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The potential of local production and processing in West Africa: How does the environmental footprint of rice and cashew from Nigeria and Ghana compare to rice imported from and cashew processed in Vietnam?

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Abstract

Purpose Even though West Africa is the largest cashew producing region, 90% of the raw cashew grown there is processed in Asia. Similarly, despite significant rice production in West Africa, large quantities are imported from Asia. The goal of this LCA is to assess the environmental impact of rice imported from and cashew processed in Asia, and compare it to the situation in which production and processing of rice and cashew happens locally, in West Africa.

Methods This LCA examines the environmental impact of 1 kg white rice (produced in Nigeria vs Vietnam) for the Nigerian market, and the impact of 1 kg cashew (produced in Ghana and processed in Ghana vs Vietnam) for the European market. Data on cultivation, transport and processing in West Africa was collected from Ghanaian cashew farmers and Nigerian rice farmers and processors linked to two GIZ projects: ComCashew and CARI. For Vietnam, data was obtained through the Institute for Agricultural Environment. The scope extends from cultivation up to transport to the end market. Climate change, particulate matter, land use, water use and fossil resource scarcity impacts were calculated using IPCC Guidelines, inventory data from Agri-footprint 5.0 and Ecoinvent 3.5 LCA databases, and ReCiPe 2016.

Results and discussion Nigerian rice has a lower environmental impact than Vietnamese rice for all impact categories under consideration, except for water use. The carbon footprint (1.37 kg CO₂-eq for 1 kg Nigerian rice and 2.6 kg CO₂-eq for 1kg rice imported from Vietnam) is mainly determined by CH₄ emissions from anaerobic conditions during flooding. Rice production in Vietnam is more resource and energy intensive and uses more intensive flooding.

Processing Ghanaian cashew in Ghana instead of Vietnam leads to 30% lower carbon footprint (2.2 kg CO₂-eq as opposed to 3.2 kg CO₂-eq for 1 kg), which is attributed to the lower transport needs. Applying sustainable farming practices (frequent drainage for rice and pruning for cashew trees) leads to significant lower environmental impacts for both rice and cashew.

Conclusions The results demonstrate the environmental benefit of production and processing in West Africa, and the effectiveness of stimulating sustainable farming practices. It should be noted that the data only refers to farmers linked to the two GIZ projects. Data quality could improve by actual measurements of GHG emissions from rice fields in West Africa, and by collecting primary data on processing of cashew nuts in Vietnam.

Keywords: Life cycle assessment; rice; cashew, West Africa; impact assessment

Introduction

This screening Life Cycle Assessment (LCA) focuses on rice and cashew in West Africa, two crops that are dominantly grown by smallholder farmers and play an important role in supporting local livelihoods. Even though West Africa is the largest cashew producing region in the world, 90% of the raw cashew nuts grown there are processed in South and South East Asia (Ton, Hinnou, Yao, & Adingra, 2018). At the same time, rice production in West Africa cannot meet domestic demand, and a large quantity is imported from South East Asia (Zenna, Senthilkumar, & Sie, 2017). The goal of this LCA is to assess the environmental impact of rice imported from and cashew processed in Asia, and compare it to the situation in which production and processing of rice and cashew happens locally, in West Africa.

For both rice and cashew, the system under consideration extends from crop cultivation (cradle) up to transport to the end market. For rice, the emphasis lies on investigating the environmental impact of different production practices (e.g. rain-fed vs. irrigation) and comparing the locally produced rice to imported rice from South East Asia. For cashew, the influence of applying good agricultural practices (GAP, such as pruning and fire protection) was assessed, as well as the impact of processing cashew locally instead of in South East Asia.

The LCA focuses on Nigeria for rice and Ghana for cashew, two countries that are part of GIZ's Competitive Cashew initiative (ComCashew) and Competitive African Rice Initiative (CARI). These projects aim to increase the competitiveness and productivity of rice and cashew value chains in East and West Africa, and strengthen linkages to national and international markets. Vietnam was selected to represent cashew processing and rice production in South East Asia, as it is the biggest processor of West African cashews (Trade for Development Centre, 2018), and also exports large quantities of rice to Africa.

