 doi:10.20944/preprints202002.0397.v1

What are the impacts of sugarcane production on ecosystem services? A Review

El Chami Daniel[1] Daccache André[2] and El Moujabber Maroun[3*]

[1] Timac Agro Italia S.P.A., S.P.13 – Località Ca' Nova I-26010 – Ripalta Arpina (CR), Italy.

[2] Department of Biological and Agricultural Engineering, University of California, Davis (UC Davis), California, 95616-5294, USA.

[3] International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM-IAM.B), Via Ceglie 9, Valenzano (BA) 70010, Italy.

[*] Corresponding author

Email: elmoujabber@iamb.it

Phone: +39 080 4606 341

Fax: +39 080 4606 206

Abstract

Since the 1950s sugarcane production has grown rapidly from less than 0.5 billion tonnes in the late 50s to reach over 1.9 billion tonnes in 2012 on about 27 million hectares of agricultural land. This expansion has been boosted by the high demand for bioethanol promoted as a sustainable bioenergy source which accounted in 2010 for the biggest share of the global biofuel market.

Despite its benefits, the scientific debate on sugar is growing especially that counterarguments are so many, including negative impacts on different interacting ecosystems and human well-being, e.g. bigger stress on land and water resources, environmental externalities on air, a harmful impact on the biodiversity and endemic species, negative environmental externalities, health, and socio-economic aspects. This paper provides a narrative systematic review (SR) of the impacts of sugarcane production on these different ecosystems employing the ecosystem services framework for its acceptance by policy-makers.

The references included for the SR were 163 and results showed that the majority of the studies are from Brazil, Australia, South Africa and the USA (≈ 75% of the literature), most of them were from peer-reviewed journals (85%), and most of the case studies adopted a quantitative research approach (93%).

The literature assessed showed that sugarcane, like all agro-systems, depends on the practices and techniques to transform negative impacts into positive externalities on ecosystems and human well-being. However, the literature studied failed to include the inter-linkage in sugarcane production impacts' and therefore to evaluate the related ecosystem services with respect to the Millennium Ecosystem Assessment (MA) framework to account for existing trade-offs. Therefore, the findings are addressed to the scientific community and decision-maker for an intensification of interdisciplinary and integrated research based on the MA framework to cover all ecosystem services, for sustainable development of the sugarcane sector.

Keywords

Sugarcane, impacts, ecosystem services, human well-being, agro-systems, sustainability

1. Introduction

Sugarcane is a perennial grass belonging to the genus Saccharum L. and comprising six different species (D'Hont et al., 1998). It is indigenous to the warm temperate to tropical climates of South and Southeast Asia, although it is now grown in more than 100 different countries around the world (FAO, 2019). The world production grew from just below 448 million tonnes harvested on around 8.9 million hectares in 1961 to reach over 1.9 billion tonnes on about 27 million hectares. While Brazil has been for years now the world producer of sugarcane (39.0% of world production in 2017), with impressive expansion rates observed every year, India is the second biggest world producer, 15.7% of world's production (**Table 1**), Guatemala and Peru had respectively the highest sugarcane productivity at around 121 t ha^{-1} (FAO, 2019).

This expansion has been accompanied with a growing demand for foodstuffs, animal feed, and industry, but the major driver of this rapid increase has been the demand for bioethanol, promoted as a sustainable bioenergy source as it offers a high energy balance and high GHG reduction (Lisboa et al., 2011; FAO, 2008; Zuurbier and Van de Vooren, 2008; Goldemberg,

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 27 February 2020 doi:10.20944/preprints202002.0397.v1

2007); it reduces uncertainty associated with prices volatility of fossil fuel (Black et al., 2012; Zuurbier and Van de Vooren 2008) giving at the same time a secured source of income for farmers boosting thus rural development (Swinnen and Squicciarini, 2012; Sexton and Zilberman, 2008); and it did not show to have a major impact on global food prices (Baffes and Dennis, 2013).

Despite the benefits of sugarcane mentioned above the scientific debate is growing (Goldemberg et al., 2008), especially that counterarguments are so many, including impact on different ecosystems[1], and environmental and socio-economic aspects (Ridley et al., 2012), and according to Millennium Ecosystem Assessment (2005), the change of ecosystems would impact "provision services" by these and human well-being would be modified. The main impacts found in the literature are as follows:

- The growing competition between sugarcane and food crops on land-use is threatening world food production already facing the challenge of feeding 9 billion people by 2030. The impacts of this competition are described to be devastating for food security (Harvey and Pilgrim, 2011; Rajagopal, 2007).
- Land use and in particular land-use change could participate in the increase of GHG emissions when a farmer replaces a forest or switches from food crop production (less emitter) to sugarcane (direct land-use change). Consequently, a direct land-use change, some other farmers would have to change the type of production or replace a natural area into productive land to fulfil the market need of the crop directly replaced. This has been defined in the literature as indirect land-use changes (ILUC) (Andrade de Sá et al., 2013; Adami et al., 2012; Lapola et al., 2010; Searchinger et al., 2008).
- A harmful impact on the biodiversity and endemic species as a result of land-use change and the expansion of ILUC especially on behalf of the Amazon forest in Brazil the world largest sugarcane producer e.g. ecosystem disequilibrium leading to the dominance of some predators (Verdade et al., 2012; Bernard et al., 2011).

[1] An ecosystem is "a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit" (Millennium Ecosystem Assessment, 2005). The inter-linkage of these natural ecosystems has always provided services the human beings who became dependent on them to maintain their living, these are called ecosystem services.

- Negative environmental externalities e.g. air quality and GHG emissions due to sugarcane burning, nutrients depletion, and related acidification and eutrophication potentials on soil pollution and erosion (Hein and Leemans, 2012; Verdade et al., 2012; Botha and von Blottnitz, 2006).
- Bigger stress on water resources due to changes in irrigation needs (Thornton et al., 2009; Smit and Singels, 2006; Everingham et al., 2002), especially in countries where water is already a constraint for agriculture such as South Africa where water withdrawal for sugarcane production is 9.8% of the total irrigation withdrawal. Water quality deterioration is a direct consequence of water exploitation increase by water pollution from agronomic and agro-processing practices in different countries (Chandiposha, 2013; Gerbens-Leenes et al., 2012; De Fraiture et al., 2008; Smeets et al., 2008; Zuurbier and Van de Vooren, 2008).
- Social impacts related to farmers health and well-being due to diseases transmitted through some predators (De Andrade et al., 2011; Silva et al., 2010), working conditions, land rights, worker rights, forced and child labour (Ridley et al., 2012; German et al., 2011; Smeets et al., 2008) and economic impacts related to costs of production and labour conditions (Goldemberg et al., 2008).

The impacts of sugarcane production on these ecosystem services and the well-being of people have not been systematically approached in the literature even though the methodology has been highlighted recently in scientific studies on biofuels and other agricultural systems (e.g. Gasparatos et al., 2011) and the interactions (benefits/impacts) have been distinguished on different scales (local level, national level, and global level), at which decision-making could take place (UN-Energy, 2010; Stromberg et al., 2009). Therefore, we need a robust and transparent scientific evidence for global policy development for sugarcane production.

Even though ecosystem services associated with sugarcane agro-systems have been assessed for the first time in Australia in 2005 (Park et al., 2008; Thorburn et al., 2005), the literature presents no evidence on the adoption of ecosystem services framework in their research methodologies. Consequently, the major objective of this research is to assess the impacts of sugarcane expansion on the ecosystem services and the impacts on human well-being employing the ecosystem services framework adopted by the Millennium Ecosystem Assessment (MA) and discuss it in the broader context of sustainable agriculture. The outcome is a synthesis of scientific evidence for different level stakeholders and decision-makers accounting for the trade-offs generated from the interrelation of these different ecosystems as suggested by the MA for sustainable sugarcane production. We adopted for this purpose an evidence-based highly structured approach, the Systematic Review (SR) known for the rigorous scientific conclusions it draws for science and decision making, reducing the susceptibility to bias (CEE, 2018).

2. Materials and methods

We adopted in this paper the SR methodology as described in the systematic review guidelines (CEE, 2018). This approach includes setting the question of the research; drafting the protocol; conducting a systematic search tailored to the question; article screening; critical appraisal and data extraction to examine any bias susceptibility, and; data synthesis (CEE, 2018).

The primary question is maybe the most important aspect in the systematic review, its formulation is a task that requires the participation of all the actors. The compromise in defining the question is between taking a holistic approach and adopting a reductionist one (Pullin et al., 2009). Ecosystem services are all the natural systems that people use to extract benefits and to increase their well-being and this includes water, land, air, biodiversity, diseases and cultural services (Fisher et al., 2009; Hassan et al., 2005). Therefore, the primary research question that would cover all the aspects of sugarcane production and the related counterarguments described above would be:

"**What are the impacts of sugarcane production on ecosystem services**?"

The research question is broken down as required by the CEE guidelines into definable elements known as the PICO/PECO: *i)* the population (Sugarcane production from 1950 onwards because world yearly data for sugarcane are collected and published since 1950 by the United Nations Food and Agriculture Organization (FAO, 2019; Zuurbier and Van de Vooren, 2008) and sugarcane consumption for bioethanol production began in the late forties in Brazil (Kovarik, 2008), without any location restriction); *ii)* interventions (The intervention is the expansion of sugarcane production since the seventies of the last century leading agricultural, environmental and social changes); *iii)* comparators (Impacts and/or benefits of this expansion on different ecosystem services. Under sugarcane/different land uses); *iv)* outcomes (defined as quantitative/qualitative changes in water, changes in soil and land use/land change, changes in air quality, changes in level of biodiversity, environment, changes in food availability and social aspects).

Different database sources have been identified to be used in the review including scientific and grey literature, but only literature published in English was considered. As for the grey literature, web-based engines have been used (google.com, googlescholar.com, dogpile.com and other organisations' websites), we only considered a maximum of 50 'hits' which are the most relevant. We exported all the retrieved references into Mendeley software before the use of inclusion criteria for relevance assessment.

All literature retrieved in the first step have been subject to relevance screening using inclusion criteria, which included *i)* relevant subjects (Any country, any scale, crop: sugarcane); *ii)* type of intervention (Increase in sugarcane productivity, expansion of sugarcane production); *iii)* comparator (Compares benefits and/or impacts on ecosystem outcomes); *iv)* Methods (experiments and/or modelling); *v)* outcomes (Studies that consider benefits/impacts on water, land and air resources, biodiversity, wildlife, environment, food, health, income and other social aspects (e.g. labour rights, child labour)).

A first filtering process has been undertaken, based on the title of the database; a second filter followed, it was based on the abstracts'. The remaining literature underwent a full-text review. All data considered relevant (Based on inclusion criteria and the 'outcome'), has been selected and tabulated using MS Excel spreadsheets. The extraction has been cautiously documented, and any reasons for data heterogeneity have been reported for transparency.

We adopted a narrative synthesis approach to explain the results because we believe it is more suited in our case, where the subject content is broad with a wide range of potential outcomes. Furthermore, the narrative approach has the potential to highlight knowledge gaps and areas for targeting for decision making.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 27 February 2020 doi:10.20944/preprints202002.0397.v1

3. Results

The systematic review results are divided into different stages as summarised in **Figure 1**.

The literature retrieved consisted of 2,626. Duplicates were removed leaving in total 2,200 records for the following step. The first screening reduced the number to 649 followed another screening based on the abstract which led to a total of 336 references (**Figure 1**), divided between countries, type of ecosystem services and year of publication.

The review included case studies from 24 different countries (**Figure 2**) including Argentina, Australia, Belize, Brazil, China, Costa Rica, El Salvador, Fiji, India, Iran, Kenya, Malawi, Mozambique, Mauritius, Mexico, New Guinea, Nicaragua, Philippines, South Africa, Swaziland, Taiwan, Thailand, the USA, and Zambia. However, many of the studies are from Brazil, Australia, South Africa and the USA (**Table 2**).

Most of the references gathered were from peer-reviewed journals (85%), while the literature from the grey literature did not exceed 15% including books and book chapters (2%), proceedings papers (6%), reports (6%), and thesis (1%); and most of the case studies adopted a quantitative research approach (93%) however qualitative and mixed approaches has also been assessed (6% adopted qualitative approach and 1% adopted a mixed approach).

According to the literature assessed, the research on the impacts of sugarcane production on ecosystem services goes back to 1961, however, the frequency increased gradually and in the last decade, it became 20 times more abundant (**Figure 3**).

Most of the literature assessed focused on physical, chemical and microbiological properties of soils, water quality and quantity and resulting soil erosion problems and air quality and pollution. Some literature analysed human well-being including health and food security and very few dealt with biodiversity and land-use change (**Figure 4**).

3.1. Soil properties

Sugarcane comes from large plantations that are either conventionally grown or mechanised, which puts very high pressure on soil resources in terms of practices adopted and nutrients load and removal and modifies soil physical, chemical, and biological properties.

3.1.1 Soil chemical properties

Soil acidification is a common problem of soils under sugarcane cropping mainly due to the use of N fertilisers (and other major components (P:K) under their different forms) and to the mineralisation of organic matter. Nutrients in soils have been studied for the major components (N:P:K) and their different forms e.g., total N, mineralised N, microbial biomass N, nitrate, ammonium, total P, Olsen-Extractable P, total K, soluble K^+, fixed K^+. Some studies included an assessment of other factors such as exchangeable cations and organic matter.

Soil carbon content is another problem that received much attention in the literature; Carbon content change in soils under long-term sugarcane has been reported in the literature (Naranjo et al., 2006; Alaban, 1990; Cerri and Andreux, 1990; Masilaca et al., 1985) and compared to different natural land uses and agricultural cropping patterns (Brackin et al., 2013; Queiroz Rossi et al., 2013; Holst et al., 2012; Souza et al., 2012; Galdos et al., 2009; Sant'Anna et al., 2009; Campos et al., 2007; Silva et al., 2007; Dominy and Haynes, 2002; Cerri and Andreux, 1990) under different soils (Holst et al., 2012; Pankhurst et al., 2005; Dominy et al., 2002) adopting different agricultural practices (Queiroz Rossi et al., 2013; Souza et al., 2012; Stirling et al., 2010; Galdos et al., 2009; Sant'Anna et al., 2009; Graham and Haynes, 2005a; Graham and Haynes, 2005b; Pankhurst et al., 2005; Pankhurst et al., 2003; Graham et al., 2002; Yadav et al., 1994). Most of the studies assessed different components of carbon in the soil such as the total carbon content, organic carbon content, mineralised carbon content, etc., but few studies e.g. Umrit et al. (2014) considered the long-term impact of sugarcane production on other C related indexes such as labile C, lability and lability index, Carbon Management Index (CMI) and Carbon Pool Index (CPI) under different soils and different vegetative cover.

In general, it is evident from the literature assessed that the conversion of pasture land into sugarcane has positive impacts on soil chemical properties (Oliveira et al., 2016; Borges et al., 2014). However, if compared to native vegetation and forests (Oliveira et al., 2016; Anaya et al., 2015; Queiroz Rossi et al., 2013; Da Silva et al., 2012; Souza et al., 2012; Stirling et al., 2010; Ye and Wright, 2010; Castillo and Wright, 2008; Campos et al., 2007; Haynes et al., 2003; Wood, 1985), results showed an initial perturbation of chemical properties followed by a long-term stability at values lower than native vegetation and forests (Morrison and

 doi:10.20944/preprints202002.0397.v1

Gawander, 2016; Borges et al., 2014; Mardamootoo et al., 2013; Queiroz Rossi et al., 2013; Mardamootoo et al., 2012; Mardamootoo et al., 2010; Naranjo et al., 2006; Hartemink, 1998a; Alaban et al., 1990; Masilaca et al., 1985).

This new *status quo* has been interpreted by some authors, who compared it to the natural systems, as a negative impact of sugarcane production (Chi et al., 2017; Ortiz et al., 2017; Franco et al., 2015); while other authors, comparing it to other agro-systems, considered it a positive long-term impact (Cherubin et al., 2016a; Cherubin et al., 2016b; Mthimkhulu et al., 2016; Anaya et al., 2015; Tavares et al., 2015).

