a viable market for future organic products from Suriname due to previously established market relationships with the Netherlands as well as due to logistical facilities (interestingly, it may be more practical to send the products to Europe than within the region due to irregular connections). Possible markets and trade structure for organic products from Suriname are presented in Supplementary Material. In order to export organic products to the EU, there is a need to obtain certification through a recognised Certification Body (CB), or achieve an 'equivalent country' status. Suriname could collaborate with regional or international CBs in the first instance. Cooperation with an approved CB, such as Bio Latina, could create the necessary expertise for Suriname to at a later date apply for an equivalent country status, Suriname could further collaborate with countries which have achieved equivalent country status, such as Costa Rica and Argentina, in order to gain a better understanding and knowledge of the requirements of EU schemes for the trade of organic products. Once expertise and safe organic farming practices have been acquired, Suriname could pursue an equivalent country status. These efforts will require a longer-term vision for the promotion of safe and organic farming practices.

3.3. Reducing environmentally harmful practices

Environmentally harmful practices include both practices that lead to land degradation (e.g. from pollution or physical soil erosion) and practices on land that may result in its unsustainable use, such as extensification. Market research (available on request from The Caribbean Institute[3]) shows a great concern with pesticide residues in vegetables, also fuelled by the warnings from the Netherlands, which regularly identifies pesticide residues in vegetables imported from Suriname. Suriname is in the top 10 countries with dangerous levels of pesticide residues that export to the Netherlands. At the same time, Surinamese consumers have an increasingly high demand for food without pesticide residues but the supply is very limited and not guaranteed, because there are no standards or controlling body. In that safe food that could eventually lead to creation of organic market offers a promising alternative.

Mining is another source of concern in Suriname (WWF, 2012). In Guianas deforestation due to gold mining has seen a two-fold increase in eight years and currently, small scale mining is the largest driver of deforestation mostly in central and eastern Suriname. Mining may contribute to temporary or permanent decreases in tree density and other changes in vegetation structure, and forest degradation affects ecosystem services such as biodiversity conservation, carbon storage, and regulation of hydrological cycles. Although deforestation from gold mining is smaller than impacts from agriculture, it represents the fastest growing driver of forest loss (WWF, 2012). Other adverse impacts of mining include chemical and physical pollution of rivers and streams due to the use of mercury in the process of gold extraction in small-scale mining (WWF, 2012). One of the positive developments in Suriname was the creation of a special Unit (OGS) for controlling and reorganizing the small-scale gold mining sector under the Office of the President (WWF, 2012).

In the context of the current international debate over pros and cons for biodiversity from agricultural intensification *versus* agroecological matrix (Anderson-Teixeira et al., 2012; Fischer et al., 2011; Hulme et al., 2013; Perfecto and Vandermeer, 2010; Phalan et al., 2012; Quinn et al., 2012; Ramankutty and Rhemtulla, 2012), further investigation into possible development of Surinamese agriculture, which combines both paths, could add an interesting argument into this vivid scientific discussion, especially given that the country preserved high levels of biodiversity. By developing a framework to stimulate organic farming and by working with smallholder farmers, Suriname may benefit from an increased value of its national agriculture, create both alternative and higher incomes (also by investing in high cash products, such as açai), offer an alternative path for rural people, create new job opportunities, achieve food security both in terms of provision and healthier products, among many other benefits. Given that organic farming may in certain circumstances lead to lower yields (Seufert et al., 2012), organic farming is suggested as only one possibility of many for the promotion of sustainable agriculture. The results from focus groups and workshops in Suriname demonstrated that it could be possible to combine implementation of both

3 http://www.caribbean-institute.org/

sustainable intensification of agriculture (provided that rebound does not follow) on current agricultural areas and more extensive, smaller-scale organic farming.

3.4. Conserving ecosystem goods and services

Suriname is a unique example of a country that managed to preserve its natural resources. Despite declarations that Suriname wants to protect its natural heritage (ATM, 2013) there are concerns that low deforestation rates may not be maintained on account of mining while agriculture and new settlements may destroy mangroves. Indeed biodiversity in general is undervalued in developing countries, wherein development (or conversion) is perceived as a way forward to achieve standards of developed countries. Although strict concession regulation on forests exists, there are fears that implementation of these regulations is often a matter of policy (and politics) and with changing political context, standing forest may not necessarily continue to be a priority.