The results of this LCA will be used by the CARI and ComCashew projects and its partners to gain insight in the environmental impact of enhanced localized production and processing, as well as the impact of applying sustainable farming practices as promoted by the projects. The study fills an important gap that exists when it comes to LCA data for food products originating from West Africa.

Method

This study is conducted in accordance with the ISO 14040 and 14044 LCA methodological standards, and is being externally reviewed at the time of submission of this paper. The study looks at the environmental impact of 1 kg white rice (produced in Nigeria or in Vietnam) for the Nigerian market, and the impact of 1 kg cashew (produced in Ghana and processed in Ghana or Vietnam) for the European market. Data on cashew and rice farming and processing in West Africa was collected from farmers and processors linked to the ComCashew and CARI projects.

For rice, data was obtained from irrigated and rainfed farms, and captured yields, input use, energy consumption, transport and farming practices related to flooding patterns during and before irrigation, the application of organic amendments, and the burning of crop residues. For cashew, data was obtained for farmers applying good agricultural practices, and a group applying conventional practices. The data collected includes yields, input use, on-farm energy use for pruning, farming practices, the use and value of the cashew nut and apple, and transport.

Data on rice production in Vietnam was obtained through the Vietnamese Institute for Agricultural Environment (IAE), data on rice processing was based on literature (Kamalakkannan & Kulatunga, 2018), and data on cashew processing was based on Jekayinfa & Bamgboye (2006). In order to make an equal comparison between production systems in Asia and Africa, it has been ensured to collect similar type of data for both regions, to use processes from the same LCA databases and to perform the same emission calculations.

To calculate the environmental impact, data on fertilizer and pesticide inputs, transportation, energy use, and packaging materials was linked to corresponding processes from Agri-footprint 5.0

and Ecoinvent 3.5 LCA databases. Direct and indirect emissions related to the application of fertilizers and organic amendments and to flooding (for rice) were calculated using the Tier 1 method as described in the IPCC guidelines (IPCC, 2019). The ReCiPe 2016 environmental impact categories for climate change, fine particulate matter formation, fossil resource scarcity, water use, and land use were taken into consideration (Huijbregts et al., 2016).

Economic allocation was applied for co-products generated during the cultivation stage and during processing of the rice and cashew. Emissions related to land use change were considered as a sensitivity analysis. As no primary data on land conversion in the past 20 years was available, default values were used from the Direct Land Use Change Assessment Tool (Blonk Consultants, 2018).

Results & Discussion

Rice

As shown in Figure 1A, the average Nigerian rice has a lower environmental impact for all impact categories under consideration, except for water use. Distinct differences can be observed between rainfed and irrigated rice, with rainfed rice having a lower carbon and water footprint, but higher land use due to its low yield.