However, management practices have a big influence on soil chemical properties. For instance, nutrients depletion depends on soil types (Satiro et al., 2017; Haynes et al., 2003; Hartemink, 1998b; Hartemink, 1998c; Ali et al., 1986), and it is slower though if good management practices are applied such as irrigation (Van Antwerpen and Meyer, 1996), organic production (Borges et al., 2014), conventional harvesting, green harvesting, trash inoculation or degree of straw removal (Assunção et al., 2018; Liao et al., 2013; Graham and Haynes, 2006; Graham and Haynes, 2005a; Graham et al., 2002; Yadav et al., 1994) and rotational farming (Souza et al., 2012; Stirling et al., 2010; Chorom et al., 2009).

One study assessed soil contamination with toxic heavy metals and showed that mercury concentration in the Everglades soils in Florida (USA), under burnt sugarcane could reach 0.15 mg per kg of soil (Patrick et al., 1994). However, Mendes et al. (2016) have reported that soil chemical contamination varies with soil type and agricultural practices.

The assessed literature showed that chemical properties of sugarcane plantations are directly affected compared to natural habitats i.e. forests. This certainly varies with soil types, with the age of the plantation, and the agricultural practices. The longer the age of the plantation (continuous cropping without any rotational crop), the bigger the impact on soil depletion and unfertilised sugarcane plantations are highly deficient compared to fertilised plantations; burnt plantations are also more affected than green harvesting. In the latter case, soil nutrients are improved if the trash is reused for mulching after harvesting.

3.1.2 Soil physical properties

Recently, mechanisation in sugarcane production is replacing the traditional way based on high labour input. Topsoil would get compacted by tractors and harvesters, which would consequently affect soil physical characteristics such as soil porosity and soil aeration reduction, decrease increase soil resistance and reduce the root system and finally affect the yield. This would also modify the infiltration rate of soils and would increase runoff and soil erosion. Similarly, the traditional burning of sugarcane before harvesting would increase topsoil temperature and would reduce soil hydraulic conductivity which would increase the runoff (Robichaud and Hungerford, 2000). Research on soil erosion under sugarcane was carried mainly in Brazil with an average ranging between 6.5 and 31 t ha^{-1} yr^{-1} (Pereira and Ortega, 2010; Macedo, 2007; Sparovek and Schnug, 2001), the average erosion in the USA was between 17 and 18 t ha^{-1} yr^{-1} (Bengtson et al., 1998). In Australia Prove et al. (1995) monitored 7 different sugarcane sites estimated the average soil erosion at 148 t ha^{-1} yr^{-1}, while Lu et al. (2003) using spatial modelling method estimated the national average at 16.1 t ha^{-1} yr^{-1}. These averages are very high compared to erosion under forest estimated by Lu et al. (2003) at 1 t ha^{-1} yr^{-1}. Further, under the same slope range (8.5%-12%) and the same rainfall (1,300 mm yr^{-1}) Macedo (2007) noted that erosion is different under different sugarcane harvesting practices.

Soil physical characteristics vary differently with the soil structure (Satiro et al., 2017; Ahmad, 1996). However, results of the review confirmed the effect of sugarcane production on soil bulk density showed to be higher especially on the top-soils (Umrit et al., 2014; Queiroz Rossi et al., 2013; Holst et al., 2012; Castillo and Wright, 2008; Wright, 2009; Srivastava, 2003; Dominy and Haynes, 2002; Hartemink, 1998c; McGarry et al., 1996; Van Antwerpen and Meyer, 1996; Yadav et al., 1994; Ali et al., 1986; Wood, 1985; Maclean, 1975; Trouse and Humbert, 1961); very few literature studies other factors such as the impact of sugarcane production on saturated hydraulic conductivity (K_s) which increases on the top-soil under sugarcane reducing drainage (De Los et al., 2014), and infiltration (Bangita and Rajashekhar Rao, 2012) and increasing cone penetration resistance (Usaborisut and Sukcharenvipharat, 2011).

However, as the literature showed, the effect of sugarcane production on these factors varied according to soil structure (Umrit et al., 2014; Usaborisut and Sukcharenvipharat, 2011; Hartemink, 1998c; Ali et al., 1986) and depending on the practices adopted e.g. rainfed and irrigated sugarcane (Van Antwerpen and Meyer, 1996), conventional tillage, zero tillage, ripping and hilling tillage (Bangita and Rajashekhar Rao, 2012; Srivastava, 2003), conventional or mechanised sugarcane and level of mechanisation (Umrit et al., 2014; Queiroz Rossi et al., 2013; Trouse and Humbert, 1961).

3.1.3 Soil biological properties

Soil biological properties are directly affected by the change in chemical and physical properties (Hartemink, 2008). Indeed, changes in soil acidity and soil organic matter as well as changes in bulk density, porosity and aeration would modify biological components in the soil and disrupt microbial activities.

Enzymes activities have been suggested as sensitive indicators of soil biological properties (Dick, 1997; Nannipieri, 1994). The literature assessed showed that natural habitats have the highest enzymes' activity followed by pasture, while sugarcane presented a low enzymes' activity (Cardoso et al., 2016; Brackin et al., 2013; Ye and Wright, 2010; Sant'Anna et al., 2009; Zou and Bashkin, 1998; Magarey et al., 1997).

However this activity varies with the field management: unfertilised/fertilised, burnt/green harvesting, trash removal/trash mulching and tillage level (e.g. Castioni et al., 2018; Liao et al., 2013; Stirling et al., 2010; Yadav et al., 2009; Graham and Haynes, 2005a; Pankhurst et al., 2003; Srivastava, 2003; Graham et al., 2002). Summed up, all these factors affect the microbial life in soils (i.e. Bacterial and fungal colonies, pachymetra, actinomycetes, and nematodes), which showed to decline under long-term sugarcane (Holt and Mayer, 1998) and different management practices. Just a few published works suggested a relation between soil pH and abundance of microbial colonies.

3.2. Water resources

The impacts of sugarcane production on water ecosystems could be quantitative where the crop is irrigated and qualitative as a result of leaching of nutrients and chemicals into the drainage water and their accumulation into the ground or the surface waters (rivers, wetlands, sea).

3.2.1 Quantitative impact

In quantitative terms, most of the literature assessed has been published from case studies in Australia, Brazil, South Africa, the impacts of sugarcane production on water resources vary with the variation of the local agro-meteorological conditions.

Irrigation in Brazilian sugarcane is not yet a limiting factor as most of the production is mainly a rainfed one, relying on natural rainfall to replace water losses by crop evapotranspiration (ET_c), which ranged according to Ghiberto et al. (2011) between 847 mm and 970 mm a year in the Southeast and according to Macedo (2007) between 1,500 mm and 2,500 mm a year at a national level. However, in the last decade, supplementary irrigation is being applied in the driest areas of the Northeast (Macedo, 2007). While quantitative impacts are still mild in tropical countries, they can be serious in drier climates.

Indeed in Iran water footprint of sugarcane under free drainage could reach 250 m^3 for each tonne produced (Jahani et al., 2017). Further, in Southern Africa where irrigation water is showing an alarming decline, Mhlanga et al. (2006) estimated the average irrigation requirement for sugarcane in Swaziland at 1,000 mm a year. In South Africa, irrigation requirements ranged between 731 and 1,062 mm a year (Olivier and Singels, 2012; Van der Laan et al., 2012). Comparing the ET_c of the previous research with the estimates of ET_c estimated by Schmidt (1997) for South Africa, we find it much lower. Another study carried out in South Africa on two different soil types simulated irrigation water requirements of sugarcane using climate data for the period 1968-2003 and showed that IWR could vary between 835 mm and 1,496 mm depending on the irrigation schedule adopted (Singels and Smith, 2006).

In the USA, Shih and Gascho (1980) estimated these irrigation requirements between 1,055 mm and 1,360 mm per year, and in Australia, they were estimated between 855 mm and 1,642 mm a year (Thorburn et al., 2011).

Kshirsagar (2006) showed that irrigation water requirements in India are about 1100 mm under conventional sugarcane farming systems that can be reduced to 500 mm adopting organic farming (45% reduction).

Finally, literature has confirmed the significance of irrigation management to reduce irrigation quantities and water footprint of sugarcane production (Jorrat et al., 2018; Carvalho et al., 2016; Olivier and Singels, 2015; Sandhu et al., 1980).

3.2.2 Qualitative impact

Agricultural practices on a sugarcane farm such as fertilisation and spraying for their importance could increase leaching and water contamination with nutrients and agro-chemicals leading to ecotoxicity, eutrophication, and acidification (Prasara-A and Gheewala, 2016).

Assessed literature showed that the impact of sugarcane production on water quality can be expressed with a deterioration of its chemical properties and contamination with nutrients and agro-chemicals and can be assessed at field level analysing drainage water and runoff (e.g. Nachimuthu et al., 2016; Oliver et al., 2014; Agostinho and Ortega, 2013; Davis et al., 2013; Masters et al., 2013; Agostinho and Ortega, 2012; Webster et al., 2012; Thorburn et al., 2011; Udeigwe et al., 2010; Ghiberto et al., 2009; Faithful et al., 2007; Mhlanga et al., 2006; Stewart et al., 2006; Faithful and Finlayson, 2005; Roth et al., 2003; Ng Kee Kwong et al., 2002; Rice et al., 2002; Bengtson et al., 1998; Southwick et al., 1992), at groundwater level (e.g. Alves et al., 2014; Rasiah et al., 2013; Camenzuli et al., 2012; Shaw et al., 2012; Thayalakumaran et al., 2008; Yu et al., 2008; Cerdeira et al., 2007; Rasiah et al., 2005), and at the river of the coastal level (e.g. Allan et al., 2017; Rohde et al., 2006; Mitchell et al., 2005; Muller et al., 1999).

Different research investigated different indicators (chemical quality, nutrients contamination, herbicides contamination) to prove different conclusions, which varied between slight to severe contamination of water bodies, and even urban water networks (Li et al., 2018), due to the excessive use of production inputs.

Studies comparing banana farms and sugarcane farms in Australia showed that under banana field pH of drainage is higher and electrical conductivity (EC) is lower, which makes drainage more acidic under banana but more saline under sugarcane (Faithful et al., 2007) this could be due to the high N and P concentrations found under banana compared to sugarcane fields, but this partially contradicted what the same authors in a previous study have found (Faithful and Finlayson, 2005), i.e. higher N concentrations under sugarcane which agrees with Rohde et al. (2006) and Bramley and Roth (2002) finding that N and P concentrations under sugarcane in Australia are higher than under grazing or forestry.

Other studies compared water contamination with nutrients under different management practices and showed that this contamination is related to the fertilisation rates (Thorburn et al., 2017; Webster et al., 2012; Yu et al., 2008; Bengtson et al., 1998), the application timing of fertilisers e.g. fertilisers applied before rains would increase losses (Ng Kee Kwong et al., 2002), and the overall farm management e.g. agro-ecological sugarcane farms have less nutrients pollution than conventional farms (Agostinho and Ortega, 2013; Agostinho and Ortega, 2012). Further, the concentration of suspended and dissolved solids is higher under manual harvesting with pre-burning (Udeigwe et al., 2010).

Mhlanga et al. (2006) assessed water quality from sugarcane fields in different seasons in Swaziland and showed seasonal deterioration of water quality in summer and autumn seasons compared to winter and spring.

Other literature assessed water contamination with agrochemicals mainly in Australia (e.g. Nachimuthu et al., 2016; Davis et al., 2013; Camenzuli et al., 2012; Shaw et al., 2012; Rohde et al., 2006; Mitchell et al., 2005; Muller et al., 2000), in Brazil (e.g. Agostinho and Ortega, 2013; Agostinho and Ortega, 2012; Cerdeira et al., 2007; Lanchote et al., 2000) and the USA (Yu et al., 2008; Bengtson et al., 1998; Southwick et al., 1992). The results showed that waters in sugarcane areas contained pesticides and herbicides concentrations, mainly "Ametrin" "Diuron", "Triazine" and "Hexazinone" all of which are molecules highly used in sugarcane growing. Further, two studies showed that crop management in terms of row spacing and spraying practice could significantly reduce contamination of water (Oliver et al., 2014; Masters et al., 2013).

Finally, this variability in results of the literature assessed proves that farm management is the key to reduce nutrients losses on the farm under any selected crop and improve water quality its toxicity by agro-chemicals.

3.3. Air quality

In the recent literature, atmospheric pollutants have received particular attention in sugarcane agro-systems especially for the pre-harvest burning practiced to facilitate the harvesting and from the fertilisation of the crops. It has been proved that CO_2 emissions from sugarcane farms (Bicalho et al., 2014; Baillie and Chen, 2012) are higher than other farms in Australia (soybean, watermelon) unless soil preparation is well managed. Panosso et al. (2011) and Panosso et al. (2009) estimated CO_2 emissions from burnt sugarcane in Brazil, to be 25-30% higher than green harvesting. However, in terms of ozone depletion, Chandra et al. (2018) have shown that sugarcane production has the least impact.

The pre-harvest burning has a direct impact on the environment with the emission increase of different atmospheric pollutants (Mugica-Álvarez et al., 2018; Agostinho and Ortega, 2013; Agostinho and Ortega, 2012). Other impacts are also on human well-being as many pollutants could have mutagenic and carcinogenic properties (Cristale et al., 2012; Silva et al., 2010; Umbuzeiro et al., 2008; Zamperlini, 1997).

According to the literature, N_2O emissions [in CO_2 equivalent] could vary between different soil types (Wang et al. 2016a) being six times lower in light soils. They also could double with nitrogen fertilisation compared to unfertilised production (Wang et al., 2016a), and the source of Nitrogen [urea, ammonium, straw, etc.] could determine the amount of N_2O emissions (Dattamudi et al., 2016; Wang et al., 2016b).

Agricultural practices are fundamental for a win-win production strategy in managing the total emissions (Bordonal et al., 2018; Chalco Vera et al., 2017; Fracetto et al., 2017; Pongpat et al., 2017). Indeed green harvesting with a rate of straw removal of about 50% (Gonzaga et al., 2018; Vasconcelos et al., 2018; Pitombo et al., 2017) combined with the optimal fertilisation rates and types (Dattamudi et al. 2016; Siqueira Neto et al. 2016), irrigation management (Fonseca da Silva et al., 2017; Cardozo et al., 2016) and optimisation of the machine traffic in the field (Pryor et al., 2017; Panosso et al., 2012); are all necessary practices to reduce emissions and improve production.

Indeed, fertilisation management increases N sequestration (Signor et al., 2013; Allen et al., 2010; Denmead et al., 2010; Macedo et al., 2008; Weier, 1999; Weier, 1996), and field management increases C sequestration such as straw mulching vs no mulch (Corradi et al., 2013), no-till or reduced till versus conventional tilling and mechanical harvest versus manual (La Scala et al., 2006). Brito et al. (2009) assessed the impact of field topography in reducing soil CO_2 emissions and showed that the concave part of a furrow has fewer emissions than the foot slope.

Contrarily to what has been published, Eustice et al. (2011) showed that mechanical harvesting in South Africa would reduce NH_3 emissions (25 kg CO_2 eq ha^{-1} less NH_3 in mechanical harvesting per season) and would save a lot of CH_4 emissions from burning (60 kg CO_2 eq ha^{-1} CH_4 saved), but it would not reduce the total crop emissions as they estimated the total CO_2 eq emissions for burnt sugarcane at 2,252 kg CO_2 eq ha^{-1} compared 3,443 kg CO_2 eq ha^{-1} for mechanical harvesting.

3.4. Human well-being

For sustainable sugarcane production, the sector should increase the socio-economic aspects of operating farmers in terms of employment and employability conditions, income, food security, and health which all participate in their general well-being. However, the literature assessed showed contradiction in the outcomes except for the impacts of sugarcane production on human health.

3.4.1 Impacts on health

Agricultural practices in sugarcane farming are the major cause of health problems. This mainly happens where the conventional pre-harvest burning is still the prevailing practice with consequences on the respiratory system and lung function (Kasambala Donga et al. 2018; Le Blond et al., 2018; Arbex et al., 2014; Goto et al., 2011; Ferreira-Ceccato et al., 2011; Romeo et al., 2009; Uriarte et al., 2009; Arbex et al., 2000; Arbex et al., 2007; Cançado et al., 2006). The development of cancerogenic symptoms due to mutagenicity risks is also discussed in different studies which relate it to sugarcane burning (Du et al., 2018; Alves et al., 2016; Cristale et al., 2012; Prado et al., 2012; Sisenando et al., 2012; Devendra, 1999; Brooks et al., 1992; Rothschild and Mulvey, 1982). Urinary functions and chronic kidney-related symptoms have been raised in the literature (Wesseling et al., 2015; Crowe et al., 2013; Peraza et al., 2012; Prado et al., 2012). Other minor health-related problems have also been noticed such as symptoms of stress, allergic reactions and different injuries (Prado et al., 2012; Arbex et al., 2010; Robins et al., 1998).