However, by keeping its native forests, supporting low deforestation rates and promoting sustainable development through greener agricultural sector, Suriname is in an extraordinary position to both benefit from increased value of agriculture and from payments for ecosystem services (PES) (Strassburg et al., 2012). As most of Suriname's forests present top levels of both carbon and biodiversity, the country may benefit from so-called 'early-action' REDD+ finance that is already being paid mostly through bilateral agreements. Because REDD+ funds (or other PES schemes) could reach up to US$ 40 billion per year it may be profitable to pursue a sustainable pathway for agricultural expansion through the routes discussed in this paper. In Suriname, a Climate Compatible Development Agency has already been created, which also falls directly under the Office of the President and is now catalyzing REDD+ readiness in Suriname (WWF, 2012). There are also governmental plans to support institutional strengthening of the National Institute on Environment and Development (NIMOS), currently tasked with guiding impact assessment processes, which should also be combined with accelerated implementation of environmental laws. Other key areas, such as the demarcation of indigenous and Maroon lands, general land use planning for central and south Suriname and the creation of new protected areas should be promoted.

4. Recommendations and conclusions: towards a landscape approach

The global trade is now moving towards higher-quality products, demanding higher social and environmental standards. The Consumer Goods Forum, an association that brings together over 400 retailers and manufacturers from 70 countries with combined sales of US$3.1 trillion and nearly 10 million people employed (CGF, 2012), representing a substantial fraction of global agricultural trade, have recently pledged to remove from their supply chains products related to deforestation before the end of this decade. The ability to access these markets by pursuing sustainable agricultural production without deforestation would bring an important competitive advantage to Suriname goods. Sustainable agriculture may also offer an alternative path for rural people and create new job opportunities. Current initiatives towards safe food and existing infrastructure (such as ADRON and CELOS) may provide a starting point for the development of a national sustainable agriculture framework. However, although a range of opportunities exists, there are constraints to overcome and set-up costs would need to be assigned in order to realize ambitious plans towards more sustainable agriculture. Management skills for integrated land management and capacity must be developed, extension should be provided as well as appropriate infrastructure and access to credit. Direct income support through the agro-environmental/rural development programs, marketing and processing support, certification support, producer information initiatives (research, training and advice), consumer education and infrastructure support should be provided for successful development of sustainable agricultural sector. Regarding small-scale farmers (vegetables, fruits and flowers), pressure on land from urbanization paired with the lack of available land due to speculation and political opportunism is also a challenge in addition to lack of policies or government structures to assist this group with new technologies or investments. There is no credit available for these farmers and many are becoming part-time farmers or hobbyists while seeking employment in other sectors. In case of organic farming, due to the lack of inputs, such as biocides and biological soil amendments, it is very difficult to grow organic, even if the desire exists. In addition, in order to enable exports to EU organic markets, Suriname needs to develop technical and legal expertise, which can potentially be acquired through cooperation with Certification Bodies recognized under the EU's equivalence scheme. To this end, liaison should be sought with regional, as well as European organizations, which could provide the necessary technical and policy-relevant know-how. Although increasing productivity and developing organic market undoubtedly pose challenges, they may at the same time create an opportunity for innovative research that could be, given complexity of reconciling protection of nature with development, a landmark example to follow. For example, new approaches to sustainable rice intensification could be tested or practices for organic farming could be investigated.

A great challenge facing the future of agriculture is how to substantially increase food production in order to meet future demand while decreasing agriculture's global environmental footprint. Sustainable intensification, closing yield gaps and increasing resource efficiency are necessary strategies towards meeting this challenge. Yet, they must be combined with efforts to halt agricultural expansion. The analyses presented in this paper show that conflict over land can be avoided as long as rice productivity does not stagnate at current levels, suggesting that Suriname already has enough land cleared for agriculture to meet ambitious targets from the rice sector and increase the area dedicated to higher value crops without deforestation. By adopting such a whole-landscape approach for sustainable land use (DeFries and Rosenzweig, 2010; Sayer et al., 2013), an approach that intrinsically incorporates human urge to further develop need to preserve biodiversity and carbon as described in this paper, it may be possible, through planning and context-tailored development of sustainable agriculture to address multiple causes of land demand, avoid adverse effects of competition for land and protect nature.