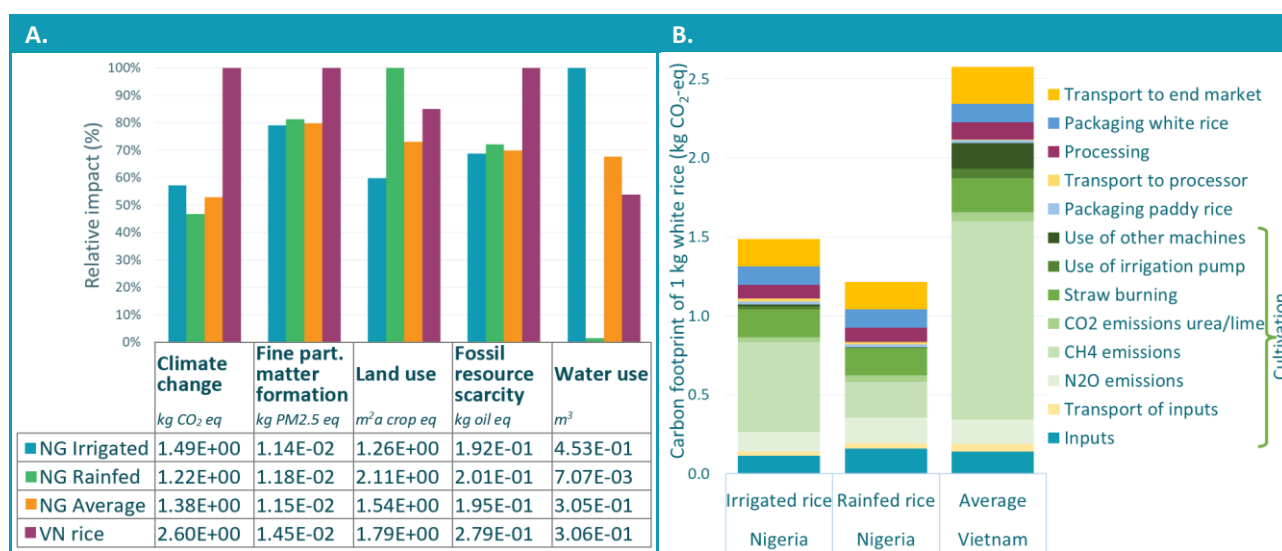


Figure 1 Environmental impact results for 1 kg of white rice: A) relative and absolute results for all environmental impact categories under consideration; B) contribution analysis for the climate change impact category

Producing rice in Nigeria instead of importing it from Vietnam, is associated with a 47% lower climate change impact (2.6 kg CO₂-eq for Vietnamese rice, 1.4 kg CO₂-eq for average Nigerian rice). The contribution analysis (Figure 1B) shows that CH₄ emissions are the main contributor to climate change. In Nigeria, the majority of irrigated rice is produced using multiple drainage periods, and most of the rainfed (upland) rice fields have no significant flooding, explaining the lower CH₄ emissions for these rice types. Rice cultivation in Vietnam on the other hand, is characterised by relative intensive flooding with few aeration periods. The higher mechanisation level (irrigation pumps, mechanical dryers, tractors and harvesters) and the frequent burning of crop residues further contributes to the higher footprint for Vietnam as opposed to Nigeria.

Adding land use change (6.75 ton CO₂-eq/ha/year for rice in Nigeria, 0 for rice in Vietnam) leads to an average footprint of 3.3 kg CO₂-eq for 1 kg of average Nigerian white rice. It should be taken into consideration, that the LUC as derived from the tool is not sensitive to site-specific conditions, as it uses country-level averages for the expansion of deforested areas and rice areas. In

Nigeria, deforestation is mostly occurring in tropical forests in southern Nigeria, whereas in northern Nigeria, where the rice is cultivated, the natural vegetation concerns savanna. Even if the sparsely vegetated savanna is converted, this would result in a much lower release of carbon than deforestation of tropical rainforest.

Cashew

Cashew that is grown with good agricultural practices (GAP) and processed in Ghana has the lowest environmental impact for all impact categories under consideration (Figure 2A). Processing the average Ghanaian cashew in Ghana instead of Vietnam, leads to a 30% lower carbon footprint (2.2 kg CO₂-eq as opposed to 3.2 kg CO₂-eq), which is attributed to the reduced transport needs.