Furthermore, a few studies have discussed the inter-linkage between impacts of sugarcane production on biodiversity and the increased risk of health-related problems i.e. skin irritation, headache, coughing, running nose (Kasambala Donga et al., 2018), malaria vectors' resistance and the use of pesticides in sugarcane production (Dusfour et al., 2010). The socio-economic impacts of sugarcane production and their relation to health impacts have also been discussed by Richardson (2010) who found that sugarcane labour migration in Zambia contributes to HIV/AIDS infection at 16% to 22%.

3.4.2 Impacts on farmers' income

Income generation from sugarcane production is very site-specific. Different studies in Kenya generated different outputs. In the late eighties, Kennedy (1988) and Kennedy and Cogill (1988) showed that income from sugarcane farming is much higher than other types of farming with a higher income from commercialisation of agricultural products (25% higher income and 60% higher commercial income). However, a year after the same other revealed that maize farming in Kenya is more beneficial than sugarcane farming and the income from the latter is about 17% lower arguing though that the income per day per family labour is higher for sugarcane as maize production employs more work-days for family and hired labour (Kennedy, 1989).

Studies from Ethiopia, Belize and Thailand showed that salaries of sugarcane growers are lower compared to other growers, but this is correlated to the size of the farm and the practices adopted (Chi et al., 2017; Prasara-A and Gheewala, 2016; Wendimu et al., 2016).

 doi:10.20944/preprints202002.0397.v1

Experiences from Malawi, Mozambique, Swaziland, Brazil reflect a different situation, where sugarcane areas seem to be better off compared to non-sugarcane area, with high living standards in terms of poverty, life expectancy, access to school, electricity and sewer system and other services (Mudombi et al., 2018; Machado et al., 2015a; Moraes et al., 2015; Macedo, 2007).

It has been noted, however, that this well-being is contributing to an increase in land price (Palludeto et al., 2018), especially in Brazil, where researchers have studied the impacts of sugarcane expansion on small farmers who are not protected by the public policies and end up losing control of their lands, and are transformed to cheap labour for the mills (Petrini et al., 2017; Frate et al., 2015).

Besides, different studies showed that farm management in terms of agricultural practices is an important factor to generate more income (Jha et al., 2015). Kshirsagar (2006) showed that organic sugarcane farming in India has 10.8% higher profits compared to conventional ones, and Liao et al. (2013) in China showed that trash addition could generate additional 10.9% profits to farmers.

3.4.3 Labour conditions

The literature assessed showed that labour requirement in sugarcane farming is lower than maize farming in Kenya (Kennedy, 1989); and in China, the average labour requirement for sugarcane farming, was calculated to be 54 person-days against 72 person-days for cassava farming (Zhang et al., 2011). However, Kshirsagar (2006) noted that organic sugarcane farming improves the sustainability of the sector increasing human labour by 21.5%.

Labour conditions have been raised by many studies because it could lead to several socio-economic and health problems which could affect human well-being considerably and many cases have been noted in the literature (Wendimu et al., 2016). For instance, in a survey led in South Africa Robins et al. (1998) reported that adding to health problems workers are facing in sugarcane fields, 14% reported receiving moral or physical aggression by farm owners; 9% reported being threatened with a knife or gun by these same individuals. Also, Xavier et al. (2011) mentioned the deterioration of cutters conditions In Brazil (workers exploitation, cases of death) due to the adoption of payment based on the amount of product and not per hour, with a continuous increase in the production quota. Recently the number of cane cutters is falling after the introduction of mechanical harvesters. The number of workers rescued in situations comparable to slavery is between 10% and 51% depending on the year.

Even though advances in the direction of "social responsibility" have intensified in Brazil towards more ethical actions in the sugarcane production (Macedo, 2007), many problems related to labour migration and health problems have been reported from other sugarcane producing countries: In Zambia, for instance, labour migration participates in HIV infection as mentioned by Richardson (2010), who stated also cases of households displacement in Mozambique (1,100 households displaced) due to water and land grabbing for the expansion of sugarcane companies. Many cases of labour exploitation in Mozambique have been perceived ($50 US per month), including threats to death to stop labour activism and work-related death. Further, health risks related to environmental pollution have been assessed in the literature in Kenya (Kennedy, 1989) and in Brazil (Cristale et al., 2012; Umbuzeiro et al., 2008; Cançado et al., 2006).

3.4.4 Food Security

Little scientific evidence has been published regarding the impact of sugarcane production on food security, the literature assessed did not depict any relation between sugarcane and food insecurity. Kennedy (1988) and Kennedy and Cogill (1988) showed that agricultural production used for own consumption is higher in non-sugarcane farms in Kenya, and later on, Kennedy (1989) has found a negative correlation between sugarcane production and increased malnutrition.

Comparing organic to conventional sugarcane production Kshirsagar (2006) showed that organic sugarcane farming not only increases income but improves also yield stability, therefore, food security (Coefficient of variation for organic sugarcane is 26.3% while the coefficient of variation for conventional sugarcane is 57.7%).

Furthermore, recent studies in Brazil have shown that sugarcane improves food security and sugarcane growers, given the higher socio-economic standards, have higher food crop production, because they reveal higher spending compared to the control in terms of food crop inputs (Defante et al., 2018; Herrmann et al., 2018).

3.5. Biodiversity

The importance of soil biodiversity resides in the fact that it is used as a soil quality indicator (Doube and Schmidt, 1997), as the micro-fauna species are involved in soil processes. To date, very little attention has been paid to the impact of biofuel crops on biodiversity which could depend on the feedstock produced and the type of land converted (Campbell and Doswald, 2009). Biofuel production is in general considered a threat to biodiversity of ecosystems (Groom et al., 2008), in particular, induced habitat destruction (Lee, 1985) and other drivers such as invasive species and disease (Fraser, 1995; Edwards et al., 1994), loss of soil fauna (Franco et al., 2016), pollution from intensive inputs use (Felício et al. 2018; Schiesari and Corrêa, 2015; Tadini et al., 2015), aquatic resources diversity and quality (Nhiwatiwa et al., 2017; Zeni et al., 2017).

The number of literature reviewed which deals with the impact of sugarcane production on biodiversity (18 references), confirms what has been mentioned about the absence of attention for this kind of research. Literature that has been assessed focused mainly on species richness in soils and waters such as fish, earthworms, termites, ants, preys, spiders and amphibians (Santos et al., 2018; Zeni et al., 2017; Stefani Margarido et al., 2013; Dlamini and Haynes, 2004; Miranda et al., 2004; Haynes et al., 2003; Zou and Bashkin, 1998; Ali et al., 1986) and results showed a reduction in these communities between sugarcane and other land uses. They also noted a difference in the number of these communities between different management practices within sugarcane fields.

Two studies have analysed mammals' abundance (Hurst et al., 2014; Gheler-Costa et al., 2013), comparing different sugarcane management practices and they concluded that mammals' abundance is correlated to the intensity of production.

However, the sugarcane expansion and intensification are not only limited to species abundance, as Degefa and Saito (2017) have found a relation between sugarcane expansion, species abundance, and species' resources requirements. Other aspects of biodiversity loss have been evaluated in terms of eco-toxicity generated by high inputs use in sugarcane production (Felício et al., 2018; Qian et al., 2017; Haynes et al., 2000), and the correlated risks on species extinction, or the invasion of a new insect acquiring more resistance to pesticide (Dusfour et al., 2010).

3.6. Land-use change

The increased demand on bioethanol has boosted the demand for sugarcane plantations, leading to direct and/or indirect land-use change which is becoming a major concern for two main reasons:

- Sugarcane plantations would expand on natural forests and agricultural land reducing crop production and threatening food security and endangering biodiversity and the quality of the environment.
- Sugarcane expansion would have an important threat to biodiversity with the conversion of natural vegetation into sugarcane plantations. This concern was subject to few studies mainly in Brazil the host of the largest part of the Amazon rainforest (around 60%), registering high levels of deforestation.

Indeed, Zhang et al. (2011) showed a negative and significant correlation between rice and sugarcane plantations in China. This is not the case in Brazil, sugarcane expansion this is not affecting food crop production, even if expansion is moving and at fast rates (Adami et al., 2012; Nassar et al., 2008). It has been estimated in 2007/08 at about two million hectares (Zuurbier and Van de Vooren, 2008), and it has been calculated between 30 and 55% (Scarpare et al., 2016; Machado et al., 2015b). In Brazil, the expansion of sugarcane replaced mainly other cropping lands on degraded pasture (Bordonal et al., 2018; Taniwaki et al., 2017; Andrade de Sá et al., 2013). Literature has suggested that land-use change in a forest or a reforestation area in Brazil was only 0.6% for sugarcane expansion (Adami et al., 2012; Adami et al., 2011; Nassar et al., 2008).

A beneficial effect of degraded land conversion to sugarcane has been monitored by many others who noted an improvement of organic carbon and nutrients accumulation in transformed soils (Romeu-Dalmau et al., 2018; Sattolo et al., 2017; Cherubin et al., 2015). Yet a negative impact on water resource quality has been observed by (Taniwaki et al., 2017).

Some authors argued that sugarcane expansion has an indirect impact on biomes even when the replacement is indirect. Unlike direct land-use change, indirect land-use change is more complicated to evaluate as its definition and methods are still under development (Nassar et al. 2008). However, in Brazil, a negative and statistically significant correlation has been confirmed between deforestation and the expansion of sugarcane fields (Andrade de Sá et al., 2013).

4. Conclusions

In this research, we implemented the systematic review methodology to assess the impacts of sugarcane production on the ecosystem services adopting the millennium ecosystem assessment (MA) which accounts for the trade-offs existing in the inter-linkage of these ecosystems.

It was noted that the studies assessing the impacts of sugarcane production focused on Brazil, Australia, USA and South Africa (≈ 75% of the literature), while many other countries such India, China, Thailand, Pakistan were not sufficiently included in the literature, even though they are international leaders in terms of sugarcane production.

In summary, the literature assessed – in all countries comprised in the SR – showed a direct impact of long-term sugarcane production on *i)* soil properties i.e. reduction of soil fertility, deterioration of soil physical properties and consequently the deterioration of the biological properties of soils; *ii)* water resources particularly pollution of ground and surface water bodies; *iii)* air quality, in particular with conventional sugarcane production based on pre-harvest burning; *iv)* human well-being including farmers' income, employment, and labour conditions, health conditions *v)* biodiversity; *vi)* land-use change with the direct impacts as well as the indirect impacts.

All the assessed literature lead us to the conclusion that sugarcane, like all agro-systems, could have different externalities, some are positive and others are negative. Thus, the summarised impacts have shown to be directly related to management rather than to the crop. This means decision making is crucial to make any agro-system sustainable or unsustainable. Indeed, the literature assessed evidence where these impacts could be reduced and sugarcane production could improve soil properties, water, and air quality, biodiversity and human well-being in case good management practices are adopted, organic sugarcane farming and agro-ecological sugarcane farming could also reduce these impacts.

Whilst the evidence collected suggests impacts of sugarcane production on different ecosystem services, the literature studied failed to include the inter-linkage in the impacts of sugarcane production and therefore to evaluate the ecosystems services and human well-being with respect to the Millennium Ecosystem Assessment (MA) framework to account for the trade-offs between ecosystem services and human well-being.

According to Kropff et al. (2001), this could be related to the absence of interconnected analysis involving multidisciplinary approaches given the complexity of the agro-ecosystem from one hand; and from another hand the conceptual and methodological barriers to using sustainability as a criterion for guiding change in agro-ecosystems (Hansen, 1996). However, many other scholars have tried in the past to integrate different production aspects into frameworks and modelling tools to improve agricultural and sugar systems' sustainability.

Finally, based on these findings and the limitations encountered and for a sustainable development of the sugarcane sector, this review suggests further research based on the MA framework, which has been suggested by El Chami et al. (Forthcoming), to cover all ecosystem services and particularly in geographic locations where studies are missing to allow an integrated and consistent evaluation of sugarcane production.

5. References

Adami M, Rudorff BFT, Freitas RM, Aguiar DA, Sugawara LM and Mello MP (2012). Remote Sensing time series to evaluate direct land use change of recent expanded sugarcane crop in Brazil. *Sustainability, 4*: 574-585. doi:10.3390/su4040574

Adami M, Rudorff BFT, Morais Freitas R, Alves Aguiar D and Pupin Mello M (2011). Remote sensing time series to evaluate direct land use change of recent expanded sugarcane crop in Brazil. *In: 1st world sustainability forum. 1-30 Novembre*.

Agostinho F and Ortega E (2012). Integrated food, energy and environmental services production as an alternative for small rural properties in Brazil. *Energy, 37 (1)*: 103-114. doi:10.1016/j.energy.2011.10.003

Agostinho F and Ortega E (2013). Energetic-environmental assessment of a scenario for Brazilian cellulosic ethanol. *Journal of Cleaner Production, 47*: 474-489. doi:10.1016/j.jclepro.2012.05.025

Ahmad N (1996). Management of Vertisols in rainfed conditions. *In: Vertisols and technologies for their management. Developments in Soil Science 24. N Ahmad and A Mermut (Eds)*: 363-428. Elsevier, Amesterdam.

Alaban RA, Barredo FC and Aguirre AL (1990). An assessment of some indicators and determinants of farm productivity and soil fertility in the VMC district: trends, associations, interactions 1969-1990. *In: Proceedings of the Philippine Sugar Technologists*: 64-83

Ali AD, Hudnall WH and Reagan TE (1986). Effects of soil types and cultural practices on the fire ant (Solenopsis Invicta) in Sugarcane. *Agriculture, Ecosystems & Environment, 18 (1)*: 63-71. doi:10.1016/0167-8809(86)90175-1

Allan HL, van de Merwe JP, Finlayson KA, O'Brien JW, Mueller JF and Leusch FDL (2017). Analysis of sugarcane herbicides in marine turtle nesting areas and assessment of risk using in vitro toxicity assays. *Chemosphere, 185*: 656-664. doi:10.1016/j.chemosphere.2017.07.029

Allen DE, Kingston G, Rennenberg H Dalal RC and Schmidt S (2010). Effect of nitrogen fertilizer management and waterlogging on nitrous oxide emission from subtropical sugarcane soil. *Agriculture, Ecosystems & Environment, 136*: 209-217. doi:10.1016/j.agee.2009.11.002

Alves DKM, Kummrow F, Cardoso AA, Morales DA and Umbuzeiro GA (2016). Mutagenicity profile of atmospheric particulate matter in a small urban center subjected to airborne emission from vehicle traffic and sugar cane burning. *Environmental and Molecular Mutagenesis, 57 (1)*: 41-50. doi:10.1002/em.21970

Alves RIS, Sampaio CF, Nadal M, Schuhmacher M, Domingo JL and Segura-Muñoz SI (2014). Metal concentrations in surface water and sediments from Pardo River, Brazil: Human health risks. *Environmental Research, 133*: 149-155. doi:10.1016/j.envres.2014.05.012

Anaya CA and Huber-Sannwald E (2015). Long-term soil organic carbon and nitrogen dynamics after conversion of tropical forest to traditional sugarcane agriculture in East Mexico. *Soil and Tillage Research, 147*: 20-29. doi:10.1016/j.still.2014.11.003

Andrade de Sá S, Palmer C and Di Falco S (2013). Dynamics of indirect land-use change: Empirical evidence from Brazil. *Journal of Environmental Economics and Management, 65*: 377-393. doi:10.1016/j.jeem.2013.01.001

Arbex MA, Bohm GM, Saldiva PHN, Conceicao GMS, Pope III AC and Braga ALF (2000). Assessment of the effects of sugar cane plantation burning on daily counts of inhalation therapy. *Journal of the Air & Waste Management Association, 50 (10)*: 1745-1749.