5. Acknowledgements

Tanja Lieuw and Inez Redjosentono are gratefully acknowledged for their time and invaluable insights into organic farming reality and practice in Suriname. We thank Chiquita Resomardono for coordination of the field trips and assistance with organizing focus groups in Suriname, including the visit in ADRON research station. Armand Moredjo and Fabio Scarano are gratefully acknowledged for their support and useful insights on land-use change in Suriname. We thank all participants of focus groups and workshops for their time and assistance throughout the duration of this study. We gratefully thank Conservation International for the funding provided for this study. Two anonymous Reviewers are gratefully acknowledged for their thorough and constructive review of this paper.

6. References

ABS, 2010 Department of National Accounts. In Rao Consultants, 2011

Alexandratos, N., Bruinsma, J. , 2012. Food and Agriculture Organization. World Agriculture: Towards 2030/2050. The 2012 Revision. ESA Working Paper No. 12-03. FAO, Rome.

Anderson-Teixeira, K.J., Duval, B.D., Long, S.P., DeLucia, E.H., 2012. Biofuels on the landscape: Is "land sharing" preferable to "land sparing"? Ecological Applications 22, 2035-2048.

Argyropoulos, C., Tsiafouli, M.A., Sgardelis, S.P., Pantis, J.D., 2013. Organic farming without organic products. Land Use Policy 32, 324-328.

ATM, 2013. The Ministry of Labour, Technological Development and Environment: Suriname, The Fourth National Report to the Convention on Biological Diversity. Paramaribo, February, 2013.

ATM, 2012. Ministry of Labour, Technological Development and Environment: Second National Communication to United Nations Framework Convention on Climate Change.

Bloor M., Frankland J., Thomas M., Robson K. 2001 Focus Groups in Social Research. SAGE Publications, London.

Bouman, B.A.M., Lampayan, R.M., and Toung, T.P. , 2007. Water Management in Irrigated Rice: Coping with Water Scarcity. International Rice Research Institute. Los Baños, Philippines.

CIS, 2010. Sebastian Eagleton Meaney, Conservation International Suriname: Assessment of biofuel production impacts on socio-economics in Suriname.

CSP, 2008. Country Strategy Paper and National Indicative Programme for the period 2008 - 2013. Republik of Suriname - European Community, Paramaribo.

Davidson, E.A., de Araujo, A.C., Artaxo, P., Balch, J.K., Brown, I.F., Bustamante, M.M.C., Coe, M.T., DeFries, R.S., Keller, M., Longo, M., Munger, J.W., Schroeder, W., Soares-Filho, B.S., Souza, C.M., Jr., Wofsy, S.C., 2012. The Amazon basin in transition. Nature 481, 321-328.