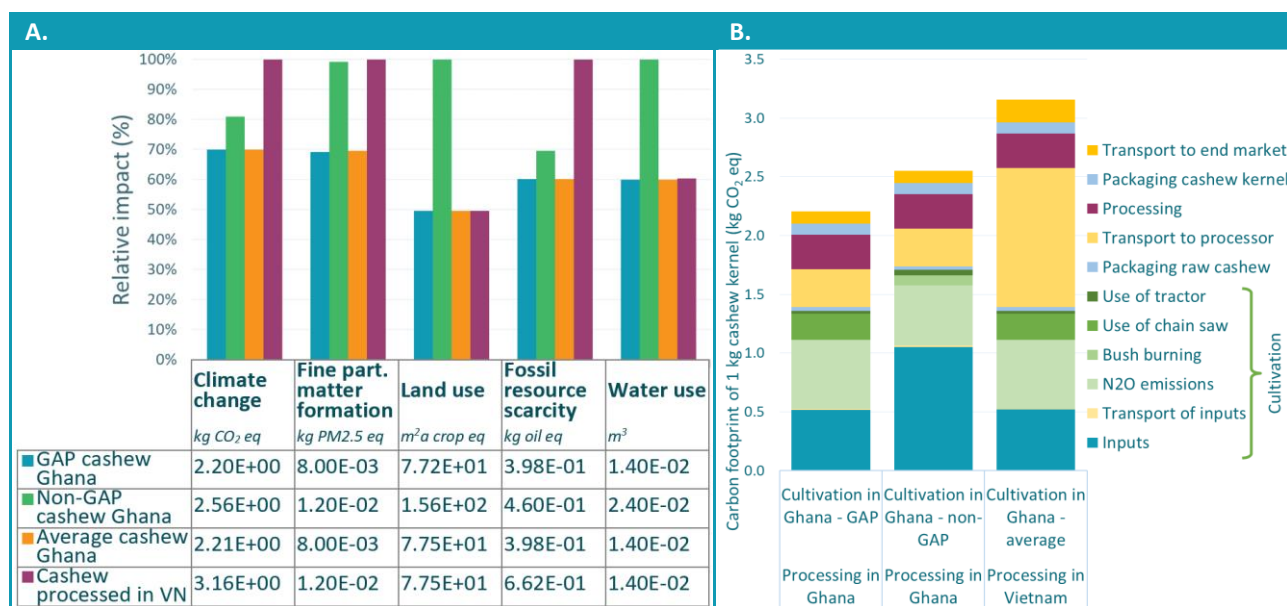


Figure 2 Environmental impact results for 1 kg of cashew kernel: A) relative and absolute results for all environmental impact categories under consideration; B) contribution analysis for the climate change impact category

Due to its low yields, cashew that is produced with conventional practices (non-GAP) has a relative high impact on land use and water consumption. It should be noted that the impact for the average Ghanaian cashew resembles the impact of the GAP cashews, as only a small number of farmers were included that applied conventional practices.

As little to no processing data was available for cashew processing in Ghana and Vietnam, the study from Jekayinfa & Bamgboye (2006) on cashew processing in Nigeria was used (with the Vietnamese electricity mix). The sensitivity analysis points out that even if processing in Ghana would have a 50% less efficient and in Vietnam 50% more efficient, cashew processed in Ghana would still have a lower carbon footprint.

Land use change associated with cashew production in Ghana was zero according to the Direct Land Use Change Assessment Tool.

Conclusions

The results demonstrate the environmental benefits of stimulating local production and processing of rice and cashew in West Africa. The application of sustainable farming practices as promoted by the two GIZ programs, leads to a significant lower environmental footprint for both cashew and rice.

The footprint of Nigerian rice could be further lowered by incorporating organic material long before cultivation, using rice straw productively (e.g. in rice processing), and by stimulating more

frequent drainage periods. Results can become more accurate by carrying out actual CH₄ measurements in rice fields, which are currently lacking for African conditions, and by a more detailed study into the impact of land use change. Land use change data is currently based on a country-level average for Nigeria, with a high level of deforestation of tropical forests (and thus high footprint), that is not representative of the savanna of Northern Nigeria where the rice is cultivated.

For cashew production, the environmental impact could be further lowered by using the cashew apple productively, instead of leaving it in the field. Data quality would improve by collecting primary data on cashew processing in Ghana and Vietnam.

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