Arbex MA, Martins LC, De Oliveira RC, Pereira LAA, Arbex FF, Cancado JED, Saldiva PHN and Braga ALF (2007). Air pollution from biomass burning and asthma hospital admissions in a sugar cane plantation area in Brazil. *Journal of Epidemiology and Community Health, 61 (5)*: 395-400. doi:10.1136/jech.2005.044743

Arbex MA, Pereira LA, Carvalho-Oliveira R, Saldiva PH and Braga AL (2014). The effect of air pollution on pneumonia-related emergency department visits in a region of extensive sugar cane plantations: a 30-month time series study. *Journal of Epidemiology and Community Health, 68 (7)*: 669-674. doi:10.1136/jech-2013-203709

Arbex MA, Saldiva PH, Pereira LA and Braga AL (2010). Impact of outdoor biomass air pollution on hypertension hospital admissions. *Journal of Epidemiology and Community Health, 64 (7)*: 573-579. doi:10.1136/jech.2009.094342

Assunção SA, Oliveira APP, Anjos LHC dos, Pereira MG and Lima E (2018). Soil organic matter fractions affected by N-fertilizer in a green cane management in Brazilian Coastal Tableland. *Bragantia, 77 (2)*: 356-364. doi:10.1590/1678-4499.2017296

Baffes J and Dennis A (2013). *Long-Term Drivers of Food Prices*. Policy Research Working Paper (WPS-6455). World Bank. 35 p.

Baillie C and Chen G (2012). Opportunities for reducing on-farm energy use and greenhouse gas emissions in sugarcane. *International Sugar Journal, 114 (1366)*: 725-730.

Bangita B and Rajashekhar Rao BK (2012). Impacts of compaction relief treatments on soil physical properties and performance of sugarcane under zonal tillage system. *Geoderma, 189-190*: 351-356. doi:10.1016/j.geoderma.2012.07.002

Bengtson RL, Selim HM and Ricaud R (1998). Water quality from sugarcane production on alluvial soils. *Transactions of ASAE, 41 (5)*: 1331-1336

Bernard E, Melo FPL and Pinto SRR (2011). Challenges and opportunities for biodiversity conservation in the Atlantic forest in face of bioethanol expansion. *Tropical Conservation Science, 4 (3)*: 267-275.

Bicalho ES, Panosso AR, Teixeira DDB, Miranda JGV, Pereira GT and La Scala N (2014). Spatial variability structure of soil CO_2 emissions and soil attributes in sugarcane area. *Agriculture, Ecosystems & Environment, 189*: 206-215. doi:10.1016/j.agee.2014.03.043

Black E, Vidale PL, Verhoef A, Cuadra SV, Osborne T and Van den Hoof C (2012). Cultivating C4 crops in a changing climate: sugarcane in Ghana. *Environmental Research Letters, 7*: 044027. doi:10.1088/1748-9326/7/4/044027

Blair BL, Magarey RC, Bull JI and Johnson EJ (1997). Biological studies of soils in paired old and new land sites growing sugarcane. *Australian Journal of Experimental Agriculture, 37 (4)*: 451-457. doi:10.1071/EA96137

Bordonal R de O, Carvalho JLN, Lal R, de Figueiredo EB, de Oliveira BG and La Scala N (2018). Sustainability of sugarcane production in Brazil. A review. *Agronomy for Sustainable Development, 38 (2)*: 13. doi:10.1007/s13593-018-0490-x

Borges LAB, Ramos GML, Vivaldi LJ, Fernandes PM, Madari BE, Soares RAB, Fontoura PR (2014). Impact of sugarcane cultivation on the biological attributes of an oxisol in the Brasilian savannah. *Bioscience Journal, 30 (5)*: 1459-1473.

Botha T and von Blottnitz H (2006). A comparison of the environmental benefits of bagasse-derived electricity and fuel ethanol on a life-cycle basis. *Energy Policy, 34 (17)*: 2654-2661. doi:10.1016/j.enpol.2004.12.017

Brackin R, Robinson N, Lakshmanan P and Schmidt S (2013). Microbial function in adjacent subtropical forest and agricultural soil. *Soil Biology and Biochemistry, 57*: 68-77. doi:10.1016/j.soilbio.2012.07.015

Bramley RGV and Roth CH (2002). Land-use effects on water quality in an intensively managed catchment in the Australian humid tropics. *Marine and Freshwater Research, 53*: 931-940. doi:10.1071/MF01242

Brito LF, Marques Junior J, Pereira GT, Menezes Souza Z and La Scala Junior N (2009). Soil CO_2 emission of sugarcane fields as affected by topography. *Scientia Agricola, 66 (1)*: 77-83. doi:10.1590/S0103-90162009000100011

Brooks SM, Stockwell HG, Pinkham PA, Armstrong AW and Witter DA (1992). Sugarcane exposure and the risk of lung cancer and mesothelioma. *Environmental Research, 58 (1-2)*: 195-203. doi:10.1016/S0013-9351(05)80215-4

Camenzuli L, Scheringer M, Gaus C, Ng CA and Hungerbuhler K (2012). Describing the environmental fate of diuron in a tropical river catchment. *Science of the Total Environment, 440 (1)*: 178-185. doi:10.1016/j.scitotenv.2012.07.037

Campbell A and Doswald N (2009). *The impacts of biofuel production on biodiversity: A review of the current literature*. UNEP-WCMC, Cambridge, UK. 36 p.

Campos AC, Oleschko KL, Etchevers JB and Hidalgo CM (2007). Exploring the effect of changes in land use on soil quality on the eastern slope of the cofre de Perote Volcano (Mexico). *Forest Ecology and Management, 248 (3)*: 174-182. doi:10.1016/j.foreco.2007.05.004

Cançado JED, Saldiva PHN, Pereira LAA, Lara LBLS, Artaxo P, Martinelli LA, Arbex MA, Zanobetti A and Braga ALF (2006). The impact of sugar cane burning emissions on the respiratory system of children and the elderly. *Environmental Health Perspectives, 114 (5)*: 725-729.

Cardoso MSO, Pedrosa EMR, Rolim MM, Oliveira LSC and Santos AN (2016). Relationship between nematode assemblages and physical properties across land use types. *Tropical Plant Pathology, 41 (2)*: 107-114. doi:10.1007/s40858-016-0075-7

Cardozo NP, Bordonal R de O and La Scala N (2016). Greenhouse gas emission estimate in sugarcane irrigation in Brazil: is it possible to reduce it, and still increase crop yield? *Journal of Cleaner Production, 112*: 3988-3997. doi:10.1016/j.jclepro.2015.09.040

Carvalho JLN, Nogueirol RC, Menandro LMS, Bordonal R de O, Borges CD, Cantarella H and Franco HCJ (2016). Agronomic and environmental implications of sugarcane straw removal: a major review. *GCB Bioenergy, 9 (7)*: 1181-1195. doi:10.1111/gcbb.12410

Castillo MS and Wright AL (2008). Soil phosphorus pools for histosols under sugarcane and pasture in the everglades, USA. *Geoderma, 145 (1-2)*: 130-135. doi:10.1016/j.geoderma.2008.03.006

Castioni GA, Cherubin MR, Menandro LMS, Sanches GM, Bordonal R de O, Barbosa LC, Franco HCJ and Carvalho JLN (2018). Soil physical quality response to sugarcane straw removal in Brazil: A multi-approach assessment. *Soil and Tillage Research, 184*: 301-309. doi:10.1016/j.still.2018.08.007

CEE (2018). *Guidelines for Systematic Review and Evidence Synthesis in Environmental Management. Version 5.0*. 483 AS Pullin et al (Eds.), Collaboration for Environmental Evidence (CEE). Available Online: www.environmentalevidence.org/information-for-authors (Accessed on September 2019).

Cerdeira Al, Desouza MD, Queiroz SCN, Ferracini VL, Bolonhezi D, Gomes MAF, Rosa MA, Balderrama O, Rampazzo P, Queiroz RHC, Neto CF and Matallo MB (2007). Leaching and half-life of the herbicide tebuthiuron on a recharge area of Guarany aquifer in sugarcane fields in Brazil. *Journal of Environmental Science and Health – Part B, 42 (6)*: 635-639. doi:10.1080/03601230701465593

Cerri CC and Andreux F (1990). Changes in organic carbon content in Oxisols cultivated with sugar cane and pasture, based on ^{13}C natural abundance measurement. *In: Transactions 14th international congress of soil science, Vol. IV*: 98-103.

Chalco Vera J, Valeiro A, Posse G and Acreche MM (2017). To burn or not to burn: The question of straw burning and nitrogen fertilization effect on nitrous oxide emissions in sugarcane. *Science of the Total Environment, 587-588*: 399-406. doi:10.1016/j.scitotenv.2017.02.172

Chandiposha M (2013). Potential impact of climate change in sugarcane and mitigation strategies in Zimbabwe. *African Journal of Agricultural Research, 8 (23)*: 2814-2818. doi:10.5897/AJAR2013.7083

Chandra VV, Hemstock SL, Mwabonje ON, De Ramon N'Yeurt A and Woods J (2018). Life Cycle Assessment of Sugarcane Growing Process in Fiji. *Sugar Tech, 20 (6)*: 692-699. doi:10.1007/s12355-018-0607-1

Cherubin MR, Franco ALC, Cerri CEP, Karlen DL, Pavinato PS, Rodrigues M, Davies CA and Cerri CC (2016a). Phosphorus pools responses to land-use change for sugarcane expansion in weathered Brazilian soils. *Geoderma, 265*: 27-38. doi:10.1016/j.geoderma.2015.11.017

Cherubin MR, Franco ALC, Cerri CEP, Oliveira DM da S, Davies CA Cerri CC (2015). Sugarcane expansion in Brazilian tropical soils—Effects of land use change on soil chemical attributes. *Agriculture, Ecosystems & Environment, 211*: 173-184. doi:10.1016/j.agee.2015.06.006

Cherubin MR, Karlen DL, Cerri CEP, Franco ALC, Tormena CA, Davies CA and Cerri CC (2016b). Soil Quality Indexing Strategies for Evaluating Sugarcane Expansion in Brazil. *PLOS ONE, 11 (3)*: e0150860. doi:10.1371/journal.pone.0150860

Chi L, Mendoza-Vega J, Huerta E and Álvarez-Solís JD (2017). Effect of Long-Term Sugarcane (Saccharum Spp.) Cultivation on Chemical and Physical Properties of Soils in Belize. *Communications in Soil Science and Plant Analysis, 48 (7)*: 741-755. doi:10.1080/00103624.2016.1254794

Chorom M, Baghernejad M and Jafari S (2009). Influence of rotation cropping and sugarcane production on the clay mineral assemblage. *Applied Clay Science, 46 (4)*: 385-395. doi:10.1016/j.clay.2009.10.001

Corradi MM, Panosso AR,Martins Filho MV, La Scala MJ (2013). Crop residues on short-term CO2 emissions in sugarcane production areas. *Engenharia Agrícola, 33 (4)*: 699-708. doi:10.1590/S0100-69162013000400009

Cristale J, Soares Silva F, Zocolo GJ and Rodrigues Marchi MR (2012). Influence of sugarcane burning on indoor/outdoor PAH air pollution in Brazil. *Environmental Pollution, 169*: 210-216. doi:10.1016/j.envpol.2012.03.045

Crowe J, Wesseling C, Solano BR, Umaña MP, Ramírez AR, Kjellstrom T, Morales D and Nilsson M (2013). Heat exposure in sugarcane harvesters in Costa Rica. *American Journal of Industrial Medicine, 56 (10)*: 1157-1164. doi:10.1002/ajim.22204

D'Hont A, Ison D, Alix K, Roux C and Glaszmann JC (1998). Determination of basic chromosome numbers in the genus Saccarum by physical mapping of ribosomal RNA genes. *Genome, 41 (2)*: 221-225. doi:10.1139/g98-023

Da Silva DKA, De Oliveira Freitas N, de Souza RG, Barbosa da Silva FS, Ferreira de Araujo AS and Costa Maia L (2012). Soil microbial biomass and activity under natural and regenerated forests and conventional sugarcane plantations in Brazil. *Geoderma, 189-190*: 257-261. doi:10.1016/j.geoderma.2012.06.014

Dattamudi S, Wang JJ, Dodla SK, Arceneaux A and Viator HP (2016). Effect of nitrogen fertilization and residue management practices on ammonia emissions from subtropical sugarcane production. *Atmospheric Environment, 139*: 122-130. doi:10.1016/j.atmosenv.2016.05.035

Davis AM, Thorburn PJ, Lewis SE, Bainbridge ZT, Attard SJ, Milla R and Brodie JE (2013). Environmental impacts of irrigated sugarcane production: Herbicide run-off dynamics from farms and associated drainage systems. *Agriculture, Ecosystems & Environment, 180*: 123-135. doi:10.1016/j.agee.2011.06.019

De Andrade SJ, Varella SD, Pereira GT, Zocolo GJ, de Marchi MRR and Varanda EA (2011). Mutagenic activity of airborne particulate matter (PM_{10}) in a sugarcane farming area (Araraquara city, southeast Brazil). *Environmental Research, 111*: 545-550. doi:10.1016/j.envres.2011.03.004

De Fraiture C, Giordano M and Liao Y (2008). Biofuels and implications for agricultural water use: blue impacts of green energy. *Water Policy, 10*: 67-81. doi:10.2166/wp.2008.054

De Los R, Portocarrero A and Acreche MM (2014). Nitrate leaching in an Argiudoll cultivated with sugarcane. *Sugar Tech, 16 (3)*: 329-332. doi:10.1007/s12355-013-0287-9

Defante LR, Vilpoux OF and Sauer L (2018). Rapid expansion of sugarcane crop for biofuels and influence on food production in the first producing region of Brazil. *Food Policy, 79*: 121-131. doi:10.1016/j.foodpol.2018.06.005

Degefa S and Saito O (2017). Assessing the Impacts of Large-Scale Agro-Industrial Sugarcane Production on Biodiversity: A Case Study of Wonji Shoa Sugar Estate, Ethiopia. *Agriculture, 7 (12)*: 99. doi:10.3390/agriculture7120099

Denmead OT, Macdonald BCT, Bryant G, Naylor T, Wilson S, Griffith DWT, Wang WJ, Salter B, White I and Moody PW (2010). Emissions of methane and nitrous oxide from Australian sugarcane soils. *Agricultural and Forest Meteorology, 150*: 748-756. doi: 10.1016/j.agrformet.2009.06.018

Devendra A (1999). *Risk for lung cancer among sugar cane farmers and processing workers*. PhD Thesis, McGill University

Dick RP (1997). Soil enzyme activities as integrative indicators of soil health. *In: Pankhurst CE, Doube BM, Gupta VVSR (Eds). Biological indicators of soil health*. CAB, Wallingford: 121-156

Dlamini TC and Haynes RJ (2004). Influence of agricultural land use on the size and composition of earthworm communities in northern KwaZulu-Natal, South Africa. *Applied Soil Ecology, 27*: 77-88. doi:10.1016/j.apsoil.2004.02.003

Dominy CS and Haynes RJ (2002). Influence of agricultural land management on organic matter content, microbial activity and aggregate stability in the profiles of two Oxisols. *Biology and Fertility of Soils, 36*: 298-305. doi:10.1007/s00374-002-0542-9

Dominy CS, Haynes RJ and van Antwerpen R (2002). Loss of organic matter and related soil properties under long-term sugarcane production on two contrasting soils. *Biology and Fertility of Soils, 36*: 350-356. doi:10.1007/s00374-002-0538-5

Doube BM and Schmidt O (1997). Can the abundance or activity of soil macrofauna be used to indicate the biological health of soils. *In: Pankhurst, C.E., Doube, B.M., Gupta, V.V.S.R. (Eds.), Biological Indicators of Soil Health*. CAB International, Wallingford: 265-295.

Du C, Kulay L, Cavalett O, Dias L and Freire F (2018). Life cycle assessment addressing health effects of particulate matter of mechanical versus manual sugarcane harvesting in Brazil. *The International Journal of Life Cycle Assessment, 23 (4)*: 787-799. doi:10.1007/s11367-017-1334-7

Duru M (2013). Combining agroecology and management science to design field tools under high agrosystem structural or process uncertainty: Lessons from two case studies of grassland management. *Agricultural Systems, 114*: 84-94. doi:10.1016/j.agsy.2012.09.002

Dusfour I, Achee NL, Briceno I, King R and Grieco JP (2010). Comparative data on the insecticide resistance of Anopheles albimanus in relation to agricultural practices in northern Belize, CA. *Journal of Pest Science, 83*: 41-46. doi:10.1007/s10340-009-0268-7

Edwards CA, Bohlen PJ, Linden DR and Subler S (1995). Earthworms in agroecosystems. *In: Hendrix, P.F. (Ed.), Earthworm Ecology and Biogeography in North America*. CRC Press, Boca Raton: 185-213.