de la Rosa, D., Anaya-Romero, M., Diaz-Pereira, E., Heredia, N., Shahbazi, F., 2009. Soil-specific agro-ecological strategies for sustainable land use - A case study by using MicroLEIS DSS in Sevilla Province (Spain). Land Use Policy 26, 1055-1065.
DeFries, R., Rosenzweig, C., 2010. Toward a whole-landscape approach for sustainable land use in the tropics. Proceedings of the National Academy of Sciences 107, 19627-19632.
Donald, P.F., 2004. Biodiversity impacts of some agricultural commodity production systems. Conservation Biology 18, 17-37.
EC, 2012. European Commission. Sustainable agriculture for the future we want. http://ec.europa.eu/agriculture.
Elmont, R.J., 2010. Adding Value to Raw Rice Bran by (Heat) Stabilization of Rice Bran, a Pre-feasibility Study. Suriname Business Forum. Suriname.
Ewers, R.M., Scharlemann, J.P.W., Balmford, A., Green, R.E., 2009. Do increases in agricultural yield spare land for nature? Global Change Biology 15, 1716-1726.
FAO, 2009. Global agriculture towards 2050. High-level Expert Forum.
FAO, 2012a. FAO Food Price Index up 1.4 percent in September, http://www.fao.org accessed on March 2013.
FAO, 2012b. Towards the future we want. End hunger and make the transition to sustainable agricultural and food systems. Rome, 2012.
Fibl, I., 2012. Research Institute of Organic Agriculture and International Foundation for Organic Agriculture. The World of Organic Agriculture.
Fischer, J., Batary, P., Bawa, K.S., Brussaard, L., Chappell, M.J., Clough, Y., Daily, G.C., Dorrough, J., Hartel, T., Jackson, L.E., Klein, A.M., Kremen, C., Kuemmerle, T., Lindenmayer, D.B., Mooney, H.A., Perfecto, I., Philpott, S.M., Tscharntke, T., Vandermeer, J., Wanger, T.C., Von Wehrden, H., 2011. Conservation: Limits of Land Sparing. Science 334, 593-593.
Foley, J.A., Ramankutty, N., Brauman, K.A., Cassidy, E.S., Gerber, J.S., Johnston, M., Mueller, N.D., O'Connell, C., Ray, D.K., West, P.C., Balzer, C., Bennett, E.M., Carpenter, S.R., Hill, J., Monfreda, C., Polasky, S., Rockstrom, J., Sheehan, J., Siebert, S., Tilman, D., Zaks, D.P.M., 2011. Solutions for a cultivated planet. Nature 478, 337-342.
Foresight, 2011. The Future of Food and Farming, 2011. Final Project Report. The Government Office for Science, London.
Friis, C., Reenberg, A 2010. Land Grab in Africa: Emerging Land System Drivers on a Teleconnected World (Glob Land Project, Copenhagen).
Gibbs, H.K., Ruesch, A.S., Achard, F., Clayton, M.K., Holmgren, P., Ramankutty, N., Foley, J.A., 2010. Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. Proceedings of the National Academy of Sciences of the United States of America 107, 16732-16737.
Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M., Toulmin, C., 2010. Food Security: The Challenge of Feeding 9 Billion People. Science 327, 812-818.
Griscom, B., Shoch, D., Stanley, B., Cortez, R., Virgilio, N., 2009. Sensitivity of amounts and distribution of tropical forest carbon credits depending on baseline rules. Environmental Science & Policy 12, 897-911.
Harvey, M., Pilgrim, S., 2011. The new competition for land: Food, energy, and climate change. Food Policy 36, S40-S51.
Herrero, M., Thornton, P.K., Notenbaert, A.M., Wood, S., Msangi, S., Freeman, H.A., Bossio, D., Dixon, J., Peters, M., van de Steeg, J., Lynam, J., Rao, P.P., Macmillan, S., Gerard, B., McDermott, J., Sere, C., Rosegrant, M., 2010. Smart Investments in Sustainable Food Production: Revisiting Mixed Crop-Livestock Systems. Science 327, 822-825.