El Chami D, Daccache A and El Moujabber M (Forthcoming). How could sustainable agriculture increase climate resilience? A systematic review. *Sustainability-Basel*.

Eustice T, Van Der Laan M and Van Antwerpen R (2011). Comparison of greenhouse gas emissions from trashed and burnt sugarcane cropping systems in South Africa. *Proceedings of the South African Sugar Technologists' Association, 84*: 326-339

Everingham YL, Muchow RC, Stone RC, Inman-Bamber NG, Singels A and Bezuidenhout CN (2002). Enhanced risk management and decision-making capability across the sugarcane industry value chain based on seasonal climate forcasts. *Agricultural Systems, 74 (3)*: 459-477. doi:10.1016/S0308-521X(02)00050-1

Faithful J and Finlayson W (2005). Water quality assessment for sustainable agriculture in the wet tropics - A community-assisted approach. *Marine Pollution Bulletin, 51*: 99-112. doi:10.1016/j.marpolbul.2004.11.007

Faithful JW, Brodie J, Hooper A, Leahy P, Henry G, Finlayson W and Green D (2007). *Plot-scale runoff of nutrients and sediment under varying management regimes on a banana and cane farm in the wet tropics, Queensland*. ACTFR Report No. 05/03.

FAO (2008). *The state of food and agriculture – Biofuels: risk, prospects and opportunities*. Food and Agriculture Organization of the United Nations (FAO). 128 p.

FAO (2019). *The agricultural production indices*. FAOSTAT, Food and Agricultural Organization of the United Nations (FAO). Available Online: http://faostat.fao.org/ (Accessed on September 2019).

Felício AA, Freitas JS, Scarin JB, de Souza Ondei L, Teresa FB, Schlenk D and de Almeida EA (2018). Isolated and mixed effects of diuron and its metabolites on biotransformation enzymes and oxidative stress response of Nile tilapia (Oreochromis niloticus). *Ecotoxicology and Environmental Safety, 149*: 248-256. doi:10.1016/j.ecoenv.2017.12.009

Ferreira-Ceccato AD, Ramos EM, de Carvalho LC Jr, Xavier RF, Teixeira MF, Raymundo-Perreira PA, Proença Cdos A, de Toledo AC and Ramos D (2011). Short terms effects of air pollution from biomass burning in mucociliary clearance of Brazilian sugarcane cutter. *Respiratory Medicine, 105 (11)*: 1766-1768. doi:10.1016/j.rmed.2011.08.003

Fisher B, Turner RK and Morling P (2009). Defining and classifying ecosystem services for decision making. *Ecological Economics, 68*: 643-653. doi:10.1016/j.ecolecon.2008.09.014

Fonseca da Silva J, Moreira de Carvalho A, Rein TA, Rodrigues Coser T, Quadros Ribeiro W, Lino Vieira D and Coomes DA (2017). Nitrous oxide emissions from sugarcane fields in the Brazilian Cerrado. *Agriculture, Ecosystems & Environment, 246*: 55-65. doi:10.1016/j.agee.2017.05.019

Fracetto FJC, Fracetto GGM, Bertini SCB, Cerri CC, Feigl BJ and Siqueira Neto M (2017). Effect of agricultural management on N2O emissions in the Brazilian sugarcane yield. *Soil Biology and Biochemistry, 109*: 205-213. doi:10.1016/j.soilbio.2017.02.004

Franco ALC, Bartz MLC, Cherubin MR, Baretta D, Cerri CEP, Feigl BJ, Wall DH, Davies CA and Cerri CC (2016). Loss of soil (macro) fauna due to the expansion of Brazilian sugarcane acreage. *Science of the Total Environment, 563-564*: 160-168. doi:10.1016/j.scitotenv.2016.04.116

Franco ALC, Cherubin MR, Pavinato PS, Cerri CEP, Six J, Davies CA and Cerri CC (2015). Soil carbon, nitrogen and phosphorus changes under sugarcane expansion in Brazil. *Science of the Total Environment, 515-516*: 30-38. doi:10.1016/j.scitotenv.2015.02.025

Fraser PM (1994). The impact of soil and crop management practices on soil macrofauna. *In: Pankhurst, C.E., Doube, B.M., Gupta, V.V.S.R., Grace, P.R. (Eds.), Soil Biota. Management in Sustainable Farming Systems*. CSIRO, Adelaide: 125-132.

Frate CA and Brannstrom C (2015). Will Brazil's ethanol ambitions undermine its agrarian reform goals? A study of social perspectives using Q-method. *Journal of Rural Studies, 38*: 89-98. doi:10.1016/j.jrurstud.2014.10.007

Galdos MV, Cerri CC and Cerri CEP (2009). Soil carbon stocks under burned and unburned sugarcane in Brazil. *Geoderma, 153 (3-4)*: 347-352. doi:10.1016/j.geoderma.2009.08.025

Gasparatos A, Stromberg P and Takeuchi K (2011). Biofuels, ecosystem services and human wellbeing: Putting biofuels in the ecosystem services narrative. *Agriculture, Ecosystems & Environment, 142*: 111-128. doi:10.1016/j.agee.2011.04.020

Gerbens-Leenes PW, van Lienden AR, Hoekstra AY and van der Meer ThH (2012). Biofuel scenarios in a water perspective: The global blue and green water footprint of road transport in 2030. *Global Environmental Change, 22*: 764-775. doi:10.1016/j.gloenvcha.2012.04.001

German L, Schoneveld GC and Pacheco P (2011). The social and environmental impacts of biofuel feedstock cultivation: Evidence from multi-site research in the forest frontier. *Ecology and Society, 16 (3)*: 24. doi:10.5751/ES-04309-160324

Gheler-Costa C, Sabino-Santos GJr, Santos Amorim L, Rosalino LM, Figueiredo LTM and Verdade LM (2013). The effect of pre-harvest fire on the small mammal assemblage in sugarcane fields. *Agriculture, Ecosystems & Environment, 171*: 85-89. doi:10.1016/j.agee.2013.03.016

Ghiberto PJ, Libardi PL, Brito AS and Trivelin PCO (2009). Leaching of nutrients from a sugarcane crop growing on an Ultisol in Brazil. *Agricultural Water Management, 96*: 1443-1448. doi:10.1016/j.agwat.2009.04.020

Ghiberto PJ, Libardi PL, Brito AS and Trivelin PCO (2011). Components of the water balance in soil with sugarcane crops. *Water Resources Management, 102 (1)*: 1-7. doi:10.1016/j.agwat.2011.09.010

Goldemberg J (2007). Ethanol for a sustainable energy future. *Science, 315*: 808-810. doi:10.1126/science.1137013

Goldemberg J, Coelho ST and Guardabassi P (2008). The sustainability of ethanol production from sugarcane. *Energy Policy, 36*: 2086-2097. doi:10.1016/j.enpol.2008.02.028

Gonzaga LC, Carvalho JLN, Oliveira BG de, Soare, JR and Cantarella H (2018). Crop residue removal and nitrification inhibitor application as strategies to mitigate N2O emissions in sugarcane fields. *Biomass and Bioenergy, 119*: 206-216. doi:10.1016/j.biombioe.2018.09.015

Goto DM, Lança M, Obuti CA, Galvao Barbosa CM, Nascimento Saldiva PH, Trevisan Zanetta DM, Lorenzi-Filho G, de Paula Santos U and Nakagawa NK (2011). Effects of biomass burning on nasal mucociliary clearance and mucus properties after sugarcane harvesting. *Environmental Research, 111 (5)*: 664-669. doi:10.1016/j.envres.2011.03.006

Graham MH and Haynes RJ (2005a). Organic matter accumulation and fertilizer-induced acidification interact to affect soil microbial and enzyme activity on a long-term sugarcane management experiment. *Biology and Fertility of Soils, 41*: 249-256. doi:10.1007/s00374-005-0830-2

Graham MH and Haynes RJ (2005b). Catabolic diversity of soil microbial communities under sugarcane and other land uses. *Applied Soil Ecology, 29 (2)*: 155-164. doi:10.1016/j.apsoil.2004.11.002

Graham MH and Haynes RJ (2006). Organic matter status and the size activity and metabolic diversity of the soil microbial community in the row and inter-row of sugarcane under burning and trash retention. *Soil Biology and Biochemistry, 38 (1)*: 21-31. doi:10.1016/j.soilbio.2005.04.011

Graham MH, Haynes RJ and Meyer JH (2002). Soil organic matter content and quality: effects of fertilizer applications, burning and trash retention on a long-term sugarcane experiment in South Africa. *Soil Biology and Biochemistry, 34 (1)*: 93-102. doi:10.1016/S0038-0717(01)00160-2

Groom MJ, Gray EM and Townsend PA (2008). Biofuels and biodiversity: Principles for creating better Policies for biofuel production. *Conservation Biology, 22 (3)*: 602-609. doi:10.1111/j.1523-1739.2007.00879.x

Hansen JW (1996). Is agricultural sustainability a useful concept? *Agricultural Systems, 50 (2)*: 117-143. doi:10.1016/0308-521X(95)00011-S

Hartemink AE (1998a). Changes in soil fertility and leaf nutrient concentration at a sugar cane plantation in Papua New Guinea. *Communications in Soil Science and Plant Analysis, 29 (7&8)*: 1045-1060. doi:10.1080/00103629809370006

Hartemink AE (1998b). Acidification and pH buffering capacity of alluvial soils under sugarcane. *Experimental Agriculture, 34*: 231-243. doi:10.1017/S0014479798002087

Hartemink AE (1998c). Soil chemical and physical properties as indicators of sustainable land management under sugar cane in Papua New Guinea. *Geoderma, 85 (4)*: 283-306. doi:10.1016/S0016-7061(98)00048-2

Hartemink AE (2008). Sugarcane for bioethanol: soil and environmental issues. *Advances in Agronomy, 99*: 125-182. doi:10.1016/S0065-2113(08)00403-3

Harvey M and Pilgrim S (2011). The new competition for land: Food, energy, and climate change. *Food Policy, 36*: S41-S50. doi:10.1016/j.foodpol.2010.11.009

Hassan R, Scholes R and Ash N (2005). *Ecosystems and human well-being: Current state and trends, volume 1*. Millennium Ecosystem Assessment. 917 p.

Haynes D, Ralph P, Prange J and Dennison B (2000). The impact of the herbicide diuron on photosynthesis in three species of tropical seagrass. *Marine Pollution Bulletin, 41 (7-12)*: 288-293. doi:10.1016/S0025-326X(00)00127-2

Haynes RJ, Dominy CS and Graham MH (2003). Effect of agricultural land use on soil organic matter status and the composition of earthworm communities in KwaZulu-Natal, South Africa. *Agriculture, Ecosystems & Environment, 95 (2-3)*: 453-464. doi:10.1016/S0167-8809(02)00223-2

Hein L and Leemans R (2012). The impact of first-generation biofuels on the depletion of the global phosphorus reserve. *Ambio, 41*: 341-349. doi:10.1007/s13280-012-0253-x

Herrmann R, Jumbe C, Bruentrup M and Osabuohien E (2018). Competition between biofuel feedstock and food production: Empirical evidence from sugarcane outgrower settings in Malawi. *Biomass and bioenergy, 114*: 100-111. doi:10.1016/j.biombioe.2017.09.002

Holst J, Brackin R, Robinson N, Lakshmanan P and Schmidt S (2012). Soluble inorganic and organic nitrogen in two Australian soils under sugarcane cultivation. *Agriculture, Ecosystems & Environment, 155*: 16-26. doi:10.1016/j.still.2010.06.013

Holt JA and Mayer RJ (1998). Changes in microbial biomass and protease activities of soil associated with long-term sugar cane monoculture. *Biology and Fertility of Soils, 27*: 127-131. doi:10.1007/s003740050410

Hurst ZM, McCleery RA, Collier BA, Silvy NJ, Taylor PJ and Monadjem A (2014). Linking changes in small mammal communities to ecosystem functions in an agricultural landscape. *Mammalian Biology, 79 (1)*: 17-23. doi:10.1016/j.mambio.2013.08.008

Jahani B, Soltani Mohammadi A, Nasseri AA, Van Oel PR and Sadeghi Lari A (2017). Reduction of Sugarcane Water Footprint by Controlled Drainage, in Khuzestan, Iran. *Irrigation and Drainage, 66 (5)*: 884-895. doi:10.1002/ird.2148

Jha CK, Sinha SK, Alam M and Pandey SS (2015). Effect of bio-compost and zinc application on sugarcane (Saccharum species hybrid complex) productivity, quality and soil health. *Indian Journal of Agronomy, 60 (3)*: 450-456.

Jorrat M del M, Araujo PZ and Mele FD (2018). Sugarcane water footprint in the province of Tucumán, Argentina. Comparison between different management practices. *Journal of Cleaner Production, 188*: 521-529. doi:10.1016/j.jclepro.2018.03.242

Kasambala Donga T and Eklo OM (2018). Environmental load of pesticides used in conventional sugarcane production in Malawi. *Crop Protection, 108*: 71-77. doi:10.1016/j.cropro.2018.02.012

Kennedy E (1988). Agricultural commercialization: food consumption effects in Kenya. *Food Policy, 13 (1)*: 104-105. doi:10.1016/0306-9192(88)90014-0

Kennedy E (1989). *The effects of sugarcane production on food security, health, and nutrition in Kenya*. Research Report, IFPRI.

Kennedy E and Cogill B (1988). The commercialization of agriculture and household-level food security: the case of southwestern Kenya. *World Development, 16 (9)*: 1075-1081. doi:10.1016/0305-750X(88)90110-6

Kovarik W (2008). Ethanol's first century. *In: the XVI international symposium on alcohol fuels*. Rio de Janeiro, Brasil.

Kropff MJ, Bouma J and Jones JW (2001). Systems approaches for the design of sustainable agro-ecosystems. *Agricultural Systems, 70 (2-3)*: 369-393. doi:10.1016/S0308-521X(01)00052-X

Kshirsagar KG (2006). Organic sugarcane farming for development of sustainable agriculture in Maharashtra. *Agricultural Economics Research Review, 19*: 145-153.

La Scala N Jr, Bolonhezi D and Pereira GT (2006). Short-term emission after conventional and reduced tillage of a no-till sugar cane area in southern Brazil. *Soil & Tillage Research, 91 (1-2)*: 244-248. doi:10.1016/j.still.2005.11.012

Lanchote VL, Bonato PS, Cerdeira AL, Guinain Santos NA, De Carvalho D and Gomes MA (2000). HPLC screening and GC-MS confnirmation of triazine herbicides residues in drinking water from sugar cane area in Brazil. *Water, Air, & Soil Pollution, 118 (3-4)*: 329-337. doi:10.1023/A:1005147405509

Lapola DM, Schaldach R, Alcamo J, Bondeau A, Koch J, Koelking and Priess JA (2010). Indirect land-use changes can overcome carbon savings from biofuels in Brazil. *Proceedings of the National Academy of Sciences of the United States of America, 107 (8)*: 3388-3393. doi:10.1073/pnas.0907318107

Le Blond JS, Woskie S, Horwell CJ and Williamson BJ (2017). Particulate matter produced during commercial sugarcane harvesting and processing: A respiratory health hazard? *Atmospheric Environment, 149*: 34-46. doi:10.1016/j.atmosenv.2016.11.012

Lee KE (1985). *Earthworms: Their Ecology and Relationships with soils and Land Use*. Academic Press, Sydney. 411 p.