Hodgson, J.A., Kunin, W.E., Thomas, C.D., Benton, T.G., Gabriel, D., 2010. Comparing organic farming and land sparing: optimizing yield and butterfly populations at a landscape scale. Ecology Letters 13, 1358-1367.
Hulme, M.F., Vickery, J.A., Green, R.E., Phalan, B., Chamberlain, D.E., Pomeroy, D.E., Nalwanga, D., Mushabe, D., Katebaka, R., Bolwig, S., Atkinson, P.W., 2013. Conserving the Birds of Uganda's Banana-Coffee Arc: Land Sparing and Land Sharing Compared. Plos One 8.
IFOAM, 2011. International Federation of Organic Agriculture Movements. How Governments can support participatory guarantee systems (PGS). Policy Brief.
Ingram, J., Morris, C., 2007. The knowledge challenge within the transition towards sustainable soil management: An analysis of agricultural advisors in England. Land Use Policy 24, 100-117.
Krueger, T., Page, T., Hubacek, K., Smith, L., Hiscock, K., 2012. The role of expert opinion in environmental modelling. Environmental Modelling & Software 36, 4-18.
Lambin and Geist, 2006. Land-Use and Land-Cover Change. Local Processes and Global Impacts. Springer, Berlin.
Lambin, E.F., Meyfroidt, P., 2011. Global land use change, economic globalization, and the looming land scarcity. Proceedings of the National Academy of Sciences of the United States of America 108, 3465-3472.
Licker, R., Johnston, M., Foley, J.A., Barford, C., Kucharik, C.J., Monfreda, C., Ramankutty, N., 2010. Mind the gap: how do climate and agricultural management explain the 'yield gap' of croplands around the world? Global Ecology and Biogeography 19, 769-782.
Meaney, S. 2010. Assessment of Biofuel Production Impacts on Socio-Economics in Suriname. Report produced for Conservation International Suriname. Mueller, N.D., Gerber, J.S., Johnston, M., Ray, D.K., Ramankutty, N., Foley, J.A., 2012. Closing yield gaps through nutrient and water management. Nature 490, 254-257.
ORC, 2012. Opera Research Center. Priorities for research and development in EU agriculture - How do we develop Sustainable Intensive Agriculture? Outcome policy Paper. Brusssels, March 2012.
National Statistics Office, 2013 www.statistics-suriname.org, accessed April 24, 2013).
Perfecto, I., Vandermeer, J., 2010. The agroecological matrix as alternative to the land-sparing/agriculture intensification model. Proceedings of the National Academy of Sciences of the United States of America 107, 5786-5791.
Phalan, B., Balmford, A., Green, R.E., 2012. Agriculture as a key element for conservation: reasons for caution. Conservation Letters 5, 323-324.
Phalan, B., Balmford, A., Green, R.E., Scharlemann, J.P.W., 2011a. Minimising the harm to biodiversity of producing more food globally. Food Policy 36, S62-S71.
Phalan, B., Bertzky, M., Butchart, S.H.M., Donald, P.F., Scharlemann, J.P.W., Stattersfield, A.J., Balmford, A., 2013. Crop Expansion and Conservation Priorities in Tropical Countries. Plos One 8.
Phalan, B., Onial, M., Balmford, A., Green, R.E., 2011b. Reconciling Food Production and Biodiversity Conservation: Land Sharing and Land Sparing Compared. Science 333, 1289-1291.
Powlson, D.S., Gregory, P.J., Whalley, W.R., Quinton, J.N., Hopkins, D.W., Whitmore, A.P., Hirsch, P.R., Goulding, K.W.T., 2011. Soil management in relation to sustainable agriculture and ecosystem services. Food Policy 36, S72-S87.
Pretty, J.N., Morison, J.I.L., Hine, R.E., 2003. Reducing food poverty by increasing agricultural sustainability in developing countries. Agriculture Ecosystems & Environment 95, 217-234.

Quinn, J.E., Brandle, J.R., Johnson, R.J., 2012. The effects of land sparing and wildlife-friendly practices on grassland bird abundance within organic farmlands. Agriculture Ecosystems & Environment 161, 10-16.

Ramankutty, G.a., 2004. Land cover change over the last three centuries due to human activities: the availability of new global data sets. GeoJournal 61, 335-344.

Ramankutty, N., Rhemtulla, J., 2012. Can intensive farming save nature? Frontiers in Ecology and the Environment 10, 455-455.

Rattanasuteerakul, K., Thapa, G.B., 2012. Status and financial performance of organic vegetable farming in northeast Thailand. Land Use Policy 29, 456-463.

Reidsma, P., Koenig, H.J., Feng, S., Bezlepkina, I., Nesheim, I., Bonin, M., Sghaier, M., Purushothaman, S., Sieber, S., van Ittersum, M.K., Brouwer, F., 2011. Methods and tools for integrated assessment of land use policies on sustainable development in developing countries. Land Use Policy 28, 604-617.

Sayer, J., Sunderland, T., Ghazoul, J., Pfund, J.-L., Sheil, D., Meijaard, E., Venter, M., Boedhihartono, A.K., Day, M., Garcia, C., van Oosten, C., Buck, L.E., 2013. Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. Proceedings of the National Academy of Sciences of the United States of America 110, 8349-8356.

Seufert, V., Ramankutty, N., Foley, J.A., 2012. Comparing the yields of organic and conventional agriculture. Nature 485, 229-U113.

Smith, P., Gregory, P.J., van Vuuren, D., Obersteiner, M., Havlik, P., Rounsevell, M., Woods, J., Stehfest, E., Bellarby, J., 2010. Competition for land. Philosophical Transactions of the Royal Society B-Biological Sciences 365, 2941-2957.

Strassburg, B., Latawiec, AE, Anna Creed, Nga Nguyen, Gilla Sunnenberg, Lera Miles, Andrew Lovett, Lucas Joppa, Ralph Ashton, Jöorn P. W. Scharlemann, Felipe Cronenberger, Alvaro Iribarrem, 2013. Biophysical suitability, economic pressure and land-cover change: a global probabilistic approach and insights for REDD+. Sustainability Science DOI 10.1007/s11625-013-0209-5.

Strassburg, B., Turner, R.K., Fisher, B., Schaeffer, R., Lovett, A., 2009. Reducing emissions from deforestation-The "combined incentives" mechanism and empirical simulations. Global Environmental Change-Human and Policy Dimensions 19, 265-278.

Strassburg, B.B.N., Kelly, A., Balmford, A., Davies, R.G., Gibbs, H.K., Lovett, A., Miles, L., Orme, C.D.L., Price, J., Turner, R.K., Rodrigues, A.S.L., 2010. Global congruence of carbon storage and biodiversity in terrestrial ecosystems. Conservation Letters 3, 98-105.

Royal Society of London, 2009. Reaping the Benefits: Science and the Sustainable Intensification of Global Agriculture

Strassburg, B.B.N., Rodrigues, A.S.L., Gusti, M., Balmford, A., Fritz, S., Obersteiner, M., Turner, R.K., Brooks, T.M., 2012. Impacts of incentives to reduce emissions from deforestation on global species extinctions. Nature Climate Change 2, 350-355.

Sutherland, W.J., Aveling, R., Bennun, L., Chapman, E., Clout, M., Cote, I.M., Depledge, M.H., Dicks, L.V., Dobson, A.P., Fellman, L., Fleishman, E., Gibbons, D.W., Keim, B., Lickorish, F., Lindenmayer, D.B., Monk, K.A., Norris, K., Peck, L.S., Prior, S.V., S.V., Scharlemann, J.P.W., Spalding, M., Watkinson, A.R., 2012. A horizon scan of global conservation issues for 2012. Trends in Ecology & Evolution 27, 12-18.

Schader, C. Lampkin, N. Christie, M., Nemecek, T., Gaillard, T., Stolze M., 2013 Evaluation of cost-effectiveness of organic farming support as an agri-environmental measure at Swiss agricultural sector level. Land Use Policy 31, 196-208

Tilman, D., Balzer, C., Hill, J., Befort, B.L., 2011. Global food demand and the sustainable intensification of agriculture. Proceedings of the National Academy of Sciences of the United States of America 108, 20260-20264.

Tilman, D., Cassman, K.G., Matson, P.A., Naylor, R., Polasky, S., 2002. Agricultural sustainability and intensive production practices. Nature 418, 671-677.
Tilman, D., Socolow, R., Foley, J.A., Hill, J., Larson, E., Lynd, L., Pacala, S., Reilly, J., Searchinger, T., Somerville, C., Williams, R., 2009. Beneficial Biofuels-The Food, Energy, and Environment Trilemma. Science 325, 270-271.
Van Passel, S., 2013. Food miles to assess sustainability: A revision. Sustainable Development 21, 1-17.
van Velthuizen, H., Huddleston, B. Fischer, G., Salvatore, M., Ataman, E., Nachtergaele, F.O., Zanetti, M., Bloise, M. (2007) Mapping biophysical factors that influence agricultural production and rural vulnerability. Environment and Natural Resources Series No. 11, FAO, Rome.
Wassmann, R., 2010. Proceedings of the Workshop Advanced Technologies of Rice Production for Coping with Climate Change: 'No Regret' Options for Adaptation and Mitigation and their Potential Uptake. International Rice Research Institute. Los Baños, Philippines.
World Bank, 2011. Rising Global Interest in Farmland. Can It Yield Sustainable and Equitable Benefits? Washington, DC.
WWF, 2012. Living Guianas Report 2012 State of the Guianas Drivers and pressures Towards green economies
www.president.gov.sr accessed May 2013
Zoomers, A., 2010. Globalisation and the foreignisation of space: seven processes driving the current global land grab. Journal of Peasant Studies 37, 429-447.