Li H, Feng Y, Li X and Zeng D (2018). Analytical Confirmation of Various Herbicides in Drinking Water Resources in Sugarcane Production Regions of Guangxi, China. *Bulletin of Environmental Contamination and Toxicology, 100 (6)*: 815-820. doi:10.1007/s00128-018-2324-6

Liao Q, Wei G-P, Chen G-F, Liu B, Huang D-L and Li Y-R (2013). Effect of Trash Addition to the Soil on Microbial Communities and Physico-Chemical Properties of Soils and Growth of Sugarcane Plants. *Sugar Tech, 16 (4)*: 400-404. doi:10.1007/s12355-013-0296-8

Lisboa CC, Butterbach-Bahl K, Mauder M and Kiese R (2011). Bioethanol production from sugarcane and emissions of greenhouse gases – known and unknowns. *GCB Bioenergy, 3 (4)*: 277-292. doi:10.1111/j.1757-1707.2011.01095.x

Lu H, Prosser IP, Moran CJ, Gallant JC, Priestley G and Stevenson JG (2003). Predicting sheetwash and rill erosion over the Australian continent. *Australian Journal of Soil Research, 41*: 1037-1062. doi:10.1071/SR02157

Macedo IC (2007). *Sugar cane's energy. Twelve studies on Brazilian sugar cane agribusiness and its sustainability*. UNICA. 233 p.

Macedo IC, Seabra EAJ and Silva EAR (2008). Greenhouse gases emissions in the production and use of ethanol from sugarcane in Brazil: the 2005/2006 averages and a prediction for 2020. *Biomass and Bioenergy, 32*: 582-595. doi:10.1016/j.biombioe.2007.12.006

Machado PG, Picoli MCA, Torres LJ, Oliveira JG and Walter A (2015a). The use of socioeconomic indicators to assess the impacts of sugarcane production in Brazil. *Renewable and Sustainable Energy Reviews, 52*: 1519-1526. doi:10.1016/j.rser.2015.07.127

Machado WS, Santos Telles T, Tavares Filho J (2015b). Sugarcane expansion in the Capivara River hydrographic basin (SP) between 1977 and 2010. *Semina: Ciências Agrárias, 36 (6)*: 4185-4192. doi:10.5433/1679-0359.2015v36n6Supl2p4185

Maclean NR (1975). Long-term effects of sugar cane production on some physical and chemical properties of soils in the Goondi mill area. *In: Proceedings of the Queensland Society of Sugarcane Technologists, 42nd Conference*: 123-126.

Magarey RC, Bull JI, Blair BL and Johnson EJ (1997). Biological studies of soils in paired old and new land sites growing sugarcane. *Australian Journal of Experimental Agriculture, 37*: 451-457. doi:10.1071/EA96137

Mardamootoo T, Ng Kee Kwong KF and Du Preez CC (2010). History of phosphorus fertiliser usage and its impact on the agronomic phosphorus status of sugarcane soils in Mauritius. *Sugar Tech, 12 (2)*: 91-97. doi:10.1007/s12355-010-0019-3

Mardamootoo T, Ng Kee Kwong KF and Du Preez CC (2012). Evolution of the agronomic and environmental phosphorus status of soils in Mauritius after a seven-year sugarcane crop cycle. *Sugar Tech, 14 (3)*: 266-274. doi:10.1007/s12355-012-0157-x

Mardamootoo T, Ng Kee Kwong KF and Du Preez CC (2013). Assessing environmental phosphorus status of soils in Mauritius following long-term phosphorus fertilisation of sugarcane. *Agricultural Water Management, 117 (31)*: 26-32. doi:10.1016/j.agwat.2012.10.022

Masilaca, AS, Prasad, RA, and Morrison, RJ (1985). The impact of sugarcane cultivation on three Oxisols from Vanua Levu, Fiji. *Tropical Agriculture, 63*: 325-330.

Masters B, Rohde K, Gurner N and Reid D (2013). Reducing the risk of herbicide runoff in sugarcane farming through controlled traffic and early-banded application. *Agriculture, Ecosystems & Environment, 180*: 29-39. DOI: 10.1016/j.agee.2012.02.001

McGarry D, Bigwood RC, Pillay-McGarry UP, Bray SG and Moody PW (1996). Is cane damaging the soil? A comparison of a ten-year old block with the adjoining treeline. *In: Proceedings of the Australian Society of Sugarcane Technologists*: 189-194

Mendes KF, Inoue MH, Goulart MO, Pimpinato RF and Tornisielo VL (2016). Leaching of a Mixture of Hexazinone, Sulfometuron-Methyl, and Diuron Applied to Soils of Contrasting Textures. *Water, Air, & Soil Pollution, 227 (8)*: 268. doi:10.1007/s11270-016-2954-4

Mhlanga BFN, Ndlovu LS and Senzanje A (2006). Impacts of irrigation return flows on the quality of the receiving waters: A case of sugarcane irrigated fields at the Royal Swaziland Sugar Corporation (RSSC) in the Mbuluzi River Basin (Swaziland). *Physics and Chemistry of the Earth, 31 (15-16)*: 804-813. doi:10.1016/j.pce.2006.08.028

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC. 137 p.

Miranda CS, Vasconcellos A and Bandeira AG (2004). Termites in sugarcane in Northeast Brazil: Ecological aspects and pest status. *Neotropical Entomology, 33 (2)*: 237-241. doi:10.1590/S1519-566X2004000200015

Mitchell C, Brodie J and White I (2005). Sediments, nutrients and pesticides residues in event flow conditions in streams of the Mackay Whitsunday region, Australia. *Marine Pollution Bulletin, 51 (1-4)*: 23-36. doi:10.1016/j.marpolbul.2004.10.036

Moraes MAFD, Oliveira FCR and Diaz-Chavez RA (2015). Socio-economic impacts of Brazilian sugarcane industry. *Environmental Development, 16*: 31-43. doi:10.1016/j.envdev.2015.06.010

Morrison RJ and Gawander JS (2016). Changes in the properties of Fijian Oxisols over 30 years of sugarcane cultivation. *Soil Research, 54 (4)*: 418. doi:10.1071/sr15173

Mthimkhulu S, Podwojewski P, Hughes J, Titshall L and Van Antwerpen R (2016). The effect of 72 years of sugarcane residues and fertilizer management on soil physico-chemical properties. *Agriculture, Ecosystems & Environment, 225*: 54-61. doi:10.1016/j.agee.2016.04.002

Mudombi S, Von Maltitz GP, Gasparatos A, Romeu-Dalmau C, Johnson FX, Jumbe C, Ochieng C, Luhanga D, Lopes P, Balde BS, Willis KJ and Willis KJ (2018). Multi-dimensional poverty effects around operational biofuel projects in Malawi, Mozambique and Swaziland. *Biomass and Bioenergy, 114*: 41-54. doi:10.1016/j.biombioe.2016.09.003

Mugica-Álvarez V, Hernández-Rosas F, Magaña-Reyes M, Herrera-Murillo J, Santiago-De La Rosa N, Gutiérrez-Arzaluz M, and González-Cardoso G (2018). Sugarcane burning emissions: Characterization and emission factors. *Atmospheric Environment, 193*: 262-272. doi:10.1016/j.atmosenv.2018.09.013

Muller JF, Duquesne S, Nack NG, Shaw GR, Krrishnamohan K, Manonmanii K, Hodge M and Eaglesham GK (2000). Pesticides in sediments from Queensland irrigation channels and

drains. *Marine Pollution Bulletin, 41 (7-12)*: 294-300. doi:10.1016/S0025-326X(00)00095-3
Muller JF, Haynes D, McLachlan M, Bohme F, Will S, Shaw GR, Mortimer M, Sadler R and Connell DW (1999). PCDDs, PCDFs, PCBs and HCB in marine and estuarine sediments from Queensland, Australia. *Chemosphere, 39 (10)*: 1707-1721.
Nachimuthu G, Halpin NV and Bell MJ (2016). Effect of sugarcane cropping systems on herbicide losses in surface runoff. *Science of the Total Environment, 557-558*: 773-784. doi:10.1016/j.scitotenv.2016.03.105
Nannipieri P (1994). The potential use of soil enzymes as indicators of productivity sustainability and pollution. *In: Pankhurst CE, Doube BM, Gupta VVSR, Grace PR (eds) Soil biota. Management in sustainable farming systems*. CSIRO, Melbourne: 238-244.
Naranjo JF, Salgado-García S, Lagunes-Espinoza LC, Carrillo-Avila E and Palma-López DJ (2006). Changes in the properties of a Mexican fluvisol following 30 years of sugarcane cultivation. *Soil & Tillage Research, 88 (1-2)*: 160-167. doi:10.1016/j.still.2005.05.006
Nassar AM, Rudorff BFT, Antoniazzi LB, De Aguiar DA, Bacchi MRP and Adami M (2008). Prospects of the sugarcane expansion in Brazil: impacts on direct and indirect land use changes. *In: Sugarcane Ethanol - Contributions to climate change mitigation and the environment. Zuurbier P and van de Vooren J (Eds)*: 63-94.
Ng Kee Kwong KF, Bholah A, Volcy L and Pynee K (2002). Nitrogen and phosphorus transport by surface runoff from a silty clay loam soil under sugarcane in the humid tropical environment of Mauritius. *Agriculture, Ecosystems & Environment, 91 (1-3)*: 147-157. doi:10.1016/S0167-8809(01)00237-7
Nhiwatiwa T, Dalu T and Brendonck L (2017). Impact of irrigation based sugarcane cultivation on the Chiredzi and Runde Rivers quality, Zimbabwe. *Science of the Total Environment, 587-588*: 316-325. doi:10.1016/j.scitotenv.2017.02.155
Oliveira DM da S, Paustian K, Davies CA, Cherubin MR, Franco ALC, Cerri CC and Cerri CEP (2016). Soil carbon changes in areas undergoing expansion of sugarcane into pastures in south-central Brazil. *Agriculture, Ecosystems & Environment, 228*: 38-48. doi:10.1016/j.agee.2016.05.005
Oliver DP, Anderson JS, Davis A, Lewis S, Brodie J and Kookana R (2014). Banded applications are highly effective in minimising herbicide migration from furrow-irrigated sugarcane. *Science of the Total Environment, 466-467*: 841-848. doi:10.1016/j.scitotenv.2013.07.117
Olivier FC and Singels A (2012). The effect of crop residue layers on evapotranspiration, growth and yield of irrigated sugarcane. *Water SA, 38 (1)*: 77-86. doi:10.4314/wsa.v38i1.10
Olivier FC and Singels A (2015). Increasing water use efficiency of irrigated sugarcane production in South Africa through better agronomic practices. *Field Crops Research, 176*: 87-98. doi:10.1016/j.fcr.2015.02.010
Ortiz PFS, Rolim MM, de Lima JLP, Pedrosa EMR, Dantas MSM and Tavares UE (2017). Physical qualities of an Ultisol under sugarcane and Atlantic forest in Brazil. *Geoderma Regional, 11*: 62-70. doi:10.1016/j.geodrs.2017.10.001
Palludeto AWA, Telles TS, Souza RF and Rodrigues de Moura F (2018). Sugarcane expansion and farmland prices in São Paulo State, Brazil. *Agriculture & Food Security, 7*: 1. doi:10.1186/s40066-017-0141-5
Pankhurst CE, Magarey RC, Stirling GR, Blair BL, Bell MJ and Garside AL (2003). Management practices to improve soil health and reduce the effects of detrimental soil biota

associated with yield decline of sugarcane in Queensland, Australia. *Soil & Tillage Research, 72 (2)*: 125-137. doi:10.1016/S0167-1987(03)00083-7
Pankhurst CE, Stirling GR, Magarey RC, Blair BL, Bell MJ and Garside AL (2005). Quantification of the effects of rotation breaks on soil biological properties and their impact on yield decline in sugarcane. *Soil Biology and Biochemistry, 37 (6)*: 1121-1130. doi:10.1016/j.soilbio.2004.11.011
Panosso AR, Marques J Jr, Milori DMBP, Ferraudo AS, Barbieri DM, Pereira GT and La Scala N Jr (2011). Soil CO_2 emission and its relation to soil properties in sugarcane areas under slash-and-burn and green harvest. *Soil & Tillage Research, 111 (2)*: 190-196. doi:10.1016/j.still.2010.10.002
Panosso AR, Marques J Jr, Pereira GT and La Scala N Jr (2009). Spatial and temporal variability of soil CO_2 emission in a sugarcane area under green and slash-and-burn management. *Soil & Tillage Research, 105 (2)*: 275-282. doi:10.1016/j.still.2009.09.008
Panosso AR, Perillo LI, Ferraudo AS, Pereira GT, Vivas Miranda JG and La Scala N Jr (2012). Fractal dimension and anisotropy of soil CO_2 emission in a mechanically harvested sugarcane production area. *Soil & Tillage Research, 124*: 8-16. doi:10.1016/j.still.2012.04.005
Paracchini ML, Bulgheroni C, Borreani G, Tabacco E, Banterle A, Bertoni D, Rossi G, Parolo G, Origgi R and De Paola C (2015). A diagnostic system to assess sustainability at a farm level: The SOSTARE model. *Agricultural Systems, 133*: 35-53. doi:10.1016/j.agsy.2014.10.004
Park S, Thorburn PJ, Pearson LJ, Kroon FJ, Westcott DA and Butler JRA (2008). Ecosystem services associated with sugarcane production in Australia. *In: 2008 ASSCT Conference – 30th Annual Conference Australian Society of Sugar Cane Technologists*. 29 April – 2 May, Townsville, Australia: 592 p
Patrick WH, Gambrell RP, Parkpian P and Tan F (1994). Mercury in soils and plants in the Florida Everglades sugarcane area. *In: Mercury pollution: Integration and synthesis (CJ Watras and JW Huckabee, Eds)*: 609-614.
Peraza S, Wesseling C, Aragon A, Leiva R, García-Trabanino RA, Torres C, Jakobsson K, Elinder CG and Hogstedt C (2012). Decreased Kidney Function Among Agricultural Workers in El Salvador. *American Journal of Kidney Diseases, 59 (4)*: 531-540. doi:10.1053/j.ajkd.2011.11.039
Pereira CLF and Ortega E (2010). Sustainability assessment of large-scale ethanol production from sugarcane. *Journal of Cleaner Production, 18 (1)*: 77-82. doi:10.1016/j.jclepro.2009.09.007
Petrini MA, Rocha JV and Brown, JC (2017). Mismatches between mill-cultivated sugarcane and smallholding farming in Brazil: Environmental and socioeconomic impacts. *Journal of Rural Studies, 50*: 218-227. doi:10.1016/j.jrurstud.2017.01.009
Pitombo LM, Cantarella H, Packer APC, Ramos NP and do Carmo JB (2017). Straw preservation reduced total N_2O emissions from a sugarcane field. *Soil Use and Management, 33 (4)*: 583-594. doi:10.1111/sum.12384
Pongpat P, Gheewala SH and Silalertruksa T (2017). An assessment of harvesting practices of sugarcane in the central region of Thailand. Journal of Cleaner Production, 142: 1138-1147. doi:10.1016/j.jclepro.2016.07.178
Prado GF, Zanetta DMT, Arbex MA, Braga AL, Pereira LAA, De Marchi, MRR, De Melo Loureiro AP, Marcourakis T, Sugauara LE, Gattas GJF, Goncalves FT, Salge JM, Terra-Filho M and De Paula Santos U (2012). Burnt sugarcane harvesting: Particulate matter exposure and

the effects on lung function, oxidative stress, and urinary 1-hydroxypyrene. *Science of the Total Environment, 437*: 200-208. doi:10.1016/j.scitotenv.2012.07.069

Prasara-A J and Gheewala SH (2016). Sustainability of sugarcane cultivation: case study of selected sites in north-eastern Thailand. *Journal of Cleaner Production, 134*: 613-622. doi:10.1016/j.jclepro.2015.09.029

Prove BG, Doogan VJ and Truong PNV (1995). Nature and magnitude of soil erosion in sugarcane land on the wet tropical coast of north-eastern Queensland. *Australian Journal of Experimental Agriculture, 35*: 641-649. doi:10.1071/EA9950641

Pryor SW, Smithers J, Lyne P and van Antwerpen R (2017). Impact of agricultural practices on energy use and greenhouse gas emissions for South African sugarcane production. Journal of Cleaner Production, 141: 137-145. doi:10.1016/j.jclepro.2016.09.069

Pullin AS, Knight TM and Watkinson AR (2009). Linking reductionist science and holistic policy using systematic reviews: unpacking environmental policy questions to construct an evidence-based framework. *Journal of Applied Ecology, 46*: 970-975. doi:10.1111/j.1365-2664.2009.01704.x

Qian Y, Matsumoto H, Liu X, Li S, Liang X, Liu Y, and Wang M (2017). Dissipation, occurrence and risk assessment of a phenylurea herbicide tebuthiuron in sugarcane and aquatic ecosystems in South China. *Environmental Pollution, 227*: 389-396. doi:10.1016/j.envpol.2017.04.082

Queiroz Rossi C, Pereira MG, Loss A, Gazolla PR, Perin A and Cunha dos Anjos LH (2013). Changes in soil C and N distribution assessed by natural $\delta^{13}C$ and $\delta^{15}N$ abundance in a chronosequence of sugarcane crops managed with pre-harvest burning in a Cerrado area of Goiás, Brazil. *Agriculture, Ecosystems & Environment, 170*: 36-44. doi:10.1016/j.agee.2013.03.008

Rajagopal D, Sexton SE, Roland-Holst D and Zilberman D (2007). Challenge of biofuel: filling the tank without emptying the stomach? *Environmental Research Letters, 2*: 044004. doi:10.1088/1748-9326/2/4/044004

Rasiah V, Armour JD and Cogle AL (2005). Assessment of variables controlling nitrate dynamics in groundwater: Is it a threat to surface aquatic ecosystems? *Marine Pollution Bulletin, 51 (1-4)*: 60-69. doi:10.1016/j.marpolbul.2004.10.024

Rasiah V, Armour JD and Nelson PN (2013). Nitrate in shallow fluctuating groundwater under sugarcane: Quantifying the lateral export quantities to surface waters. *Agriculture, Ecosystems & Environment, 180 (1)*: 103-110: doi:10.1016/j.agee.2012.07.002

Rice RW, Izuno FT and Gracia RM (2002). Phosphorus load reductions under best management practices for sugarcane cropping systems in the everglades agricultural area. *Agricultural Water Management, 56 (1, 2)*: 17-39. doi:10.1016/S0378-3774(01)00196-2

Richardson B (2010). *Sugar cane in southern Africa: A sweeter deal for the rural poor*. Ethical-Sugar. 19 p.