Figures

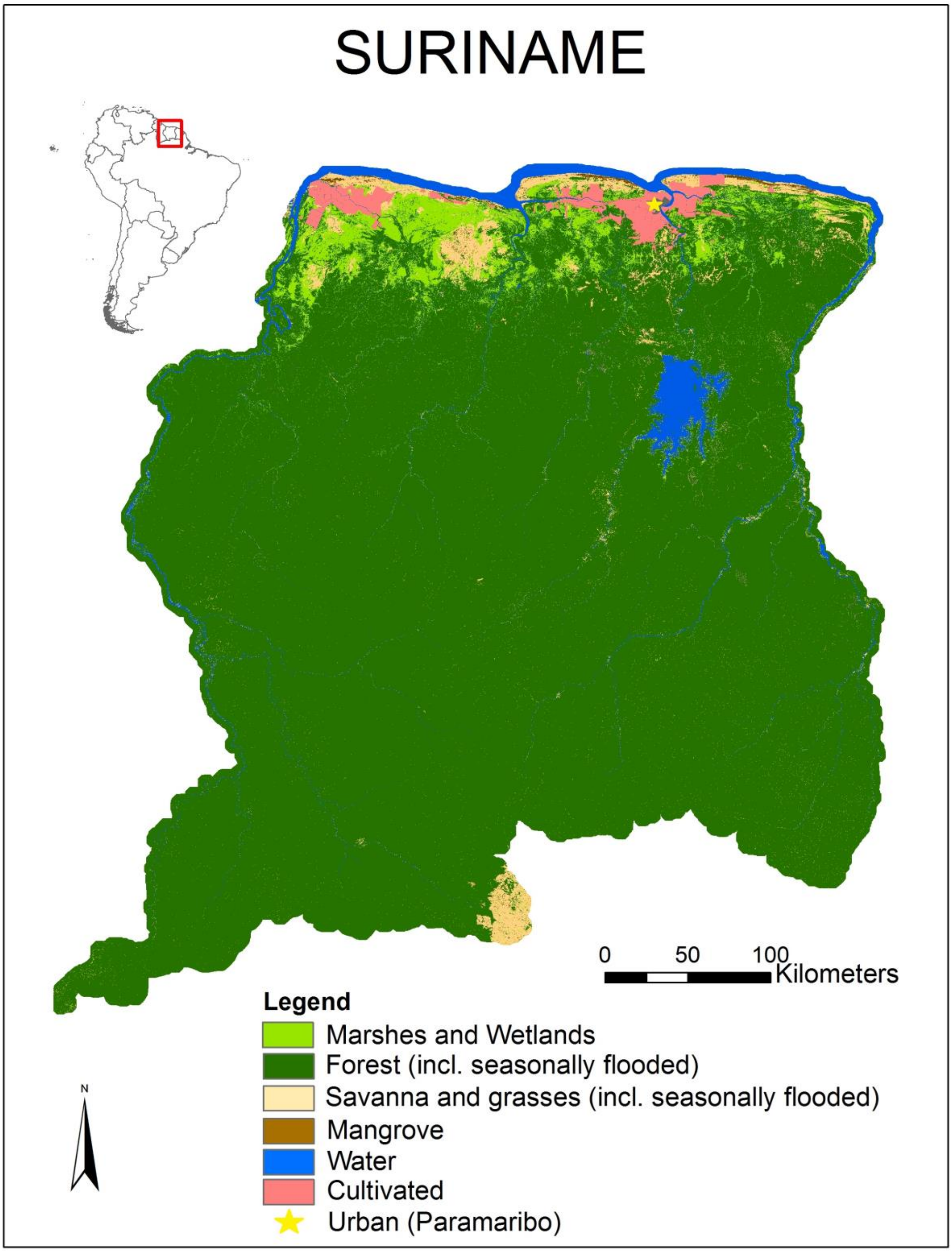


Fig. 1. Land use in Suriname. Data source: Conservation International Suriname

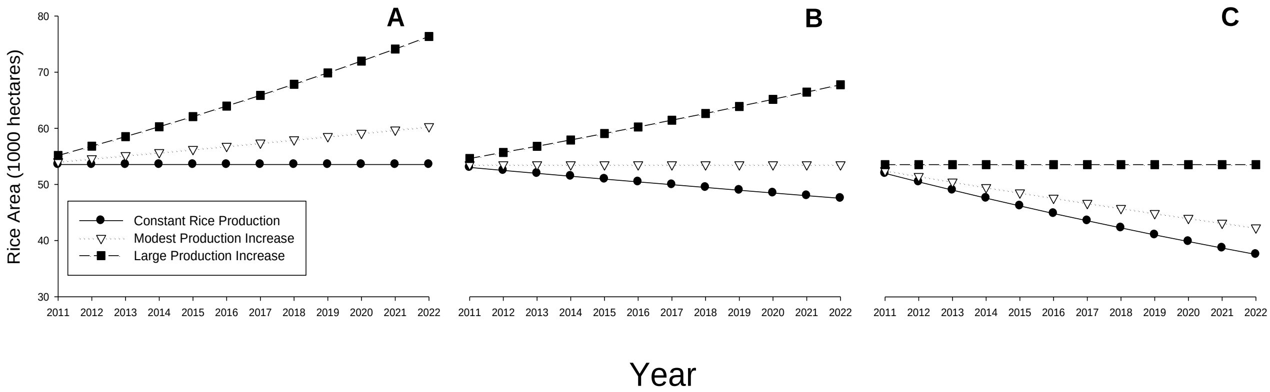


Fig. 2. Area needed for rice production under different production and productivity levels: A – constant productivity (4.23 tonnes per hectare), B – small productivity increase (1% per year, 4.77 tonnes per hectare in 2022), C – large productivity increase (3%; 6.04 tonnes per hectare in 2022). Black bullet represents constant rice production of 227 tonnes, empty inverted triangle corresponds to modest production increase (255 tonnes in 2022), black square relates to large production increase up to 323 tonnes in 2022. Description in subsection 3.1.

Table 1. Future land productivity scenarios. Rice production and productivity data (based on FAOstat, 2012 and validated during the focus group) in Suriname were used to analyze land availability for a range of productivity scenarios over the next decade. Three scenarios were analyzed: stagnation, where values remain constant until 2022; modest increase, where there is an increase of 1% per annum until 2022; and high increase, where there is an increase of 3% per annum until 2022.

	Rice Production Scenarios												
	Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Production(1000 t)	Constant	227	227	227	227	227	227	227	227	227	227	227	227
	Modest Increase	229	231	234	236	238	241	243	245	248	250	253	255
	High Increase	233	240	248	255	263	271	279	287	296	305	314	323
Productivity (t/ha)	Constant	4.23	4.23	4.23	4.23	4.23	4.23	4.23	4.23	4.23	4.23	4.23	4.23
	Modest Increase	4.28	4.32	4.36	4.40	4.45	4.49	4.54	4.58	4.63	4.68	4.72	4.77
	High Increase	4.36	4.49	4.63	4.76	4.91	5.05	5.21	5.36	5.52	5.69	5.86	6.04

Table 2. Area available for increase in agricultural products. The spared land can be used for organic agriculture, or devoting to high-cash products, such as açai, or spared for nature.

Area Available for Increase in Agricultural Products in 2022 (hectares)			
	Rice Productivity		
	Constant	Modest Increase	High Increase
Constant Production	15,000	20,497	29,432
Modest Production Increase	8,744	15,000	25,189
High Production Increase	-6,194	1,853	15,000