Ridley CE, Clark CM, Leduc SD, Bierwagen BG, Lin BB, Mehl A and Tobias DA (2012). Biofuels: Network analysis of the literature reveals key environmental and economic unknowns. *Environmental Science & Technology, 46 (3)*: 1309-1315. doi:10.1021/es2023253

Robichaud PR and Hungerford RD (2000). Water repellency by laboratory burning of four northern Rocky Mountain forest soils. *Journal of Hydrology, 231*: 207-219. doi:10.1016/S0022-1694(00)00195-5

Robins TG, Salie F and Gwagwa T (1998). Occupational hazards, living conditions, and physical assault of sugarcane workers in Kwazulu-Natal, SA. *South African Medical Journal, 88*: 1117-1127.

Rohde K, Masters B, Brodie J, Faithful J, Noble R and Carroll C (2006). *Fresh and Marine water quality in the Mackay Whitsunday region 2004/2005*. Volume 1, Main Report. Department of Natural Resources and Mines, Mackay, Queensland. 91 p.

Romeo L, Dalle Molle K, Zanoni G, Peretti A, Marangi G, Conrado LGL aragón A and Perbellini L (2009). Respiratory Health Effects and Immunological Response to Thermoactinomyces among Sugar Cane Workers in Nicaragua. *International Journal of Occupational and Environmental Health, 15*: 249-254. doi:10.1179/oeh.2009.15.3.249

Romeu-Dalmau C, Gasparatos A, von Maltitz G, Graham A, Almagro-Garcia J, Wilebore B and Willis KJ (2018). Impacts of land use change due to biofuel crops on climate regulation services: Five case studies in Malawi, Mozambique and Swaziland. *Biomass and Bioenergy, 114*: 30-40. doi:10.1016/j.biombioe.2016.05.011

Roth CH, Visser F, Wasson R, Reghenzani J and Prosser I (2003). *Quantifying and managing sources of sediments and nutrients in low-lying canelands*. CSIRO Land and Water. 40 p.

Rothschild H and Mulvey JJ (1982). An increased risk for lung cancer mortality associated with sugarcane farming. *Journal of the National Cancer Institute, 68 (5)*: 755-760.

Sandhu B, Prihar S and Khera K (1980). Sugarcane response to irrigation and straw mulch in a subtropical region. *Agricultural Water Management, 3 (1)*: 35-44. doi:10.1016/0378-3774(80)90013-x

Sant'Anna SAC, Fernandes MF, Ivo WMPM and Costa JLS (2009). Evaluation of soil quality indicators in sugarcane management in Sandy Loam Soil. *Pedosphere, 19 (3)*: 312-322. doi:10.1016/S1002-0160(09)60122-3

Santos LAO, Bischoff A and Fernandes OA (2018). The effect of forest fragments on abundance, diversity and species composition of predatory ants in sugarcane fields. *Basic and Applied Ecology, 33*: 58-65. doi:10.1016/j.baae.2018.08.009

Satiro LS, Cherubin MR, Safanelli JL, Lisboa IP, Rocha Junior PR da, Cerri CEP and Cerri CC (2017). Sugarcane straw removal effects on Ultisols and Oxisols in south-central Brazil. *Geoderma Regional, 11*: 86-95. doi:10.1016/j.geodrs.2017.10.005

Sattolo TMS, Mariano E, Boschiero BN and Otto R (2017). Soil carbon and nitrogen dynamics as affected by land use change and successive nitrogen fertilization of sugarcane. *Agriculture, Ecosystems & Environment, 247*: 63-74. doi:10.1016/j.agee.2017.06.005

Scarpare FV, Hernandes TAD, Ruiz-Corrêa ST, Picoli MCA, Scanlon BR, Chagas MF, Garbelini Duft D, Cardoso T de F (2016). Sugarcane land use and water resources assessment in the expansion area in Brazil. *Journal of Cleaner Production, 133*: 1318-1327. doi:10.1016/j.jclepro.2016.06.074

Schiesari L and Corrêa DT (2015). Consequences of agroindustrial sugarcane production to freshwater biodiversity. *GCB Bioenergy, 8 (3)*: 644-657. doi:10.1111/gcbb.12279

Schipanski ME, Barbercheck M, Douglas MR, Finney DM, Haider K, Kaye JP, Kemanian AR, Mortensen DA, Ryan MR, Tooker J and White C (2014). A framework for evaluating ecosystem services provided by cover crops in agroecosystems. *Agricultural Systems, 125*: 12-22. doi:10.1016/j.agsy.2013.11.004

Schmidt EJ (1997). Impacts of sugarcane production on water resources. *Proceedings of the South African Sugar Technologists' Association, 71*: 73-75

Searchinger T, Heimlich R, Houghton RA, Dong F, Elobeid A, Fabiosa J, Tokgoz S, Hayes D and Yu T-H (2008). Use of U.S. croplands for biofuels increases greenhouse gases through emissions from Land-Use change. *Science, 319*: 1238-1240. doi:10.1126/science.1151861

Sexton SE and Zilberman D (2008). *Biofuel impacts on climate change, the environment and food*. Report to the Renewable Fuels Agency. 36 p.

Shaw CM, Brodie J and Mueller JF (2012). Phytotoxicity induced in isolated zooxanthellae by herbicides extracted from Great Barrier Reef flood waters. *Marine Pollution Bulletin, 65 (4-9)*: 355-362. doi:10.1016/j.marpolbul.2012.01.037

Shih SF and Gascho GJ (1980). Water requirement for sugarcane production. *Transactions of the ASAE*: Paper No. 79-2095.

Signor D, Cerri CEP and Conant R (2013). N_2O emissions due to nitrogen fertiliser applications in two regions of sugarcane cultivation in Brazil. *Environmental Research Lettersers, 8*: 015013

Silva AJN, Ribeiro MR, Carvalho FG, Silva VN and Silva LESF (2007). Impact of sugarcane cultivation on soil carbon fractions, consistence limits and aggregate stability of a Yellow Latosol in Northeast Brazil. *Soil & Tillage Research, 94 (2)*: 420-424. doi:10.1016/j.still.2006.09.002

Silva FS, Cristale J, André PA, Saldiva PHN and Marchi MRR (2010). PM2.5 and PM10: The influence of sugarcane burning on potential cancer risk. *Atmospheric Environment, 44 (39)*: 5133-5138. doi:10.1016/j.atmosenv.2010.09.001

Singels A and Smith MT (2006). Provision of irrigation scheduling advice to small-scale sugarcane farmers using a web-based crop model and cellular technology: A South African case study. *Irrigation and Drainage, 55 (4)*: 363-372. doi:10.1002/ird.231

Siqueira Neto M, Galdos MV, Feigl BJ, Cerri CEP and Cerri CC (2016). Direct N2O emission factors for synthetic N-fertilizer and organic residues applied on sugarcane for bioethanol production in Central-Southern Brazil. GCB Bioenergy, 8 (2): 269-280. doi:10.1111/gcbb.12251

Sisenando HA, Batistuzzo de Medeiros SR, Artaxo P, Saldiva PHN and de Souza Hacon S (2012). Micronucleus frequency in children exposed to biomass burning in the Brazilian Legal Amazon region: a control case study. *BMC Oral Health, 12*: 6. doi:10.1186/1472-6831-12-6

Smeets E, Junginger M, Faaij A, Walter A, Dolzan P and Turkenburg W (2008). The sustainability of Brazilian ethanol – An assessment of the possibilities of certified production. *Biomass Bioenerg, 32*: 781-831. DOI: 10.1016/j.biombioe.2008.01.005

Smit MA and Singels A (2006). The response of sugarcane canopy development to water stress. *Field Crops Research, 98 (2-3)*: 91-97. doi:10.1016/j.fcr.2005.12.009

Southwick LM, Willis GH and Selim HM (1992). Leaching of agrazine from sugarcane in Southern Louisiana. *Journal of Agricultural and Food Chemistry, 40*: 1264-1268. doi:10.1590/S0103-90162011000100013

Souza RA, Telles TS, Machado W, Hungria M, Filho, JT and de Fatima Guimarães M (2012). Effects of sugarcane harvesting with burning on the chemical and microbiological properties of the soil. *Agriculture, Ecosystems & Environment, 155*: 1-6. doi:10.1016/j.agee.2012.03.012

Sparovek G and Schnug E (2001). Temporal erosion-induced soil degradation and yield loss. *Soil Science Society of America Journal, 65 (5)*: 1479-1486. doi:10.2136/sssaj2001.6551479x

Srivastava AC (2003). Energy savings through reduced tillage and trash mulching in sugarcane production. *American Society of Agricultural and Biological Engineers (ASABE)*: 13-18. doi:10.13031/2013.12729

Stefani Margarido TC, Arantes Felicio A, de Cerqueira Rossa-Feres D and de Almeida EA (2013). Biochemical biomarkers in Scinax fuscovarius tadpoles exposed to a commercial formulation of the pesticide fipronil. *Marine Environmental Research, 91*: 61-67. doi:10.1016/j.marenvres.2013.02.001

Stewart LK, Charlesworth PB, Bristow KL and Thorburn PJ (2006). Estimating deep drainage and nitrate leaching from the root zone under sugarcane using APSIM-SWIM. *Agricultural Water Management, 81 (3)*: 315-334: doi:10.1016/j.agwat.2005.05.002

Stirling GR, Moody PW and Stirling AM (2010). The impact of an improved sugarcane farming system on chemical, biochemical and biological properties associated with soil health. *Applied Soil Ecology, 46 (3)*: 470-477. doi:10.1016/j.apsoil.2010.08.015

Stromberg P, Esteban M and Thompson-Pomeroy D (2009). *Inter-linkages in climate change: Vulnerability of a mitigation strategy? Impact of Increased Typhoon Intensity on Biofuel Production in the Philippines*. United Nations University Institute of Advanced Studies (UNU-IAS) in collaboration with Kyoto University. 31 p.

Swinnen J and Squicciarini PM (2012). Mixed messages on prices and food security. *Science, 335*: 405-406. doi:10.1126/science.1210806

Tadini AM, Constantino IC, Nuzzo A, Spaccini R, Piccolo A, Moreira AB and Bisinoti MC (2015). Characterization of typical aquatic humic substances in areas of sugarcane cultivation in Brazil using tetramethylammonium hydroxide thermochemolysis. *Science of the Total Environment, 518-519*: 201-208. doi:10.1016/j.scitotenv.2015.02.103

Taniwaki RH, Cassiano CC, Filoso S, Ferraz SF de B, Camargo PB de and Martinelli LA (2017). Impacts of converting low-intensity pastureland to high-intensity bioenergy cropland on the water quality of tropical streams in Brazil. *Science of the Total Environment, 584-585*: 339-347. doi:10.1016/j.scitotenv.2016.12.150

Tavares RLM, de Souza ZM, Siqueira DS, La Scala Júnior N, Panosso AR and Campos MCC (2015). Soil CO_2 emission in sugarcane management systems. *Acta Agriculturae Scandinavica, Section B — Soil & Plant Science, 65 (8)*: 755-762. doi:10.1080/09064710.2015.1061048

Thayalakumaran T, Bristow KL, Charlesworth PB and Fass T (2008). Geochemical conditions in groundwater systems: implications for the attenuation of agricultural nitrate. *Agricultural Water Management, 95 (2)*: 103-115. doi:10.1016/j.agwat.2007.09.003

Thorburn P, Park S, Pearson LJ, Kroon FJ, Butler JRA and Westcott DA (2005). *Ecosystem services in sugarlands: Where are we now and how can they be enhanced?* SRDC Research Project CSE020 – Final Report. CSIRO Sustainable Ecosystems, Queensland, Australia: 96 p

Thorburn PJ, Biggs JS, Attard SJ and Kemei J (2011). Environmental impacts of irrigated sugarcane production: Nitrogen lost through runoff and leaching. *Agriculture, Ecosystems & Environment, 144 (1)*: 1-12. doi:10.1016/j.agee.2011.08.003

Thorburn PJ, Biggs JS, Palmer J, Meier EA, Verburg K and Skocaj DM (2017). Prioritizing Crop Management to Increase Nitrogen Use Efficiency in Australian Sugarcane Crops. *Frontiers in Plant Science, 8*: 1504. doi:10.3389/fpls.2017.01504

Thornton PK, Jones PG, Alagarswamy G, Andresen J and Herrero M (2009). Adapting to climate change: Agricultural system and household impacts in East Africa. *Agricultural Systems, 103 (2)*: 73-82. doi:10.1016/j.agsy.2009.09.003

Trouse AC and Humbert RP (1961). Some effects of soil compaction on the development of sugar cane roots. *Soil Science, 91*: 208-217

Udeigwe TK, Wang JJ, Viator HP and Gaston L (2010). Surface water quality as affected by sugarcane residue management techniques. *Water, Air, & Soil Pollution, 208*: 119-128. doi:10.1007/s11270-009-0153-2

Umbuzeiro GA, Franco A, Magalhoes D, De Castro FJV, Kummrow F, Rech CM, De Carvalho LRF and De Castro Vasconcellos P (2008). A preliminary characterization of the mutagenicity of atmospheric particulate matter collected during sugar cane harvesting using hte Salmonella/microsome microsuspension assay. *Environmental and Molecular Mutagenesis, 49 (4)*: 249-255. doi:10.1002/em.20378

Umrit G, Ng Cheong R, Gillabel J and Merchx R (2014). Effect of conventional versus mechanized sugarcane cropping systems on soil organic carbon stocks and labile carbon pools in Mauritius as revealed by ^{13}C natural abundance. *Plant and Soil, 379 (1-2)*: 177-192. doi:10.1007/s11104-014-2053-5

UN-Energy (2010). *A decision support tool for sustainable bioenergy – An overview*. Prepared by the Food and Agricultural Organization of the United Nations (FAO) and the United Nations Environment Program (UNEP) as a UN_Energy publication. 48 p.

Uriarte M, Yackulic CB, Cooper T, Flynn D, Cortes M, Crk T, Cullman G, McGinty M and Sircely J (2009). Expansion of sugarcane production in Sao Paulo, Brazil: Implications for fire occurrence and respiratory health. *Agriculture, Ecosystems & Environment, 132 (1-2)*: 48-56. doi:10.1016/j.agee.2009.02.018

Usaborisut P and Sukcharoenvipharat W (2011). Soil compaction in sugarcane fields induced by mechanisation. *American journal of Agricultural and Biological Sciences, 6 (3)*: 418-422.

Van Antwerpen R and Meyer JH (1996). Soil degradation under sugarcane cultivation in northern KwaZulu-Natal. *Proceedings of the South African Sugar Technologists' Association, 70*: 29-33

Van der Laan M, Jumman A, Tweddle P, Wettergreen T and Van Antwerpen R (2012). Application of a cycle assessment approach to quantify the environmental benefits of improved irrigation scheduling in sugarcane. *Proceedings of the South African Sugar Technologists' Association, 85*: 174-179

Vasconcelos ALS, Cherubin MR, Feigl BJ, Cerri CEP, Gmach MR and Siqueira-Neto M (2018). Greenhouse gas emission responses to sugarcane straw removal. Biomass and Bioenergy, 113: 15-21. doi:10.1016/j.biombioe.2018.03.002

Verdade LM, Gheler-Costa C, Penteado M and Dotta G (2012). The impacts of sugarcane expansion on wildlife in the state of So Paulo, Brazil. *Journal of Sustainable Bioenergy Systems, 2 (4)*: 138-144. doi:10.4236/jsbs.2012.24020

Wang W, Park G, Reeves S, Zahmel M, Heenan M and Salter B (2016b). Nitrous oxide emission and fertiliser nitrogen efficiency in a tropical sugarcane cropping system applied with different formulations of urea. *Soil Research, 54 (5)*: 572-584. doi:10.1071/sr15314

Wang WJ, Reeves SH, Salter B, Moody PW Dalal RC (2016a). Effects of urea formulations, application rates and crop residue retention on N_2O emissions from sugarcane fields in Australia. *Agriculture, Ecosystems & Environment, 216*: 137-146. doi:10.1016/j.agee.2015.09.035

Webster AJ, Bartley R, Armour JD, Brodie JE and Thorburn PJ (2012). Reducing dissolved inorganic nitrogen in surface runoff water from sugarcane production systems. *Marine Pollution Bulletin, 65 (4-9)*: 128-135. doi:10.1016/j.marpolbul.2012.02.023

Weier KL (1996). Trace gas emissions from a trash blanketed sugarcane field in tropical Australia. *In: Sugarcane; Research towards Efficient and Sustainable Production (eds Wilson JR, Hogarth DM, Campbell JA et al.)*: 271-272. CSIRO Division of Tropical Crops and Pastures, Brisbane, Australia.

Weier KL (1999). N_2O and CH_4 emission and CH_4 consumption in a sugarcane soil after variation in nitrogen and water application. *Soil Biology and Biochemistry, 31 (14)*: 1931-1941. doi:10.1016/S0038-0717(99)00111-X

Wendimu MA, Henningsen A and Gibbon P (2016). Sugarcane Outgrowers in Ethiopia: "Forced" to Remain Poor? *World Development, 83*: 84-97. doi:10.1016/j.worlddev.2016.03.002

Wesseling C, van Wendel de Joode B, Crowe J, Rittner R, Sanati NA, Hogstedt C and Jakobsson K (2015). Mesoamerican nephropathy: geographical distribution and time trends of chronic kidney disease mortality between 1970 and 2012 in Costa Rica. *Occupational and Environmental Medicine, 72 (10)*: 714-721. doi:10.1136/oemed-2014-102799

Wood AW (1985). Soil degradation and management under intensive sugarcane cultivation in north Queensland. *Soil Use and Management, 1 (40)*: 120-124. doi:10.1111/j.1475-2743.1985.tb00972.x

Wright AL (2009). Phosphorus sequestration in soil aggregates after long-term tillage and cropping. *Soil & Tillage Research, 103 (2)*: 406-411. doi:10.1016/j.still.2008.12.008

Xavier CV, Pitta FT and Mendonca ML (2011). *b: The Cosan-Shell merger: The Cosa-Shell merger*. Milieudefensie. 42 p.

Yadav RL, Prasad SR, Singh R and Srivastava VK (1994). Recycling sugarcane trash to conserve soil organic carbon for sustaining yields of successive ratoon crops in sugarcane. *Bioresource Technology, 49*: 231-235. doi:10.1016/0960-8524(94)90045-0

Yadav RL, Suman A, Prasad SR and Prakash O (2009). Effect of Gluconacetobacter diazotrophicus and Trichoderma viride on soil health, yield and N-economy of sugarcane cultivation under subtropical climatic conditions of India. *European Journal of Agronomy, 30 (4)*: 296-303. doi:10.1016/j.eja.2009.01.002

Ye R and Wright AL (2010). Multivariate analysis of chemical and microbial properties in histosols as influenced by land-use types. *Soil & Tillage Research, 110 (1)*: 94-100. doi:10.1016/j.still.2010.06.013

Yu K, DeLaune RD, Tao R and Beine RL (2008). Nonpoint source of nutrients and herbicides associated with sugarcane production and its impact on Louisiana coastal water quality. *Journal of Environmental Quality, 37*: 2275-2283. doi:10.2134/jeq2008.0082

Zamperlini GCM, Silva MRS and Vilegas W (1997). Identification of polycyclic aromatic hydrocarbons in sugar cane soot by gas chromatography-Mass spectrometry. *Chromatographia, 46 (11/12)*: 655-663. doi:10.1007/BF02490527

Zeni JO, Hoeinghaus DJ and Casatti L (2017). Effects of pasture conversion to sugarcane for biofuel production on stream fish assemblages in tropical agroecosystems. *Freshwater Biology, 62 (12)*: 2026-2038. doi:10.1111/fwb.13047

Zhang Y, Ni J and Zhang S (2011). Sustainable Energy Crop Production: A Case Study for Sugarcane and Cassava Production in Yunnan, China. *In: The 55th Annual Australian Agricultural and Resources Economics Society National Conference*. February 8-11, Melbourne, Australia.

Zou X and Bashkin M (1998). Soil carbon accretion and earthworm recovery following revegetation in abandoned sugarcane fields. *Soil Biology and Biochemistry, 30 (6)*: 825-830. doi:10.1016/S0038-0717(97)00155-7

 doi:10.20944/preprints202002.0397.v1

Zuurbier P and Van de Vooren J (2008). Introduction to sugarcane ethanol contributions to climate change mitigation and the environment. *In: Sugarcane ethanol – Contributions to climate change mitigation and the environment*. Zuurbier P and Van de Vooren Eds. Wageningen Academic Publishers. 255 p.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 27 February 2020 doi:10.20944/preprints202002.0397.v1

Table 1. Main producers, world production and harvested area of sugarcane in 2012

Origin	Production		Area Harvested	
	Tonnes	%	Hectares	%
Brazil	758,548,292	39.0	10,184,340	37.2
India	306,069,000	15.7	4,389,000	16.0
China	209,586,066	10.8	2,754,210	10.1
Thailand	102,946,001	5.3	1,368,269	5.0
Pakistan	73,401,199	3.8	1,216,894	4.4
Mexico	56,954,993	2.9	77,003	2.8
Australia	36,561,497	1.9	453,470	1.7
Colombia	34,638,019	1.8	397,387	1.5
Guatemala	33,758,389	1.7	278,967	1.0
USA	30,153,010	1.5	365,880	1.3
Rest of the World	303,704,955	15.6	5,173,620	18.9
Total	**1,946,321,421**	**100**	**27,354,040**	**100**

(*Source: FAO 2019*)

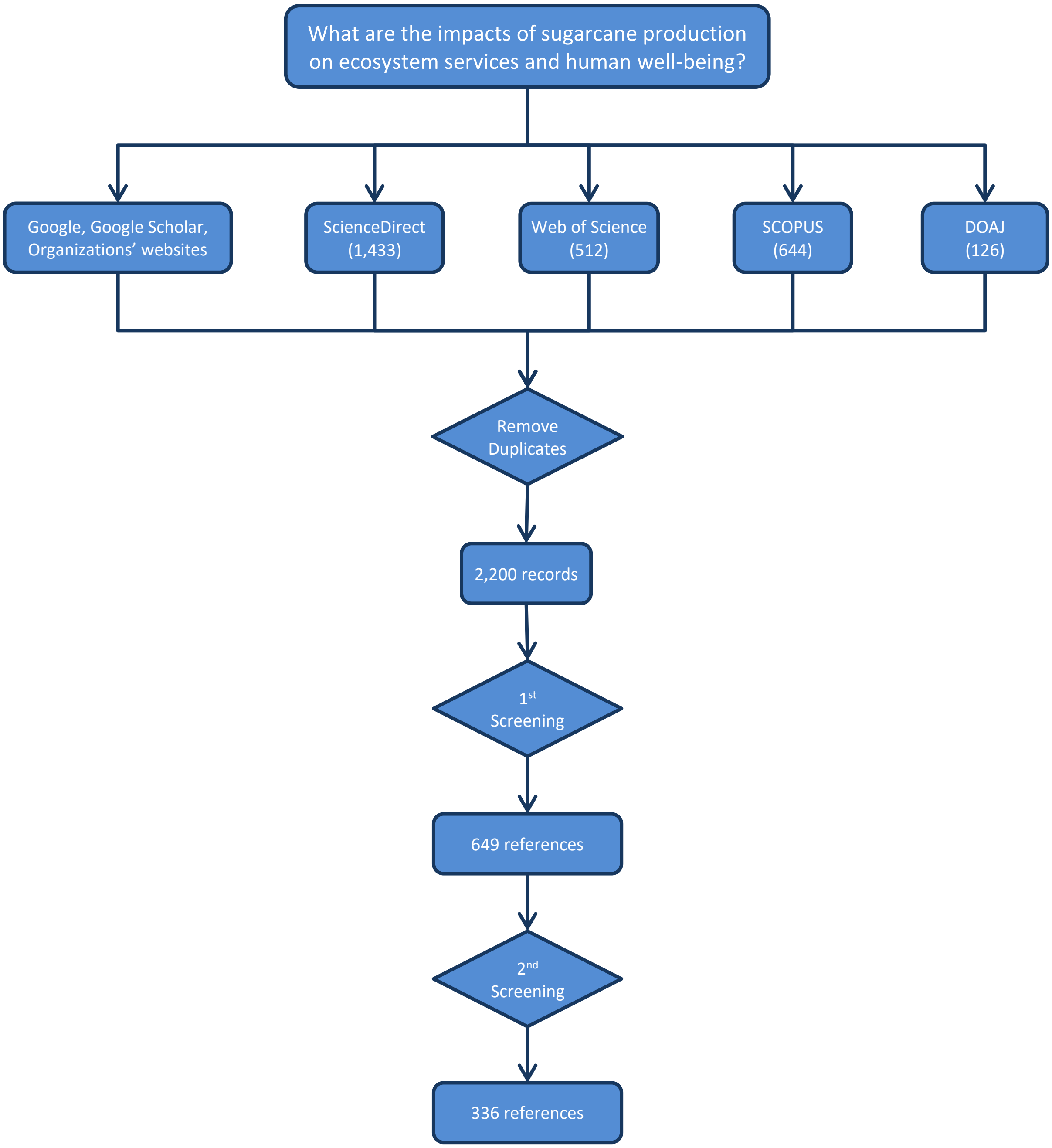

Figure 1: Schematic overview of the SR process

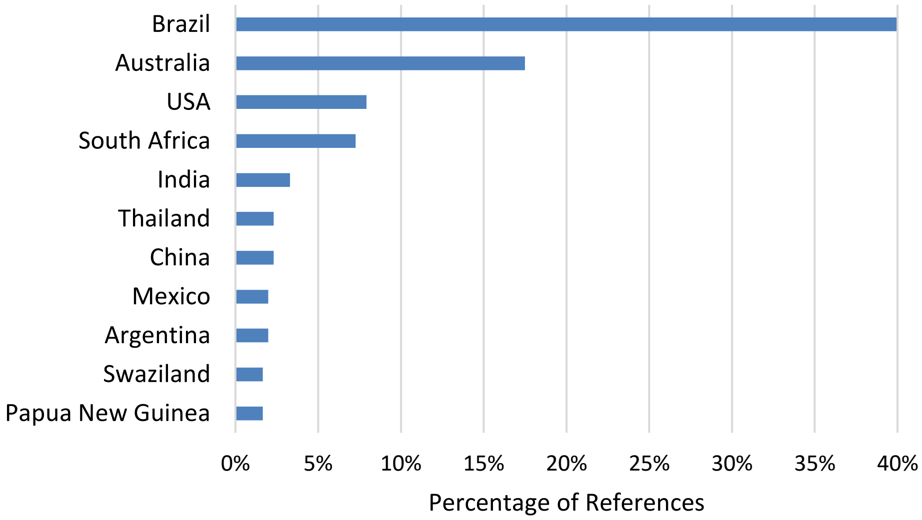

Figure 2: Distribution of the literature reviewed (%) by country

Table 2. Percentage of the literature reviewed by the main countries

Country	**Percentage (%)**
Brazil	39.9
Australia	17.5
USA	7.9
South Africa	7.3
India	3.3
Others	24.1
Total	**100**

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 27 February 2020 doi:10.20944/preprints202002.0397.v1

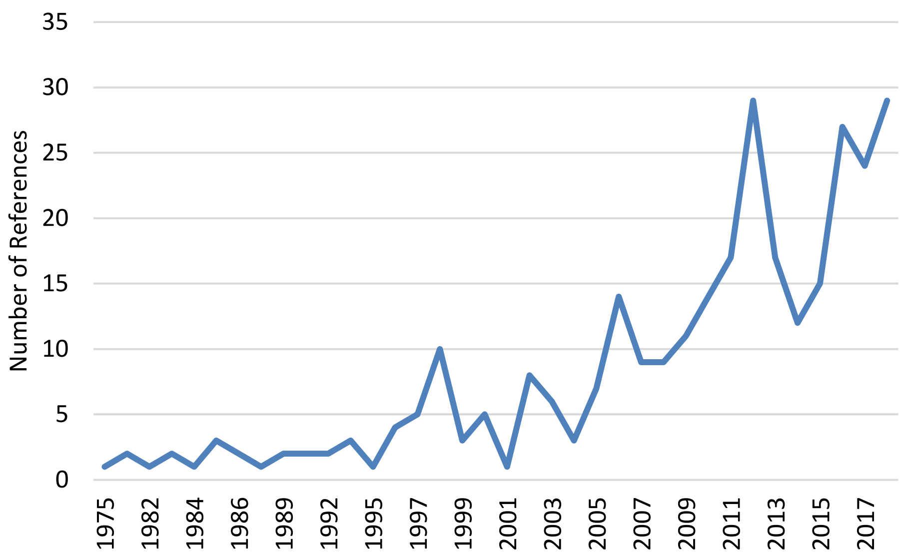

Figure 3: Distribution of the literature over the years

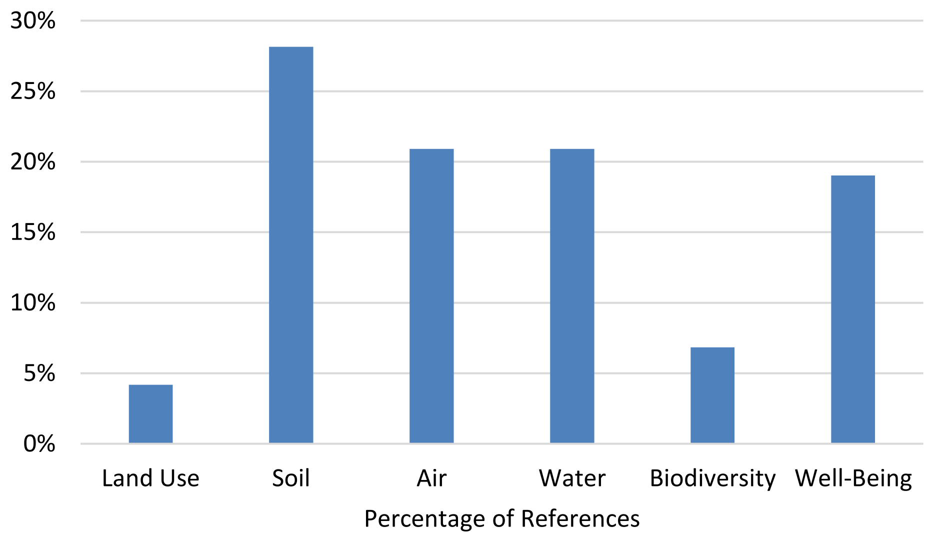

Figure 4: Distribution of the literature (%) by the impact on the ecosystem services